Business Meets Technology

4th International Conference

Ansbach University of Applied Sciences
7th to 9th July 2022

Barbara Hedderich
Michael Walter
Sebastian Stadler
Eva Didion
M Rosario Perello-Marín
Daniel Catalá Pérez (Eds.)

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UNIVERSITAT POLITÈCNICA DE VALÈNCIA
HOCHSCHULE ANSBACH

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INTRODUCTION

„Was klein begann, nimmt Formen an"

"What began small is taking shape"

The first installment of the International Conference on Business meets Technology took place in 2018. This year, 2022, we are proud to call the conference a joint scientific event since we teamed up with our colleagues from the Polytechnic University of Valencia (UPV) to host the fourth edition of the conference in Ansbach.

This not only means that jobs and ToDos are shared among more shoulders. It shows that the cooperation of two universities results in more than just the sum of their individual strengths. Since last year, the conference is hosted by both universities in annual rotation - in 2023, the colleagues from Valencia will welcome us at the UPV for the second time. In addition, the contributions to both venues will now be published in conference proceedings, which are available Open Access on the internet platform of the UPV, making the research freely accessible to anyone, from anywhere, at any time.

As expected, you will find the various peer-reviewed papers presented and discussed at the conference in the present proceedings - arranged thematically according to the conference sessions. But also, something new awaits you in these proceedings - extended abstracts of contributions to an exhibition, which took place this year for the first time in a new and fresh format. Besides classical research posters, virtual reality research applications, short movies, and language learning portfolios could be actively experienced. A first overview follows directly after the introduction. Enough words – enjoy and happy researching!

Ansbach, December 2022
Barbara, Daniel, Eva, Michael, Sari and Sebastian

SCIENTIFIC OVERVIEW

ADVANCES IN ENGINEERING RESEARCH

3D printing is, without any doubt, a paradigm-switching technology in industrial production. Therefore, it is not surprising that several papers in the engineering field deal with topics related to 3D printing. The most common 3D-printing process, Fused Filament Fabrication, is used by Vasile Ermolai, Alexandru Sover, and Gheorghe Nagit to design and test multi-material flexure hinges. The research collaboration of Ismail Hakki Tekiner, Anke Knoblauch, Bahar Özatila, and Murat Ay presented on soft matter physics that can set the biological clock of industrial food sciences and (bio)technology. Martin Michalak, Marius-Andrei Boca, and Alexandru Sover characterized various welding notch designs and quantified their impact on the mechanical properties of 3D-printed PLA parts, which are joined using a so-called 3D pen. Stefan Geißelsöder and Andriy Narovlyanskyy looked in-depth at the intelligence of interacting autonomous robots and virtual agents. Anette Lang, Marius-Andrei Boca, and Alexandru Sover investigated the influence of cooling conditions during 3D printing on the switching temperature of a TPU with SME. Further work also focused on the product design and its resulting characteristics from 3D printing. Alexandru Sover, Markus Zink, Marius-Andrei Boca, and Thomas Schönbucher present the development of 3D-printed recyclable jointless plastic grippers for medical application that are based on the design of compliant mechanisms. Furthermore, Silviu-Christian Eva, Alexandru Sover, and Vasile Ermolai analyzed the impact of the G-Code flavor on the 3D-printing process. Another current topic in the engineering session were the possibilities and limitations of computer science and its application for communication and industrial demands. Adapting new and disruptive technologies is highly relevant for modern industry, but the providers of such technologies pay surprisingly less attention. In their paper, Beatriz Garcia-Ortega, Daniel Catala-Perez, Blanca De-Miguel-Molina, and María De-Miguel-Molina classify the intrinsic risk factors related to their specific nature, grouped by subjects, along with the potential derived negative impacts on their businesses. The session was closed by Ana Isabel Almerich-Chulia, Jesica Moreno-Puchalt who showed potential perspectives of 3D laser scanner for real life domains.

BUSINESS 1

The workshop Business one started with three papers in the area of circular economy. Joaquín Sanchez-Planelles, Yolanda Trujillo-Adriá, Belén Silva-Cardenas, and María de Miguel-Molina gave a first introduction on how to set the basis for further research by defining key concepts and testing them with cases in the hotel and restaurant sector. M Rosario Perello-Marín, Conrado Carrascosa-Lopez, María de Miguel-Molina, and Miguel Angel Mas Gil analyzed existing labels looking for their content with respect to circular economy goals to help understand which aspects are already covered and how especially small and medium size enterprises could, in the long run, better communicate their advances in this area and thus gaining a new instrument for publicity., María de Miguel-Molina, Virginia Santamarina-Campos, Marival Segarra-Oña, Ángel Peiró-Signes and Daniel Catalá-Pérez concluded this part of the workshop by presenting their focus group design and preliminary results for information gathering in the tourism sector in the Valencia region. Benjamin Korder, Julien Maheut, and Matthia Konle showed the first results of their literature review on the subject of the Ripple Effect in Supply Chains. Ines Diez-Martinez and Angel Peiró-Signes presented their results of an in-depth analysis of possible causal conditions for understanding differences in environmental orientation when innovating. This paper is not included in the proceedings. Cornelius Pöpel and Egbert Jürgens analyzed the challenge of overcoming the separation between academia and industry in the field of music technology, giving examples of their own experience and showing preliminary possibilities for explaining why most promising ideas in academia will never end up helping industry in reaching their goals as a basis for generating ideas for overcoming those barriers. Rebecca Oberst, Barbara Hedderich, Blanca de Miguel-Molina, and Daniel Catalá-Pérez summed up some suggestions for reducing stress for first-semester students, which were also based on a survey.

BUSINESS 2

In Business two, Christian A. Gebhard showed through the analysis of interview results that there is still considerable potential in building up China competence at enterprise levels. This paper is not included in the conference proceedings. Angel Peiró-Signes and Oscar Trull-Dominguez showed an interesting analysis of human pressure on the Hawaiian Islands, thus testing a possible methodology for measuring such effects in the controlled environment of an island. This paper is also not included in the proceedings. Ritam Garg introduced the necessity of a new perspective when analyzing cross-cultural collaboration. He presents indigenous management concepts as a promising approach for overcoming the limitations of the more classical management literature. Eva Didion, María Rosario Perelló-Marín, Ute Ambrosius, and Daniel Catalá Pérez introduced a possible research agenda based on a structured literature review.

INFORMATION SYSTEMS

The session started with a review on potential usages of virtual reality in design research and practice by Sebastian Stadler. Carsten Lanquillon and Sigurd Schacht illustrate how cognitive agents grounded on continuously enhanced knowledge graphs constructed based on state-of-the-art AI solutions and appropriate feedback mechanisms for quality assurance can support organization and domain-specific knowledge management. Pavlina Kröckel, Alexander Piazza, and Pascal Wessel demonstrate that emotion recognition software captures unexpected emotional reactions from football coaches, which could then be used to calculate statistics and increase fan engagement and entertainment. A digital study assistant based on conversational Artificial Intelligence that meets the multi-faceted needs of students in their day-to-day studies is presented by Sophie Henne, Vanessa Mehlin, Elena Schmid, and Sigurd Schacht. The assistant acts as a communicator, a motivator, and an analyzer and supports mentoring. The session on information systems was closed by a review of the use of machine learning techniques in eco-innovation research by Inés Diez Martinez and Ángel Peiró Signés.

EDUCATION

The closing session Education and Teaching Sciences was opened by Christian A. Gebhard, who introduced the profile of learners of Chinese. Christian Riess, Michael Walter, Maria Tyroller, Lisa Gomolka, and Johannes Augustin showed benchmarks for a learning experience with real prototypes. Patrick Gröner, Barbara Hedderich, and Lena Dittrich gave an overview of the different possibilities a model project offers for giving Universities of Applied Sciences a chance to train their staff. Christian A. Gebhard and Monica Baudracco-Kastner pleaded not to forget the positive experiences of online teaching, basing their recommendations on several surveys with students.

POSTER SESSION

The exhibition was set up for the first time in the conference series and gave young researchers and students the possibility to present their work to an international scientific audience. The Executive Summaries of selected contributions are included in the conference proceedings.

Mascha-Lea Fersch, Sophie Henne, Vanessa Mehlin, Sigurd Schacht, Elena Schmid, Vincent Su talked about the project “DIAS” which introduces a digital intelligent study assistant at the University of Applied Sciences Ansbach. Janine Riemann gave insights on the influence of virtual reality on the feeling of hunger and the consequences for the feeling of satiety and food cravings, while Markus Kenderes took a closed look on sustainability at the UAS Ansbach. Annika Bölz and Sibylle Gaisser analyzed the public perception of nonpharmacological interventions for COVID-19-pandemic containment. Finally, Sibylle Gaisser and Christopher Hain took into account pattern recognition programming to predict the productivity of Yarrowia lipolytica DSM 3286 for citric acid production.

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DESIGN AND TESTING OF MULTI-MATERIAL FLEXURE HINGES FOR FUSED FILAMENT FABRICATION

Ermolai, Vasile [a]; **Sover Alexandru** [b] **and Nagît, Gheorghe** [c]

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ABSTRACT: Flexure hinges are non-assemble flexible joints that allow the relative rotation of two adjacent rigid parts through bending. Traditionally thermoplastic material hinges are made through injection moulding. 3D printing technologies such as Fused Filament Fabrication (FFF) introduced new possibilities regarding hinges development due to design freedom and the availability of multiple materials. However, the current state of the art focuses mainly on single materials hinges with non-symmetrical design for one-way folding. For this reason, this paper aimed to identify and test multiple design solutions for two-way folding hinges made of compatible and low-compatible thermoplastic materials using design thinking methods. The design process considered the materials' bond formation, resulting in overlapping designs for compatible materials and interlocking designs for the others. The considered materials were acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA) with thermoplastic co-polyesters (TPC) for the hinge. The resulting designs of multi-material two-way folding hinges were tested using a tensile test to evaluate the performance of the interlocking mechanism. The results show that macroscopic interlocking provides the best results.

Keywords: *Flexure hinge; Two-way folding; Fused filament Fabrication, Multi-material; Macroscopic interlocking mechanism*

1. INTRODUCTION

The flexible or compliant mechanisms are systems that use the flexibility of their components to achieve motion. Such components are flexure hinges or living hinges

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(Howell, 2013). A conventional living hinge is generated by starting from a blank piece thinned by one or two cutouts. It results in a thin beam connecting two adjacent bodies, allowing relative rotation between bodies through bending (Liu et al., 2017).

Conventionally, living hinges are made through injection moulding with no assembly required and are single materials designs. Polypropylene (PP) is a material that can exceed one million folding cycles (Balderrama-Armendariz, 2019). Depending on their application, living hinges can have multiple designs, such as simple beams, with transition radiuses or rounded profiles (Figure1).

The development of 3D printing technologies introduced new possibilities regarding part manufacturing (Jandyal et al., 2022), and living hinges design can be one of them. As presented in figure 1, the design solutions refer to non-symmetrical geometries allowing one rotational degree of freedom in one direction (i.e., one-way folding). Even if multiple researchers have studied the behaviour of the same design (figure 1a, c, f) made of the same materials, the results have differed due to the distinct testing methods (Lussenburg et al., 2021). Multi-material 3D printing can introduce new possibilities regarding living hinge designs by using flexible materials only for the bending component. Currently, FFF technology offers the widest variety of materials that can be explored. However, standard multi-material 3D printing uses a head-to-head contact interface for the mating bodies and is limited to materials compatibility.

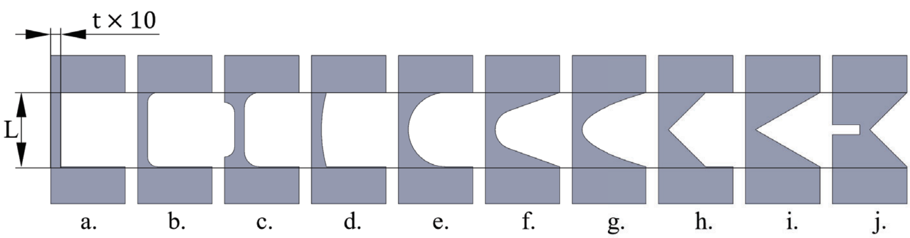


Figure 1. Side view of flexure hinges design with equal hinge thickness (t) and length (L) and different geometries. Adapted from Lussenburg et al., 2021 & Liu et al., 2018.

Ando et al., 2021 and Ermolai et al., 2022 showed that a head-to-head interface would not result in a flat-to-flat bonding profile when printing with FFF technology. Instead, the materials are printed layer-wise, and the materials are zigzagging at the boundary region of the mating bodies. Zones of vertical and horizontal contact characterise the resulting bond. They also concluded that overlapping parts' bodies is necessary to increase bond strength. The overlap provides a design direction for multi-material hinges.

Ribeiro & Carneiro, 2018 investigated the tensile properties of multi-material samples of high-compatible PLA-PLA and low-compatible PLA-TPU materials. They concluded that a standard head-to-head contact interface does not offer good mechanical properties. Therefore, a more robust macroscopic interface is required.

This paper explores the various designs of multi-material hinges for two-way folding made of compatible (i.e., ABS-TPU) and low-compatible (i.e., PLA-TPU) materials. Design thinking methods were used to identify as many solutions as possible (i.e., axiomatic design principles and idea map). A fraction of the resulting hinges concepts were designed as samples in a CAD environment for the FFF 3D printing process. The resulting models were tested using a tensile test to evaluate the performance of the interlocking mechanism. The results show that macroscopic interlocking interfaces provide the best results.

2. METHODS

2.1. Design method

A design methodology was developed consisting of five steps to provide a framework for the design process of the two-way folding hinges. The first two steps establish the hinge design's functional requirements, design parameters, and constraints. These steps are based on the axiomatic design principles developed by Nam Suh (Suh, 2001). Because the axiomatic design method leads to a unique solution, it was considered that, in this case, testing multiple solutions is more beneficial for the aim of this paper. For the third step, the development of an idea map was considered. Finally, the last two steps refer to concept testing and validation. The design steps are as follows: *Step I - Define functional requirements and constraints, Step II - Identify design parameters and process variables, Step III - Create the idea map, Step IV - Prototyping and testing, and Step V - Concept validation*.

The first step was identifying the hinges' functional requirements and design constraints based on customer needs (i.e., researchers). Secondly, those were redefined as design parameters with their process variables. The resulting design matrix for the multi-material two-way folding hinges is presented in figure 2.

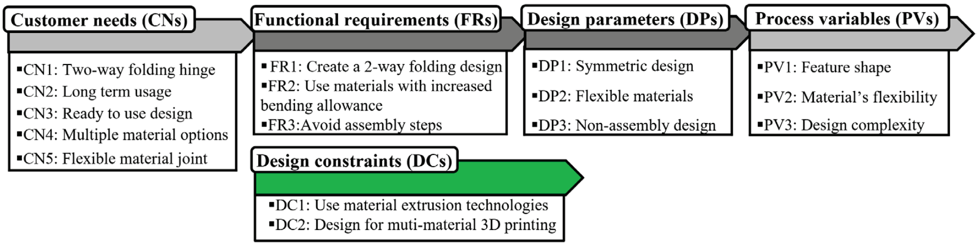


Figure 2. Definition of functional requirements and constraints.

The idea map was defined in the third step of the ideation process. It consists of two design directions: the flexible hinge geometry and the multi-material interlocking mechanism (figure 3). Regarding the flexible hinge design, the most convenient solution was to adapt the design of the existing hinges (figure 1) to the two-way folding requirement. Besides this, the development of new hinge designs was considered. The solutions are profiles based on regular hinges and shape morphing structures, which can change their 2D shape into a 3D shape under plastic deformation (Wu et al., 2022). In addition, possible morphing designs can be based on corrugated and auxetic structures (see figure 3). However, these solutions are limited to material compatibility. The bonding mechanism depends on mating bodies' interface contact area size and the materials' chemical adhesion. Macroscopic (geometrical) interfaces between the hinge's body and mating elements were considered to compensate for those limitations. This approach can be used for both material groups, compatible and low-compatible.

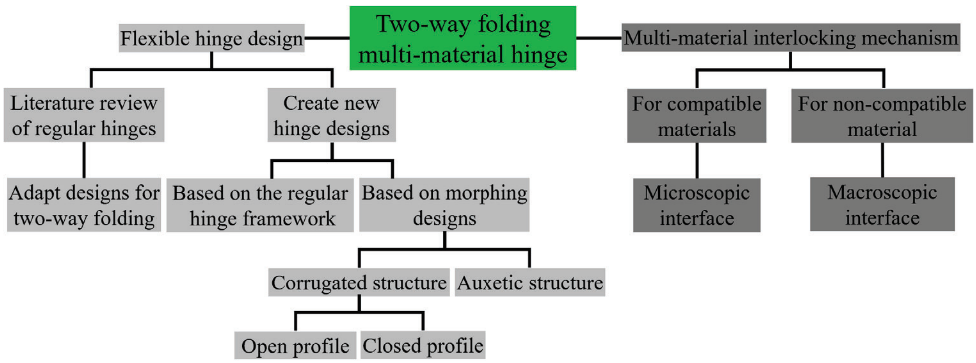


Figure 3. The idea map of the multi-material two-way folding hinges.

In this study, only a fraction of the identified hinges solutions from the idea map were considered for testing. Those are adapted profiles and new geometries based on existing hinges (i.e., from figure 1). Furthermore, microscopic and macroscopic interfaces were studied for the multi-material interlocking mechanism.

Based on those mentioned above, two testing groups were considered. The first group consists of the adapted regular hinges and the second with an interlocking mechanism. Those were designed for compatible thermoplastic materials (i.e., ABS and TPU). The second group with the new hinges designs combined the microscopic interlocking mechanism. Their behaviour was tested for compatible and low-compatibility materials (i.e., PLA and TPU).

2.2. Specimens and contact design

As for the design consideration, based on DC1 and DC2 (figure 2), all models were drawn based on the DfAM rules (i.e., Design for Additive Manufacturing). All models were designed for FFF 3D printing with a 0.4 mm nozzle.

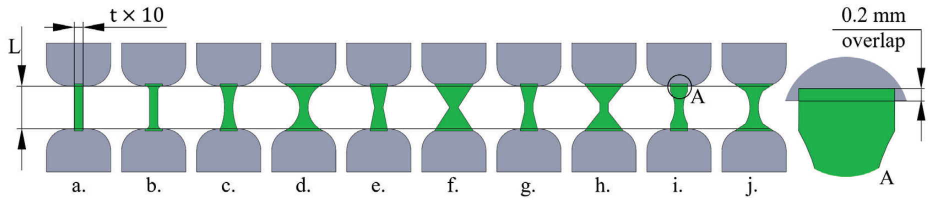


Figure 4. Side view of hinges based on (figure 1) adapted for two-way folding: a. rectangular profile, b. rectangular profile with transition radius, c. narrow hyperbolic profile, d. wide hyperbolic profile, e. narrow hourglass profile, f. wide hourglass profile, g. combined narrow profile (a&e), h. combined wide profile (a&f), i. combined narrow profile (a&c), j. combined wide profile (d&f).

Ten adapted profiles resulted based on regular hinge profiles (figure 1). Their shape varies from a rectangular shape (figure 4a, b) to a hyperbolic shape (figure 4c, d) to an "hourglass" profile (figure 4e, f) or combinations of them (figure 4g-j). The basic dimensions were hinge length L (i.e., 4mm) and thickness t (i.e., 0.8 mm). The remaining unquoted sizes were constrained with linear dimensions as multiples of 0.4 mm (i.e., nozzle diameter). Based on the findings of Ando et al., 2021 and Ermolai et al., 2022 , a constructive overlap was designed between the flexible hinge and mating bodies (detail A of figure 4).

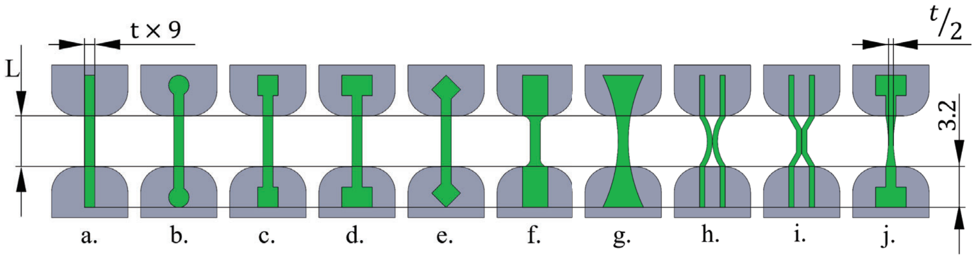


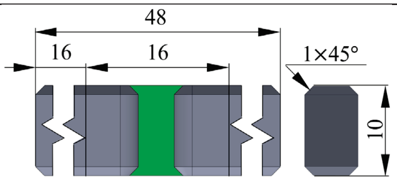
Figure 5 – Side view of the design of the new hinges based on regular profiles with a macroscopic interlocking interface: a. straight rectangular profile, b. rectangular profile with circular ends, c. rectangular profile with square ends, d. rectangular profile with rectangle ends, e. rectangular profile with rhomboid ends, f. rectangular profile with transitory ends, g. hyperbolic profile, h. biconcave circular profile, i. biconcave hexagonal profile, j. necked rectangular profile with a rectangular end.

The second group of hinges consists of 10 geometry designs. Six are based on rectangular profiles with various ends for the interlocking geometry, such as circle, square, rectangle, and rhomboid (figure 5a-f). Other designed profiles were hyperbolic with the wider region as an interlocking geometry (figure 5g), biconcave circular profile (figure 5h), and biconcave hexagonal profile (figure 5i), both with straight ends. The last considered profile (figure 5j) is based on figure 5d but with a thining in the midzone.

2.3. Printing process parametrisation

Two materials were chosen for the specimens' bodies, a dark-grey PLA from 3Dimensionals and a light-grey ABS from REC. As for the hinge, a green Innoflex 45D TPC material from BASF was selected. The printing files were generated using Cura 4.13.0 and printed on an Ultimaker 3 3D printer. Each design configuration was printed with four replicates with the same setup regarding geometrical specifications (e.g., layer height, number of walls). All considered settings are shown in table 1.

Table 1. Print process parameters



Abbreviations:

- extr. - extrusion;	- dist. – distance;
- temp. - temperature;	- thk. – thickness;
- spd. - speed;	- no. - number.

Values in Italic refer to ABS material;
Values in Bold refer to TPC material.

Parameter	PLA/*ABS*/**TPC**	Parameter	Value
Extr. temp. (°C)	215/*245*/**240**	Layer thk. (mm)	0.15
Bed temp. (°C)	60/*90*/**60**	Extr. width (mm)	0.4
Print spd. (mm/s)	30/30/**5**	No. of perimeters	3
		No. of top/bottom layers	6
1st layer spd. (mm/s)	15/*15*/**5**	Infill pattern	Gyroid
Retraction dist. (mm)	7/7/**4**	Infill density (%)	10
Retraction spd. (mm/s)	35/*35*/**40**	Brim	Yes
Fan spd. (%)	100/*0*/**25**	Brim width (mm)	3
Closed environment	No/*Yes*/**No**		

3. Result and discussion

All samples were tested for tensile strength using an Instron 4411 universal machine at 10 mm/s speed. The laboratory conditions were 22.5°C with 39% humidity. The average results were used to evaluate the hinges design and the interlocking mechanism.

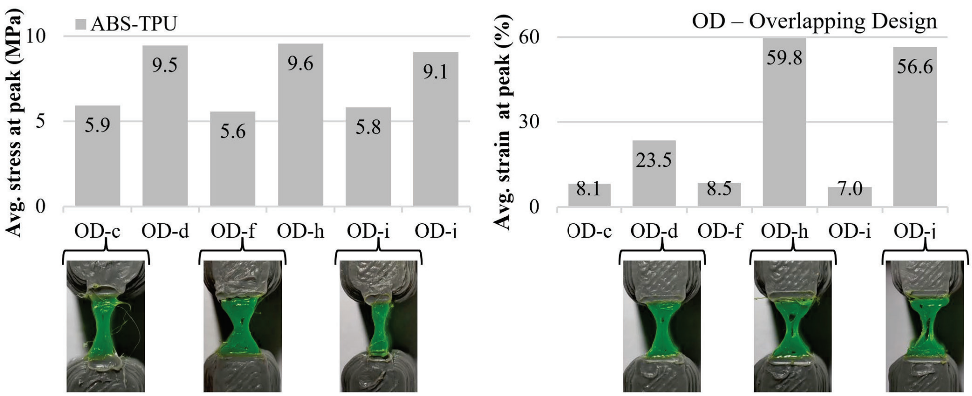


Figure 6. Average stress and strain for the overlapping design hinges.

Only a part of the printed samples of hinges with overlapping designs was tested for contact interface bond strength. Due to the poor bond formation between the ABS and TPC materials, only c, d, f, h, i, and j designs were tested (figure 4). It can be observed that the bonding mechanism is influenced by the size of the interface surface between the hinge and mating bodies. Thus, the vertical and horizontal adhesion areas are affected by interface size. Regarding stress and strain, designs with a wider contact interface had the best results under static load conditions (figure 6, designs d, h, and j). The h design achieved the highest tensile strength, characterised by a wide "hourglass" body and a narrow square region of 0.8 mm. Based on the print result and tensile tests, a rule of thumb can be followed in future work. For multi-material 3D printing, the overlapping design is recommended only for the product that does not require high load capacity. In addition, a minimum interface size should be considered (e.g., a minimum of 1.2 mm in width).

Compared to the overlapping design, the print result had no bonding issue due to the macroscopic interface for the interlocking design hinges. However, a behaviour difference regarding the failure mode was observed between the PLA-TPC and ABS-TPC configurations. After reaching the peak, the TPC hinge split into multiple strings for samples with the PLA body stress. As for specimens with ABS bodies, the hinge body maintained its structural integrity, delaminating only near the ABS mating body. This behaviour was observed for all tested models. The printing conditions can explain the different failure behaviour of the hinge among PLA-TPC and ABS-TPC samples. Because the ABS is sensitive to temperature changes, a closed environment was required. Therefore, it is assumed that the constant environment temperature of 45°C during printing increased the layers fuse between TPC layers. An example of TPC hinge failure behaviour for ID-e design is presented in figure 7 for both materials configurations. Moreover, it can be observed that the tensile strength increases due to the layer's better fuse.

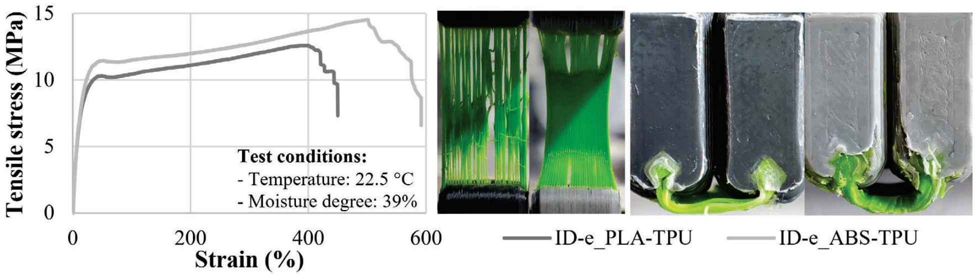


Figure 7. Stress-strain diagram of ID-e hinge design for PLA-TPC and ABS-TPC materials configurations, failure mode at peak and folding results (from left to right).

According to the average test results (figure 8), hinges with the macroscopic interlocking interface showed a considerable increase in tensile stress and strain compared to the overlapping hinge designs. The hinge designs ID-a to ID-f showed comparable results regarding the load capacity but significant differences referring to strain. The best-resulting design was ID-d with 12.6 MPa tensile strength and 684.9 % elongation for the PLA-TPC configuration. For the second group of materials, ABS-TPC, the same design registered 13.9 MPa tensile strength and 619.4 % strain on average. Interestingly, for the same design, by performing a thinning on the hinge design (i.e., ID-j) along with a closed environment during printing, the tensile strength increased to 18.2 MPa with 660.6% elongation. The hyperbolic profile achieved the best performance of the other tested designs, with 14.5 MPa tensile strength and 364.4 % elongation for PLA-TPC and 14.5 MPa strength with 497.3% strain for ABS-TPC. Overall, the best results were obtained for the ID-j hinge printed with ABS-TPC.

Another possible variable responsible for the different behaviour of each hinge design under testing is the travel path during the material deposition. Depending on the feature shape (i.e., the hinge), each contour's starting and closing point can act as a tension concentrator because of the inconsistent amount of deposited material. For example, consider the Seam Alignment parameter (which controls the closing point location) with the Sharpest corner option. For the ID-b design composed of a rectangular beam and two circular profile ends, the sharpest corner is at the intersection between the two profiles. The Seam Alinement setting brings the weld line closer to the outer surface of the hinges' mating body. On the other hand, for the ID-c design constructed using the same beam profile but with two square ends, the sharpest corner identified by the slicing tool is an edge inside the hinge's body. Comparing the test results from the mentioned design, it can be considered that the tool path can significantly influence the multi-material hinges.

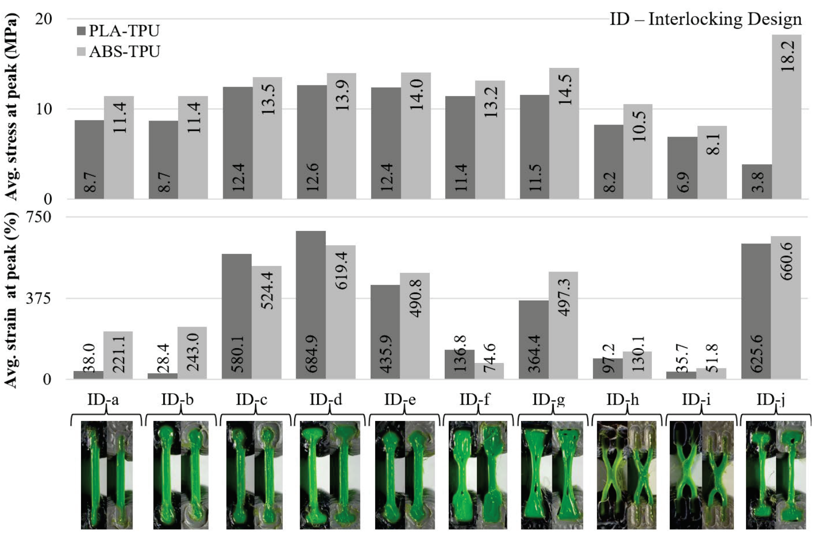


Figure 8. Average tensile strength and strain for the interlocking design hinges.

4. CONCLUSIONS

Multi-material FFF 3D printing offers new possibilities regarding flexure hinge designs. The use of flexible hinge materials allows both one-way and two-way folding hinges. It was shown that multi-material hinges could be made in configurations of compatible and non-compatible materials. The first configuration can achieve good results if there is enough contact surface between mating bodies. However, the resulting bonds between materials lack strength for functional applications. Even with an increased overlap between hinges' bodies, some printed samples could not be tested due to improper bond formation.

On the other hand, the hinges with a macroscopic interlocking mechanism design showed an increased performance compared to the previous designs. It was shown that the printing conditions of the specimens could influence the failure mode of the flexible hinges. A closed printing environment increases layers fuse. Regarding the hinge's design, performing a thinning of the profile in the mid-region can improve load capacity and failure behaviour.

Conflict of interests

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

E.V. conceived, designed, and performed experiments, analysed the results, and wrote the manuscript S.A. and N.G. analysed the experiments, technical proof of results, and reviewed the manuscript. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Ando, M., Birosz, M., & Jeganmohan, S. (2021). *Surface bonding of additive manufactured parts from multi-colored PLA materials.* Measurement,169, 108583.

Balderrama-Armendariz, C. O., MacDonald, E., Roberson, D., et al., (2019). Folding be havior of thermoplastic hinges fabricated with polymer extrusion additive manufacturing. *Int. J. Adv. Manuf. Technol.*, 105, 233-245.

Ermolai, V., Sover, A., & Nagit, G. (2022). *Influence of contact geometry over the fila ment bond of poly-lactic acid blends.* IOP Conf. Ser.: Mater. Sci. Eng, Bristol, 1235, 012004.

Howell, L. L. (2013). *Compliant Mechanisms.* In McCarthy, J. (eds) 21st Century Kine matics. (pp. 189-216). Springer.

Jandyal, A., Chaturvedi, I., Wazir, I., Raina, A. & Ul Haq, M. (2022). *3D printing – A review of processes, materials, and applications in industry 4.0. Sustainable Operations and Computers,* 33-42.

Liu, M., Zhang, X., & Fatikow, S. (2017). *Design and analysis of a multi-notched flexure hinge for compliant mechanisms.* Precision Eng., 48, 292-304.

Liu, S. Q., Zhang, H. B., Yin, R. X., Chen, A., & Zhang, W. J. (2018). Flexure Hinge Based Fully Compliant Prosthetic Finger. Proc. of SAI Intelligent Systems Conf. (IntelliSys), Cham., 16, 893-849.

Lussenburg, K., Sakes, A., & Breedveld, P. (2021). Design of non-assembly mechanisms: A state-of-the-art review. Addit. Manuf. J., 39, 101846.

Ribeiro, M., & Carneiro, O. S. (2019). Interface geometries in 3D multi-material prints by fused fil-ament fabrication. Rapid Prototyp. J., 25(1), 38-46.

Suh, N. (2001). *Axiomatic Design: Advances and Applications.* New York: Oxford Univ. Press.

Wu, Y., Guo, G., Wei, Z., & Qian, J. (2022). Programming Soft Shape-Morphing Systems by Harnessing Strain Mismatch and Snap-Through Bistability: A Review. Materials, 15(7), 15:2397.

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SOFT MATTER PHYSICS CAN SET BIOLOGICAL CLOCK OF INDUSTRIAL FOOD SCIENCE AND (BIO)TECHNOLOGY

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ABSTRACT: Tom McLeash (2005), Professor of Natural Philosophy, says that "in science nothing stays the same. This is true not only at the level of discoveries, experiments, and theories, but also for the coherent structures and disciplines of the scientific community itself. A fascinating recent example has been the emergence of the field of 'soft matter' from a recognition that problems in polymer science, colloid science, liquid crystals, surfactant systems, foams, and even biological materials must draw on the same experimental and theoretical tools to make progress." In this paper, we aim to highlight the concept of soft (condensed) matter physics and its association with industrial food science and (bio)technology within the scope of a new term "food physics".

KEYWORDS: *Soft matter; Food physics; Food science and technology; Biotechnology*

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1. INTRODUCTION

In 1970, Madeleine Veyssié, a close collaborator of Pierre-Gilles de Gennes, invented the term soft matter as a joke – in French, 'matière molle.' Following that, in 1991, Pierre-Gilles de Gennes, also so-called the Isaac Newton of our time, won the Nobel Prize in Physics "for discovering that methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter, in particular to liquid crystals and polymers." His Nobel Lecture was entitled "Soft Matter" (Zhou, 2019).

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Foods are considered as complex soft condensed matter systems containing food colloids, proteins, and amphiphilic polymers with the characteristics of complex components, diverse time scales and length scales, and diverse aggregation states. The intermolecular assembly structure of food soft matter is complex and diverse, and determines the food quality (Zhang, Wu, Qian, Ramachandran, & Jiang, 2021). Additionally, food science and technology needs a better understanding of how structuring assemblies of protein-starch, -polysaccharides, or protein-protein behave at various length scales, from nano to macro, and their interactions lead to the formation of structures in food as described by Professor Milena Corredig from Aarhus University (Corredig, 2022). Therefore, soft matter science can deepen our understanding of foods' nature and behavior by providing theoretical and experimental findings on the relations among the critical elements of food structure and the associated physical phenomena and food functionality (Ubbink, 2012). Similarly, Professor Thomas Vilgis from Max Planck Institute emphasizes research on soft matter to understand the non-equlibrium, multistage molecular processes of foods and food model systems (Vilgis, 2022).

Understanding the properties of food is paramount for improving appearance, taste, and texture, health-related factors such as minimizing the onset of allergies or improving the digestibility of nutrients, and preserving food and extending its shelf-life (Assenza & Mezzenga, 2019). Because of a broad range of materials and systems that can be considered soft matter, soft matter science is an interdisciplinary field in which physics, chemistry, materials science, biology, nanotechnology, and engineering meet. However, implementing soft matter physics in food science and technology is not easy for different reasons. Because most foods are not static items and (1) structure development by human intervention comes on top of a complex structure as laid down by nature, (2) exhibit both a complex structure and complex composition, (3) originate from a broad range of sources and geographical locations, (4) influenced by cultural preferences, (5) transformed by processing approaches and (6) breakdown by consumption and digestion, respectively. Therefore, from the pure physics perspective, foods are 'dirty' systems with their complex, applicable and advanced characteristics in engineering, processing, and applied science (Ubbink, 2012; Vilgis, 2015).

As Ingvar Lindgren of the Royal Swedish Academy of Sciences said in his Presentation Speech in 1991 that "the major progress in science is often made by transferring knowledge from one discipline to another." Therefore, soft matter physics can not be separated from the significant problems and current challenges in food science, technology, and biotechnology. In other words, Stenhammar (2021) tells that soft matter physics can be considered as a truly interdisciplinary field in the crossroads between physics, chemistry and biology, and it has significant influences on a broad range of diverse fields including medicine, microbiology, food technology, and materials design.

In this paper, we aim to highlight the concept of soft (condensed) matter physics and its association with industrial food science and (bio)technology within the scope of a new term "food physics".

2. SOFT (CONDENSED) MATTER

De Gennes explains the essence of soft matters by using the example of the Indian boot. Indians take the sap from the Hevea tree and smear their feet. After 20 minutes, the liquid sap coagulates under the effect of oxygen and turns into a solid boot. Oxygen was later substituted with sulfur to make a sturdy boot. The liquid matter becomes solid matter. Small causes create significant effects: weak external actions can transform soft matter. De Gennes says, "this is the central and fundamental definition of soft matter." (Grosberg & Khokhlov, 2010; Zhou, 2019).

Thinking of a boiling kettle to demonstrate the phases of matter, the kettle is solid, whereas the water is liquid. With the increasing temperature, some of this water in the kettle turns to gas billowing from the spout. On the other hand, is your skin solid? Skin is as hard as the kettle and does not flow like water. Skin is something in between, something spongy. Physicists, therefore, call it soft matter (Institute of Physics, 2021).

Physicists define condensed matter as any extensive collection of interacting atoms that form a material. Similarly, soft matters can be considered soft condensed matters — the materials other than those in gas and solid states, but usually do not include simple fluids (Institute of Physics, 2021).

Soft matter is characterized by subtle forces and weak interactions, including hydrogen bonds, van der Waals forces, and π-π interactions that cause a complicated hierarchy of organization through some techniques (X-ray scattering, Calorimetry, Optical microscopy, rheology, and dielectric spectroscopy as a function of temperature and pressure) (Soft Matter Physics Lab, 2022).

Soft matter is commonly defined as that subset of physical states which are easily deformable by thermal fluctuations or whose total energy and the corresponding energy minima are of the order of kT or less (Ubbink, Burbidge, & Mezzenga, 2008), or it refers to the materials that are easily deformed by thermal fluctuations and external forces (van der Gucht, 2018).

In other words, soft matter physics is interested in the physical principles governing the behaviors of foams, liquid crystals, polymers, colloidal dispersions, microemulsion, micelle, and various types of biological liquids, suspensions, and even granular materials, because of their wide applications (Zhou, 2019).

3. FOOD AS SOFT (CONDENSED) MATTER

Process optimization relies on an underlying assumption of (near) equilibrium, and this naturally yields scale-up rules and optimization paths for chemical reactions. On the other hand, food does not follow this underlying assumption of near-equilibrium because the optimization of food processing is a much more difficult problem than that of chemicals. Consequently, most food processing has remained relatively artisanal, resembling a scaled-up culinary operation. Based on this fact, food processes tend to simultaneously create structure, texture, and flavor, leading to a series of complicated interactions that are difficult to separate (Burbidge & le Révérend, 2016).

Hard matters are usually not sensitive to external actions, while soft matters are very sensitive to them. Physicists often take pride in dealing with systems as simple and 'pure' as possible. However, de Gennes' work has shown that even 'untidy' physical systems can successfully be described in general terms (Zhou, 2019). Food aspects from 'hard matter systems,' such as chocolates or crystalline fats, to 'soft matter' in emulsions, dough, pasta, and meat can be explained by the molecular interplay on all length and time scales because foods are generally non-universal systems (Vilgis, 2015).

Van der Sman refers to "the dispersed phase and length scales" in the soft matter approaches to food structuring (van der Sman, 2012), whereas Ubbink et al. (2008) use "softness" as the defining property. Van der Sman and van der Goot say: that "all soft matter is in principle thermodynamically unstable, and needs to be stabilized." (van der Sman & van der Goot, 2009). Mezzenga (2021) states that most processed foods are inherently unstable but do not generalize to all foods and soft matter structures. De Kruif agrees with van der Sman that most foods are dynamically arrested, as van der Sman points out. On the other hand, he indicates the thermodynamically stable casein micelle in milk (de Kruif, 2012).

Ubbink (2012) asks, "Does one need a dedicated physical science to deal with food-related issues? To which extent can principles, concepts, and even quantitative results be transferred from more fundamental physical disciplines?". According to Vilgis (2015), there is a need for 'food physics' except for food chemistry and food engineering because physics can provide some 'order' into food systems by using simple model systems, which provide a basis for new ideas, fundamental aspects and the predictability of a structure–texture–property–flavor relationship, based on molecular grounds.

Food is rich in types of soft matter and often includes mixtures of various mesoscale building blocks. For instance, milk, as a food colloid, is an oil-in-water emulsion with protein particles as a stabilizer. Many very stable colloidal particles called casein micelles result in the appearance of milk emulsion and can survive sterilization at high temperatures or homogenization at high shear rates. Similarly, mayonnaise is another example of natural stabilization. The lipoprotein particles of the egg yolk behave as a stabilizer through the oil-water interface adsorbed in the adsorption layer and discrete tiny droplets. Similarly, polysaccharides/polysaccharides (thickening or gelling agents) and polysaccharides/proteins (emulsion stabilizers) are soft matter combinations in food processing. Their interactions and self-assembly nature determine the high-level structure of food, thus impacting on texture, sense, and stability of food (Zhang, Wu, Qian, Ramachandran, & Jiang, 2021).

Soft condensed matter is where physics meets biology. Living things are comprised of complex fluids – liquids containing mesoscopic structures with length scales of 1 µm and less – and physicists have investigated complex fluids such as colloids, polymers, liquid crystals, and solutions containing soap-like molecules. However, the dialogue between soft-condensed-matter physics and biology is not as well developed as expected (Physics World, 2019).

Furthermore, the soft matter concept provides some opportunities for biotechnology, such as hierarchical media tools controlled by interface stability in foams and emulsions, routes to stop coarsening and drainage, couples of proteins forming microspheres, control of interface thickness, doping with soft particles (Foamulsions), dual dispersions (highly durable materials) and minor structural modifications to control foam stability (Beaufils et al., 2013).

Additionally, physics, biology, and food are therefore focused on some questions relating to physical aspects of foods and food constituents and their interaction with the human body, as well as the interface with biotechnology and microbiology: the biophysics of microorganisms concerning food fermentation and human health (Ubbink, 2012).

In the Edinburgh Soft Matter Physics group, colloidal and granular model systems for phenomena ranging from jamming to bacterial colonies and to rationally design novel soft materials for use in applications ranging from foods to energy material are studied by experiments, computer simulations, and theoretical calculations. Major research interests include rheophysics of soft matter, physics of barriers in soft matter and biology, new soft materials, physics of cellular motion and bacterial populations (The University of Edinburgh, 2022).

4. CONCLUSION AND FUTURE OUTLOOK

There is still a lack of interest in soft matter physics to examine food, although many foods are soft materials, and among food types, polymers and gels present simple model systems (Pedersen & Vilgis, 2019).

Furthermore, the association between microscopic and macroscopic structures in robust food systems remains unclear. In particular, mesoscopic structures (intermediate length scales from molecular to the millimeter) determine the macroscopic characteristics of food and constitute the primary focus of soft matter science (Hogan, O'Loughlin, & Kelly, 2016).

In the last decades, food science and (bio)technology researchers have used soft matter approaches, for instance, to understand the correlation between food protein interactions, phase transitions, and structural properties, particularly at the interfaces, in a condensed state, or complex coacervation conditions, to build functional structures. Recent demographic and food transitions, environmental and energy constraints, and links between these factors and public health are stressing the food and biotechnology researchers to consider sourcing, production method, composition/structure, processing methods, and digestive deconstruction by-products to reach sustainability criteria. Within these challenges, alternative sources of food proteins (plant, algae, insect) and by-product valorization require novel extraction strategies, the screening and design of functional mixed protein assemblies, and the understanding of aggregation and self-assembly of proteins to generate functional assemblies. Of course, these problems cannot be solved with a physical approach alone. However, for many of them, a physical understanding can contribute to food and biotechnology researchers and the industry towards new solutions (Vilgis & Limbach, 2016; Boire et al., 2018).

The influence of soft matter physics on foods remains limited, presently excludes fresh and artisanally prepared foods, and foodstuffs developed by soft matter approaches at the industrial scale are somewhat restricted. To overcome these issues, both academy and industry should strongly encourage multidisciplinary studies integrating soft matter approaches with food chemistry, biology, and physiology. Interestingly, it is clear that physical approaches will highly find application in the food industry, in particular by a shift to food design based on defined properties of the end product, often based on insights from consumer studies or on nutritional recommendations. Additionally, soft matter approaches for food structuring can also help formulate societal issues relating to food, such as health, environmental impact, and food culture and diet under a rational translation (Ubbink, 2012). de Kruif (2012) also points out that the food researchers are familiar with all the concepts in soft matter physics even though they have introduced all food products one can find on the supermarket shelves. However, de Kruif also reminds General De

Gaulle's once said, "How can one reign a country with 250 varieties of cheese" (developed by food technologists and not by soft matter physics).

As Scott Shane (2009) says, management of technological innovation requires novel theories for influencing a broad range of business activities with novel products, and the products that they can create, as well as firm strategy. Overall, soft matter physics can help food scientists and (bio)technologists understand food complexity to meet the technology and innovation management needs on the food industry.

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Conflict of interests

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AUTHOR CONTRIBUTIONS

All authors have contributed equally.

REFERENCES

Assenza, S., & Mezzenga, R. (2019). Soft condensed matter physics of foods and macronutrients. *Nature Reviews Physics*, *1*(9), 551–566. https://doi.org/10.1038/s42254-019-0077-8

Beaufils, S., Renault, A., Saint-Jalmes, A., Paboeuf, G., Pezennec, S., le Floch-Fouéré, C., . . . Bouhallab, S. (2013, June). How Soft Matter Approaches Bring New Tools For Biotechnology [Slides]. Retrieved from https://hal.archives-ouvertes.fr/hal-01209456/document

Boire, A., Bouchoux, A., Bouhallab, S., Chapeau, A. L., Croguennec, T., Ferraro, V., . . . Anton, M. (2018). Proteins for the future: A soft matter approach to link basic knowledge and innovative applications. *Innovative Food Science & Emerging Technologies*, *46*, 18–28. https://doi.org/10.1016/j.ifset.2017.06.012

Burbidge, A. S., & le Révérend, B. J. D. (2016). Biophysics of food perception. *Journal of Physics D: Applied Physics*, *49*(11), 114001. https://doi.org/10.1088/0022-3727/49/11/114001

Corredig, M. (2022, March 28). A soft matter physics approach to designing food matrices with novel sustainable ingredients. Retrieved May 10, 2022, from https://food.au.dk/masters-thesis-projects/a-soft-matter-physics-approach-to-designing-food-matrices-with-novel-sustainable-ingredients

de Kruif, C. G. K. (2012). Concluding remarks: the future of soft matter and food structure. *Faraday Discussions*, *158*, 523. https://doi.org/10.1039/c2fd20122d

Grosberg, A. Y., & Khokhlov, A. R. (2010). *Giant Molecules: Here, There, and Everywhere* (2nd ed.). Singapore, Singapore: World Scientific Publishing Company.

Hogan, S., O'Loughlin, I., & Kelly, P. (2016). Soft matter characterisation of whey protein powder systems. *International Dairy Journal*, *52*, 1–9. https://doi.org/10.1016/j.idairyj.2015.07.005

Institute of Physics (IOP). (2021). Soft matter physics. Retrieved April 23, 2022, from https://www.iop.org/explore-physics/physics-stepping-stones/soft-matter-physics

McLeish, T. (2005). Analysing soft matter. *Materials Today*, *8*(9), 51. https://doi.org/10.1016/s1369-7021(05)71087-7

Mezzenga, R. (2021). Grand Challenges in Soft Matter. *Frontiers in Soft Matter*, *1*. https://doi.org/10.3389/frsfm.2021.811842

Pedersen, M. T., & Vilgis, T. A. (2019). Soft matter physics meets the culinary arts: From polymers to jellyfish. *International Journal of Gastronomy and Food Science*, *16*, 100135. https://doi.org/10.1016/j.ijgfs.2019.100135

Physics World. (2019, December 4). Soft condensed matter: where physics meets biology –. Retrieved April 24, 2022, from https://physicsworld.com/a/soft-condensed-matter-where-physics-meets-biology/

Shane, S. (2009). *The Handbook of Technology and Innovation Management* (1st ed.). NJ, USA: Wiley-Blackwell.

Soft Matter Physics Lab. (2022). Soft Matter Science. Retrieved April 23, 2022, from http://softmatter.physics.uoi.gr/

Stenhammar, J. (2021, November 22). Research – Soft matter out of equilibrium. Retrieved May 10, 2022, from https://www.stenhammargroup.com/?page_id=79

The University of Edinburgh. (2022, March 31). Soft Matter Physics. Retrieved May 11, 2022, from https://www.ph.ed.ac.uk/icmcs/research-themes/soft-matter-physics

Ubbink, J. (2012). Soft matter approaches to structured foods: from “cook-and-look” to rational food design? *Faraday Discussions*, *158*, 9. https://doi.org/10.1039/c2fd20125a

Ubbink, J., Burbidge, A., & Mezzenga, R. (2008). Food structure and functionality: a soft matter perspective. *Soft Matter*, *4*(8), 1569. https://doi.org/10.1039/b802183j

van der Gucht, J. (2018). Grand Challenges in Soft Matter Physics. *Frontiers in Physics, 6*, 87. https://doi.org/10.3389/fphy.2018.00087

van der Sman, R. (2012). Soft matter approaches to food structuring. *Advances in Colloid and Interface Science*, *176–177*, 18–30. https://doi.org/10.1016/j.cis.2012.04.002

van der Sman, R. G. M., & van der Goot, A. J. (2009). The science of food structuring. *Soft Matter*, *5*(3), 501–510. https://doi.org/10.1039/b718952b

Vilgis T. A. (2015). Soft matter food physics--the physics of food and cooking. *Reports on progress in physics. Physical Society (Great Britain)*, *78*(12), 124602. https://doi.org/10.1088/0034-4885/78/12/124602

Vilgis, T., & Limbach, H. J. (2016). The physics of food. *Journal of Physics D: Applied Physics*, *49*(11), 110401. https://doi.org/10.1088/0022-3727/49/11/110401

Vilgis, T. (2022). The soft matter food physics. Retrieved May 10, 2022, from https://sites.mpip-mainz.mpg.de/vilgis

Zhang, Q., Wu, K., Qian, H., Ramachandran, B., & Jiang, F. (2021). The advances of characterization and evaluation methods for the compatibility and assembly structure stability of food soft matter. *Trends in Food Science & Technology*, *112*, 753–763. https://doi.org/10.1016/j.tifs.2021.04.034

Zhou, L. (2019). *Introduction to Soft Matter Physics* (1st ed.). Singapore, Singpore: World Scientific.

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CHARACTERIZATION OF WELDING NOTCH DESIGNS AND THE IMPACT ON MECHANICAL PROPERTIES OF 3D-PRINTED PLA PARTS JOINED BY A 3D PEN

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Abstract: 3D-printing has been established as a fast and low-cost technology to produce prototypes in small numbers. However, depending on the geometry of a part the print time still can be reduced by splitting the part in two or more smaller parts and later joining them. The reduction of the print time is caused by the possibility of printing the smaller parts with less or maybe even without any support or the use of two or more 3D printers. The joining can be done by different welding or gluing methods. For this paper 3D printed polymer parts with different welding notch designs were welded by a 3D pen and after characterized based on their mechanical properties. The notches were designed in CAD and the parts were then 3D printed. The material chosen was PLA as it is one of the most common polymer materials for FFF 3D printing. For testing and mechanical characterisation of the strength of the joined samples, four different kinds of notches were designed, manufactured and tested according to the norms for the tensile strength test and the Charpy impact test of thermoplastic polymers. The results were compared to the one of a single part printed sample. Although the mechanical properties of the welded samples were not as good as the ones of a fully printed one, the assembly even of the weakest variant, the triple notch, is still strong enough for most applications in the field of rapid prototyping. The method is easy applicable and can be fast done to ensure a good connection between 3D printed PLA parts.

Keywords: *Joining; 3D printing; Welding; PLA; 3D pen*

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1. INTRODUCTION

Nowadays the 3D printing of polymer parts is a common and widespread method, not only in the industry, but as well as in private households. Whether it is the need of rapid prototyping or the fast and easy construction of models or repair parts, the 3D-printer offers great solutions. However, there are limitations to this method like the size of the build plate on a 3D-printer, which prevents the user from printing bigger parts. Problems can occur also for tall and especially thin models that require extra stability to remain upright during the printing process. For this kind of parts, the occurring problems are for example dimensional inaccuracy, rough surface with imperfection or even failed prints. Solutions for these problems are stabilizer support structure, extra cooling, lower print speed or a bigger footprint (brim or rafts) which can be considered either in the designing stage or during slicing. To avoid the problem of the limitation of the build plate, parts which are too big are split into smaller parts and later joined. This can be done by a lot of different joining methods like fastening, adhesive or solvent bonding, fusion, friction and vibration welding or mechanical interlocking. Nowadays, widely popular joining methods are Friction Stir Welding (FSW) and Friction Stir Spot Welding (FSSW) techniques, which have proven their feasibility since 1991, when they were patented as a welding technology for Al-based alloys (Iftikhar, 2021). Lately these techniques prove their capabilities in the field of polymer welding and even in the case of hybrid joints (polymer-metal). The process is capable of repeatedly producing continuous weld seams with very high joint efficiencies, (Lambiase, 2020). However, because of the resulting temperatures in the welding area for some polymers appears the risk of self-lubrication or the occurrence of a hard shell. Last effect appears when the outer material cools quicker than the inner one, which will make the material contract and pull away from the surfaces of the parts which are being welded. In this case it is mandatory to obtain a consistent cooling rate on the entire volume of the welding seam. To compare the previously mentioned disadvantages, a new technology is proposed, the welding by using a 3D pen (Jaksic, 2015). This approach is fast and easy to apply to obtain a solid and durable mechanical connection between the parts. Even though the process is based on extrusion welding without an external heat source, it is barely documented in polymer welding literature. It is an affordable and fast process of welding polymer parts together as it just requires a 3D pen, and some filament that will be further melted and extruded directly into the joint. The main purpose of this paper is to characterize this method and test it. Different kind of welding notches were designed and applied on CAD models of samples. The v-notch, the triple-notch, the s-notch and the d-notch. The purpose of using notches for the welding with the 3D pen is to ensure that the nozzle of the 3D pen gets in contact with the parts to plasticize the contact surfaces and create a better weld connection. The samples were welded and then tested on their mechanical properties.

2. METHODOLOGY

The purpose of this study is to present straightforward measurement techniques to characterize the strength and efficiency of a weld formed between two 3D printed parts. The mechanical feasibility of the proposed joint forms is determined in terms of tensile strength, elongation at break and absorption of impact energy. To gain values which describe the quality of the welding of two joined parts compared to a single part, two tests were chosen, the tensile strength test and the Charpy impact test. These tests show the mechanical properties on load which can occur to welded parts. To produce the samples a professional desktop 3D printer the BCN3D SigmaX R19 was used due to the accuracy along the axes and to the IDEX (Independent Double Extrusion System) printheads working system. Mirror printing mode allowed two sets of samples to be printed in half the time which is required on a single printhead printer due to the mirror movements of the second extruder. The material which was used is the 2,85 mm in diameter PolyTerra™ PLA in cotton white for the tensile strength test and in savannah yellow for the impact test. PLA was chosen as it is one of the most common used materials for 3D printing of polymer parts. Due to the risk of delamination of the layers during elongation, (for tensile tests) and bending (for Charpy) of the specimen, the build orientation plays an important role in the evaluation of the welding efficiency (Ai, 2022). Therefore, horizontal orientation was considered for all printed tensile strengts specimens. Since the influence of the printing parameters is not considered, all samples were printed using the following same process parameters,Table 1.

Table 1. Printing parameters used for the samples

Printing conditions					
Layer height [mm]	0.15	Infill density [%]	35	Infill print speed [mm/s]	40
Line width [mm]	0.4	Infill pattern	Grid	Wall print speed [mm/s]	35
Wall line count	3	Infill overlap percentage [%]	15	Cooling [%]	95
No. of top layers	8	Printing temperature [°C]	210	Support structure	No
No. of bottom layers	8	Build plate temperature [°C]	45	Print mode	Mirror

For the selection of the printing parameters, the recommendations of the material manufacturers but also the capability and configuration of the 3D printer was taken into consideration. Wall, top and bottom shell thickness were kept uniformly in order to avoid the influence of printing parameters (such as numbers of top and bottom layers) over the efficiency of the joints. The quality of the weld is also influenced by the flatness of the plate contact surface. In the case of FFF (fused filamenmt fabrication), layer thickness has a significant influence on the surface roughness and printing time. Considering that the nozzle diameter is 0.4 mm, a layer height of 0.15 mm was used. To keep the contact surfaces between the sample flat, the Z seam was kept outside the welding zone. Further the starting point of each layer was set in the clamping/attachment area of the part in the jaws of the tensile strength test machine to avoid a weak spot in the area of testing.

The samples for the tensile strength test were designed according to EN ISO 527 test specimen type 1A (International Organization for Standardization [ISO], 2012). The samples for the Charpy impact test were designed after EN ISO 179 test specimen type (ISO, 2010). Five different variants were chosen to be compared with each other, four of them with notches for welding and one as a fully printed single part. The variants with notches were designed in CAD as two similar parts with no connection but notches (Figure 1) on the front and the back of the sample at the joining surfaces. The 3-notch was designed unsymmetric to prevent two thin areas of the part wich would result in two weakpoints of the material.

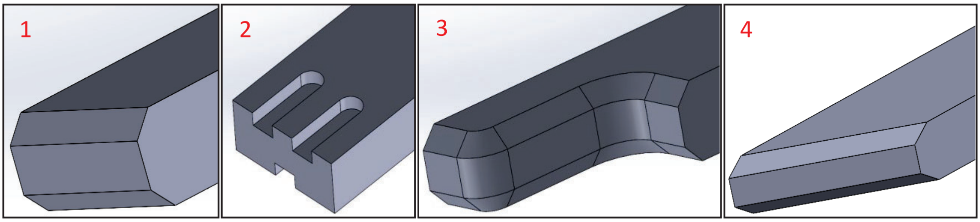

Figure 1. Different notch variants: 1) v-notch, 2) 3-notch, 3) s-notch, 4) d-notch

The used 3D pen is the 3D Simo Multipro (Figure 2) with the settings for PLA and the lowest extrusion speed setting. The material for the weld lines is a PLA filament which was included in the 3D pen kit and has a similar melting temperature as the PLA of the parts, which is important for the welding process.

Figure 2. 3D Simo Multipro with settings and purple PLA filament

For each test five samples of each variant were printed and conditioned at room temperature for at least 24 hours. After they were welded together (Figure 3) by using the 3D pen with a different PLA filament another conditioning of 24 hours was done before the specimen were tested.

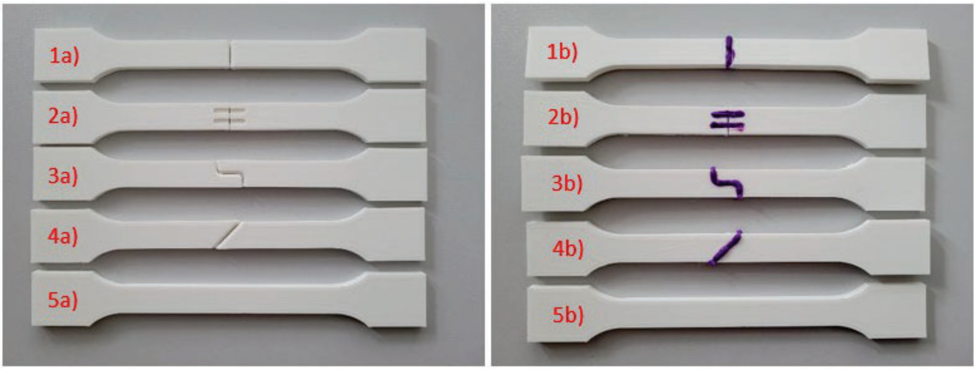

Figure 3. Test specimen for the tensile strength test: 1) v-notch, 2) 3-notch, 3) s-notch, 4) d-notch, 5) fully printed part; a) unwelded, b) welded

For the welding process no pretreatment of the samples was done because additional work steps should be avoided to keep the process simple. The joining parts where fixed by a form during the welding process and hold in place for several seconds to cool down before being turned around and welded on the opposite side. The v-notch and the d-notch samples were more convenient to weld as it is a straight line wich is easier to weld than curved lines or lines with interruptions. The 3-notch samples took the longest to weld as a short break was required between the two lines on the front side to avoid additional material between the notches.Tensile test samples were tested on a universal testing machine (INSTRON, 4411 H4193, max. load 5 kN), at a crosshead speed of 50 mm/min. Charpy test samples were tested on a pendulum impact testing machine (Zwick, 5102.201, max. pendulum length 225 mm and max energy of 5 J). The hammer was chosen according to the norm.

3. RESULTS

The tensile strength test results show (Figure 4) that all variants which were welded had lower maximum tension forces which caused a break of the material, then the sample which was printed as a single part. The average of 18,44 MPa for the single part is much higher than the triple notch variant with 8,31 MPa. However, the d-notch with an average of 13,67 MPa showed the best result of the welded variants. The average elongation at break was for all variants below 5% as PLA is a very stiff material.

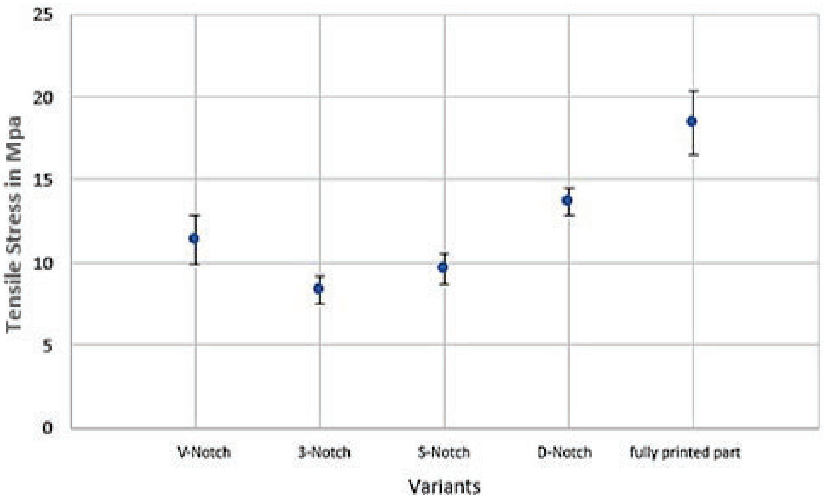

Figure 4. Average tensile stress at break of the different samples

The results of the Charpy impact test (Figure 5) show a far range of the impact resistance from the average of 1,99 KJ/m^2 for the triple notch up to the 9,96 KJ/m^2 for the fully printed variant. The s-notch and the d-notch showed good results with both close to an average of 7 KJ/m^2.

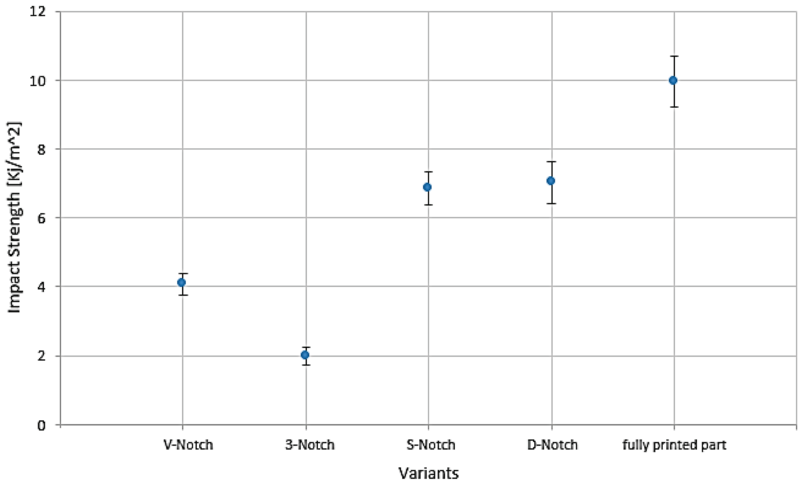

Figure 5. Average impact strength of the variants

Both tests show that of the welded variant the d-notch had the best mechanical properties and was not too far of the results from the fully printed part. The 3-notch however had the lowest mechanical properties which is related to the joining surfaces which are responsible for taking the forces of the two tests. Figure 6 shows the different types of breaking of the 3-notch, the s-notch and the d-notch.

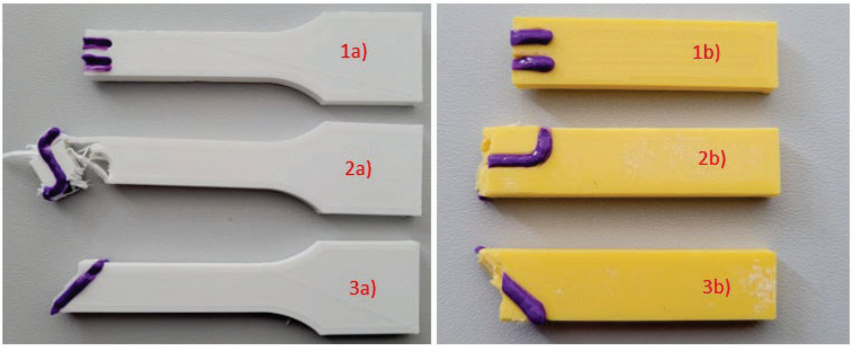

Figure 6. Broken test specimen: 1: 3-notch, 2: s-notch, 3: d-notch, a) tensile strength tested, b) impact tested

It is clearly visible, that some of the material of the s-notch version and the d-notch version is still connected to the weld line and one of the joined parts broke partially. The 3-notch sample broke at the joining surfaces of the two separate printed parts. A cross section picture of a welded part (Figure 7) shows the connection between the part and the filler material. The mixture of the colours in the joining zones show that a welding process has taken part and both materials were plasticized. On the picture a gap is visible between the parts, which indicates, their mechanical properties tested, were the ones of the connection itself.

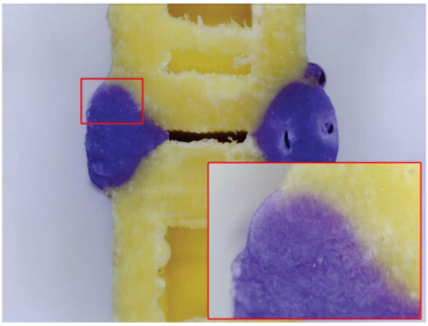

Figure 7: Cross-section of the welded v-notch sample for Charpy

4. CONCLUSION

The method of welding by using a 3D pen has proven to be a fast and easy applicable technique which shown good results for mechanical properties of the joined parts. However, the notch design is important and should be considered while constructing parts which later must be joined. The d-notch shows good results in both tests and offers a strong joint for 3D printed parts. Depending on the application of a 3D printed part which must be joined, other notches can be considered as well. If a part just has the purpose of being a prototyping design model and has no mechanical loads affecting it other weld lines like the 3-notch can be used as well.

REFERENCES

Ai, JR.; Vogt, B.D. (2022). Size and print path effects on mechanical properties of material extrusion 3D printed plastics. Progress Additive Manufacturing. https://doi.org/10.1007/s40964-022-00275-w

Iftikhar, S.H.; Mourad, A-HI.; Sheikh-Ahmad, J.; Almaskari, F.; Vincent, S. (2021, April). A Comprehensive Review on Optimal Welding Conditions for Friction Stir Welding of Thermoplastic Polymers and Their Composites. Polymers, Vol. 13 No. 8: 1208. https://doi.org/10.3390/polym13081208

International Organization for Standardization. (2010). Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test (ISO Standard No. 179-1:2010). https://www.iso.org/standard/44852.html

International Organization for Standardization. (2012). Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics (ISO Standard No. 527-2:2012). https://www.iso.org/standard/56046.html

Jaksic, N. I. (2015, June). BYOE: Using 3D Pens for Enhancement and Rework of 3D-Printed Parts, Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.23656 https://peer.asee.org/23656

Lambiase, F.; Derazkola, H: A.; Simchi, A. (2020, May). Friction Stir Welding and Friction Spot Stir Welding Processes of Polymers- State of the Art. Materials, Vol. 13 No. 10: 2291. https://doi.org/10.3390/ma13102291

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ON THE INTELLIGENCE OF INTERACTING AUTONOMOUS ROBOTS AND VIRTUAL AGENTS

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Abstract: This work explains some aspects why it is hard to pinpoint what intelligence is and more specifically, how to assess the intelligence of AI. It motivates a setup that is designed to foster the investigation of this question using reinforcement learning agents as complex AI systems. Such a setup can be used in an attempt to sidestep theoretical considerations on the cognitive power of Machine Learning algorithms. Instead, an example is given how the well-established experimental testing of intelligence in animals could be translated to the described AI system. While the published work-in-progress state of the implementation allows similar experiments of multiple interacting virtual robots to be conducted and a theoretical outline for future tests is sketched, a lot of further research will be required before a robot can demonstrably recognize itself in a mirror.

Keywords: *Artificial Intelligence; Reinforcement Learning; Intelligence Test*

1. INTRODUCTION

In recent years the field of artificial intelligence has seen a resurge in popularity initiated by the vast success of deep neural networks. However, the definition of AI has become very broad, often encompassing algorithms from mathematical optimization, database lookups or even the control flow of programs as hardcoded rule systems. While all of these aspects are important factors for AI systems, the naive understanding of the term "intelligence" implies different expectations. These different capabilities are frequently referred to as weak and strong, a.k.a. general AI (Russel & Norvig, 2003). Most typical current AI applications can be categorized as weak AI, focused on solving a particular problem. To investigate how far the abilities of current deep neural network architectures

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can reach, we need to define what we are looking for and consider a problem complex enough for any difference to be distinguishable.

2. INTELLIGENCE

The term intelligence itself eludes a rigorous definition. Common among many definitions is the ability to memorize and learn from information and to adapt to new circumstances (Webster, 2022). The issue doesn't resolve itself when it comes to artificial intelligence. Over the course of history, there have been many attempts to make intelligent algorithms. An example that was convincing for its time would be the chatbot ELIZA (Weizenbaum, 1966). While it did not incorporate any learning component, it was able to mimic intelligent behavior well enough to fool several humans that interacted with it. The famous Turing Test (Turing, 1950) builds upon the idea of an algorithm conversing with humans in such a way, that humans cannot reliably distinguish it from other humans. While the details required by different versions of the test vary significantly, a common criticism is, that it relies on the ability to fool human, not necessarily true intelligence. For example, a hypothetical machine that memorizes all human responses to all statements ever uttered would likely pass the test without any intelligence besides a giant database lookup.

One of the common requirements besides a working memory is the ability to generalize knowledge or to form new ideas based on memorized ones. While this has been achieved in academic settings by rule-based systems decades ago (Dai et al., 1990), these attempts did not continue to see wide success in most real-word applications. Deep neural networks do exhibit some implicit form of generalization when they create concepts that generalize their training data (Madan et al., 2021), but it is unclear if this can be considered an abstraction or any form of comprehension of the data. Due to the highly complex but essentially deterministic nature of the training process, it can be argued that all forms of machine learning are merely a mathematical optimization. Considering published literature it remains unclear if these processes can at some point in time yield aspects of strong AI such as high-level intelligence or even self-aware systems through emergence. To this day any such claim the author is aware of, e.g. (Sutskever, 2022), remains without corroborating evidence.

3. INVESTIGATION USING REINFORCEMENT LEARNING

To be able to distinguish "more intelligent" capabilities, the task needs to be able to prefer complex but beneficial behaviors over simple solutions. It is also helpful if the optimal solution is highly dynamic and can be changed over time, since this benefits the ability to adapt already learned knowledge.

A training scenario that fits these requirements is reinforcement learning for robots or virtual agents. In a nutshell, in a given situations a so-called agent is tasked to decide upon its next action(s) based on its current state and perception (Kaelbling et al., 1996). Virtual agents are more convenient for this type of study than actual robotic agents, as a virtual environment in which agents learn to act can be designed to focus on important aspects and it can be simulated faster than real-time data recording. The logic used for this decision is called a policy. More favorable policies do not just exploit the current sensorial input but rely on an internal memory of key aspects of their environment. These allow for more complex strategies to arise during training. Especially when long-term causal connection has to be exploited, these more strategic policies outperform short sighted systems. A memory of previous states can be explicitly given to an agent, but deep neural networks, especially with recurrent architectures, can also learn to remember relevant aspects of previous states. To be able to estimate the expected outcome of an action, an agent must not only be able to act upon key aspects of its current state (and potentially previous states), but it also needs to predict the effect of any known action on the environment. This can be achieved using a world model. Sometimes this is explicitly implemented as a simulation of the environment, but again, deep neural networks have been shown to learn predictions for actions in arbitrary environments (Dashkina et al., 2021).

There is a selection of published frameworks for simulations coupled with reinforcement learning (Brockman et al., 2016) (Beattie et al., 2016) (Körber et al., 2021), but besides the benefit of a simulated environment tailored to answer a specific question, a simplified simulation makes it easier for students to participate with own experiments. The current state of this framework can be found at (Geißelsöder, 2021). It simulates a basic world where agents need to rely on certain actions to survive. Coupled with the ability to reproduce, this setup creates a selection pressure favoring fit agents which maximize the chance of survival for their entire species. The setup already contains several different simple agents that follow fixed policies which can serve as interaction partners or additional selection pressures. To allow different roles as well as a comparison of different policies for the same role, the actions an agent is capable of (e.g. templates for wolf, sheep, ape, ...) are split from the implementation of their policies (brains). With these basics set up, a new policy may be implemented as the "brain" in class Ape. For educational purposes it is foreseen that many students can implement their own policies and compete against each other.

3.1. Survival

Due to an intrinsic pressure for survival of agents caused by slowly diminishing health over time, any policy has to identify and favor actions that are beneficial for the health of the individual agent. The goal of reaching a high health level doesn't have to be set explicitly for the training of the RL policy (these functions are called reward functions), but can be intrinsic to the environment, as policies that do not fullfil this criterion do not manage to persist in the environment. However, setting this as an explicit reward function simplifies training.

3.2. Cooperation

By default, an environment contains multiple individuals of a given policy. The simulation is designed such, that the policy is identifiable in the sensorial perception of every agent, theoretically allow them to recognize each other. There are also dedicated actions available for every agent to try communication with any object in its vicinity and arbitrary as well as fixed alphabets. This is designed with the intention of fostering cooperation between individuals that share the same (or compatible) policies to further enhance the survival probabilities of policies that incorporate actions benefitting its entire population. An example for such an action is described in the next section.

4. ADAPTING FROM BIOLOGY AND PSYCHOLOGY

Policies that are entirely created based on learning in an environment and that are intelligent enough to keep agents alive and allow its population to thrive through cooperation must be recognized as some kind of intelligence. However, the counterargument that the entire process can be seen as a complex mathematical optimization of an implicit reward function cannot be invalidated.

With this perspective in mind, we might want to turn our attention to domains that have more experience with the struggle to find empirical tests for the intelligence of beings. While the gap to and specialization of human level IQ tests seems a bit challenging, many years of testing the intelligence of animals have proven to yield well established and reproducible results. Besides communication (Seyfarth & Cheney, 2003), counting, abstract thinking etc., the famous tests of animals recognizing themselves in mirrors comes to mind (Gallup, 1970).

To test this scenario, we need to add mirrors to the simulation that alter the perception of agents accordingly. Similar to the markings applied to the foreheads of animals in the mirror tests, we also need to add a property to each individual that encodes a marking, which must be perceivable for the agents. And lastly, the agents need to be able to perform the action of removing the mark. If we were to now set an explicit reward function that directly rewards the removal of a mark, the setup would not be comparable to the same test with animals. The way chosen for this implementation considers some important details that are meant to motivate the behavior but also to discern altruism from self-recognition. To motivate the behavior, the mark has been assigned with a long delayed, but severe drop in health of the agent if it is not removed by any agent. This is to motivate the behavior as an altruistic act. However, it is also penalized by a prolonged time of forced inaction for the removing individual. This is meant to inhibit frequent but casual and inconsiderate removal actions to minimize the chance of the mark removal action being triggered without clear motivation. Furthermore, the action of removal requires the concept of a mirror to be at least partially understood by the agents, as it requires a target to be specified relative to the location of the acting agent. If the agent tries to remove the mark from another individual at twice the distance to the mirror instead of itself, the concept is not yet understood (and of course the mark is not removed).

The status of the ongoing research revolves around options how to discern an altruistic action intended to help another agent that happens to be perceived at the same location as the acting agent from an action that is deliberately performed on itself. Introducing yet another action to clear the mark from oneself currently is the preferred option, but this introduces the additional complexity that the connection between the two actions (removing a mark on another agent versus removing the mark for the acting agent itself) needs to be learned on top of all previously required learning. However, once successfully designed and implemented, this approach could allow the assessment of the intelligence of AI agents with similar justification as intelligence research in animals established over decades.

5. SUMMARY AND OUTLOOK

This work mentions some aspects why it is hard to pinpoint how intelligent AI actually is. It briefly describes a setup that is designed to allow the investigation of some of the tangible aspects and it motivates what could be suited aspects. In its current state, the environment is suited to perform basic RL experiments. In the future this setup is intended to be used for the more detailed investigation of the intelligence of AI as it tries to recreate situations similar to tests of intelligence in animals. The next big step is to perform training of agents that can go beyond pure survival. Shooting for the moon would be to find ways to train AI agents that can demonstrably recognize themselves in a mirror.

REFERENCES

Russel & Norvig (2003). Artificial Intelligence: A Modern Approach, Pearson, ISBN 0130803022

Webster (2022). https://www.merriam-webster.com/dictionary/intelligence, last accessed May 2 2022

Joseph Weizenbaum (1966). ELIZA – A Computer Program For the Study of Natural Language Communication Between Man And Machine. in: Communications of the ACM., ISSN 0001-0782

Alan M. Turing (1950). Computing Machinery and Intelligence, in Mind. Band LIX, Nr. 236, ISSN 0026-4423, p. 433–460

Dai et al. (1990). Issues of Real-Time Expert Systems, in AI and Cognitive Science'89, pp179-197, Springer

Madan et al. (2021). When and how CNNs generalize to out-of-distribution category-viewpoint combinations, Nature Machine Intelligence volume 4, pages 146–153 (2022), https://arxiv.org/abs/2007.08032

Ilya Sutskever (2022). Twitter, February 9 2022,

https://twitter.com/ilyasut/status/1491554478243258368

L. P. Kaelbling, M. L. Littman and A. W. Moore (1996), Reinforcement Learning: A Survey, Journal of Artificial Intelligence Research, Vol 4, (1996), 237-285, https://arxiv.org/abs/cs/9605103

Alexandra Dashkina et al. (2021). Neural Network Modeling as a Method for Creating Digital Twins: From Industry 4.0 to Industry 4.1, SPBPU IDE '20: Proceedings of the 2nd International Scientific Conference on Innovations in Digital Economy

Marian Körber, Johann Lange, Stephan Rediske, Simon Steinmann, Roland Glück (2021). Comparing Popular Simulation Environments in the Scope of Robotics and Reinforcement Learning, https://arxiv.org/abs/2103.04616

G. Brockman, V. Cheung, L. Pettersson, J. Schneider, J. Schulman, J. Tang and W. Zaremba (2016). OpenAI Gym, https://arxiv.org/abs/1606.01540 and https://gym.openai.com, last accessed May 2 2022

C. Beattie et al. (2016). DeepMind Lab, https://arxiv.org/abs/1612.03801,

https://www.deepmind.com/blog/open-sourcing-deepmind-lab

Stefan Geißelsöder (2021). https://github.com/sgeisselsoeder/erkenntnis

R. Seyfarth & D. Cheney (2003). Signalers and Receivers in Animal Communication,

Annual Review of Psychology. 54 (1): 145–173

GG Jr. Gallup (1970). Chimpanzees: Self recognition, in Science. 167 (3914): 86–87

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INFLUENCE OF COOLING CONDITIONS DURING 3D PRINTING ON THE SWITCHING TEMPERATURE OF A TPU WITH SME

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ABSTRACT: Shape memory polymers (SMP) are materials with a special structure, designed to react to a certain stimulus. Using such SMPs with 3D printing technology opens up further fields of application thus providing for the so-called 4D printing. After such a printing process it is mandatory for the SMP to still be able to form a crystalline structure, maintaining its own shape memory effects (SME). The crystalline portion or the hard section of polymers is strongly influenced by the cooling rate during the printing process. In order to evaluate the influence of the cooling on the formation of the segments, thermal measurements using Differential Scanning Calorimetry (DSC) were carried out. The test shows that the cold crystallization was evident in each case in the first heating run, but the cooling rate in the FFF (Fused Filament Fabrication) technology could not be reduced to such a level that the switching temperature changed. In order to have an influence on the melt peak, the cooling rate must be increased further. This was demonstrated in the 2nd heating run of the DSC measurements.

KEYWORDS: *Shape memory polymers, 3D printing, Differential Scanning Calorimetry, Cold crystallization, Melting point*

1. INTRODUCTION

The use of smart materials, such as shape memory polymers (SMP), has opened new ways in many areas of life. The application areas include for example automotive, aerospace and medicine implicating traditional applications such as heat-shrinkable tapes and tubes

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but also, for example, in the medical field, biodegradable sutures, actuators, catheters and smart stents. Other interesting examples in the technical field include information storage, which allows for thermally reversible recording, but also temperature sensors and actuators. Due to their structure, SMPs have the ability to change their shape after a certain stimulus is reached. Depending on the polymer, the external stimulus can be e.g. temperature, radiation, pH and many others (Mater, 2007).

Using such materials, a conversion from classical 3D printing to a programmable 4D printing is possible and enhanced. The obtained products can be exposed to a predetermined external stimulus resulting in a self-transforming or self-assembling new object with new forms or functions.

Thermoplastic polyurethanes can exhibit shape memory effects (SME) due to their structural configuration and consequently belong to the group of SMPs (Sahoo NG,2007). The SME in this TPU is based on the fact that shape memory polymers have a network structure and the crossing of a phase transition is associated with a significant change in mechanical properties. The hard segments of the TPU, which consist of the polyurethane groups, form the phase with the highest transition temperature. This temperature is exceeded when the material is fully melted and injection moulded or extruded to give it its permanent shape. The soft segments of the TPU, which consist of long-chain polyester regions, form another phase with a much lower transition temperature. If only the soft segments are melted, a temporary shape can be imposed on the component and this can be physically crosslinked by crystallisation of the soft segments and stabilized in this way. Subsequent melting of the soft segment crystallites then triggers the SME (Thakur and Hu, 2017).

During the last decades, both equipments and materials related to additive manufacturing have evolved rapidly. Those changes gain the attention of researchers and companies. Linking such SMPs with 3D printing technology, for example FFF-technology, opens up further fields of application due to the simple adaptation to new conditions. Even though nowadays, most 4D prints are made using Polyjet 3D printing technology (Ly S. T., 2017), technologies such as FFF are increasingly being implemented, due to their price-related advantages and their user-friendly characteristics.

In any case, for the SME of this SMP, it is important that the crystalline phase and thus the hard segment can form well after processing. The crystalline portion of polymers is always formed as a function of the time and therefore of the cooling rate. These two factors can be strongly influenced by the printing settings in the FFF technology and as a consequence can have an effect on the mechanical properties, but also on the SME itself. In order to be able to evaluate the influence of the cooling on the formation of the segments, thermal measurements were carried out through/using Differential Scanning

Calorimetry (DSC). The main focus was on the cold crystallisation and the melting temperature of the soft segment.

2. EQUIPMENT AND EXPERIMENTAL WORK

For the following experimental research, material Desmopan® 2795A-SMP in the form of granules was used. The TPU based polymer, from Covestro AG, Leverkusen-Germany, has a density of approx. 1.2 g/cm^3 and a switching temperature of approx. 40 ºC. Prior to use, SMPs pellets were dehumidified using AIRID Polymer Dryer, from 3devo B.V., Atoomweg- Netherlands. The device uses heated air and a stirring rotator to obtain dried materials across all surface areas. Based on the material manufacturer's recommendation, the drying process has to be done at 110 ºC for 4 h and with a rotation speed of the mixing device of 15 rpm, followed by a slow cooling in the covered hopper. Subsequently, the granular material is transformed into a 2,85 mm filament using Composer 350 filament maker, from 3devo B.V.. The temperatures used for the four zones of the desktop extruder are 195 ºC/ 205 ºC/ 210 ºC/ 195 ºC and the automatic screw rotation is about 5 rpm. At this stage, the cooling of the filament is extremely important and it is performed with the help of two fans directing the cold air into the outlet area of the hot filament from the nozzle. Using inadequate cooling can lead to an ovalisation of the filament in the guiding area and during winding on the coil or to a varying diameter of the filament due to rapid uncontrolled shrinkage.

The Ultimaker 3 professional desktop printer was used to further create the DSC samples. Because this is the last stage of the material processing, cooling during printing can affect the shape-changing properties of the finished product. Inadequate rapid cooling at this stage is also associated with the effect of physical aging of the material and further post- or cold-crystallisation which lead to an increased degree of crystallisation and a lower melting point of the new lamelar formation (Weeks, 1963). The main considered printing parameters that can affect the shape memory properties are printing and build plate temperatures, printing speed and cooling percentage. Table 1 summarizes the printing conditions for the sample preparation:

Table 1: Printing conditions for the samples

Printing conditions	Sample		
	1	2	3
Layer height [mm]	0.2	0.2	0.2
Printing temperature [°C]	230	230	230
Build plate temperature [°C]	**40**	**40**	**24** (RT)
Printing speed [mm/s]	20	20	20
Cooling of fan [%]	**30**	**100**	**100**

The DSC measurements were done with the DSC822 from Mettler Toledo. One measurement comprised several heating and cooling runs, which allows to differentiate between the sample history and the material properties. The temperature range in which the measurement was carried out was always between -100 °C and 230 °C. This temperature range ensured that both the hard and soft segments are melted. The heating rate was constant at 10 K/ min each time, only the cooling rate was changed for each run. The following cooling rates were represented by the experiment: -16 K/min, -8 K/min and -4 K/min.

3. RESULTS

Printing the sample with a 3D printer ensures an optimal contact surface on the aluminum crucible and thus optimal heat transfer into the TPU. As a result, the sample receives a specific prehistory, which can be seen in the first heating run. The following figure shows the whole DSC measurement of the printed TPU sample 1 with the described test sequence (see Figure 1). It was printed under the conditions described in Table 1.

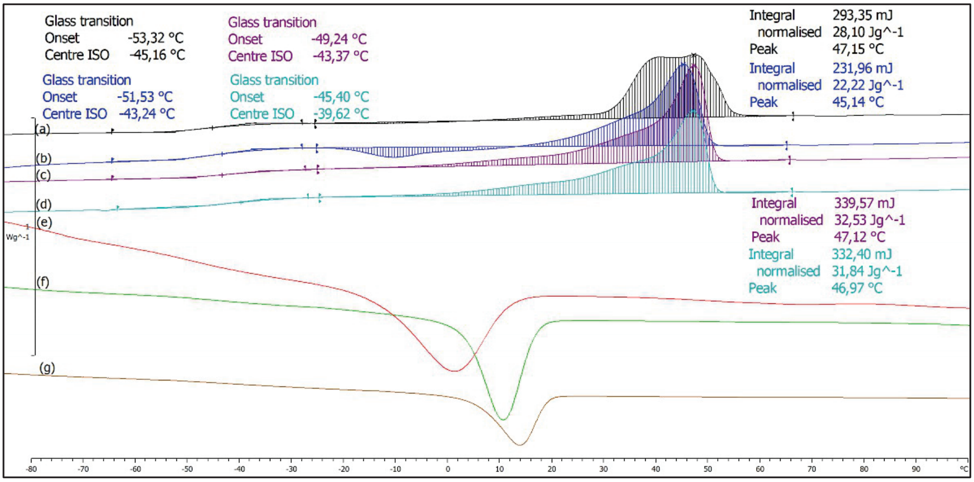

Figure 1. DSC measurement of sample 1 [(a) 1st heating run, (b) 2nd heating run, (c) 3rd heating run, (d) 4th heating run, (e) 1st cooling rung, (f) 2nd cooling run, (g) 3rd cooling run]

In the first heating run of sample 1, the glass transition temperature was -45.16 °C, cold crystallisation was observed and the melt peak of the soft segment is 47.15 °C. Cold cristallization is also established in the 2nd heating run, since the preceding cooling rate was very high, at -16 K. From a cooling rate of -8 K, cold crystallisation no longer occurs. It can be concluded from this that the hard segment has formed completely and also the cristalline phase of the soft segment.

When the melt peaks of the soft segment in the individual heating runs are compared with each other, the melt peak of the 2nd heating run stands out. This differs from the others by approx. 2 K. However, it can be concluded for 3D printing that the current printing conditions (plate temperature 40°C, cooling 30%) have no effect on the melt peak and thus on the switching temperature.

Since only the temperature range between -70 °C and 80 °C is of interest for the current investigations, the results for samples 2 and 3 are only shown in this temperature range (see Figure 2 and Figure 3)

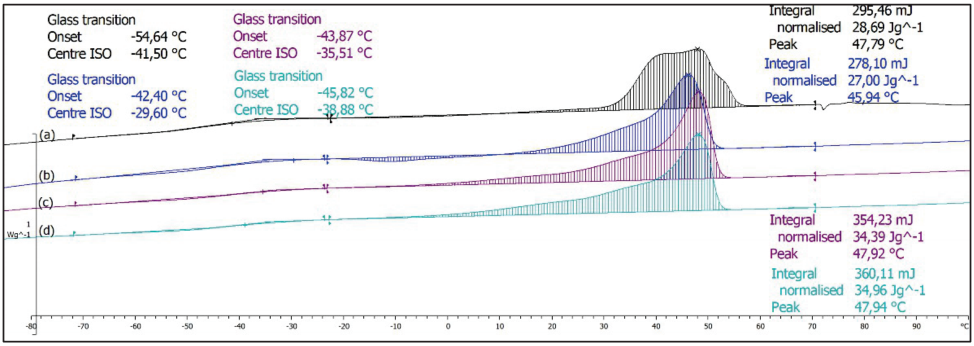

Figure 2. DSC measurement of sample 2 [(a) 1st heating run, (b) 2nd heating run, (c) 3rd heating run, (d) 4th heating run]

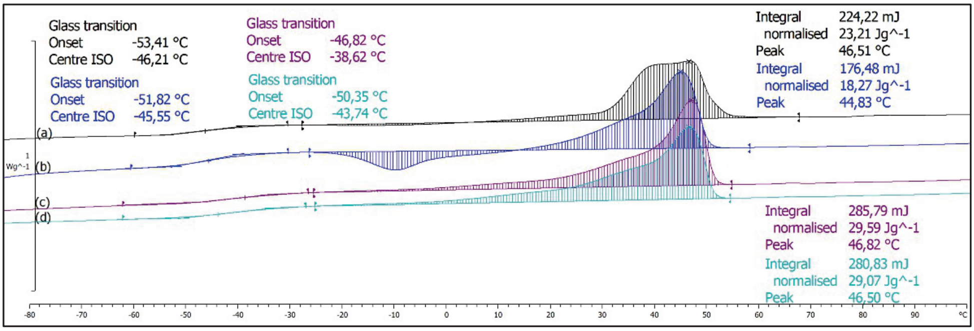

Figure 3. DSC measurement of sample 3 [(a) 1st heating run, (b) 2nd heating run, (c) 3rd heating run, (d) 4th heating run]

A similar picture is obtained for the samples 2 and 3. The glass transition temperatures in the first heating run are about -46°C for both samples. The melt peak in the first heating run is also at the same temperatures as in the 3rd and 4th heating run. Thus, the printing settings used have no influence on the switching temperature of the SMP. In order to have an influence on the switching temperature, the cooling would have to be even faster. This is evident from the second heating run. Because at a cooling rate of -16 K, the melt peak shifts slightly to lower temperatures which could be observed in all three samples. As a result, the crystallisation and therefore the structure of the two segments - the hard one and the soft one - can be influenced.

4. CONCLUSION

The switching temperature is essential for the application of SMPs. It is possible to influence this switching temperature through the manufacturing process if the polymer is not given the opportunity to form its crystalline regions correctly. The cooling rate in the 3D printing application with FFF technology using the Ultimaker 3 could not be reduced to such a level that the switching temperature changed. Nevertheless, cold crystallisation was evident in each case in the first heating run, indicating that a higher degree of crystallisation of the TPU would be possible. Further investigations can determine the influence on the SME. It is also interesting to note that in each case in the first heating run, the melt peak encloses a different area. The extent to which an SME is already stored by the 3D printing must be clarified by further investigations.

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AUTHOR CONTRIBUTIONS

A.L. conceived, designed, performed experiments, analysed the results, wrote the manuscript. M.A.B prepared the samples, analysed the results, wrote the manuscript. A.S. analysed the experiments, technical proof of results, and review of the manuscript. All authors have read and agreed to the published version of the manuscript.

REFERENCES

J. Mater. Chem., 2007,17, 1543-1558

Sahoo NG, Jung YC, Yoo HJ, Cho JW. Influence of carbon nanotubes and polypyrrole on the thermal, mechanical and electroactive shape-memory properties of polyurethane nanocomposites. *Composites Science and Technology.* 2007;67:1920-1929. DOI: 10.1016/j. compscitech.2006.10.013

Thakur, S.; Hu, J. Polyurethane: A Shape Memory Polymer (SMP). In Aspects of Polyu rethanes; *TechOpen*: London, UK, 2017; pp.53–71

Ly, S.T.; Kim, J. Y. (2017). 4D Printing – Fused Deposition Modeling Printing with Thermal-Responsive Shape Memory Polymers. *International Journal of Precision Engineering and Manufacturing-green Technology,* Vol. 4, No. 3, pp. 267-272. DOI:10.1007/s40684-017-0032-z.

Weeks, J. J. (1963). Melting Temperature and Change of Lamellar Thickness with Time for Bulk Polyethylene. *Journal of Research of the National Bureau of Standards-Section A: Physics and Chemistry,* Vol., 67A, No. 5, pp. 441-451. DOI:10.6028/jres.067A.046.

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DEVELOPMENT OF RECYCLABLE JOINTLESS PLASTIC GRIPPERS FOR USE IN THE MEDICAL TECHNOLOGY SECTOR

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Abstract: Medical grippers can be used for various purposes. They are a standard instrument in medical technology and are widely used every day for multiple applications. Jointless grippers, which, due to their geometry and material properties, allow for an easy gripping function, are very welcome to the medical sector in order to make the work and especially the hygiene or sterilisation of the products easier. The application of a single-use instrument made of thermoplastic and 100% recyclable plastic is an ideal response to the current trend toward the increasingly frequent application of single-use instruments in medical technology. Moreover, the infected plastic material can be easily disposed of.

The development of a new type of gripper made of plastic is a step towards partially fulfilling this need. This article presents the development and validation of a jointless medical gripper produced by additive manufacturing and injection moulding technologies, using a compliant mechanism and thermoplastic material.

Keywords: *Gripper; Jointless; Surgical products; Medical sector; Single-use products*

1. INTRODUCTION

In hospitals and medical facilities, many instruments made of metal are still in use. The trend is moving more and more towards plastics and single-use tools for the maintenance of a sterile environment. (Blessy J., Jemy J., Nandakumar K., Sabu T. 2021) In medical

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technology, more than 50% of all materials used are already made of plastic. In the future, the need for single-use plastic surgical products will increase more and more. (Sastri V. 2021)

The use of plastics has many essential advantages in medical technology. In addition to the low weight and the lower purchase price, the easier handling and the possibility of processing recyclable materials speak using polymer materials in medical technology. (Gamba A., Napierska D., Zotinca A. 2021). The forceps should be produced as a sterile disposable instrument and thus, in contrast to the tools made of metal, do not have to be sterilised after each use, which is time and cost-intensive. (Sun Y., Zhang D., Lueth T. 2020)

A new feature of this development is that the whole gripper consists of a single component and therefore does not have to be assembled in a further step. The gripper was designed so that the gripping area clamps safely and closes as soon as a specific force is applied using an adaptadet-compliant mechanism. (Hasse A., Campanile L. F. 2009) This type of gripper has many advantages, such as lightweight, easy use and recyclability, and the fact that it can be mass-produced through the injection moulding technique.

The gripper based on the compliant mechanism's development, optimisation, and production is presented in detail in the following chapters.

2. CONCEPTION AND DESIGN

The goal was to develop the gripper so that it consists of a single component made of plastic, can be produced in one step for mass production, and is fully functional. The gripper should be 100% recyclable, weigh a maximum of 20 g, and be designed for a maximum force of 300 N. The focus here was on the optimal force transmission from the gripping area of the gripper to its top using a compliant mechanism with a structural optimization approach. The closing of the gripper is caused by the force generated when the handles are tightened and transmitted to the tip of the gripper through its structure. The centre of the gripper has a decisive role as it transmits the motion and is responsible for the optimal movement of the gripper. The geometry of the centre is also an important factor for the optimum force transmission from the gripping area to the tip of the gripper, as well as for the optimum sustainment of the clamping force.

Various structures featuring different centres (see Figure 1 – red circles) and thicknesses were designed in CAD and validated using Finite Element Analysis.

The collected results were then evaluated against the defined requirements, and the best geometry combination was created as a CAD model, see Figure 1.

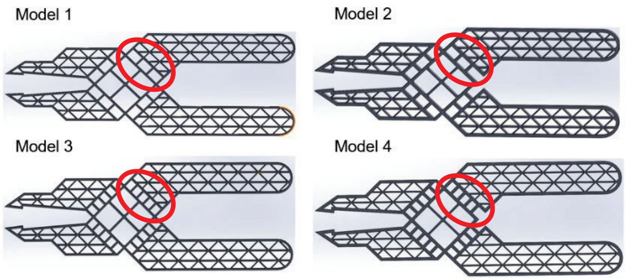

Figure 1. Different designs of the gripper as CAD model

3. DEFINITION OF THE OPTIMAL GEOMETRY

The Finite Element Analysis (FEA) is used to analyse virtual components with the help of a mathematical calculation (Barkanov, 2001). The FEA is a general numerical method used in various physical tasks. The main application of FEA analysis is for strength and deformation studies of solids with geometrically complex forms. For the FE Analysis of the gripper, tetrahedrons elements were used, and a PLA material was created and used. Here, the displacement of the tip, the strain, and stress on the part are calculated and analysed under a defined force. The simulation of how a human hand presses the gripper was simplified using a specific force of 100 N distribute on the whole gripping surface (see Figure 2).

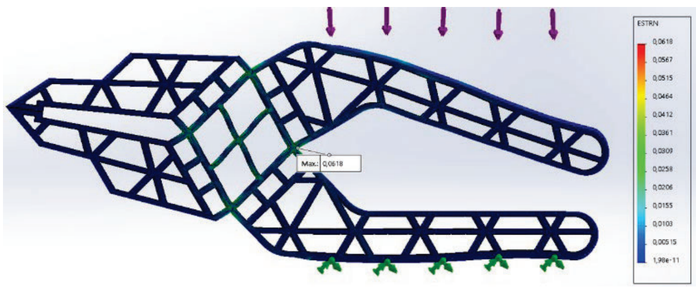

Figure 2. Finite element analyses (maximum strain [%]) on the 3D gripper model

For the static simulation, the force was applied to the upper side of the gripper (upper handle) while the other side of the gripper (bottom handle) was constrained. In total, four different structural models (M1-M4) were investigated using the Finite Element Method (FEM). Each model was further divided into four other variations by changing the walls thickness and the width of the gripper. The design parameters considered to exert a strong influence on the behaviour of the force transmission thru the structure were the wall thickness of 1 mm (W1) and 1.5 mm (W1.5). and a gripper thickness of 5 mm (T5) and 10 mm (T10). In summary, 16 models with different wall thicknesses and geometries were analysed. The FEM was used to determine the maximum displacement of the tip, the stress, and the maximum strain of the gripper. The results are shown in Table 1.

Table 1. The results of the FEA (Mx: Model number, Wx; Thickness of the wall; Tx: Gripper thickness

	Model 1				Model 2			
Version	M1 W1 T5	M1 W1 T10	M1 W1,5 T5	M1 W1,5 T10	M2 W1 T5	M2 W1 T10	M2 W1,5 T5	M2 W1,5 T10
Maximum stress [N/mm²]	110,5	198,2	83,14	107	90,9	346,3	114,8	176,3
Maximum displacement [mm]	11,68	21,3	7,82	9,93	9,52	37,8	8,29	16,89
Maximum strain [%]	0,0269	0,048	0,0219	0,027	0,0215	0,0843	0,0194	0,042

	Model 3				Model 4			
Version	M3 W1 T5	M3 W1 T10	M3 W1,5 T5	M3 W1,5 T10	M4 W1 T5	M4 W1 T10	M4 W1,5 T5	M4 W1,5 T10
Maximum stress [N/mm²]	98,35	213,1	77,1	137,7	95,6	241	90,38	148,3
Maximum displacement [mm]	10,8	18,32	6,08	8,16	10	27	7,09	12,3
Maximum strain [%]	0,024	0,04	0,0191	0,0281	0,0229	0,0591	0,0231	0,04

In Figure 3, the maximum displacement from the FEA of the gripper was evaluated. The design concept specifies 12 mm (red line in Figure 3) for the width of the top; therefore, the maximum displacement at the top of the gripper should not exceed this value. Based on these results, some versions could already be eliminated. The evaluation also reveals that the required properties of the gripper do not benefit from an increased gripper thickness.

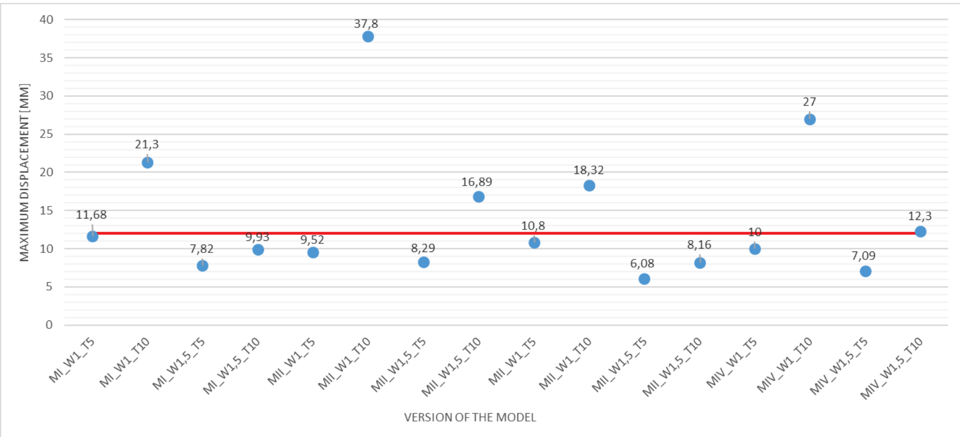

Figure 3. The maximum displacement at the top of the gripper resulting from the different designs.

Figure 4 shows that the maximum strain (grey line) is very similar for the remaining versions. This means that neither the gripper nor the wall thickness have a significant influences on the maximum strain. The green line from the figure displays the maximum stress inside the gripper. The load should not be too high to prevent critical stress concentrations in some areas, which could avoid the gripper from breaking easily while being used.

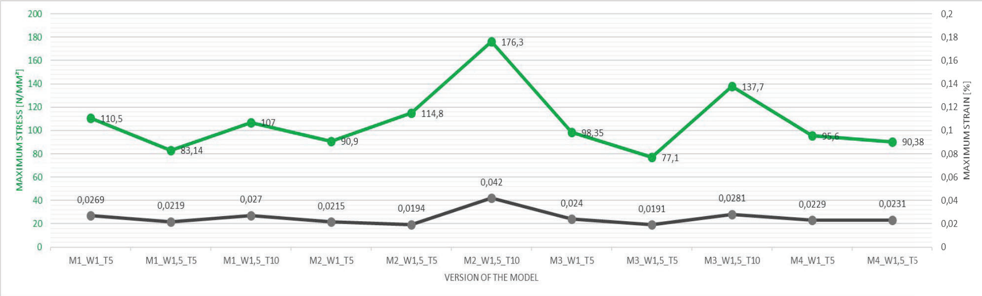

Figure 4. The maximum stress (green line) and the maximum strain (grey line) of the different gripper models from the FEA.

Based on these results, model 2, featuring a wall thickness of 1 mm and a thickness of 5 mm, was selected as the optimum gripper for the later fabrication and tests. The goal of the FEA was to determine the optimal structure of the gripper, especially the thickness of the wall and the gripper.

4. TRANSFER OF THE VIRTUAL MODELS TO RAPID PROTOTYPING

In the next step, all the knowledge that had been gained in terms of material and geometry was transferred to the rapid prototyping process. Rapid prototyping is an additive manufacturing process in which a virtually created model is transformed for the first time into an individual 3D prototype, produced with different techniques. Figure 6 shows the created virtual model of the single-use gripper for the 3D FFF (Fused Filament Fabrication) printer.

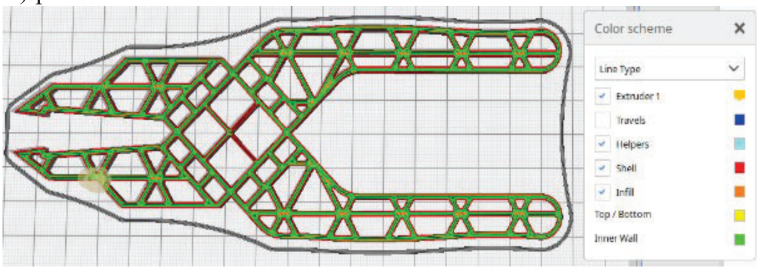

Figure 5. The virtual model of the gripper prepared for 3D FFF printer

Using this process, the virtually generated model was transformed into prototypes for the first time with the help of a 3D printer to check the function of the gripper and the essential design concept. Different parameters, such as the nozzle diameter of the 3D printer, and the layer thickness, which can influence on the strength or elasticity of the gripper during 3D printing, were analysed in detail. During this analysis, it was also found that wrongly generated printer tracks can cause holes in the component or bad adhesion between the individual layers. In the next step, the grippers were manufactured as 3D printed models (see Figure 5) using various materials (PLA, PP, Medical ABS, PA, PET CF15, and PETG) applying the FFF technology. The rapid prototyping process helps the developer transform the concept idea into a realistic model and to convert it into high-precision prototypes. The gripper was optimised several times, and some more parts were produced via FFF technology. After optimizing the geometry, the new gripper geometry was prepared for the injection moulding process. Several grippers were produced via injection moulding process by the company priomold GmbH.

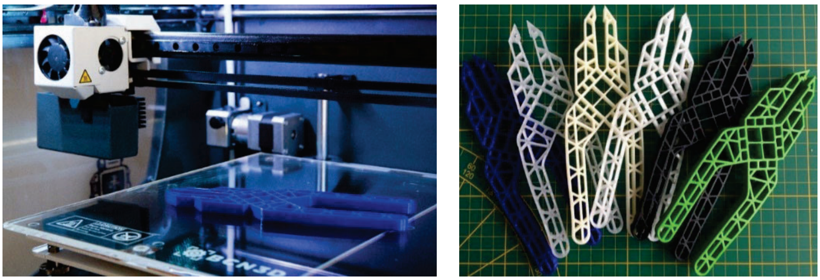

Figure 6. Manufacturing the prototypes with a 3D FFF printer using different materials

5. RESEARCH AND EVALUATION OF GRIPPER PROPERTIES

The quality features of the injection-moulded disposable grippers made of different materials were mechanical tested in detail for characterisation and comparison purposes. For the pressure test, the grippers were statically stressed for two minutes applying a constant force of 300 N using a test apparatus in the universal testing machine (see Figure 7).

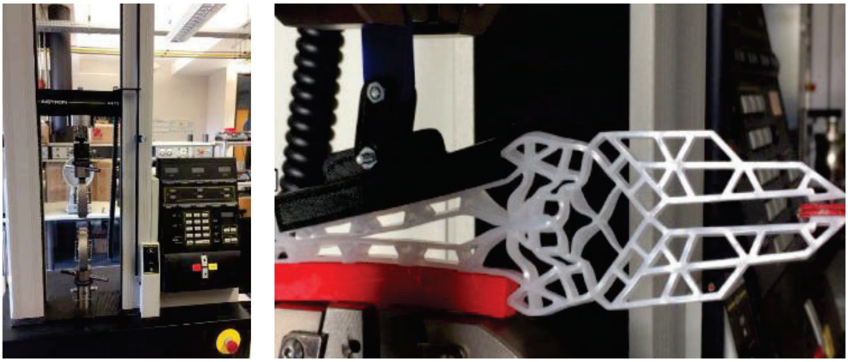

Figure 7. Testing of the mechanical properties of the inceted moldedgriper with a universal testing machine.

Here it was analysed which force exerted on the handles is necessary to make the tips of the gripper touch each other and which maximum clamping force can be measured at the tip. With this equipment, different grippers were tested to study the influences of the polymer material used in detail, their geometry, and the influences of the manufacturing process. The tests showed that a force of up to 50 N was measured at the tip of the gripper. This force ensures the safe gripping of medical products such as swabs, plasters, and many others.

Figure 8. Test device for dynamical testing of the gripper

In addition, the dynamic mechanical load of the grippers was simulated with the help of a self-developed testing system (see Figure 8) to discover weak points in the geometry. The grippers were cyclically opened and closed about 150 times for 60 minutes.

The dynamic and static pressure tests showed that various (PP and PETG) materials did not sustain the required loads and broke during the test. In addition, the material used must be approved for medical/pharmaceutical purposes. An HD-PE polymer was discerned as an optimal material for the injection-moulding process of the grippers.

The goal of the mechanical tests was to study different types of materials with the optimal structures determined during the FEA.

6. CONCLUSIONS

Using a disposable gripper made of recyclable thermoplastic material optimally picks up the current trend toward the increasing use of disposable instruments in medical technology. A jointless gripper based on the compliant mechanism, which allows for a gripping function based only on its geometry and material properties, is in great demand from the medical sector to simplify the work and especially the hygiene. The research results show that with the developed gripper, a force of up to 300 N can be applied to the handles without causing the gripper to break, which should be sufficient for a hand-operated device. The present research proves that it is possible to manufacture a jointless gripper through FFF as a prototype and injection moulding for mass production using thermoplastic materials. Furthermore, the mechanical static and dynamical tests prove that the jointless gripper, based on the compliant mechanism produced by the injection-moulding process and using a medical-grade thermoplastic as PE, can fulfill the requirements for a medical device.

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Conflict of interests

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

B.M.A conceived, designed, performed experiments and analysed the results, wrote a part of the manuscript S.A. and Z.M. analysed the experiments, technical proof of results, wrote and reviewed the manuscript. S. T. provide the material and injection moulded parts, and reviewed the manuscript. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Gamba A., Napierska D., Zotinca A. (2021). Measuring and reducing plastics in the healthcare sector, https://noharm-europe.org/sites/default/files/documents-files/6886/2021-09-23_Measuring-and-reducing-plastics-in-the-healthcare-sector.pdf

Sun Y., Zhang D. and Lueth T.C., "Bionic Design of a Disposable Compliant Surgical Forceps With Optimized Clamping Performance" (2020) 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), 2020, pp. 4704-4707, doi: 10.1109/EMBC44109.2020.9176027.

Barkanov E. (2001) "Introduction to the finite element method", Institute of Materials and Structures
Faculty of Civil Engineering Riga Technical University,
http://kxcivileng.gr/archive/technical/Introduction-The_Finite_Elements_Method.pdf

Sastri R. V. (2021) Plastics in Medical Devices, ISBN: 978-0-323-851526-8

Blessy J., Jemy J., Nandakumar K., Sabu T. (2021) Recycling of medical plastics, Advanced Industrial and Engineering Polymer Research, Volume 4, Issue 3, Pages 199-208, https://doi.org/10.1016/j.aiepr.2021.06.003.

Hasse A., Campanile L. F. "Design of compliant mechanisms with selective compliance" (2009) Smart Materials and Structures, Volume 18, Number 11, https://doi.org/10.1088/0964-1726/18/11/115016

Kirkup, John. (1999). The history and evolution of surgical instruments. X Clamps, haemostats and related pivot-controlled forceps. Annals of the Royal College of Surgeons of England. 81. 420-8.

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THE IMPACT OF THE G-CODE FLAVOUR SELECTION IN FFF

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ABSTRACT: Fused Filament Fabrication has become one of the most popular additive manufacturing technologies due to many hardware options and materials at affordable prices. A reason for its success is the open-source status of the technology. This allowed both professionals and amateurs to contribute to the development of material extrusion technology. Furthermore, a wide range of available equipment brought slicing software developers to improve the user experience by expanding the equipment library and making the interface user-friendly and intuitive. In order to successfully print a part, the printer's firmware must interpret a compatible G-code file generated by a slicer. For this reason, each slicing software has multiple G-code flavours available to match the equipment. This paper aimed to evaluate the influence of all G-code flavours available in Cura slicing software by using a benchmark model. The evaluation refers to the resulting models' G-code characteristics analysis and print quality. The results show that the printed models' quality depends on G-code flavour and equipment.

Keywords: *G-code flavour; Firmware; Slicing software; G-code interpreter; Fused Filament Fabrication*

1. INTRODUCTION

Nowadays, Additive Manufacturing (AM) technologies are largely used in various fields of activity such as automotive, medicine, electronics, research, and development or education (Gibson et al., 2015). Even if AM family holds a considerable number of technologies, most people refer to them as 3D Printing (Kokovic, 2017). Regardless of

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the AM technology, all of them produce parts layer by layer based on 3D data, which is generally called a mesh (Gibson et al., 2015).

Fused Filament Fabrication (FFF) is one of those technologies, and due to the affordable equipment and the great variety of materials (e.g., thermoplastic material blend, colour, properties) available on the market, it has become one of the most popular 3D printing technologies (Oztan et al., 2019). The material is sourced from a spool of filament, then melted and forced through a nozzle, and deposited layer-wise based on tool path instructions (Gardner et al., 2019). Those are generated in the printer's software (i.e., slicing software) as geometrical code (G-code). Each G-code is generated for the printer's hardware specification and firmware (Jones et al., 2011).

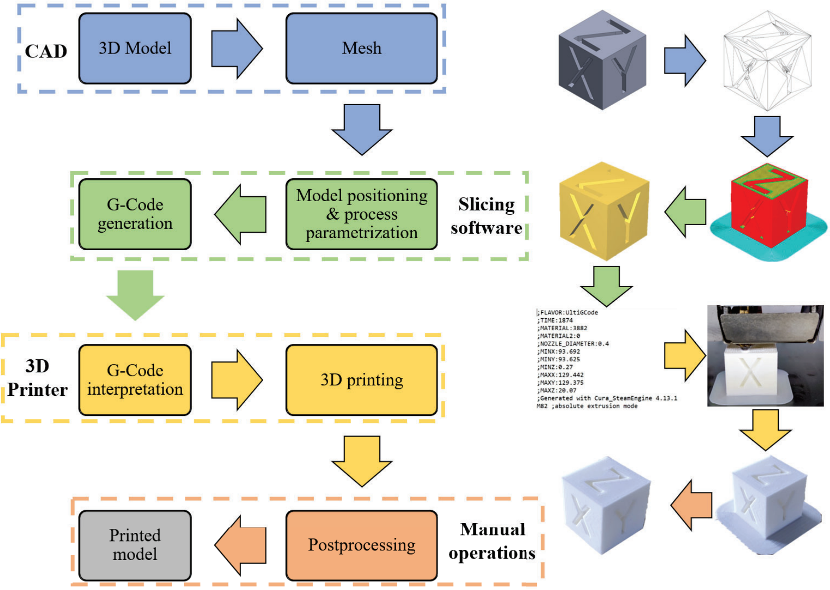
Depending on the manufacturers of the 3D printers, the firmware architecture can vary, having a G-code interpreter that accepts only one or more G-code types (flavours). For example, Cura from Ultimaker, along with other software (e.g., Simplify 3D, Fusion 360, Prusa Slicer), is an open-source slicer that is compatible with many 3D printers (e.g., Ender, Prusa, Anycubic), and for this reason, it has multiple G-code flavours options available.

Considering that there is no information available regarding the flavours and their influence on the printing process at the current state of the art, this research aimed to find the impact of G-code type in the 3D printing process and geometrical product specification. Furthermore, it is interesting to find out if the G-code type can influence the printing time and other characteristics of the 3D printed parts.

2. G-CODE FLAVOURS AND TESTING METHODS

2.1 *General considerations*

In general, any 3D printing process creates models based on the same workflow, as presented in figure 1. The majority of open-source FFF 3D printers build models based on a numerical control list of commands. In order to obtain the G-code, the mesh model is uploaded into slicing software. Therefore, a compatible 3D printer has to be selected from a list, along with the type of algorithm (flavour) that will generate the G-code file. After positioning the model and parameter selection (e.g., material, speed, layer height, temperature), the mesh model is sliced, generating the G-code. Then the G-code is loaded onto the physical printer, depending on the model, via a USB port or from a memory card. Finally, the firmware (software that runs on the printer's microcontroller) interprets the compatible G-code line by line and starts to execute.(Horvath, 2014, Horvath & Cameron, 2015).



a. Workflow chart **b.** Exemplification of the workflow

Figure 1. Workflow of FFF 3D printing process

As a 3D printer, for this research the Ultimaker 2+ with the firmware version 3.3.0 was selected, and as a slicing software, Ultimaker Cura, version 4.13.1. This software is compatible with approx. 400 3D printers and can generate nine types of G-codes (flavours). These flavours and a short description of each are presented in Table 1. Conventionally, for the Ultimaker 2+, the manufacturer recommends to use the Ulticode flavour to generate the G-code.

Table 1. Description of G-code flavours available in Cura 4.13.1

No.	G-Code flavour	Brief description
1	Marlin	-considered as the default g-code flavour -most popular firmware and the basis of most alternative firmwares
2	Marlin Volumetric	-a variant of Marlin where the extruded quantity in cubic millimeters is specified via extrusion commands
3	RepRap	-flavour focused on supporting printers that evolved from the RepRap project
4	Ultimaker2 (Ulticode)	-flavour intended for the Ultimaker 2 family -it doesn’t allow to control the material-related settings
5	Griffin	-flavour for modern Ultimaker printers, UM3 and newer. -g-code starts with a large header of metadata (e.g., name of the print job, duration of the print, starting temperature)
6	Repetier	-flavour aims at Repetier 3D printers -mimics the output of Repetier slicer
7	Makerbot	-flavour intended for Salifish based firmware -used for original Makerbot printers
8	Bits from Bytes	-flavour targets Bits from Bytes printers which had their own custom firmware
9	Mach3	-flavour that generates a G-code similar to the ones used in CNC milling

2.2 TESTING METHODS

In order to evaluate the influence of each G-Code flavour on the geometrical product specification, a test model was chosen. This is the XYZ calibration cube, a widely used benchmark model in the 3D printing community. The cube is 20x20x20 mm and has three marks with the letters X, Y, and Z with different angles and a depth of 2mm, representing the cartesian coordinates (see figure 2). The selected filament was a white color polylactic acid (PLA), with a diameter of 2.85 mm from Aprinta Pro. The depth and the angles of the letters make the printed part subject to bridging and ghosting.

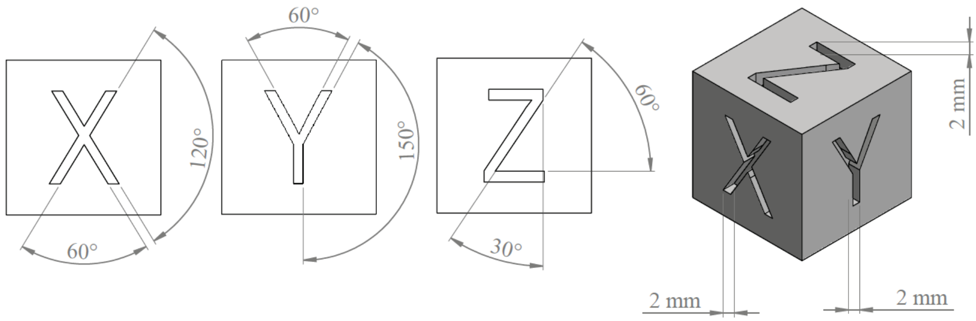


Figure 2. XYZ calibration cube specifications

In order to have comparable results, for each flavour a default printing setting profile generated by Cura was preset. The main parameter values are presented in table 2. The model was positioned centrally on the building plate with an orientation respecting the XYZ marks for each print.

Table 2. Normal profile parameters values.

Profile name	Layer height (mm)	Infill (%)	Support	Adhesion	Brim lines (No.)	Print speed (mm/s)	Printing temperature (°C)	Build plate temperature (°C)
Normal	0.15	30	No	Brim	23	60	200	60

Each resulting model will be evaluated based on six criteria. Those are file size, number of g-code lines, printing time, weight, ghosting, and general surface aspect. The file size, the number of g-code lines, and the printing time will provide an overview of the algorithm's performance. The flavour that requests the smallest number of tool paths will be considered the most efficient. By scaling the part, the real weight of the part can be compared with the slicer estimation. Ghosting is a visual defect of the printed part that creates fades (patterns) of an existing mark. It is usually caused by high printing speeds and vibrations that appear in the machine. The general surface aspect was considered because aesthetics are essential to the final product. Based on a visual inspection of the printed part, the criteria that can't be quantified will get a score between 1 and 5 (being the best).

3. RESULTS

From the resulting g-code files, two of them, Bits from Bytes and Mach3, failed from the beginning because the firmware of the Ultimaker 2+ could not interpret the flavours. The remaining prints were evaluated according to the methodology described in the previous chapter.

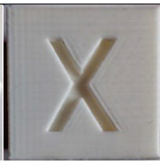
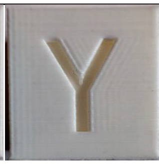
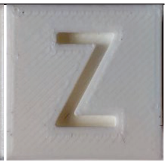
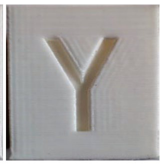
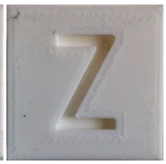
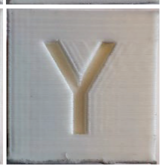
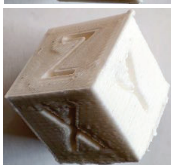
There are no significant differences regarding the file size, number of lines, and printing time. On average, the resulting file size was ≈653 KB and had a number of lines of ≈ 23042. By analyzing the g-codes, it was observed that the header and the footer of the instructions were written in distinct styles. For example, the Griffin flavour contains more metadata than the others. In the case of noninterpretable flavours, Bits from Bytes generated a set of instructions with a size of 1.014 KB containing 76031 lines, while Mach3, has a size of 652 KB and 23042 lines. Regarding the estimated printing time, all flavours had ≈1875 s. All compared data are presented in table 4.

The dimensional accuracy of the resulting specimens was evaluated using a digital caliper. For each side, three measurements were taken. For the XY dimensions, it can be observed that the Repetier flavour generated a model with 20.02 mm on the X side and 20.06 mm on the Y side. From the Z dimensional, the best results were achieved by the Griffin flavour, having 20.14 mm.

Regardless of the used flavour, the slicer estimated a usage of 5 g of filament for the benchmark model and printing adhesion helpers. As shown in table 4, the weight closest to the estimation was Ulticode, having 4.8 g. On the other hand, the smallest quantity of material was used by the Repetier flavour, with 4.56 g, and the biggest by Marlin Volumetric, having 8.84 g. This difference in weight can be explained by different values of hidden parameters in the basic printing mode, such as layer width, extra line count, connecting fill lines, and how each flavour's algorithm interprets these parameters.

Ghosting defect was visible on all the printed models, as seen in the captions presented in table 3. The least noticeable ghosting was obtained for Ulticode and Griffin flavours. On the other hand, the most visible one was from Marlin Volumetric.

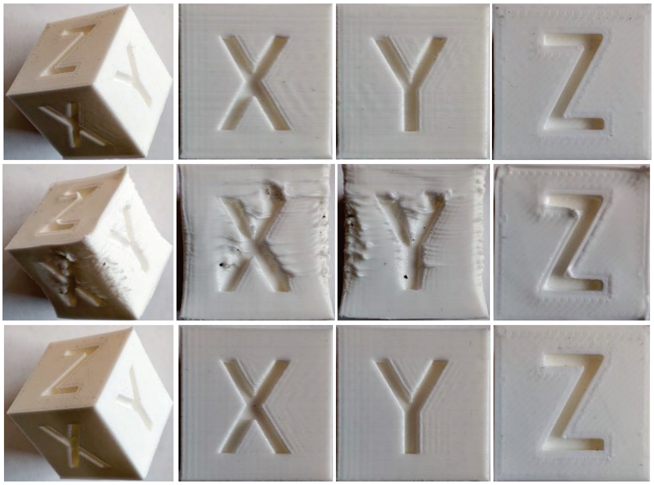
Table 3. Printed parts – visualisation of seven flavours

Flavour name	Isometric view	X view	Y view	Z view
Ultimaker2 (Ulticode)				
RepRap				
Repetier				
Marlin Volumetric				

Marlin

Makerbot

Griffin



Regarding the general surfaces' aspect, the most aesthetic models were Ulticode and Griffin, followed by RepRap, Repetier and Marlin. The poorest surface quality was obtained for Marlin Volumetric and Makerbot which showed heavy warping defects. This defect can be caused by improper cooling settings, high printing speeds, and vibrations. Overall, Ulticode (also recommended by the manufacturer) and Griffin obtained the best results.

Table 4. Results score

G-Code Type	File size (KB)	Lines (No.)	Printing time (s)	X/Y/Z dimensions (mm)	Weight (g)	Ghosting	General surfaces' aspect
Marlin	652	23047	1875	20.03/20.09/20.2	4.73	2	3
Marlin Volumetric	660	23044	1874	20.34/20.44/20.45	8.84	1	1
RepRap	652	23045	1875	20.03/20.09/20.22	4.69	3	3
Ultimaker2 (Ulticode)	659	23019	1874	20.07/20.13/20.2	4.80	4	4
Griffin	652	23056	1875	20.07/20.13/20.14	4.72	4	3
Repetier	652	23042	1875	20.02/20.06/20.23	4.56	3	3
Makerbot	652	23043	1875	19.67/19.86/21.34	4.77	1	1
Bits from Bytes	1.014	76031	1870	N/a	N/a	N/a	N/a
Mach3	652	23042	1875	N/a	N/a	N/a	N/a

4. CONCLUSIONS

Nowadays, Fused Filament Fabrication is one of the most commonly used 3D printing technologies. The open-source character of this technology accounts for this success. This allowed professionals and the user community to develop rapid hardware and software. The Cura slicing tool is a great example of an open-source software supporting more than 400 commercial printers and nine G-code flavours.

This study evaluated the influence of available G-code flavours in the Cura slicing software by using an XYZ calibration cube as a benchmark model. The resulting parts were evaluated using multiple criteria such as G-code file size, number of lines, printing time, weight, dimensional accuracy, and defects. The results showed that there is no significant difference in metadata generation. The registered differences in G-code size are based on flavours' algorithms' way of generating headers and footers. The best model quality can be obtained using Ulticode or Griffin flavours.

For average users, the best approach is to stick to the flavour recommended by the manufacturer of each 3D printer. However, for more experienced users, almost all flavours can be used because the resulting model quality can be improved by fine-tuning the settings of parameters unavailable in the default profile.

Conflict of interests

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

E.S.C. conceived, designed, performed experiments, analysed the results, wrote the manuscript S.A. and E.V. analysed the experiments, technical proof of results, and reviewed of the manuscript. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Gardner, J.. M., Hunt, K., A., Ebel, A., B., Rose, E., S., Zylich, S., C., Jensen, B., D., Wise, K., E., Siochi, E., J. & Sauti G. (2019) Machines as Craftsmen: Localized Parameter Setting Optimization for Fused Filament Fabrication 3D Printing. Adv. Mat. Technol. 4 (3), 1800653.

Gibson, I., Rosen, D. & Stucker, B. (2015). Introduction and Basic Principles. In: Addi tive Manufacturing Technologies. (pp. 1-18) Springer.

Horvath, J. (2014) Driving Your Printer: G-code. In: Masterring 3D Printing. (pp. 65-76). Apress.

Horvath, J. & Cameron, R. (2015) Controlling Your 3D Printer. In: 3D Printing with MatterControl (pp. 71-83). Apress.

Jones, R., Haufe., P., Sells, E., Iravani., P., Olliver, V., Palmer, C. & Bowyer, A. RepRap – the replicating rapid prototype. In: Carbone, G. (eds): Robotica. (pp. 177-191). Cambrige University Press.

Kokovic, P. (2017). History of Additive Manufacturing. In Davim, P. J. (eds) : 3D Print ing and Its Impact on the Production of Fully Functional Components: Emerging Research and Opportunities. (pp. 1-24). IGI-Global.

Oztan, C., Ballikaya, S., Ozgun, U., Karkkainen, R., & Celik, E. (2019) Additive manu facturing of thermoelectric materials via fused filament fabrication. Applied Materials Today. 15, 77-82.

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ASSESSING THE REPORTED RISK FACTORS BY THE TOP CLOUD COMPUTING PROVIDERS

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ABSTRACT: The literature has widely investigated the risks from the perspective of the companies adopting new and disruptive technologies. However, less attention has been paid from the side of the providers of such technologies. This paper aims to address this gap by assessing and initiating a discussion on the reported risk factors in the annual reports of five of the considered top providers of cloud computing services: Amazon, Google, IBM, Microsoft, and Alibaba, characterized by their avant-garde or disruptive technologies, their dependence on the internet and technological infrastructure, and their operation on a global scale. As main contributions, this research offers from the viewpoint of these companies a classification of the intrinsic risk factors related to their specific nature, grouped by subjects, along with the potential derived negative impacts on their businesses, and critically discusses some positive aspects and some potentially missing factors to be further addressed. Through this paper, we prepare the avenue for ongoing research including more companies and further assessment methods and criteria to further expand and enrich the findings.

Keywords: *Risk factors; cloud computing; annual reports; disruptive technologies; ethics.*

1. PURPOSE OF THE PAPER

Under the umbrella of industry 4.0 and digital transformation, and as one of its main gears, cloud computing emerged a few years ago as an on-demand network access and

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service-centric model that delivers information technology resources such as infrastructure, components, and applications (Benlian et al., 2018).

Despite its inherent potential problems, risks, or challenges (i.e., privacy and security issues), cloud computing is taking off and growing vertiginously due to its multiple and substantial advantages and opportunities for companies adopting this service. Among its main contributions, cloud computing enables large-scale innovations for the benefit of its users and society (Benlian et al., 2018).

Moreover, in relation to the cloud computing risks, scholars have widely addressed such concerns and mitigation strategies from the perspective of the companies adopting this service (Alouffi et al., 2021). Nonetheless, to the best of our knowledge, little has been investigated in this respect from the side of the providers of this technology, which lean on new or avant-garde technologies, depend on the internet, and operate at a global scale. These providers shall also deal with their risks, which may affect their prospects and future performance. In this venue, as a starting point to fill this gap, this work aims to study the risks factors declared by the considered top five cloud provider companies worldwide, focusing on those more firm-specific, directly related to the very nature of these businesses. To this end, the authors examine their SEC Form 10-K annual corporate reports, section 1A, to assess and classify the potential risks these companies disclose and that could threaten their business operation, results, expansion, success, or even continuity.

As a main practical implication, the outcome offers a first approach to the main idiosyncratic risks or concerns declared by these companies at the technological avant-garde, which are in turn referent in their sector and beyond, as well as global main players, considering that those risks are highly significant for investors, governments, employees, banks, customers, users, and other relevant stakeholders. Likewise, this study points out certain missing aspects to be further considered as potential risks.

2. THEORETICAL BACKGROUND

2.1 Cloud computing service model

Cloud computing is one of the key ingredients in the puzzle of I4.0 and business digitization (Garcia-Ortega et al., 2021), and thus it is one of the main available new technologies for companies to adopt. As an on-demand network access model, and as a service-centric model, cloud computing is devised to provide information technology resources such as infrastructure, components, and applications (Benlian et al., 2018), and integrates artificial intelligence and machine learning capabilities (Kumar, 2016). Cloud computing services can be private, public, or hybrid, a combination of the two, and may comprehend three main types of services: Infrastructure as a Service (IaaS), Platform as a Service (Paas), and Software as a Service (Saas) (CSA, 2009).

Through the cloud computing model, organizations, companies, or individuals as users may operate their data and applications on-demand from any device with an internet connection, at any time and from any place, as a measured service they pay for, thereby permitting transferring fixed costs to variable costs (Shimba, 2010). The adoption of this model provides potential benefits such as enhanced agility and flexibility, better efficiency, easier control of costs, scalability, and maintenance, and enables innovative services and business models which lead to large-scale innovations that ultimately benefit their users and society (Benlian et al., 2018).

2.2 Risks for companies adopting new technologies

According to Garcia-Ortega et al. (2021), the main potential difficulties or barriers identified by senior management of leading corporations when facing the adoption of new technologies are the lack of regulation, the code of conduct and ethical use, the security, the need to ensure specifically trained staff, the complexity and the high investments required, and the lack of top management support. In particular, the adoption of cloud computing involves a series of changes for a company, for example at the organizational level (Simba, 2010), and also a series of potential risks related to security, technology lock-in or licensing, monitoring, legal compliance, service level, performance, costs, governance, competencies, or industry structure (Bannerman, 2010). Dutta et al. (2013) classify those risks into four main categories: organizational, operational, technical, and legal risks. Some of these risks may be shared by companies providing this service.

2.3 Risks for companies providing new technologies

New and disruptive technologies involve risks not only for those companies adopting them but also for those acting as providers of such technologies. As proof of this, a number of leading companies in their industries dominating the market, with highly appraised top management, have failed and lost their privileged positions in front of other players when facing the situation of offering disruptive technologies (Christensen, 2013). According to Christensen, disruptive technologies usually target emerging markets that initially do not offer enough revenue for the growth expected in large companies, and there is also a risk of offering customers more than they actually need, require, or are willing to pay for; it is complicated to encompass the rate of offer and demand, and hard to justify investments that will not be sufficiently paid off at present or short-term.

However, as advanced in the introduction section, little attention has been paid by scholars to the intrinsic risks of the providers of new technologies and in particular cloud computing services.

3. DATA AND METHOD

The sample comprises the considered top five technological companies owning divisions that provide artificial intelligence and machine learning services through their cloud platforms, according to the Datamation portal (Maguire, 2022). These companies (and their cloud platforms) are respectively: Amazon (Amazon Web Services), Google (Google Cloud Platform), IBM (IBM Cloud), Microsoft (Microsoft Azure), and Alibaba (Alibaba Cloud). These companies are mainly characterized by their avant-garde or disruptive technologies, their dependence on the internet and technological infrastructure, and their operation on a global scale, being one of the leading and more scrutinized companies, not only in their sector but also worldwide.

Corporate annual reports are one of the most relevant sources of information about a company for investors, policymakers, and other stakeholders (Zhu et al., 2016; Huang & Li, 2011). In particular, Form 10-K is an annual report to be submitted to the Securities and Exchange Commissioning (SEC), compulsory for most U.S. publicly listed companies. Since 2005, the SEC mandates to include a specific section, Section 1A, comprising a discussion on the company's individual risk factors. In this section, which has an important and growing weight in the total extension of Form 10-K reports in the last years, the factors that make the company speculative or risky are reported in a sequential way by themes, with detailed explanations and examples reasoning them and their potential consequences. In fact, and especially after the financial crisis in 2008, the SEC has made more emphasis on the explanations and details about the specific risks they face (Campbell et al., 2014). According to Zhu et al. (2016), the companies' self-disclosed risk factors provide forward-looking information that may actually reveal the future risk of the companies and can be even used to predict potential stock change. In the same line, market participants consider risk factor disclosures for their firm risk assessment (Campbell et al., 2014). Furthermore, this disclosure, by warning investors of negative outcomes in advance, can also serve companies to protect against litigation risk, thereby acting as a 'litigation shield' (Skinner, 1994).

For each of the five companies selected, the Form 10-K annual reports published in 2021 were downloaded from the publicly available database *The Electronic Data Gathering, Analysis and Retrieval* (EDGAR), and the section Item 1A -Risk Factors- from each report was considered for the assessment. According to the SEC regulation, companies shall present and discuss in this section the most significant specific risk factors for the firm, along with the specific adverse outcomes, in a logical and concise manner, leaving apart those that could apply to any issuer or any offering. In this sense, and in line with the SEC recommendations, we set the focus on those reported risk factors more inherent to the very nature of these businesses, above those risks that, although could also be somehow regarded as leading to a specific negative impact, would apply and impact any company irrespectively of their scope or activity (i.e., macroeconomic risks).

Two previous annual reports published were randomly revised with similar content, with the exception of the allusion to the Covid-19 pandemic; thus, a one-year publication was considered for this study. The authors carried out a joint examination of this section through a comprehensive and interpretative reading in order to screen and classify the main individual issues identified by these companies as risk factors for their prospects, by focusing on those risk factors that may be influenced by the nature of the business and leaving aside those that would apply to any company. Additionally, the overall potential consequences derived from such risks were identified. For the text classification of the main groups of risk factors, the authors leaned as a point of departure on the risk factor categorization adopted by Huang and Li (2011), consisting of a topic-based structure, and subsequently grouped and adapted it in accordance with the particular outcome and background. Thus, the outcome consisted of a list of raised risk topics with a brief description, gathering the most recurrently and emphasized risks declared by companies across the sample, along with other risks more seldomly reported by these companies, plus the overall potential consequences for their businesses.

4. FINDINGS AND IMPLICATIONS

The companies examined did report an extensive set of bullets or topics that may bring risks to their business. The general risk factors (i.e., economic downturn, recession, financial crisis, logistics crisis, energy or raw materials price increase, catastrophes, etc.) are here collected only in case they have some special significance for these companies in relation to the nature of their business when comparing to other companies in other industries, with different scope and activity.

Table 1 presents the results of the analysis with the risk factors reported by each company, classified by categories, factors that are particularly relevant or inherent to these companies to a more or less degree.

Table 1. Risk factors

Risk factor	Assessment				
	AMAZON	**GOOGLE**	**IBM**	**MICROSOFT**	**ALIBABA**
Technological risks:					
-Rapid technological advances/disruption	YES	YES	YES	YES	YES
Business models risks:					
-Rapidly evolving market, emerging business models	YES	YES	YES	YES	YES
Competition risks:					
-Low entrance barriers to new products, services, and business models, favored by new technologies	YES	YES	YES	YES	YES
-Alliances, acquisitions, consolidations within the industry	YES	YES	YES	YES	YES
Investments risks:					
-Uncertainties in investments in new products and services or new markets, not commercially viable, not attracting the interest of users to generate the revenue required to succeed, or without an adequate return of capital	YES	YES	YES	YES	YES
Innovation risks:					
-Failure of developing, implementing, or commercializing innovation initiatives	YES	YES	YES	YES	YES
Integration risks:					
-Integration challenges and other risks from mergers, acquisitions, alliances, and dispositions	YES	YES	YES	YES	YES
International and expansion risks:					
-Difficulties to manage international growth and expansion	YES	YES	YES	YES	YES
-Risks for continuous business expansion into a variety of new fields	NO	YES	NO	NO	YES
Lower levels of use of the Internet in certain countries	YES	NO	NO	NO	NO
Volatile/cyclical demand:					
-Changes in user/consumer needs, demands, or expectations	YES	YES	NO	YES	YES
-Seasonality demand (i.e., holidays) or peaks that can make systems collapse or affect results	YES	YES	YES	NO	YES

Financial risks:					
-Difficult to predict the company's financial results for particular periods (return of investments, sales cycles, and seasonality of technology and purchases, with new products, new customers, and new and evolving competitors)	YES	YES	YES	NO	YES
-Expenditures by advertisers tend to be cyclical, reflecting overall economic conditions and budgeting and buying patterns	NO	YES	NO	NO	NO
-Payment uncertainties. Need for a secure and trusted payment method	YES	YES	NO	NO	YES
-Risk of working with governmental entities as clients, who depend on fundings, with unfavorable provisions for the company (higher liabilities, unilateral termination of the contract…), or risk or being suspended as a governmental contractor	NO	NO	YES	YES	NO
Security risks:					
-Cybersecurity threats, increasingly sophisticated and complex, (cyberattacks, viruses, spyware, spam, outages, etc.) causing security and privacy breaches and threat, data leakage/damage/lost, privacy threat, poorer or interrupted service…	YES	YES	YES	YES	YES
Stakeholders risks:					
-Dependance on stakeholders' practices. Risk on how stakeholders collect, store and use contents, data and service (i.e., disinformation, low-quality contents...). Difficult to fulfill the obligation to monitor and detect the inappropriate contents, copyrights, trademarks or patents infringement	YES	YES	YES	YES	YES
-Risk of stakeholders violating laws, regulations, contractual terms, intellectual property rights…	YES	YES	YES	YES	YES
-Websites violate or attempt to violate our guidelines, including by seeking to inappropriately rank higher in search results than our search engine's assessment of their relevance and utility would rank them (web spam)	NO	YES	NO	NO	NO

-Dependance on third-party providers and other suppliers. Need to attract or retain them	YES	YES	YES	YES	YES
-Dependance on third-party distribution channels (distributors, resellers, independent software vendors, independent service providers…)	YES	YES	YES	YES	NO
-Failures on data encryption. Dependance on third parties-providers	YES	NO	NO	NO	NO
Potential product/services defects and reliability risks:					
-Risks of products defects, quality or reliability problems, security issues or delivery failures, claims or disputes with clients and other stakeholders, product/service warranty or liability	YES	YES	YES	YES	NO
-Interdependence of products and services that magnifies the impact of quality and reliability issues	NO	NO	NO	YES	NO
-Dependence on reliability, security, and pricing of the Internet, telecommunications and computer infrastructure, operational failures, and dependence on third-party service providers	YES	YES	YES	YES	YES
-Vulnerability of products and services caused by interruptions due to modifications or upgrades, terrorist attacks, natural disasters or pandemics, climate change effects, power loss, telecommunications failures, cyberattacks…	YES	YES	YES	YES	YES
Operational risks:					
-Company data center networks and capabilities difficult to cope with demand and expansion	YES	YES	NO	YES	NO
-Risk during implementation of a new ERP system in the company	NO	YES	NO	NO	NO
Increase of remote working increases risks (i.e., access challenges)	NO	YES	YES	NO	NO
Ethical risks:					
-Products, services or business practices regarded as unethical	YES	YES	NO	NO	NO

-Artificial intelligence ethical issues	NO	YES	NO	YES	NO
Human resources risks:					
-Dependence on skilled employees. Difficulties to keep and attract talent, trained, motivated and capable, sharing company culture, mission, vision, and values. Competition between companies. Need to expand the roles of existing employees	YES	YES	YES	YES	YES
Regulation risks:					
-Laws, rules, and regulations. Complex, rapidly evolving, difficult to interpret, subject to uncertainties, different across countries or regions, or inconsistent. Potential/ongoing lawsuits	YES	YES	YES	YES	YES
-Protectionism by governments (trade restrictions, intellectual property rights, or patents…)	YES	YES	YES	YES	YES
Intellectual property rights and licensing related risks:					
-Difficult to adequately protect patents and intellectual property rights for the company and obtain and keep their license. Difficult to protect from copies	YES	YES	YES	YES	YES
-Risk of losing protection of trademark or trade secrets	YES	YES	NO	YES	YES
-Risk of intellectual property or patents claims against the company	YES	YES	YES	YES	YES
-Utilization of open source and other third-party software licensed with limited or no warranties, indemnification, or other contractual protections for the company	NO	NO	YES	NO	NO
-Claims about business practices and initiatives, product releases, and technologies adopted….	YES	YES	YES	YES	YES
-False statements or complaints about the company, products, and services	NO	NO	NO	NO	YES
Sustainability risks:					
-Not successful sustainability initiatives	YES	NO	NO	NO	NO

Source: Own elaboration

Moreover, Table 2 collects the overall potential consequences on the business of such risk factors.

Table 2. Potential consequences

Potential consequences	Assessment				
	AMAZON	**GOOGLE**	**IBM**	**MICROSOFT**	**ALIBABA**
Public scrutiny, negative publicity, and reputational harm	YES	YES	YES	YES	YES
Trust and engagement	NO	YES	NO	YES	YES
Increased regulatory scrutiny, investigations, and government inquiries	YES	YES	YES	YES	YES
Change of business practices	YES	YES	NO	YES	YES
Deviation of human and economic resources, increased operation costs	YES	YES	YES	YES	YES
Reduced efficiency/productivity	YES	YES	YES	YES	YES
Deviation of management resources	YES	YES	NO	YES	NO
Difficulties to innovate	NO	YES	YES	YES	NO
Harm to competitive position. Difficulties to compete	YES	YES	YES	YES	YES
Affection to offered products and services or pursuance of certain business models	YES	YES	YES	YES	YES
Affection to market share growth	NO	YES	NO	YES	YES
Loss of customers	YES	YES	YES	YES	YES
Additional taxes and expenses	YES	YES	YES	YES	YES
Fines, sanctions, penalties, or criminal liabilities	YES	YES	YES	YES	YES
Affection to business growth	YES	YES	YES	YES	YES
Affection to economic results (sales, revenues, profits)	YES	YES	YES	YES	YES
Affection to long-term success	NO	YES	YES	NO	NO

Source: Own elaboration

Most of the risk factors and their potential impacts reported are shared across the firms examined and presented in similar terms. This is in line with Campbell et al. (2014), who concluded that the public availability of the disclosures decreases information differences.

In general, the reports appear sound and logical to the audience. As a positive example, companies refer to the risks related to rapid changes, technological advances, or new business models, addressing the risk of offering customers more than they actually need, require, or are willing to pay for, which is one of the potential problems identified in the literature for various leading companies that have failed at offering disruptive technologies (i.e., Christensen, 2013).

Another positive outcome is that companies appear to update their disclosures depending on the context, instead of merely copying and pasting reports over years. One clear example of it is the reference found to certain risk factors aggravated by the Covid-19 pandemic or to recent cases of litigations as proof of the reported risk factors.

However, it does not mean the list is exhaustive enough for all companies examined or that all the actual risks are covered. One striking finding in this direction is that three out of the five companies examined do not refer at all to the ethics related to the use of artificial intelligence as a factor risk, whereas the artificial intelligence ethics and its responsibility is a trending topic among scholars and practitioners (i.e., Orr & Davis, 2020). Likewise, three of these companies do not report the possibility that their products, services, or business practices may be regarded as unethical. In turn, the ethical approach when facing the adoption of new technologies is however one of the raising concerns in our society and an identified difficulty or barrier for companies embracing them (i.e., Garcia-Ortega et al., 2021). In addition, considering the apogee and rising relevance of sustainability in our world, only one of these companies gives significant consideration to it as a risk factor, in terms of sustainability initiatives potentially not being successful.

As for main implications, these findings may serve as a reference for high tech companies and their senior management to deeper assess and become more self-aware of the risks and challenges they face when embracing high technologies and the relevance of reporting them in an appropriate and comprehensive manner, to be transparent and also protect their companies from future litigation. It can be also of interest to shareholders and other stakeholders to better appraise them and make better-informed decisions accordingly. In addition, this work aims to encourage the adoption of this underexplored approach among scholars and to foster the discussion about how to further improve such disclosures.

5. ORIGINALITY AND VALUE OF THE PAPER

We propose an underexplored approach, by putting the spotlight on the identification and classification of the inherent risk factors identified by companies offering new, avant-garde, or disruptive technologies such as cloud computing services, instead of considering the risks for companies adopting such high and new technologies offered, which have been in turn more widely investigated.

Thus, we offer a classification of the intrinsic risks from the cloud computing providers' perspective related to the specific nature of these companies, grouped by subjects, along with the potential derived negative impacts on their businesses, and critically discuss some positive aspects and some potentially missing factors to be further addressed by companies.

Finally, through this paper, we prepare the avenue for ongoing research including more companies and further assessment methods and criteria to further expand and enrich the findings.

6. RESEARCH LIMITATIONS AND FUTURE RESEARCH DIRECTION

For future research, we plan to expand the sample, considering more companies to reduce the bias of examining a limited number of companies. Likewise, although the contents in the two previous years were found similar for the companies analyzed, the time frame may also be expanded, and the effects on risks disclosure of certain events may be also assessed. The use of software for content analysis and algorithms (i.e., Huang and Li, 2011) may help for further assessment of larger samples and to reach further findings.

Furthermore, the criteria to determine which risks might be somehow intrinsic to the nature of the business, although quite intuitive, could be further supported by comparing the identified risks with those reported in other industries.

Lastly, future research may address more specifically the subcategories addressed within each risk factor group, the relations between them, and the derived impacts of each category and subcategories of risks on businesses.

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Conflict of interests

The authors declare no conflict of interests.

AUTHOR CONTRIBUTIONS

Beatriz Garcia-Ortega and Daniel Catala-Perez: Design, conceptualization, formal analysis, and findings and implications.

Blanca de-Miguel-Molina y Maria de-Miguel-Molina: Formal analysis, review, editing, and validation.

REFERENCES

Alliance, C. (2009). Security Guidance form Critical Areas of Focus in Cloud Computing V2. 1. *Cloud Security Alliance*.

Alouffi, B., Hasnain, M., Alharbi, A., Alosaimi, W., Alyami, H., & Ayaz, M. (2021). A systematic literature review on cloud computing security: threats and mitigation strategies. *IEEE Access*, *9*, 57792-57807.

Bannerman, P. L. (2010). Cloud computing adoption risks: state of play. *Governance*, *3*(16), 2.0.

Benlian, A., Kettinger, W. J., Sunyaev, A., Winkler, T. J., & Editors, G. (2018). The transformative value of cloud computing: a decoupling, platformization, and recombination theoretical framework. *Journal of management information systems*, *35*(3), 719-739.

Campbell, J. L., Chen, H., Dhaliwal, D. S., Lu, H.-m., & Steele, L. B. (2014). The infor--mation content of mandatory risk factor disclosures in corporate filings. *Review of Accounting Studies*, *19*(1), 396-455.

Christensen, C. M. (2013). *The innovator's dilemma: when new technologies cause great firms to fail*. Harvard Business Review Press.

Dutta, A., Peng, G. C. A., & Choudhary, A. (2013). Risks in enterprise cloud computing: the perspective of IT experts. *Journal of Computer Information Systems*, *53*(4),39-48.

Garcia-Ortega, B., López-Navarro, M. Á., & Galan-Cubillo, J. (2021). Top Management Support in the Implementation of Industry 4.0 and Business Digitization: The Case of Companies in the Main European Stock Indices. *IEEE Access*, *9*, 139994-140007.

Huang, K.-W., & Li, Z. (2011). A multilabel text classification algorithm for labeling risk factors in SEC form 10-K. *ACM Transactions on Management Information Systems (TMIS)*, *2*(3), 1-19.

Kumar, M. (2016). An incorporation of artificial intelligence capabilities in cloud computing. *International Journal of Engineering and Computer Science*, *5*(11),19070-19073.

Li, F. (2006). Do stock market investors understand the risk sentiment of corporate annual reports? *Available at SSRN 898181*.

Maguire, J. (2022). *Top performing artificial intelligence companies of 2022*. Datama tion. Retrieved 12 April, 2022 from https://www.datamation.com/featured/ai-companies/

Orr, W., & Davis, J. L. (2020). Attributions of ethical responsibility by Artificial Intelligence practitioners. *Information, Communication & Society*, *23*(5), 719-735.

Shimba, F. (2010). Cloud computing: Strategies for cloud computing adoption.

Skinner, D. J. (1994). Why firms voluntarily disclose bad news. *Journal of accounting research*, *32*(1), 38-60.Hayes, R.H.; Wheelwright, S.C. (1979). Link Manufacturing Process and Product Life Cycles. Harvard Business Review, Vol. 57, No. 1, pp. 133-140.

Zhu, X., Yang, S. Y., & Moazeni, S. (2016). Firm risk identification through topic anal ysis of textual financial disclosures. 2016 IEEE Symposium Series on Computational Intelligence (SSCI).

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POTENTIAL PERSPECTIVES OF 3D LASER SCANNER FOR REAL-LIFE DOMAINS

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ABSTRACT: The 3D laser scanning technology called the accurate scene reproduction technology can support the 3D design of all kinds of tested objectives in the favorable data. It simplifies the construction project cost and improves work efficiency, but the results of its data evaluation are more reliable and comprehensive. During the last half of the 20th century, 3D laser scanning was developed to recreate the surfaces of various objects and places accurately. Technology is beneficial in the fields of research and design. The 3D laser scanner has been applied in some industries to represent its immeasurable value. In this paper, these cases used in cultural heritage, sculptures, engineering applications are more than representative to show a variety of laser scanner applications. The data processed in the follow-up are used in mapping, finite element analysis, simulation analysis, virtual reality, and other aspects.

Keywords: *Technology; Point cloud; 3D laser scanner; Reality capture.*

1. INTRODUCTION

Laser scanning is the state-of-the-art technology for high-quality focusing on real objects. It is becoming an essential tool for producers who need an accurate dimensional inspection, virtual imaging, analysis, and even manufacturing physical prototypes. 3D object scanning improves the design process, speeds up and reduces errors in data collection, and saves time and money. Therefore, it is an attractive alternative to traditional data

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collection techniques because conventional methods are slow, time-consuming, and present many evident limitations.

3D laser scanning is used in a variety of fields and academic research. 3D laser scanning is used in numerous applications: industrial, architectural, civil surveying, urban topography, mining, reverse engineering, quality, archaeology, dentistry, and mechanical and dimensional inspection are just a few of the versatile applications. 3D laser scanning technology allows for high resolution and dramatically faster 3D digitizing over other conventional metrology technologies and techniques. Animation and virtual reality are fascinating applications (Edl et al., 2018).

The domain of 3D scanning serves a variety of typical engineering sectors apart from the societal spheres. Javaid et al. reflect in Figure 1 the several potential areas of 3D scanning applications that are most dominating, specifically in science and education sectors, design and manufacturing domains, reverse engineering fields, art & design, etc. (Javaid et al., 2021)

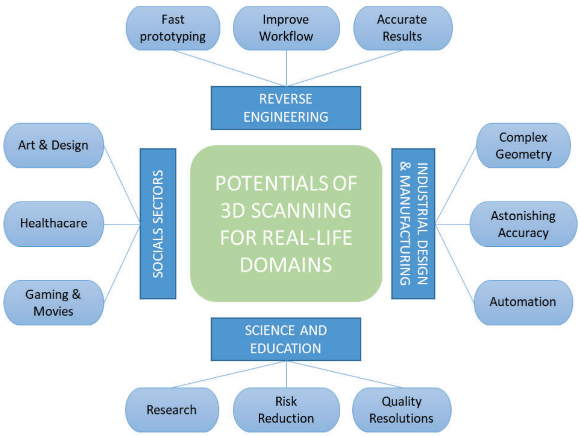


Figure 1. Capabilities of 3D scanning for Various Industrial Spheres.

3D scanning technology applies environmental analysis techniques to obtain information about shape, color, or texture. This information becomes the basis for the creation of the 3D digital model. The device used to perform this type of analysis is a 3D scanner. Many different technologies can be used to build these 3D scanning devices. In Figure 2, Todea et al. show a classification of the 3D digitization in contact scanning (refers to mechanical contact of surfaces) and non-contact 3D scanning (using optical sources, laser, or a combination of both for accurate reproduction of the scanned surface) (Todea et al., 2018).

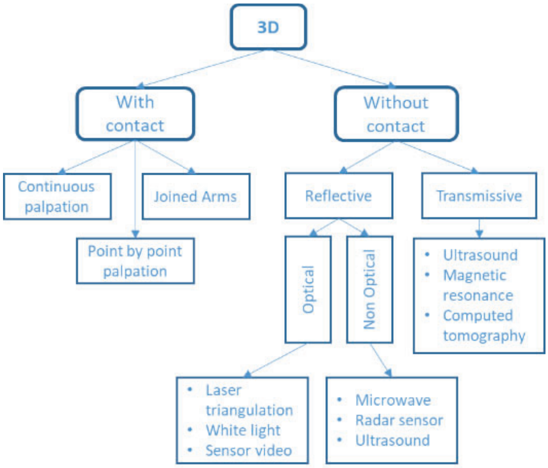


Figure 2. Types of 3D digitization

2. 3D LASER SCANNER

The 3D scanner is a device that captures the shape and characteristics of any volume or environment. It is possible to build a three-dimensional model of it on a real scale through specific software. Several technologies are used for capturing with the 3D scanner, such as physical touch, optics, and ultrasound. Each type of technology has its advantages and disadvantages and is used for various purposes. But it is necessary to establish a reference system between the object and the scanner in all of them.

Laser scanning systems (LSS) make it possible to obtain spatial coordinates of millions of surface points on objects with a very complex shape (Fig. 3) (Pukanská, 2013), which cannot be obtained by classical methods or photogrammetry in the concise term. The result of a scan is a cloud of points, which later has to be processed, known as reconstruction, to determine how those points are united and obtain the 3D model that represents the three-dimensional image of the objects, scans, and complex shapes.

Figure 3. Point cloud of the Likava castle and survey stations of scanning.

2.1. 3D model acquisition process

The 3D model acquisition process consists of two main stages, which are:

- 3D scanning,
- data processing.

The purpose of a 3D scanner is usually to create a 3D model. This 3D model consists of a point cloud of geometric samples on the subject's surface. These points can then be used to extrapolate the subject's shape (reconstruction). If color information is collected at each point, the colors on the subject's surface can also be determined.

3D scanners share several traits with cameras. Like most cameras, they have a cone-like field of view; like cameras, they can only collect information about surfaces that are not obscured. While a camera collects color information about surfaces within its field of view, a 3D scanner collects distance information about surfaces within its field of view. The "picture" produced by a 3D scanner describes the distance to a surface at each point in the picture. This allows the three-dimensional position of each point in the image to be identified.

In most situations, a single scan will not produce a complete subject model. Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject. These scans must be brought into a standard reference system, a process usually called alignment or registration, and then merged to create a complete 3D model. This whole process is generally known as the 3D scanning pipeline.

Measurement of spatial data with a laser scanner consists of several steps influencing the qualitative result of measured data, thereby affecting the quality of the final model. It consists of the following steps (Fig. 4) (Pukanská, 2013).

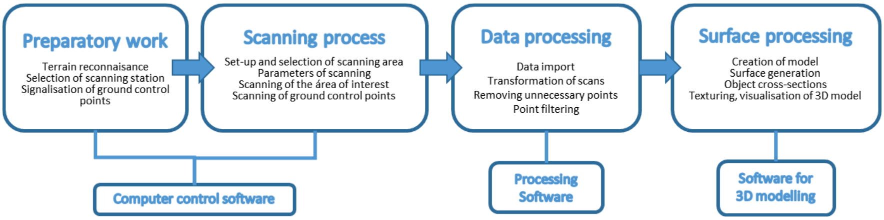


Figure 4. Overview of 3D laser scanning process.

3D scanners can be very accurate and even capture color information, so the models obtained will be completely realistic and proportionate, with the type of technology being a determining factor. Usually, the capture with a 3D scanner will not produce a complete model in the first scan. Still, multiple scans from different directions will be necessary to obtain information from all sides of the object. These scans are integrated into a standard reference system. Then, through alignment of the information obtained at all stations, a complete model is obtained in a single file (Fig. 5) (Pukanská, 2013).

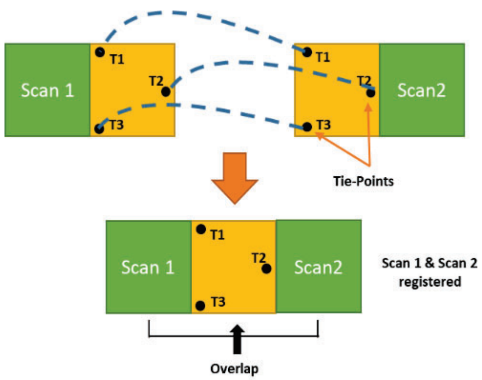


Figure 5. Registration using tie points.

After the initial processing of data – joining and deleting unnecessary data – it is possible to proceed to further processing into 3D models, according to the required outputs. For specific particular tasks, the initially processed point cloud is usually sufficient for the object visualization, project activities, measuring the direction and size of changes in a shift of the point cloud.

The resulting display is the final part of object modeling so that it resembles reality as close as possible and accurately represent the object. It is a process rather graphically intensive regarding the assignment of colors, materials, textures, and illumination. The resulting model can be used further for virtual animation, video sequences, overflights, etc.

3. CASES IN REAL-TIME DOMAINS

3D model creation and visualization are often used to preserve the looks and structure of historical buildings digitally. Virtual reality (VR) technologies facilitate this 3D model creation and visualization. A 3D scanner can be used to accelerate data collection and model creation. 3D displays can improve visual perception, and 3D printing can be used for physical model creation (Hrozek et al., 2012).

In this paper, sculpture, tower, church, pipeline, and other scenes will serve for the demonstration of 3D laser scanning capabilities.

Statue of Marc Anton (Austria)

In Vienna, the Marc Anton sculpture shows the Roman commander and statesman Marcus Antonius sitting on a chariot and being pulled by three lions. There is a fourth lion next to the chariot (Fig. 6). The socket is approximately 5m by 2.5m and has a height of 0.8m. The highest point (Marc Anton's head) is about 3m above the ground. The object's surface contains numerous regions with high detail (e.g., the lions' manes, Marc Anton's face, clothing). Some holes between the spokes of the chariot's wheels increase the surface's complexity. Due to the complex structure, occlusions cannot be avoided, and some areas cannot be acquired without tremendous effort (Fig. 7) (Vozikis et al., 2004).

Figure 6. Marc-Anton sculpture at the Viennese Secession

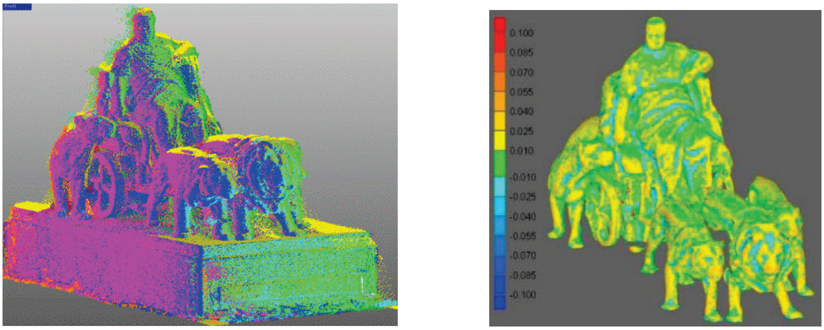
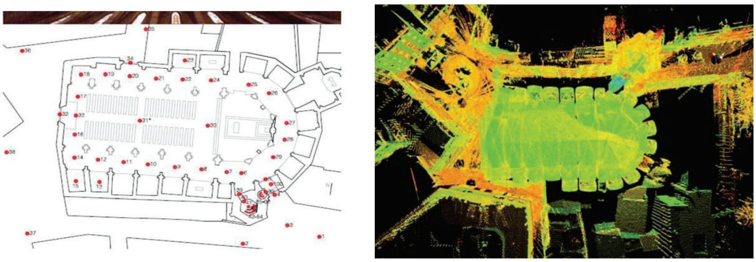


Figure 7. a) Individually Coloured Point-Clouds b) Differences: Original minus Final

Santa Catalina Church in Valencia (Spain)

The Church of Santa Catalina is a unique building within the historical heritage of the city of Valencia due to different aspects. Its medieval origin and unusual plan layout should be noted, because of the asymmetry of its side chapels and its particular ambulatory with an even number of radial chapels. Moreover, uncertainties of its constructive evolution are reflected in the façade of Lope de Vega square. In addition, its bell tower is important, which is considered a vital example of the Valencian Baroque (Fig. 8) (Moreno Puchalt, 2016).



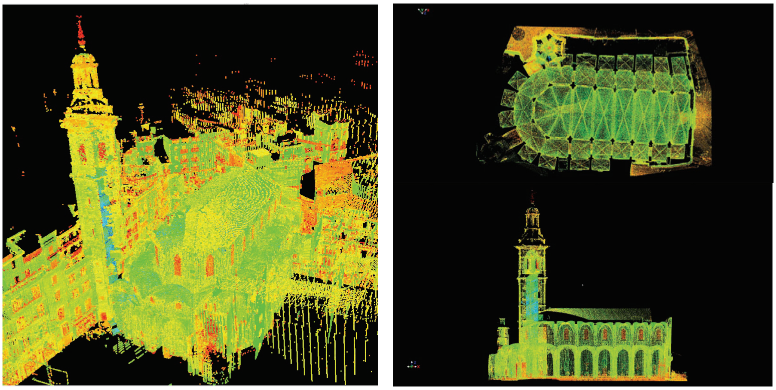


Figure 8. Point cloud of Church of Santa Catalina

Historic Greek catholic Church in Hačava (Slovakia)

This church is in a small village, Hačava, situated in the Slovak Karst. The sacral dominant in Hačava is the Greek Catholic church of the Nativity of the Blessed Virgin Mary from the 18th century. The church was built in the period of artistic directions of Baroque and Classicism. The use of an accurate 3D laser scanning solution made it possible to automatically create accurate sections and elevations of the building(Fig. 9) (Tkáč & Mesároš, 2016).

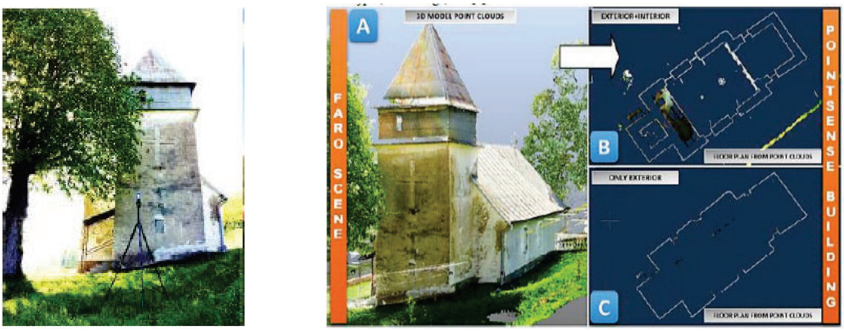


Figure 9. Nativity of the Blessed Virgin Mary Greek Catholic Church- Hačava. a) 3D model point clouds, b) floor plan (exterior & interior), c) floor plan (only exterior)

The riblike sheet of the Eduardo Torroja Institute (Spain)

The exterior chapel built in the Alarifes' courtyard of Eduardo Torroja Institute was designed as a riblike sheet in 1969 to symbolize the possibilities that reinforced concrete technology offered at that time. The result was a reinforced concrete sheet 10 m long and

6.5 m high with thicknesses ranging between 6 and 40 cm and defined by a Bernoulli Lemniscate guideline. Through a 3D scanning (Fig. 10), the volumetric survey of the structure and the three-dimensional modeling were carried out to perform the FEM analysis. It allowed an evaluation of the flaws observed in the sheet, a study of the deformations suffered, and its resistant behavior and structural safety (Echevarría et al., 2014).

Figure 10. Point cloud of the riblike sheet, stations of scanning.

Engineering Applications

Laser scanning has a wide range of applications in areas with poor access, for example, industrial plants or under hazardous conditions. Expansion of laser scanning within the engineering works allows re-searches and companies to construct of different as-built models of engineering projects and for monitoring their conditions and safety.

Point clouds are used, for example, as the basis for collision detection, volume inspection, and verification, structure testing, geometric measurement, detection of spatial position... The scanners are ideally suited for capturing contoured surfaces, complex geometries, and high-density of infrastructure where massive amounts of measurement data are required to ensure accurate depiction. The laser captures exact size and shape and converts real-world objects into 3D digital representations for storage and manipulation on a computer (Garvey, 2012).

Typical measurement problems in the industrial field deal with (i) the control of machined surfaces, for the quantitative measure of roughness, waviness and form factor, (ii) the dimensional measurement and the quality control of products (Fig.11a), and (iii) the reverse engineering of complex shapes (Setkowicz, 2014). The data appears as a "point cloud" which accurately represents the surface of the physical objects (Fig. 11b). The laser captures exact size and shape and converts real-world objects into 3D digital representations for storage and manipulation on a computer.

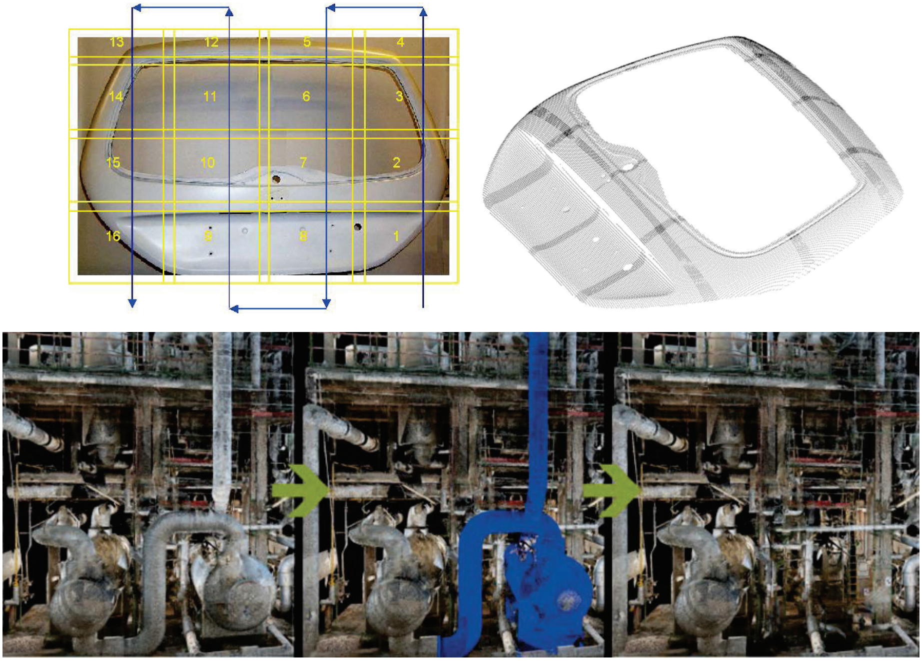


Figure 11. a) point cloud of the car back door (Sansoni et al., 2009). b) 3D laser scanning of the pipeline system (Fraunhofer IFF Magdeburg, 2018)

Others Scenes

3D point cloud that allows for virtual analysis and examination of the area of investigation. Especially significant applications of this technology are systems that use models of the human body, e.g., in the medical, forensic, clothing, and gaming industries (Škorvánková et al., n.d.).

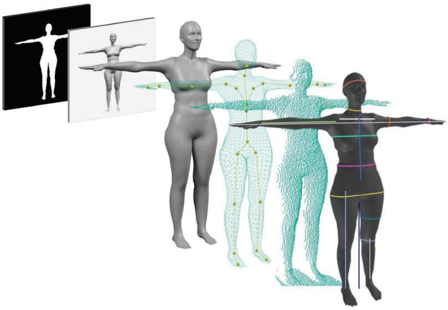


Figure 12. Human silhouette images, gray-scale images, 3D models, skeleton data, 3D point clouds

In consumer technology, depth cameras and, more recently, sensors have been integrated into handheld devices, allowing near-real-time 3D reconstruction. They are also used in 3D scanners and autonomous robotic devices. Thanks to combining these developments, most of the environments encountered in everyday life can now be digitized in three dimensions as shown in Figure 13. (*Visualizing Point Clouds in Game Engines | GIM International*, n.d.)

Figure 13. Digital models of real-time scenes.

In forensic applications, introducing laser scanners on the scene specialist save a lot of time. Furthermore, all necessary measurements can proceed with millimeter accuracy. Figure 14 presents the example of 3D modeling the crime scene (Sansoni et al., 2009)

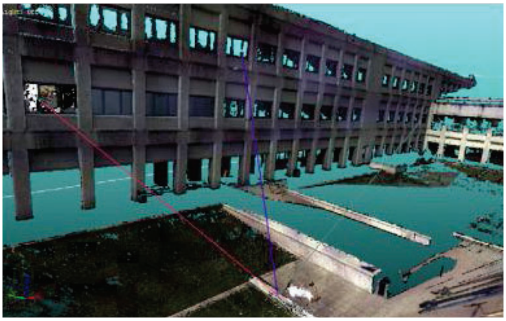


Figure 14. Crime scene capture by a 3D laser scanner

CONCLUSIONS

In this paper, a review of the most important 3D laser scanning uses has been presented. The aim is to highlight the wide range of measurement problems that can be solved by using 3D laser scanning. 3D laser scanning is, probably today, the most progressive non-contact method for the actual surveying state.

This research establishes the viability of using the 3D laser scanning technology to perform 3D data acquisitions at different stages. The overview of the state-of-art 3D acquisition systems proposed in this paper yields several conclusive remarks. Some advantages of 3D laser scanning are that a dense point cloud is faster obtained with precision and accuracy. And some disadvantages are the specialist equipment for the 3D acquisition and skilled personnel.

It is believed that with the development of information technology, 3D laser scanning technology will continue to improve, and the application of 3D terrestrial scanners will continue to be deep-en and extensive.

Conflict of interests

The authors declare no conflict of interest

AUTHOR CONTRIBUTIONS

A-C.A: Conceptualization, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Supervision. **M-P.J**: Conceptualization, Methodology, Validation, Writing - review & editing, Visualization, Supervision.

REFERENCES

Echevarría, L., Garnica, C., & Gutiérrez, J. P. (2014). La costilla laminar del Instituto de Ciencias de la Construcción Eduardo Torroja (IETcc-CSIC). Levantamiento mediante láser-escáner y evaluación estructural. *Informes de La Construcción*, *66*(536), e038–e038. https://doi.org/10.3989/IC.14.116

Edl, M., Mizerák, M., & Trojan, J. (2018). 3D Laser scanners: History and Applications. *Acta Simulatio*, *4*(4), 1–5. https://doi.org/10.22306/ASIM.V4I4.54

Fraunhofer IFF Magdeburg. (2018). *Guidelines on laser scanning in plant design*. https://www.iff.fraunhofer.de

Garvey, M. (2012). 3D Laser Scanning Technology Benefits Pipeline Design. *Pipeline & Gas Journal*, *239*(10). www.pipelineandgasjournal.com

Hrozek, F., Sobota, B., & Szabó, C. (2012). Digital preservation of historical buildings using virtual reality technologies. *Open Computer Science*, *2*(3), 272–282. https://doi.org/10.2478/S13537-012-0022-8

Javaid, M., Haleem, A., Pratap Singh, R., & Suman, R. (2021). Industrial perspectives of 3D scanning: Features, roles and it's analytical applications. *Sensors International*, *2*, 100114. https://doi.org/10.1016/J.SINTL.2021.100114

Moreno Puchalt, J. (2016). *La iglesia de Santa Catalina de Valencia: Historia, construcción y estructura* [Universitat Politècnica de València]. https://doi.org/10.4995/Thesis/10251/64074

Pukanská, K. (2013). *3D visualisation of cultural heritage : by using laser scanning and digital photogrammetry : monograph*. Vysoká škola báňská - Technická univerzita Ostrava.

Sansoni, G., Trebeschi, M., & Docchio, F. (2009). State-of-The-Art and Applications of 3D Imaging Sensors in Industry, Cultural Heritage, Medicine, and Criminal Investigation. *Sensors 2009, Vol. 9, Pages 568-601*, *9*(1), 568–601. https://doi.org/10.3390/S90100568

Setkowicz, J. A. (2014). *Evaluation of algorithms and tools for 3D modeling of laser scanning data*. Norwegian University of Science and Technology.

Škorvánková, D., Riečick´y, A., & Madaras, M. (n.d.). *Automatic Estimation of Anthropometric Human Body Measurements*. Retrieved May 12, 2022, from http://skeletex.xyz/portfolio/datasets

Tkáč, M., & Mesároš, P. (2016). 3D Laser Scanning of the Historic Greek Catholic Church - Case Study. *Czech Journal of Civil Engineering*, *2*(1), 123–128. https://doi.org/10.51704/CJCE.2016.VOL2.ISS1.PP123-128

Todea, N.-A., Dolga, L., & Dolga, V. (2018). *Reconstruction of 3D Part Models for Flexible Technology Systems Robotica Management*. 23–25.

Visualizing Point Clouds in Game Engines | GIM International. (n.d.). Retrieved May 13, 2022, from https://www.gim-international.com/content/article/visualizing-point-clouds-in-game-engines

Vozikis, G., Haring, A., Vozikis, E., Kraus, K., & Greece, A. /. (2004). Laser Scanning: A New Method for Recording and Documentation in Archaeology. In *Workshop-Archaeological Surveys WSA1 Recording Methods*.

Business 1

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A MODEL TO EXPLORE CIRCULAR ECONOMY ACTIVITIES IN HOTELS AND RESTAURANTS

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ABSTRACT: This work explores the different frontline and offline activities during the use of hotels and restaurants -represented as the touchpoints of a customer journey- to establish what circular actions could be implemented by stakeholders throughout the process, which lead to more circular business models that integrates the seven R's (redesign, reduce, reuse, renovate/repair, refurbish/remanufacture, recover/return and recycle) to achieve more efficient and sustainable performance. From the reservation step to the customer satisfaction evaluation, the interactions of hotels or restaurants with suppliers from many different economic sectors determine a variety of activities in their value chain that creates synergies, enhance circularity, and add value to the tourism sector through the implementation of sustainable practices or the acquisition of sustainable products and services. Based on the literature, reports and lessons learned in the sector through specific Focus Groups previously carried for the research team, the proposed model can help hotels and restaurants decision-makers to take steps toward circular economy.

Keywords: *Circular economy; Sustainability; Tourism; Hotels; Restaurants*

1. PURPOSE OF THE PAPER

The aim of this analysis is to provide a model that could help hotels and restaurants in their transition to a circular business model, specifying the activities in the frontline and offline touchpoints of a customer journey. We summarize all these activities and visualize them for a clearer understanding through infographics.

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2022, Editorial Universitat Politècnica de València

The work is part of the Innoecotur project, that "seeks to thrust the Circular Economy in the Tourism Sector through the transfer of results and incorporation of eco-innovations and circular economy actions, in terms of product and process, business model or organizational practices" (https://innoecotur.webs.upv.es/en/el-proyecto/).

2. RELATED WORK

Circular economy (CE) is defined like the system that replaces 'the end-of-life' concept of the existing linear model, promoting the reduction, reusing, recycling and recovering materials (Kirchherr et al., 2017). In other words, it is an opportunity to create value in ways that benefit society, business and environment while contribute to delivery of the sustainable development goals (SDGs). According to the Ellen MacArthur Foundation, the framework widely used in the CE research, relies on three principles driven by design: eliminate waste and pollution, circulate products and materials and regenerate nature (EMF, 2021). The Capgemini Research Institute (2021) summarizes EMF framework for enabling a CE, in 7R's that can help organizations to assess their current impact: reduce, reuse, redesign, repair/renovate, refurbish/remanufacture, return/recover, recycle. Practices related to CE might be adapted to each kind of businesses. The tourism industry is a vast complex industry covering a variety of sectors and connecting with multiple other industries and value chains (Font and Lynes, 2018; Einarsson and Sorin, 2020; Rosato, et al., 2021). In this case, this paper offers a study about the way that the tourism sector could integrate these kinds of practices among their organizations; specifically, hotels and restaurants assessing their customer journey to identify where in the value chain is possible to implement more sustainable practices, either directly or through its suppliers (Image 1).

Image 1. Eco-mugs in a hotel

3. METHODOLOGY

A qualitative method is used for exploring these circular activities. After reviewing the literature, some reports from companies and organizations, and the experiences of some companies through focus group interviews (De Miguel et al., 2022), service process models have been applied to follow all the steps that could contribute to a circular model (Kirchherr et al., 2017; Geissdoerfer, 2017). For representing the flow of these services processes, we have used customer journey (Tueanrat et al., 2021; Lemon & Verhoef, 2016) and infographics (Gareau et al., 2015).

4. FINDINGS

Tables 1-9 represent all the circular activities that hotels and restaurants could perform thoughout their service process. Moreover, the specific codes of the National Classification of Economic Activities, CNAE (INE, 2007), are provided to connect these activities with different suppliers that could create synergies in the tourism sector.

Table 1. Reservation process (hotels/restaurants)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE
Search, comparison and booking of hotels/restaurants	Search engines (Google, Trivago, Booking, etc.) Website or corporate social networks// Reception (telephone reservation, walk-in, mail) // Booking engine	Webpages with environmental awareness (e.g., compensate carbon footprint with tree plantations)	Accommodation/reservation s-specific software (J)
Reservation payment	Online payment through websites// payment at reception (with cards or money) // bank transfers	Reduce document printing // online vouchers	Electronic payment systems (K)

Table 2. Travel process (hotels/restaurants)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE

Travel to the service	Private or rented car, public transport	The search engine or the corporate website propose sustainable transport (e.g., train, hybrid vehicles, electric vehicles, etc.)// agreements with environmentally responsible companies// encourage their clients// provide public transport cards	Sustainable mobility (H)
Parking	Private or rented car + Parking	The car park has electric chargers for customers// offers bicycles for local transport	Electric chargers for vehicles (D)

Table 3. Check-in process (hotels/restaurants)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE
Queue to be served (or self-check in)	Reception	Using digital systems to avoid paper	Accommodation/reservation -specific software (J)
Collection/review of data (names, DNIs, etc.)	Reception	Using digital systems to avoid paper	Accommodation/reservation -specific software (J)
Key delivery along with a cardboard envelope (hotels)	Digital keys, physical keys, etc.	Reduce the use of cartons, envelopes, etc.// If used, they are made of recycled material// digital locks// reusable cards	With fingerprint (J), recycled and reusable plastic (C), recycled and reusable paper (C)
Delivery of paper with keys for the wifi	Physical documents	Reduce the use of cardboard, envelopes, paper etc.// In case of using it, that are made of recycled material// use of QR codes// include this information in other contacts	QR codes (J), recycled and reusable paper (C)
Delivery of welcome gifts// amenities (hotels)	E.g. water bottle	Delivery of sustainable gifts (e.g. auara water bottles)// facilitate the use of products with less impact// eliminate single-use plastics	Lower impact amenities (C)

Table 4. Access process (hotels/restaurants)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE
Elevator ride up	Lift	Energy-efficient electrical and lighting systems// renewable energy// power generation	Renewable energies (D), Efficient systems A (C)
Stairs climb on foot	Stairs	Efficient lighting systems (e.g. LED, with people detector, etc.)	Efficient systems A(C)

Table 5. Room use process (hotels)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE
Open suitcases	Furniture to locate suitcases, cabinets, etc.	Furniture made using circular practices (e.g., furniture made with waste from plastic bottles)// furniture of recyclable materials	Recycled and reusable furniture (C)
Hanging clothes in the closet	Hangers	Hangers made using circular practices	Recycled and reusable plastic (C)
Check hotel services (restaurant)	Book or brochure with the services// menu of the restaurant	Digital system// In case of being physical, it is made with paper and recycled materials	QR codes (J), recycled and reusable paper (C)
Food request via room service (restaurant)	Hotel kitchen	Avoid single-use plastics// sustainable and reusable utensils and dishes	Cutlery and utensils of recycled and reusable materials (C)
Shower and hygiene	Sanitary water, shampoos, soaps, towels, paper, hygienic bags offered by the hotel	Hygiene developed through sustainable practices// avoid single-use plastics// water consumption reduction systems (e.g., aerators in taps, pushbuttons in bathroom taps, small toilet cisterns)// awareness of water consumption// products purchased in bulk (minimum packaging)//eco-textiles	Water reuse systems (C, E), Renewable energy (D), eco chemicals (C), reusable packaging (C), Eco textiles (C)
Hair drying	Private hairdryer or offered by hotel	Installation of dryers with energy efficiency seal	Efficient systems A (C)

Rest	Bed, sheets, pillows, mattress, duvet, other products	The textile materials have been treated under circular practices	Textiles eco (C)
Comfort/ room temperature	A/C and heating systems	Equipment with energy efficiency certification// awareness of energy consumption// use of home automation or other technologies to avoid use when there is no one or open windows// sustainable heating sources	Efficient systems A (C), renewable energies (D)
Use of minibar	Fridge minibar and products inside	Energy-efficient refrigerators// Sale of products in the minibar that come from sustainable brands// choose recyclable containers// offer filtered water instead of bottles	Renewable energy (D), eco food and beverages (A, C), reusable packaging (C)
Cleaning of the room	Chemicals used for cleaning, gloves, garbage bags, replacement of hygiene products	Raising awareness for customers to use towels and sheets again// Use of cleaning products made under sustainable criteria (e.g. garbage bags that are easily recyclable)// cleaning chemicals with low impact on the environment// reusable or returnable packaging// containers to separate waste	Water reuse systems (C, E), eco chemicals (C), recycled and reusable packaging (C)
White washing	In-house laundry or external provider	Energy-certified machines // minimum water consumption// supplier with sustainable standards // detergent with low environmental impact// reuse of wash water	Efficient systems A (C), Water reuse systems (C, E), Renewable energies (D), eco chemicals (C)

Table 6. Table process (restaurants)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE

Consult menu	Menu of the restaurant	Digital system (QR, tablet, screen)// In case of being physical, it is made with paper and recycled materials	QR codes (J), recycled and reusable paper (C)
Food Request	Kitchen	Process that unites energy, food/drink, and physical elements	Efficient systems A (C), renewable energies (D), Cutlery and utensils of recycled and reusable materials (C), Eco textiles (C), eco food and beverages (A, C), reusable packaging (C)
Bathrooms	Sanitary water, soaps, towels, paper, hygienic bags	Sustainable hygiene products// avoid single-use plastics// water consumption reduction systems (e.g., aerators in taps, pushbuttons in bathroom taps, small toilet cisterns)// awareness of water consumption// use of products purchased in bulk (minimum packaging)/ Use of paper with dispenser, not rol // Eco textiles	Water reuse systems (C, E), Renewable energy (D), eco chemicals (C), reusable packaging (C), Eco textiles (C)
Comfort/ temperature	A/C and heating systems	Equipment with energy efficiency certification// awareness of energy consumption//sustainable heating sources	Efficient systems A (C)
Cleaning	Chemicals used for cleaning, gloves, garbage bags, replacement of hygiene products	Sustainable cleaning products (e.g., garbage bags easily recyclable)// cleaning chemicals with low impact on the environment// reusable or returnable evases// containers to separate	Water reuse systems (C, E), eco chemicals (C), recycled and reusable packaging (C)

		waste	
White washing	In-house laundry or external provider	Energy-certified machines// minimum water consumption// supplier with sustainable standards // detergent with low environmental impact// reuse of washing water// ECO materials in tablecloths for sustainable washing	Efficient systems A (C), Water reuse systems (C, E), Renewable energies (D), eco chemicals (C)

Table 7. Check-out process (hotels)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE
Queue to be served (or self-checkout)	Reception	Digital system for self-checkout	Accommodation-specific software (J)
Delivery of key together with a cardboard envelope by the customer	Reception	Reduce the use of cartons, envelopes, etc.// If used, they are made of recycled material// digital locks // reusable cards	Key with fingerprint (J), recycled and reusable plastic (C), recycled and reusable paper (C)
Delivery of the invoice	Reception	Reduce document printing // online vouchers// use of recycled paper	Recycled and reusable paper (C), Specific software for accommodations (J)
Delivery of customer satisfaction survey	Reception	It can be filled out digitally //have tablets at the same reception// send an email to the customer// reply directly to the person at the reception (short survey)	QR Codes (J), Recycled and Reusable Paper (C), Accommodation-Specific Software (J)

Table 8. Others (hotels)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE

Gym	Gym, machines, implements	Energy-efficient machines// LED lighting system// Sustainable towels // sustainable implements	Efficient systems A (C), renewable energies (D), eco textiles (C)
Swimming pool/SPA	Changing rooms, swimming pool, jacuzzi,	Environmentally friendly chemical products// Minimum efficient pool size// Sustainable heating systems (efficient boilers, biomass boilers, solar panels for domestic hot water, photovoltaic panels for lighting, etc.)	Water reuse/reduction systems (C, E), Renewable energy (D), eco chemicals (C)
Bicycles	Bicycle parking	Promote their use// offer parking for own bicycles and guests// sustainable manufacturing	Manufacturers (C)

Table 9. Cross-sectional actions (hotels/restaurants)

Process	Interacting Elements	Circular Practices	Supplier Activity and CNAE
Construction	Building materials	Durable building materials// Techniques that promote energy efficiency (e.g. insulation, ventilation, etc.)// building certification	Sustainable construction (F)
SPA	Technology for power generation	Renewable sources (e.g., solar)// renewable energy guarantee certificates from electricity companies// energy certification// diversify energy sources and required fuel// heat recovery	Renewable energies (D), Efficient systems A (C)
Suppliers	Supplier Management	Promotion of procurement of goods and services from local and environmental certificated suppliers// sustainability standard applied to suppliers// collaborate to improve supplier practices	Sustainable mobility (H), local suppliers (A, C, G, R)

Water	Technology for water recovery and saving	Wastewater or rainwater reuse systems for irrigation// water consumption reduction systems (e.g., aerators in taps, pushbuttons in bathroom faucets, small toilet cisterns)	Water reuse/reduction systems (C, E)
Sensitization of guests and hotel staff	Elements of communication and strategy	Posters// conferences and events// sustainability in advertising// communicate sustainable practices// examples in place// sustainability at the strategy level	Environmental Consulting (M)
Waste separation and management	Containers // municipal withdrawal // external company	Waste separation containers// recycling management// return of returnable materials to suppliers// compost bin// manage the end of life of utensils and furniture	Waste managers (E, O)
Appearance of the hotel	Furniture and decoration	Recyclable materials // sustainable manufacturing	Recycled and reusable furniture (C)
Textile Recycling	Textiles	Recycling of whites (sheets, towels) and uniforms	Recycled and reusable textiles (C)

5. LIMITATIONS AND IMPLICATIONS

From the methodology point of view, we have not tested the model, however we will do it in the course of the Innoecotur project. As we are working hand-in-hand with the tourism sector, we have proposed our model to hotels and restaurants, especially SMEs, as well as different suppliers that could work with them. Moreover, we have created some infographics (Figures 1 and 2) to visualize the processes in a clear and easy way to show how they could develop an integrated circular model. Small and medium hotels and restaurants in the Valencian Community have little access to information on these kinds of practices, therefore we provide a clear and understandable model that can help them, as well as contribute to the literature on the CE in the hospitality sector.

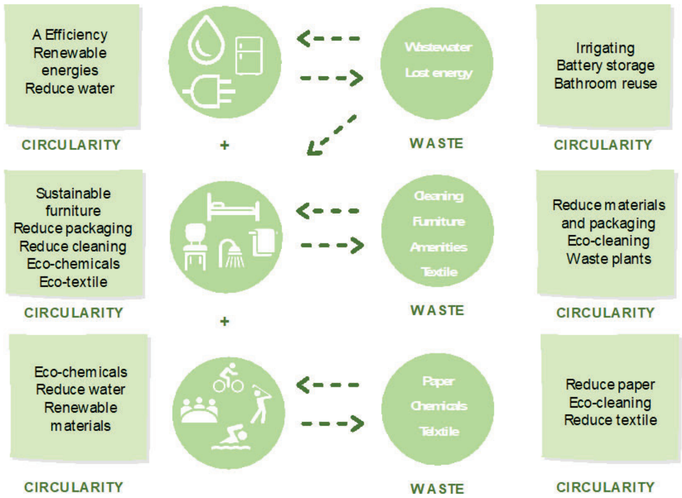

Figure 1. Circular operations in a hotel

The qualitative data obtained through the realization of three Focus Groups with stakeholders in the tourism sector are from the Valencian Community in Spain, specifically, and for this reason the results of this work might not be representative in all geographic areas. The results of this work will be used to develop a platform were hotels and restaurants can find all kind of suppliers of a variety of solutions with different approaches on sustainable practices to facilitate the implementation of circular actions in the Valencian Community.

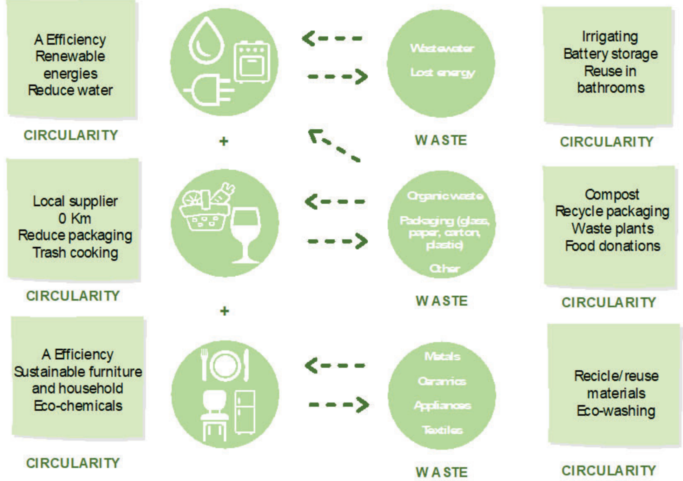

Figure 2. Circular operations in a restaurant

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AUTHOR CONTRIBUTIONS

J. Sánchez Planelles: Data curation; Formal analysis; Methodology; Y. Trujillo-Adriá: Investigation; Roles/Writing - original draft; B. Silva Cárdenas: Investigation; Writing - review & editing; M. de Miguel Molina: Conceptualization; Supervision; Visualization; Roles/Writing - original draft.

REFERENCES

De Miguel-Molina, B., De Miguel-Molina, M., Santamarina-Campos, V., Segarra-Oña, M. (2022). Informe de necesidades del sector turístico para la transición a la economía circular. https://doi.org/10.5281/zenodo.6325274

Einarsson S. and Sorin, F. (2020). Circular Economy in Travel and Tourism: A Conceptual Framework for A Sustainable, Resilient and Future Proof Industry Transition, CE360 Alliance.

Ellen MacArthur Foundation - EMF. (2021). Completing The Picture: How The Circular Economy Tackles Climate Change. https://emf.thirdlight.com/link/w750u7vysuy1-5a5i6n/@/preview/1?oMolina, D. B. M. (2022, March 3).

Font, X., Lynes, J. (2018) Corporate Social Responsibility in Tourism and Hospitality, *Journal of Sustainable Tourism*, 26:7, 1027-1042

Gareau, M., Keegan, R., Wang, L. (2015). An Exploration of the Effectiveness of Infographics in Contrast to Text Documents for Visualizing Census Data: What Works? In: Yamamoto, S. (eds) *Human Interface and the Management of Information. Infor-mation and Knowledge Design*. HIMI 2015. Lecture Notes in Computer Science, 9172. Springer, Cham. https://doi.org/10.1007/978-3-319-20612-7_16

Geissdoerfer, M.; Savaget, P.; Bocken, N.; Hultink, E. (2017) The Circular Economy – A New Sustainability Paradigm? J. Clean. Prod., 143, 757–768.

INE (2007). Clasificación Nacional de Actividades Económicas. Available in: https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177032&menu=ultiDatos&idp=1254735976614

Kirchherr, J.; Reike, D.; Hekkert, M. (2017) Conceptualizing the circular economy: An analysis of 114 definitions, Resources. Conserv. Recycl., 127, 221–232.

Lemon, K. N. & Verhoef, P. C. (2016). Understanding Customer Experience Through-out the Customer Journey. *Journal of Marketing*, 80(6), 69–96. https://doi.org/10.1509/jm.15.0420

Rosato, P.F., Caputo, A., Valente, D., Pizzi, S. (2021) 2030 Agenda and sustainable business models in tourism: A bibliometric analysis, Ecological Indicators, Volume 121.

Tueanrat, Y., Papagiannidis, S., Alamanos, E. (2021) Going on a journey: A review of the customer journey literature. *Journal of Business Research*, 125, 336-353.

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LOST IN THE FOREST OF CIRCULAR ECONOMY CERTIFICATES IN TOURISM SECTOR

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ABSTRACT: Circular economy represents a paradigm shift compared to the linear economy (producer, use and throw away). This offers the possibility of producing by reducing waste and even seeks mechanisms to reuse them. This concept allows companies to show more responsible behavior. Moreover, it is shown as a source of improvement and efficiency. Circular economy has been implemented for a long time in industrial sectors, but it is not so widespread so far in the tourism sector. However, it is known to be one of the sources of improvement available to tourism companies, and in the last few years, these types of companies are showing great interest in adopting it. One of the difficulties for them is finding the right way to adopt specific measures. One of the paths that help companies to make their efforts more effective and also more visible is going for an official certificate that may show their stakeholders that they are consistent with circular economy principles. For this reason, most of the companies implementing circular economy also seek the reward of the visibility that a certification gives. However, many tourism companies feel lost in the forest of the huge amount of certificates available nowadays in the market, which supposedly analyze and identify such behavior. This article tries to shed some light to help companies within this context.

Keywords: *Circular economy, Hospitality industry, Certificate*

1. INTRODUCTION. CIRCULAR ECONOMY.

There are many definitions of circular economy in the scientific literature. (Kirchherr et al., 2017; Vinante et al., 2021). Opposite to the traditional idea of linear manufacturing, based on extracting, manufacturing, using, and throwing away, cicular economy also

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includes some other steps such as designing without generating waste or pollution. (European Commission, 2020). The integration of a circular economy in the activity of companies can mean an increase in competitiveness for the company itself since their resources are optimized and their waste is reduced. At the same time, society and the environment also benefit from these actions.
Among all the studies on circularity, this work relies on the work done by MacArthur Foundation (MacArthur, 2013), which uses three fundamental principles on which circularity is based:
1.- Eliminate waste and pollution
2.- Circulate products and materials
3.- Regenerate nature
These three general principles can be better concretized and developed through the concept of the "Rs". The first models initially considered 3 R's (Reduce, Reuse and Recycle) (Campbell et al., 2020). This concept evolve over the year and the 3 R's were expanded to 7 (Reduce, Reuse, Redesign, Repair, Recondition, Recover and Recycle). (Araujo-Morera, et al, 2021; Universitat Politècnica Valencia, 2022).

The model has evolved even more, and the most recent studies increase R's in their development by up to 10 (Recover, Recycling, Repurpose, Remanufacture, Refurbish, Repair, Re-use, Reduce, Rethink, Refuse.) (Morseletto, 2020).

2 APPLICATION TO THE TOURIST SECTOR

The circular economy applied to the tourism sector is based on three main strategies (Ghisellini et al., 2015) 1.- Conservation and improvement of natural resources.
2.- Resource optimization
3.- Promotion of efficiency.
These main strategies are based on the initial three R's (Reduce, Reuse and Recycle). Subsequently, these strategies have been expanded to include more Rs in the tourism sector (Redesign, Remanufacture, and Recover).
In the specific case of the tourism industry, efforts are concentrated above all on energy and water saving and promoting recycling in all its possible versions. Although these initiatives are not considered circular economy per se, the pioneers in sustainability in the tourism industry have started with them, and it has been demonstrate their contribution to circularity in the sector. Some examples can be cited of the first steps taken in the circular economy for instance Manniche et al. (2017) analyzed the situation of circular economy in tourism in the Baltic region and found that many hotels had carried out sustainability practices for many years and its transition to increasing its circularity is observed above all by adopting reduction strategies.

Recently, other authors point to eco-innovation as responsible for the first steps taken towards a circular economy model. Alonso-Almeida et al. (2017) analyzed the degree of eco-innovation in four industrial sectors and identified tourism as the most involved. Some of these eco-innovations could be ideally identified as circular economy practices, such as the utilization of rainwater or geothermal energy and electric vehicles for internal transport.

Manniche et al. (2017) found some initiatives related to the circular economy in hotels about its construction, reforms, and redecoration of their operational services. Vourdoubas (2016) studied in Greece the use of renewable energy sources for the tourism sector. Girard and Nocca (2017) explained some additional examples in Italian hotels, such as electric buses and km 0 menus. These strategies allow CO_2 emissions to be reduced and present a differentiation model based on sustainability (Alonso-Almeida et al., 2017).

Regarding water, elements of control and efficiency are found above all in places where it is scarce, or is a costly resource, for example, in Morocco (Alonso-Almeida, 2012). Finally, regarding waste management (Deselnicu et al., 2018), many hotels have developed strategies to improve such management. Florido et al. (2019) affirms in this sense that these reuse and reuse strategies certainly contribute to the circular economy, much more than recycling itself, because waste is reduced at the source. Other authors relate collaborative consumption strategies between different industries (Singh & Giacosa, 2019). Manniche et al. (2017) recommend after analyzing several cases in the Baltic region that environmental management systems be adopted and water management. In this sense, they suggest responsible cleaning services in the short term, and in the long term, they even recommend investments in improving the management of gray water.

Regarding restaurants, these same authors point to them as a key player in reducing food waste, thus suggesting the redesign and planning of menus to reduce waste, reuse leftover food as much as possible, and even expand distribution networks or collaborative economy platforms when necessary. Although research in this regard is scarce, it can be affirmed that the tourism industry is slowly incorporating circular economy practices and evolving on the first applied sustainability practices, incorporating innovations, especially in energy, water, and the reduction of all kinds of waste.

3. MEASUREMENT OF CIRCULAR ECONOMY BEHAVIOR.

One of the most critical questions is to verify how the circular behavior of companies could be evaluated. We have proceeded to carry out a bibliographic search in the academic literature in this regard. For the manufacturing sector, there are some examples, forinstance, Kumar, et al. (2019) evaluate the impact of the circular economy in the manufacturing sector. Indicators have also been developed for the industrial sector that allow measuring the degree of involvement in the circular economy, even developed by countries at a macro level, such as for China in (Geng et al., 2012).

However, the literature that has been found on circular economy is mainly developed for the manufacturing sector, and only a few references are found in the tourism sector, even though it is said sector consumes enormous amounts of energy and water, produces a lot of food waste and causes a lot of CO2 emissions as well (Rodríguez et al., 2020). An isolated example of this fact is the work of Hernández & Yagui (2021) which identifies the circular behavior in tourism companies in Peru according to the Global Reporting Initiative. The Global Sustainability Standards Board has developed this certificate. This identifier is simply one of many found to measure some aspects related to the circular economy.

4. CERTIFICATIONS FOUND

We have searched for and classified certifications that allow us to identify circular behavior by analyzing them. There is not a single certificate that can demonstrate such behavior; on the contrary, many certificates, certificates, and accreditations have been found that could indicate part of the circular behavior or at least some aspect related to them. Many of these certificates are developed by private, public, and non-profit organizations. Many offer certification services, and some have even developed mechanisms and documentation that allow self-certification by companies.

In the tourism sector, many certificates certify environmental behavior, basically, they analyze environmental behavior to different degrees and scales as it can be seen in table 1.

Table 1. Certifications in environmental management specific to tourist industry

Certification of environmental management for the tourist industry.
Actively Green Standard
Asian Ecotourism Standard for Accommodations (AESA)
Bioscore
BIOSPHERE
Booking Accommodations of the sustainable travel program.
Certificate "S" (ICTE)
EarthCheck
Eco hotels tripadvisor
European Ecotourism Labeling Standard (EETLS)
GREEN GLOBE

Certification of environmental management for the tourist industry.
Green Key Global (Foundation for Environmental Education)
Green Step
Green Tourism
Green Tourism Active
Greenview Portal
Hilton LightStay
Hostelling International's Quality and Sustainability Standard (GSTC)
Sustainable Hotels Certificate (HES)
Travelife (Travel agencies)

Although we have also found other certificates, many of them originally come from industrial sectors. Nevertheless, they are applicable, and we have found evidence of tourist companies that have been certified in them. These certificates are also related to specific environmental aspects, energy efficiency..., which are also identified as circular economy behavior. They have been classified and ordered according to the related aspect. This information is grouped and sorted, and the results are shown in table 2.

Table 2. General environmental certifications applied in the tourism sector

Certificate	**Reuse**	**Proximity**	**Residues reduction**	**Water footprint**	**Energy efficiency**	**Carbon footprint**	**Environmental impact of the product**	**Global environmental management**
0 km stamp (Ivac)		**X**						
Breeam					**X**			
Carbon neutrality certification						**X**		
Carbon Proof						**X**		
Certificate of reciclability (Ivac)			**X**					
Cradle to Cradle	**X**							
EMAS						**X**	**X**	**X**
Energy Star					**X**			
Global Report Initiative							**X**	
Green Certificate							**X**	
ISO 14001 (Environmental management system)								**X**
ISO 14046 Water footprint				**X**				
ISO 14064 / 14065 Carbon footprint						**X**		
ISO 50001 (Energy management system)					**X**			
IVAC Reciclability and residues			**X**					
Residues as non residues (Ivac)			**X**					
Zero food waste (Aenor)	**X**		**X**					
Zero waste (aenor)			**X**					

4 CONCLUSION AND PLANNED NEXT STEPS

As can be seen from the information above, there are many certificates available to certify aspects related to the circular economy: many cover environmental aspects, others energy efficiency, waste reduction, and proximity. In short, individual aspects. We have not found any that relate to a broad circular behavior. We think that this fact makes the visibility of the circular economy very difficult and therefore it is an obstacle for companies that have these concerns and would like to show their behavior.

REFERENCES

Alonso-Almeida, M.M.; Robin, C.F.; Pedroche, M.S.C.; Astorga, P.S. (2017.) Revisiting green practices in the hotel industry: A comparison between mature and emerging destinations. J. Clean. Prod., 140, 1415–1428.

Alonso-Almeida, M.M (2012) Water and waste management in the Moroccan tourism industry: The case of three women entrepreneurs. Women's Stud. Int. Forum, 35, 343–353.

Araujo-Morera, J., Verdejo, R., López-Manchado, M. A., & Santana, M. H. (2021). Sustainable mobility: The route of tires through the circular economy model. Waste Management, 126, 309-322.

Campbell-Johnston, K., Vermeulen, W. J., Reike, D., & Brullot, S. (2020). The circular economy and cascading: towards a framework. *Resources, Conservation & Recycling: X*, *7*, 100038.

Comisión Europea. (2020). Nuevo Plan de acción para la economía circular por una Europa más limpia y más competitiva. Bruselas: Comisión Europea. Recuperado el 6 d 2 de 2022, de https://eur-lex.europa. Euresource.html?uri=cellar:9903b325-6388-11lea-b735-O1aa75ed71a1.OO18.O2/DOC_1&format=PDF

Deselnicu, D.C.; Militaru, G.; Deselnicu, V.; Zăinescu, G.; Albu, L. (2018). Towards a Circular Economy–A Zero Waste Programme for Europe. In Proceedings of the 7th ICAMS, Bucharest, Romania, 18–20 October 2018; pp. 563–569

Florido, C.; Jacob, M.; Payeras, M.(2019) How to Carry out the Transition towards a More Circular Tourist Activity in the Hotel Sector. The Role of Innovation. Adm. Sci, 9, 47.

Geng, Y., Fu, J., Sarkis, J., & Xue, B. (2012). Towards a national circular economy indicator system in China: an evaluation and critical analysis. *Journal of cleaner production*, *23*(1), 216-224.

Ghisellini, P.; Cialani, C.; Ulgiati, S. (2015) A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. J. Clean. Prod., 14, 11–32.

Hernández Pajares, J., & Yagui Nishii, V. (2021). Análisis de información y factores de desempeño ambiental y de economía circular en empresas peruanas. *Comuni@ cción*, *12*(1), 37-52.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, conservation and recycling*, *127*, 221-232

Kumar, V., Sezersan, I., Garza-Reyes, J. A., Gonzalez, E. D., & Moh'd Anwer, A. S. (2019). Circular economy in the manufacturing sector: benefits, opportunities and barriers. *Management Decision*.).

MacArthur, E. (2013). Towards the circular economy. Journal of Industrial Ecology, 2(1), 23-44.

Manniche, J.; Topsø Larsen, K.; Brandt Broegaard, R.; Holland, E. (2017) Destination: A Circular Tourism Economy: A Handbook for Transitioning toward a Circular Economy within the Tourism and Hospitality Sectors in the South Baltic Region; Project Mac-CIRTOINNO; Centre for Regional & Tourism Research (CRT): Nexø, Denmark

Morseletto, P. (2020). Targets for a circular economy. *Resources, Conservation and Recycling*, *153*, 104553.

Rodríguez, C., Florido, C., & Jacob, M. (2020). Circular economy contributions to the tourism sector: A critical literature review. *Sustainability*, *12*(11), 4338.

Singh, P.; Giacosa, E. 2019. Cognitive biases of consumers as barriers in transition towards circular economy. Manag. Decis. 2019, 57, 921–936.

Universidad politécnica Valencia. (2022). Informe de necesidades del sector turístico para la transición a la economía circular. Recuperado el 6-5-22 de https://innoecotur.webs.upv.es/

Vinante, C., Sacco, P., Orzes, G., & Borgianni, Y. (2021). Circular economy metrics: Literature review and company-level classification framework. *Journal of Cleaner Production*, *288*, 125090.

Vourdoubas, J. 2016. Energy consumption and use of renewable energy sources in hotels: A case study in Crete, Greece. J. Tour. Hosp. Manag. 2016, 4, 75–87.

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FOCUS GROUP DESIGN FOR INFORMATION GATHERING: AN APPLICATION FOR CIRCULAR ECONOMY IN TOURISM

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ABSTRACT: The Circular Economy opens a scenario of key business opportunities to improve tourism firms' competitiveness now and in the future. InnoEcoTur is a research project promoting models and strategies based on the Circular Economy in the tourism sector by the creation of a network in the area of hotels and restaurants. Members of the network will analyze first and later propose the implementation of a Circular Economy Strategy for the Tourist Sector of the Valencian Community, transferring also the results to companies of the industry. In the first stage of the project, we performed an audit of the industry needs and detected the potential improvements through the participation of the different stakeholders involved using focus groups. In this paper, we justify the design of the focus groups parameters such as size, location, or type of stakeholder to gather meaningful information for analysis. The methodology reveals to be adequate to draw a rough picture of the situation of Circular Economy in hotels and restaurants in the Valencian Community.

KEYWORDS: *Circular economy; Tourism; Focus group; Qualitative methods and tools*

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1. PURPOSE OF THE PAPER

The Circular Economy opens a scenario of key business opportunities to improve tourism firms' competitiveness now and in the future. InnoEcoTur is a research project promoting models and strategies based on the Circular Economy. InnoEcoTur is a research project promoting models and strategies based on the Circular Economy. The focus of the project is the tourism sector, for which it is proposed the creation of a Network in the area of hotels and restaurants. Members of the Network will analyze first and later propose the implementation of a Circular Economy Strategy for the Tourist Sector of the Valencian Community, also transferring the results to companies in the industry. To achieve this, in the first stage of the project, we need to carry out different activities with key agents in the Valencian Community. Particularly, we look to perform an audit of the industry needs and detect the potential improvement from the sustainable point of view through the participation of the different stakeholders involved and analyze the results to connect them with the R&D&i activity, which will allow the development and incorporation of eco-innovative technologies and methodologies in those fields of improvement.

2. RELATED WORK

Circular economy relates to processes that are restorative and regenerative by design aiming to maintain the elements in use at all times (Ellen MacArthur Foundation, 2016). The MacArthur Foundation, one of the most prominent organizations in the dissemination of the circular economy, uses three principles and seven "Rs" as support for the transition to the circular economy (Ellen MacArthur Foundation, 2021). The three principles on which circularity is based are:

a) eliminate waste and contamination,

b) circulate the products and materials and

c) regenerate nature

The seven "Rs" (figure 1) reflect some of the options that can be used to promote the circular economy.

Figure 1. The seven R's of circular economy

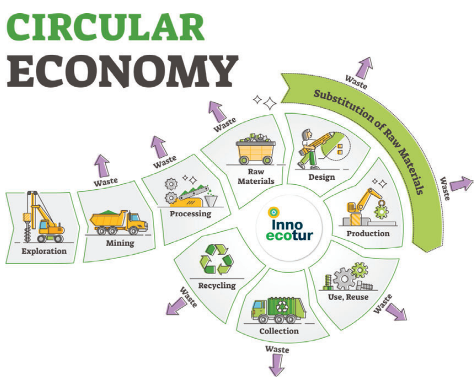

Table 1 shows the meaning of each "Rs".

Table 1. Circular Economy R's

R	Description
Reduce	Reduce the use of raw materials and design the products so that are more durable, repairable and recyclable
Re-use	Sharing, renting, leasing of products and buy products second-hand, to encourage their reuse and keep them in use for a longer time
Redesign	Design products in such a way what can they be Remanu-fatured
Repair/ Rehabilitate	Partially repair/renovate goods instead of discarding them.
Recondition/ Rework	Restore the products to their native functionality
Return / recovery	Return / recovery of products, materials and packaging
Recycle	Recycle materials or return them to return to production cycle

It differentiates from linear economy in that there is little generation of waste because waste becomes a resources in another processs creating a close loop (Wysokinska, 2016). Then in a circular economy, the value of products and materials is maintained for as long as possible; waste and resource use are minimised, and resources are kept within the economy. When a product has reached the end of its life it is used again to create further value (European Commission, 2015).

In this context, circular economy becomes crucial in those industries that are among the most pollutant. Particularly, tourism industry has been pointed as one of the target industries in which more effors have to be taken.

3. METHODOLOGY

To achieve our goal, we decided to start by using focus group methodology. Focus group is an information gathering technique that seeks to know what the participants think about an idea (Krueger and Casey, 2015). In our case, we aimed to obtain information to identify challenges and needs of the tourism industry companies (hotels and restaurants) located in the Valencian Community in the transition to circular economy. Additionally, this methodology allows to integrate companies from the beginning to our project. Participants in a focus group form a small group of people, typically around six, with a specific profile, who will discuss on a topic of interest guided by a person who moderates the session. The design of the focus group session it is a very important stage to succeed in meeting the goals of the session. The design included decisions about the number of participants, their profile, the script of the dynamic, who will moderate, how the session will be recorded and how the transcription will be done, and how the information will be analyzed.

The number of participants in each focus group was established in six people, with a time limit estimated in no more than an hour and a half for each focus, following the suggested values for the technique and our previous experiences in its application. The selection of participants is crucial to collect valuable information to reach the objective of the activity. In this first stage of the project, it is necessary that the participants are experts in the tourism industry, to ensure they have experience in the transition to the circular economy. Thus, the participant profile would be a high-level executive, with decision-making capacity about the transition of their companies to circular economy. We included participants from different activities, combining profiles from hotels, restaurants, and hotel and restaurant suppliers. We also took into account the range of age of the participants to ensure a that they frequently use new technologies. In this first dynamic we avoided small companies ensuring that they have experience in transition to the circular economy. We considered hotels with a minimum of four stars and restaurants with recognition, such as been included in a ranking or that have received a gastronomy award.

One other important issue is the number of focus group sessions to perform. In the context of the project, the tourism sector in the Valencian Community there were some limitations and external conditions to consider. First, tourism represents an important part of the economy globally in the area, but the weight of the tourism, the type of tourism in the three regions and the other industries in each of the three regional areas, Castellón, Valencia and Alicante, are completely different. Thus, we decided to cope with these conditions performing one session in each of the three regions with participants from the region. Second, the tourism ecosystem is also comprised or interrelated by many other industries, such as the art industry or passenger transport, which widens the spectrum of companies that could be included or that are affecting the tourism activities. Therefore, we decided to narrow down the spectrum of the study to hotels and restaurants really understand the two most representative areas in the industry.

Table 2. Focus group profiles

Location	Alicante	Castellón	Valencia
Participants (experts)	6	6	6
Age range	30-50	30-50	30-50
Hotel industry áreas:			
Hotels	2	2	2
Restaurants	2	2	2
Hotel supplier	1	1	1
Restaurant supplier	1	1	1

We elaborated a guide of topics or thematic aspects for the dynamic that served as guidance in discussion. We considered as topics of interest the following: BARRIERS and SUPPORT in the transition to the circular economy; PRACTICES in circular economy and industrial symbiosis; DIGITAL TOOLS to measure the circularity of a company; Eco-innovative RESULTS; CHANGE INITIATIVES in the environmental care; and USERS awareness to know and value initiatives. However, the script does not have a sequential order, it serves as support to the moderator to control the session, and it is adapted to the dynamic created by the participants in each focus group.

For the content analysis of the transcripts, we proposed QDAMiner 5 qualitative analysis software. This software allows to code the opinions of the participants on each one of the six topics indicated in the script and to assign them codes, which can be grouped by related themes. In some cases, the groups overcome the initial designed groups, enriching and uncovering interesting areas that should be considered.

4. FINDINGS

The results of this methodology to gather information reveal to be adequate. The three groups were balanced, with 6 participants in each group (18 in total), 2 from hotels, 2 from restaurants, 1 hotel supplier and 1 restaurant supplier. We generated 174 codes of related opinions which were classified into barriers, measures, incentives, supplier selection, information and communication and wastes, drawing a rough picture of the situation of Circular Economy in hotels and restaurants in the Valencian Community.

5. ORIGINALITY

This is the first study of this kind related to circular economy in the tourism industry in a geographical area where we have a special combination of different types of tourism, rural, sun&beach and urban, and a high dependency of the local economy on the tourism activities. This study justifies the selection of the focus group members for a useful prospection in a research study in its infancy state. Selecting front runners in a topic which is undeveloped in an industry such us, tourism, gives a good amount of valuable information about the needs and barriers that need to be worked from several areas such us, public administrations, to make companies in the industry to involve in these kind of practices.

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REFERENCES

European Commission. (2015). Circular economy package: Questions & answers: MEMO/15/6204.

MacArthur, E. (2015). Towards a circular economy: business rationale for an accelerated transition.

Wysokińska, Z. (2016). The" new" environmental policy of the European Union: A path to development of a circular economy and mitigation of the negative effects of climate change. *Comparative Economic Research*, 19(2), 57-73.

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RIPPLE EFFECT IN SUPPLY CHAINS: A SYSTEMATIC LITERATURE REVIEW PROTOCOL

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ABSTRACT: Recently, supply chains had to cope with various exogenic disruptions. These disruptions are resulting in cascading failures that are spreading across all the supply networks, a phenomenon called the Ripple. Analyzing this phenomenon is the goal of this protocol. To do so, this paper aims to describe the structural steps of the protocol used to carry out an upcoming systematic literature review. Furthermore, the planned work on the way to the final literature review is defined. Therefore, research questions, for a qualitative argumentation with the ripple effect are phrased. The aim is to find out how resilient supply chain networks react on the ripple effect, how the effects of the exogenic shocks can be measured to compare supply chain networks, and which simulation techniques are appropriate to justify and quantify the results. Furthermore, the target quantitative bibliometric analyze patterns are defined and a brief conclusion is capturing achievments and stating out next steps.

Keywords: *Supply chain management; Supply chain resilience; Supply chain risk management, Supply chain network, Ripple effect*

1. PURPOSE OF THE PAPER

Supply chains need to cope with exogenic shocks like pandemics, environmental disasters, logistical interferences, and many more. All these shocks result in cascading failures spreading across entire supply chain networks (Hearnshaw & Wilson, 2013) (Zobel & Khansa, 2014). This phenomenon in logistical chains is called the "Ripple effect" (Sokolov, Ivanov, Pavlov, & Dolgui, 2015) (Bellamy & Basole, 2013).

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Against the background of the growing importance of global value chains and their increasing complexity, there is a consequently increasing susceptibility to errors in the processes of these chains. The COVID-19 pandemic, that caused immense disruptions in global supply chains, is on extreme example how an exogenic shock can negatively influence supply chains. Global shortages in construction material, computer chips and other goods caused by capacity restrictions enforced by the pandemic can be seen all over the world. Virtually every globally acting company is facing the challenges of returning to former competitiveness after a supply chain disruption. Consequently, building a resilient supply chain in the post-pandemic world will be one of the main tasks for leading decision makers in globally operating companies (Shih, 2020).

Constantly developing management approaches and combining them with research around the systematic network setups can, therefore, help to temper ripple effects. However, research on ripple effects in the context of management practices and approaches seems to be a potential white research spot to cover. Addressing this gap, the upcoming systematic literature review, based on this protocol, has been initiated. The aim of this literature review is to continue the idea of the paper "Ripple effect and supply chain disruption management: new trends and research directions" were Alexandre Dolgui & Dmitry Ivanov are proclaiming that future research in dynamic analysis of the supply chain ripple effect (simulations & control theory), and the network structures with their influence on coping with the ripple effect, is necessary (Ivanov & Dolgui, 2021). Grounding on that ideas the following research questions will be investigated:

- In order to compare supply chain network designs against each other - what interdisciplinary set of key performance indicators can be used to characterize supply chain networks?
- Which supply chain network design is helping supply chains to be resilient against exogenic shocks?
- Furthermore, is there a difference in performance losses of supply chain networks in order to where the exogenic shock is hitting a supply chain network (Upstream/Downstream)?
- Simulation techniques can be mainly split into two groups, Continuous simulation, and Discrete-event simulation (Fishman, 1978). Which simulation approaches are the most suitable for modeling the ripple effect of global supply chains?

2 METHODOLOGY

2.1 Expected steps in a literature review

According to the PRISMA procedure, a literature review is split into 4 phases (Moher, Liberati, Tetzlaff, & Altman, 2009). Currently this research project is in the phase of identification. That means research approaches, search strategies, and research results for the first PRISMA phase will be descripted and justified in the following paragraph. An outlook of the upcoming research activities in the screening - and eligibility phase will be given in the methodology section, and the planned analysis done on the identified record set will be described.

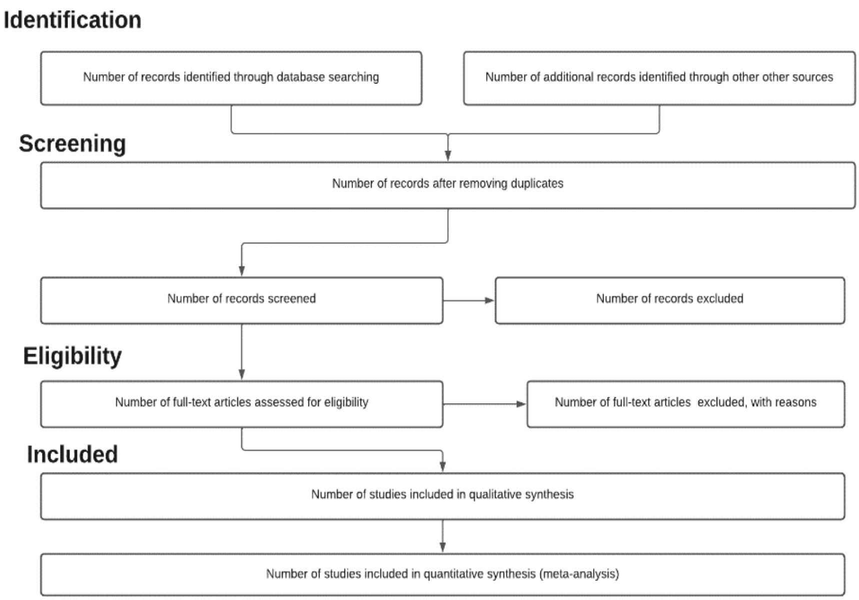

Figure 1. Flow of information through the different phases of a systematic review (Moher, Liberati, Tetzlaff, & Altman, 2009)

Bibliometric analyses are gaining great popularity in research though the last years (Donthu, Satish, Debmalya, & Weng, 2021). To give guidance for bibliometric analysis, the "Prisma-Statement", published in 2009, describes a four-step methodology to execute bibliometric analysis. Figure 1 shows this process. The phases described are the identification-, screening -, eligibility- and inclusion phase. Within the first phase, the relevant records are identified. Therefore, the results of the publications identified within a scientific database and other sources are combined.

A predefined search strategy, containing inclusion and exclusion criteria, is used to determine the boundary conditions of the identification phase. As a bibliometric analysis is usually done utilizing several research databases, the set of identified records might contain duplicates. These are removed in the screening phase. Within the eligibility phase, the identified and screened records are checked for their full text availability. All records that passed the screening and eligibility phase will build the basement for qualitative and quantitative synthesis (Donthu, Satish, Debmalya, & Weng, 2021) (Moher, Liberati, Tetzlaff, & Altman, 2009).

For the quantitative synthesis the technique of bibliometric analysis, a method to retrospect and descript publishes papers, is used (Ding, 2019). With the aid of this technique selected research areas are assessed (Small, 1973). Sophisticated bibliometric studies can build a solid foundation for advancing a research field in significant ways by enabling and empowering scholars to gain an overview over a research area, helping to identify knowledge gaps and research ideas, and positioning their intended contributions to the field (Donthu, Satish, Debmalya, & Weng, 2021). Bibliometric analyses are, thereby, analyzing secondary data acquired on research databases from a quantitative perspective (Albort-Morant & Domingo, 2016). Therefore, the results of such analysis can be characterized as systematically, transparent, and reproduceable. Thereby, they are enhancing the reliability and the quantity of the literature review (Bellis, 2012).

The techniques for bibliometric analysis can be split in the categories performance analysis and science mapping (Donthu, Satish, Debmalya, & Weng, 2021). Performance analysis focusses on the contribution of research groups to a given field (Cobo, Lopez-Herrera, & E., 2011). The descriptive analysis is a standard practice for reviewing and presenting the performance of different research constitutes (e.g., authors, institutions, countries, and journals) in a certain research field. There are a lot of acknowledged measures that are used in performance analysis. The most prominent measures are the number of citations or publications per year or per research constituent (Donthu, Reinartz, Kumar, & Pattnaik, 2020) (Donthu, Satish, Debmalya, & Weng, 2021). Not all of them are individually named here. For an holistic overview and possible metrics of performance analysis, see article “How to conduct a bibliometric analysis: An overview and guidelines” from Naveen Donthu and colleagues gives an good overview about the metrics for performance analysis. (Donthu, Satish, Debmalya, & Weng, 2021)

In contradistinction to the performance analysis, the technique of science mapping is investigating the relationship between certain research constituents (Baker, Kumar, & Pandey, Forty years of the Journal of Futures Markets: A bibliometric overview, 2021) (Rodrigues & Navarro, 2004) by analyzing the intellectual interaction and structural connection between research constitutes. Some famous representatives for science mapping are the citation analysis or bibliographic coupling (Baker, Pandey, Kumar, &

Haldar, 2020). Further techniques are highlighted in the article "How to conduct a bibliometric analysis: An overview and guidelines" from Naveen Donthu and colleagues. (Donthu, Satish, Debmalya, & Weng, 2021)

Besides the quantitative synthesis, the identified record out of the PRISMA flow will be analyzed in a qualitative way. Therefore, the included record sets will be read and interpreted with the goal of answering the detained research questions.

2.2 Progress, context, strategies and expected results

A protocol describes how a research question will be answered, in such a way that it allows to obtain a global vision of every aspect related to the research to be conducted. The main objective of a research protocol is to guide investigators and other parties through the elements that should be considered during the planned study (Silverman & Kwiatkowski, 1998). Picking up the definition of the work that should be done in a research protocol, the aim of the following paragraph is to reflect the steps that will be proceeded during the planned literature review. Furthermore, the section aims to reflect the actual status of the research activities.

a) Search Strategy for the identification phase

The search strategy for the identification phase needs to reflect the goals and objectives of the overall research plan. The research question that should be answered with that literature review are narrowing down the professional scope of the search strategy. Nevertheless, supply chain management is an interdisciplinary management area that is covering many individual disciplines (New & Payne, 1995). Considering the right research databases to use, Scopus and Web of Science (WOS), which represent research area overreaching platforms, seems to be most suitable.

Following the idea of Ivanov stating that the ripple effect and the research around that issue is a quite new and unexplored research area, it seems obvious to not chronically restrict the search scope in advance (Ivanov & Dolgui, 2021). Furthermore, an interesting question to answer is the first appearance of the ripple effect in the research area of supply chain management. Consequently, there is no time limitation set up in the research strategy.

Moreover, a worldwide search perspective is important to analyze the geographic distribution of the resulting record set. A science map will be used to find out which are the most influential or active regions in that research perspective. English as the global leading language should be a key criterion for the search strategy. Furthermore, due to the authors' personal backgrounds, publications written in German are also included.

During the execution of shaping the search strategy, reflecting the goals and objectives in the inclusion criteria emphasizes that the ripple effect is a phrase used in many research disciplines. For example, it is described as a model for software maintenance as well as an effect impacting the global housing prices (I-Chun, 2018).

By limiting the search phrases, almost all irrelevant research areas where excluded. Only a variety of publications addressing software maintenance and development approaches remained. To avoid diluting the result record set with these results, the research area computer science was excluded from the search strategy. Details are shown in the table below.

Table 1. Inclusion and exclusion criteria of the search strategy

Index	Inclusion criteria - description
1	Journal, books, book chapters and articles indexed on the database of SCOPUS and Web of Science (WOS).
2	Published in any year (including in press).
3	They research the ripple effect in supply chain networks worldwide.
4	Written in English or German.
Index	Exclusion criteria - description
1	Articles, book chapters, congress articles or any source that has not passed a sophisticated review process.
2	Publications referring to a ripple effect that is not related to supply chain management, business logistics management and supply chain networks.
3	Research that has no clear relevance for the further research on the ripple effect in supply chain networks.
4	Papers with a straight technological focus.

The inclusion and exclusion criteria are building the framework to tailor down the search strategy to the predefined goals of the upcoming literature review. Taking these criteria and the reflection of the initial search activities into consideration, search terms were established. Depending on the used database, a different syntax for the search term is used and, therefore, the search terms slightly differ in their composition. But the expression of the search phrase is the same.

For the identification of the relevant record sets, a search phrase based on the topic is used. This means the title, the abstract, and keywords of the records on the database will be checked against the relevant search term. The search terms are thereby built up in three different search statements that are connected via the logical operand AND. This means that a relevant result record will use the connected search words in title, abstract and keywords. The via AND connected blocks are containing individual search phrases connected by the logical operand OR. This means a relevant record needs to contain at least one of the search words in a block.

Taking a closer look into the first search block shows the combination of the search terms “supply chain management” and “supply chain resilience”. These phrases are limiting the scope of the relevant record set to the main relevant research area. The second search block is containing the search terms “supply chain networks” and “supply networks”. Explicitly pointing out that resulting documents should contain information around network structures is a key element to fulfill the goals of the upcoming literature review and the predefined exclusion criteria. The third search block is characterized by the search terms "ripple effect", "cascading failure*", “contagion” and “disruption*”. Ripple effect, cascading failure and contagion are similar used words in the research area supply chain management (Young Woong, Blackhurst, Chinju, & Scheibe, 2021). To prevent that the result is negatively influenced by a missing synonym all of them were used in the search term. The word “disruption*” is basically also describing an exogenic shock that can impact supply chains. Therefore, it is taken into consideration. To prevent a limited research quantity by not naming the plural of disruption in the search term, an asterisk /* was used. The final search terms are shown in the table below.

Table 2. Search terms for WOS and Scopus

Database	Quantitative Results	Search term:
Web of Science	82	(TS=("supply chain management" OR "supply chain resilience")) AND TS=("supply chain network" OR "supply network") AND TS =("ripple effect" OR "cascading failure*" OR contagion OR disruption*)
		Additional exclusion criteria: All papers of the research area “computer science”
Scopus	141	TITLE-ABS-KEY (("supply chain management" OR "supply chain resilience") AND ("supply chain network" OR "supply network") AND ("ripple effect" OR "cascading failure*" OR "contagion" OR disruption*)) AND (EXCLUDE (SUBJAREA , "COMP"))

The PRISMA flow diagram below gives an overview of the status of the literature review. Recently the identification phase was completed. Therefore, this is the only phase with available results. For all the other phases the estimated results and planned tasks will be described. While the database search in WOS revealed 82 relevant records, Scopus indicated 141 relevant records.

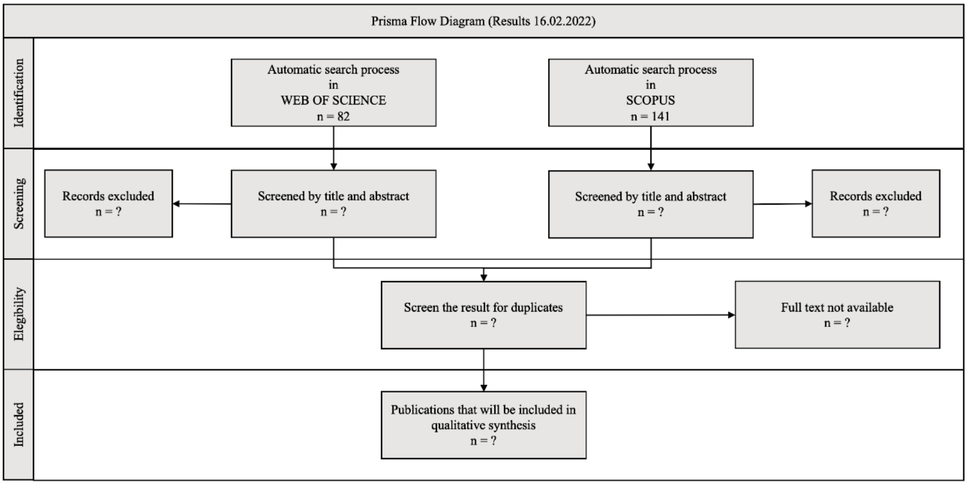

Fig. 2. PRISMA diagram showing the results of the identification phase

b) Screening strategy for the screening phase

After the identification phase, it cannot be ruled out that there are irrelevant data records embedded in the identified record set. Therefore, the identified records will be sorted by descending publication date, title, and keywords. Moreover, the abstract of every relevant record set will be screened and compared manually against the research objectives. Duplicates are manually removed. The results of the manual screening process will be clustered. Cluster one will gather all the accepted (A) articles. Keywords, title, and abstract are clearly related to the research objectives. This record sets will pass the screening phase. Excluded publications (E) are mismatching the research objectives because of absenting matches in title, abstract and keywords. The records are excluded. There might be some articles where a comparison of title, abstract and keywords against the research objectives is sufficient to include or exclude one article. These records will be clustered for revision (R) and full text analysis will be done to decide if the article will be included or exclude. Table 3 highlights this process of the screening phase (Martinez-Tomas & Marin-Garcia, 2019).

Table 3. Selection codes and screening approach for the screening phase (Marin-Garciaa, Vidal-Carrerasb, & Martinezd, 2019)

Code	Definition	When used	Action
A: Approved	Title, abstract and keywords are clearly related to the objectives of the research.	When the item meets criteria of inclusion.	Include the item in the reference list. tagging as revision (R) or item (A)

E: Excluded	The title, abstract and keywords are not related to the objectives of the study.	When the article meets the exclusion criteria.	Exclude the reference. Tagging as item (E).
R: Questionable	The article and abstract are not clearly related to the objectives of the study.	When there is no clear evidence that the summary is in accordance with the inclusion criteria but appears to be related to them.	Analyze the full text to determine whether this reference should be included in the study. Tagging it as item (A) or item (E).

c) *Screening strategy for the eligibility phase*

Articles that passed the screening matched the defined research objectives. During the eligibility phase the availability of the full text of the publication will be guaranteed. Therefore, the records classified as accepted will be checked for full text availability in WOS and Scopus.

d) *Planned analytics based on the included publications*

All articles that pass the eligibility phase will be taken into consideration for the bibliometric analysis. Therefore, different techniques and programs will be used to interpret the results of the upcoming literature review. Beside Microsoft Excel for performance analysis, VOSviewer (https://www.vosviewer.com/) will be used to perform scientific mapping. Both will be used to illustrate the results of the automatic literature search process. The following list shows the planned analytical approaches, divided by techniques for performance analysis and scientific mapping.

Table 4. Analytical techniques that are planned to use

Used technique for performance analysis	
	Descriptive statistics
	Chronological distribution of publications
	Most cited publications
	Most important authors
	Most impacted journals
	Most influential institutions
	Most outstanding countries
	Origin of authors
Scientific maps	
	Map of cited references
	Co-citation of cited references

	Map of the most cited authors
	Map of the most cited journals

3 CONCLUSION AND PLANNED NEXT STEPS

The objective of this protocol structure the future work done in the upcoming literature review. Therefore, the PRISMA methodology is introduced. Using this framework, the actual status of research is exposed and planned next steps are defined. The initial screening of the spawned results of the database query allows the conclusion that more research strands and areas should be reflected. The research area around simulation approaches to define the right strategic approach for the used simulation technique is not reflected adequately. Furthermore, the research strands around disaster theories or strategic risk management might be good candidates for extending the research query. These ideas are characterizing the planned next steps. Iterating and adapting the search terms so that they better reflect the research question will the main tasks for the next research phase. After that the results of the database search will be processed like explained with the PRISMA scheme. The final number of record sets will be quantitatively and qualitatively, with respect to the described research questions, analyzed and interpreted.

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AUTHOR CONTRIBUTIONS

Benjamin Korder: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing.

Julien Maheut : Supervision; Validation; Writing - review & editing

Matthias Konle : Supervision; Validation; Writing - review & editing

REFERENCES

Martínez, R., Melgarejo, P., Salazar, D., Martínez, J., Hernández, F., & Martínez, R. (2001). *Prácticas integradas de viticultura.* Madrid: Vicente/Mundi-Prensa.

Huglin, P., & Schneider, C. (1998). *Biologie et écologie de la vigne.* París. Francia.: Lavoisier. Tec-Doc.

Caballero, P., & Ferré, J. (2001). *Bioinsecticidas: fundamentos y aplica¬ciones de Bacillus thuringiensis en el control integrado de plagas.* Valencia: Phytoma-UPN.

Hearnshaw, E., & Wilson, M. (2013). A complex network approach to supply chain network theory. *International Journal of Operations & Production Management, 33*(4), 442-469.

Zobel, C., & Khansa, L. (2014). Characterizing multi-event disaster resilience. *Computer and Operations Research, 42*(1), 83-94.

Sokolov, B., Ivanov, D., Pavlov, A., & Dolgui, A. (2015). Structural quantification of the ripple effect in the supply chain. *International Journal of Production Research, 54*(1), 152-169.

Bellamy, M., & Basole, R. (2013). Network Analysis of Supply Chain Systems: A Systematic Review and Future Research. *Systems Engineering, 16*(2), 236-249.

Shih, W. (2020, October 01.). *Havard Business Review*. Retrieved February 21, 2022, from https://hbr.org/2020/09/global-supply-chains-in-a-post-pandemic-world

Ivanov, D., & Dolgui, A. (2021). Ripple effect and supply chain disruption management: new trends and research directions. *International Journal of Production Research , 59*(1), 102-109.

Fishman, G. (1978). *Principles of discrete event simulation.* New York: John Wiley & Sons, Inc.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ, 339*.

Donthu, N., Satish, K., Debmalya, M., & Weng, M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133*, 285-296.

Ding, X. (2019). Knowledge Mapping of Platform Research: A Visual Analysis Using VOSviewer* .

Small, H. (1973). Co-citation in the Scientific Literature: A New Measure of the Relationship between Two Documents. *Journal of the American Society for Information Science, 24*(4), 265-269.

Albort-Morant, G., & Domingo, R.-S. (2016). A bibliometric analysis of international impact of business incubators. *Journal of Business Research,, 69*(5), 1775-1779.

Bellis, N. D. (2012). Bibliometrics And Citation Analysis, from the Science Citation Index to Cybermetrics. *Toruńskie Studia Bibliologiczne, 5*(1), 8.

Cobo, M., Lopez-Herrera, A., & E., H.-V. (2011). An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. *Journal of Informetrics, 5*(1), 146-166.

Donthu, N., Reinartz, W., Kumar, S., & Pattnaik, D. (2020). A retrospective review of the first 35 years of the International Journal of Research in Marketing. *International Journal of Research in Marketing, 38*(1), 232-269.

Baker, H., Kumar, S., & Pandey, N. (2021). Forty years of the Journal of Futures Markets: A bibliometric overview. *Journal of Futures Markets, 41*(7), 1027-1054.

Rodrigues, A., & Navarro, J. (2004). Changes in the intellectual structure of strategic management research: a bibliometric study of the Strategic Management Journal, 1980–2000. *Strategic Management Journal, 25*(10), 981-1004.

Baker, H., Pandey, S., Kumar, S., & Haldar, A. (2020). A bibliometric analysis of board diversity: Current status, development, and future research directions. *Journal of Business Research, 108*(1), 232-246.

Silverman, R., & Kwiatkowski, T. (1998). Research fundamentals: III. elements of a research protocol for clinical trials. *Academic Emergency Medicine, 5*(12), 1218-1223.

New, S., & Payne, P. (1995). Research frameworks in logistics: three models, seven dinners and a survey. *International Journal of Physical Distribution & Logistics Management, 25*(10), 66-77.

I-Chun, T. (2018). The cause and outcomes of the ripple effect: housing prices and transaction volume. *The Annals of Regional Science volume, 61*(1), 351-373.

Young Woong, P., Blackhurst, J., Chinju, P., & Scheibe, K. (2021). An analysis of the ripple effect for disruptions occurring in circular flows of a supply chain network*. *International Journal of Production Research, 30*(1), 1-19.

Martinez-Tomas, J., & Marin-Garcia, J. (2019). Protocol: What does the wage structure depend on? Evidence from the INE salary national survey (pilot study with 2006 data). *WPOM-Working Papers on Operations Management, 10*(1), 70-103.

Marin-Garciaa, J., Vidal-Carrerasb, P., & Martinezd, J. (2019). Protocol: Value stream mapping in healthcare. A systematic literature review. *Working papers on operations management, 10*(2), 36-54.

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ON OVERCOMING THE GAP BETWEEN INDUSTRY AND ACADEMIC RESEARCH IN THE FIELD OF MUSIC TECHNOLOGY

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ABSTRACT: The field of industrial music technology, as well as academic research on music technology, strives for a high innovation potential and depends on it. Therefore, it would make a lot of sense if both areas were in an intensive exchange and cooperative collaboration. In the experience of the two authors, this is the case only to a very small extent. In this paper, observations of islands in research and development are presented. Actions are shown with which attempts were made to establish the transfer between the two areas. On the basis of the experience of the authors where this has more or less worked, it is analysed which factors are decisive for the fact that it is still extremely difficult to establish the transfer. In view of these factors, suggestions are made as to how a better degree of transfer can be achieved in the future.

Keywords: *Academic and industry collaboration; Music technology; Transfer; Innovation; Sound synthesis; Interaction*

1. INTRODUCTION

On a general level, transfer and innovation are known to be key factors for success in industrial development. These factors are treated differently depending on the industrial field. The present paper focuses on the area of music technology and in this field in particular digital musical devices for sound synthesis, sampling, sound effects and music

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production. The two authors are experts in the field of academic research and in industry research and development for innovations in digital music technology, respectively. The objective here is to draw conclusions from (sometimes problematic) experiences gained over years in the transferal and innovative openness in both these fields.

One may ask why a transfer of knowledge from academic research to industry research and development is of use. To our knowledge academic research and especially the applied research of UASs (Universities of Applied Sciences) as well as governmentally funded research has not only the aim to enlarge the body of knowledge. In addition, it should create research outcomes that can be used in industry for new developments and a strong economy which is known to be crucial for securing jobs prosperity of society in the future (c.f. here for example the Bavarian High-Tech-Agenda plus, https://www.bayern.de/bericht-aus-der-kabinettssitzung-vom-14-september-2020/)

In order to give insights into the surrounding research field of our research topic selections of background and related research are presented in chapter 2. According to open research areas, not covered by the current body of knowledge and further motivational aspects e.g., such coming from politics and the conviction of the German *Hochschullehrerbund* the motivation of the present research is described in chapter 3, followed by three main questions and the methods we use to answer them.

Since the practical work of research and development builds the base on which our findings are built, we present in chapter 4 selected areas and experiences from the research in both areas academia and industry. In chapter 5 we analyse the facts and observations presented in chapter 4 and draw conclusions on factors disturbing the collaborative research between academia and industry in the field of music technology.

Chapter 6 uses the method of contrasting opposing approaches, goals and values to gain further insight into factors hindering the fluent cooperative work between both fields of research and development. Based on our findings we propose then in chapter 7 a set of 19 ideas to shorten the gap or ideally overcome - at least in parts - the gap between industry and academic research in the field of music technology. This is followed by chapter 8 which presents future work we see to be done.

2. BACKGROUND AND RELATED WORK

Summing up, an article of the journal *Nature* very precisely describes one issue relevant for our field: “The science done in university laboratories can change the world, but only when discoveries can be transformed into innovations.” (Wapner, 2016, p. 13). According to Wapner, one “... of the most difficult aspects of moving a technology from academic concept to valuable product is crossing the chasm between early innovation and readiness for licensing — a stretch often referred to as the 'valley of death'." (p. 14). The University of Massachusetts Amherst holds an office for technology transfer and a senior advisor in this office states as follows: "One of the greatest challenges for academic technology transfer is trying to interest either established companies or venture investors in our early-stage discoveries" (p. 14). While academic researchers may be convinced of their research outcome and its use for successful new industrial products, taking the risk to develop such new products to a state where they can go to the market is the Death Valley where the transfer struggles. Following, core questions are first, whether academic researchers are really focusing to gain interest in companies and investors and, secondly, how this can be done successfully.

With respect to Software Engineering, Garousi et al. (2016) criticise that "... the level of joint industry-academia collaborations in Software Engineering is still relatively very low" (p. 1). After a systematic literature review, they propose 17 best practice themes and methods to select which of the best practice themes can be chosen according to a specific Software Engineering project and its framework.

Perkmann et al. (2013) describe differences between academic and industry research. They ask for preconditions which are necessary when academic researchers want to engage in industry and commercialisation, and they further ask what consequences such an engagement has. In addition, they propose methods to improve collaborative working between companies and academia and the political actions supporting such collaborative processes.

On a more general level, with respect to the general transfer of knowledge, Schmid (2013) gives a broad overview over barriers hindering the processes of transferring knowledge. Asking the question what is understood as the objective of knowledge transformation he writes: "Insgesamt hat Wissenstransfer die Aufgabe, Wissen, über das einzelne Personen oder Gruppen verfügen, auf andere Personen oder Gruppen zu übertragen." (p. 20) [transl. by the authors: Overall, knowledge transfer has the task of transferring knowledge owned by individuals or groups to other individuals or groups]. Summing up, hindering key factors described here are obstacles and egoisms (p. V). The base to overcome these hindering factors is found within the institutional economic approach. 26 hypotheses are presented allowing for a successful transfer of knowledge especially when it comes to companies and the transfer of knowledge between different groups of persons inside these companies.

3. MOTIVATION AND QUESTIONS

In section 2 we have seen that there is knowledge of the difference between academic and industry research (Perkmann et al., 2013) and suggestions to enhance collaborations between industry and academia in products developed by Software Engineering. However, there is a lack in the field of music technology where artistic needs go along with software and hardware issues.

The authors of the present paper have years of experience in academic music technology research and in the industry of music creation technology. They have each made major efforts on their part to make various attempts to contact and cooperate with the other side.

In parallel to Wapner (2016), the authors consider exchange and cooperative work to be very important for their work. The question arises: What are the death valleys (Wapner, 2016, p. 14) in which research outcome struggles instead of going into new music technological innovations?

It has long been emphasised by the Hochschullehrerbund of Germany that the transfer of innovations is an extremely important point in the development of society and sustainability (Grotjahn et al. 2018). The current so called "Ampelkoalition" of the federal government of Germany also follows this view and has therefore included the creation of the so-called DATI (Deutsche Agentur für Transfer und Innovation) as a goal in its government program (SPD et al. 2021, p. 20). This concrete political engagement underlines the importance and actuality of our topic here.

Furthermore, looking at the political agenda, this is also a point where the motivation for this work comes from: such a centre for transfer and innovation will need concrete methods and its application, which can then successfully carry out the actual content-related transfer work. Thus, the personal interest of the authors in the most communicative and fruitful work of the two fields of academia and industry comes together with the recent political agenda that pursues a vital social development.

In summary, the need for this paper comes from a lack in the body of knowledge about factors hindering academia-industry collaborations and methods to overcome these hindrances in the field of music technology. The driving motivation is based on the actual political agenda and the societal need for the improvement of transfer and - last but not least - from the interest of the authors.

3.1 Questions

With our research work, we would like to contribute to overcoming the gap between industry and academic research in the field of music technology. Doing so, we consider the following questions and methods to answer them to be of use:

I. Is the transferal process and cooperation on innovation between industry and academic research in music technology disturbed?
II. If yes, what are potential factors disturbing this transferal and cooperative work?
III. What are structural differences between academia and industry in the area of music technology research?

3.2 Method

In order to answer question I. we select examples or fields of research and development in music technology of both academia and industry. We describe these examples and fields with regard to the essential aspects and facts we find there that are relevant to answering question I. These selected examples and fields are described in section 4. We are aware that this selection introduces a certain subjective element into our investigation. However, this paper is not intended as a presentation of a final research project on how to generally bridge the gap between academic and industrial research in music technology, but as a collection of experiences that are analysed and from whose analysis ideas are generated to reduce the problems of this gap.

To answer question II. aspects and facts presented in section 4 are analysed and conclusions are drawn to answer question II. This is done in section 5.

A further step to identify disturbing factors, strengthening the gap between industry and academic research in music technology, section 6 presents structural differences between academia and industry of music technology we found so far.

Based on the findings presented in sections 4 to 6, we propose a set of ideas and steps to shorten the gap between industry and academic research in the field of music technology in section 7.

4. SELECTED EXAMPLES OF RESEARCH AND DEVELOPMENT IN MUSIC TECHNOLOGY

In this section areas are described that we consider to be relevant to answer the first question and to further provide material to work on the second question.

From the academic side, first a music technology conference is chosen which is highly respected in the academic field of research (section 4.1). Such scientific-artistic conferences are a core place for exchange of latest research outcomes relevant in music technology. Secondly, two examples are described when trying to get in touch with music technology companies to collaborate in terms of academic research outcomes in order to get innovative sound synthesis methods involved into their products (section 4.2). Thirdly, an example of the application for third party government funding is presented, which was created for the development of a product, where both the innovative new technology was available, and a company was available who wanted to develop and sell the product (section 4.3).

From the industry side experiences of a leading researcher in an international music creation technology company are described. In parallel to Wapner (2016) we consider the working field of such a person as a key point for transforming the "...science done in university laboratories […] into innovations" (p. 13). (Section 4.4).

4.1 International Conference on New Interfaces for Musical Expression (NIME)

There are many international scientific-artistic conferences in the field of music technology. Examples are the *ICMC* (International Computer Music Conference), the *DAFx* (Digital Audio Effects), the *SMC* (Sound and Music Computing), the *audiomostly* (a conference on interaction with sound) to name just a few. We have selected the *NIME* (New Interfaces for musical expression) and we will explain in the following sections why this conference has been selected.

Since we are addressing the research in music technology, the first question to answer is, whether the *NIME* shows indeed a bigger work invested by music technology researchers. Secondly, we want to know if we do see collaborations of industry and academic research here and we want to know which role or which importance is seen here in research participation of industry. When it comes to concrete developments of new musical instruments the question is of course: Who are the target users of the innovations presented here? Industry companies have to sell their products to a larger number of customers, are such larger groups of target users indeed addressed with *NIME*-developments? Or asking from the perspective of musicians seeking for new instruments for musical expression - which of the presented new technologies have come into products we now see in the market of music technology and which of them can we buy and use for our newly created music?

4.1.1 Scientific Reputation of NIME

The *NIME* Conference is a B1 ranked international conference (http://www.conferenceranks.com) and has amongst the Music Technology conferences together with the *ICMI* the highest scientific standing. With respect to section 4.4. and the research experiences in the industry of music creation technology the topic of the *NIME* comes with "… for musical expression" closest to this area. The yearly conference has taken place at universities of bigger towns in North and South America, Asia, Europe and Australia. An extensive survey of the past 20 *NIME* conferences is given by Fasciani & Goode (2021). The authors state that "NIME has grown into one of the largest and most vital international conferences within the field of music technology." (p. 2)

4.1.2 Scientific Effort put into the NIME Research Field

With respect to the investment in the review process of papers we can read: "A total of 1024 unique reviewers have been involved in scrutinising NIME works so far, and these have been appointed for a total of 2755 times." (p. 9). We can conclude that a lot of working time of researchers from the academic world has been involved because besides the research work presented, the peer-review process needs peers and those are research persons investing a lot of time onto the reviews.

This sentence "A total of 1867 papers have been published in the NIME conference proceedings…" (p. 11) presents the number of research works that are described in the papers, each of them with a contribution to the field which needs to have a useful addition to the body of knowledge. If not, a paper would have to be rejected (especially in a B1 ranked conference) by the reviewers due to the review factors (one of the authors of the present paper has been reviewer at this conference for several times).

With respect to the number of researchers that have been working extensively in the field we can read: "The 1867 papers published in the NIME conference proceedings present a total of 4661 authors representing 2550 unique individuals." (p. 19). We can see the huge body of persons that have been intensively working in this field. Concerning the relevance for the field of academic research the "… 1867 NIME papers have been cited so far 20,658 times, with an average of approximately 11 citations per paper." (p. 15). So it becomes clear that the research outcome plays a big role in the academic field of music technology research.

Looking at these numbers we can clearly state that a huge amount of research work in music technology work has gone into this research direction and has been presented at the *NIME* conference.

4.1.3 Collaborations between Industry and Academia in the NIME Research Field

With respect to the affiliations the authors come from, we find a table of the "Top 20 institutes according to number of affiliated non-unique authors and received citations." (p. 28). We find only one industry affiliation which is on No. 20 the *Deutsche Telekom Laboratories* which does work with audio and interaction; however, it is not at first a music technology company.

We ask how far in general the music technology industry plays a role inside the NIME research community. To find answers we see the paper of Fasciani & Goode (2021) as relevant, because it has the "...aim at identifying trends and patterns" (p. 2) and it states to show "... the growth and heterogeneity of the NIME demographic, …".

Looking through this paper we do not find any pattern on research collaborations between academia and industry. The term "music technology" is found only two times in the paper and the term "industry" is not found at all. An analysis on the impact of the research outcome is found in the paper only with respect to the academic research world. It is not found with respect to the industry nor to the world of musicians. And of course, musicians should be the main target group when it comes to what the title of the conference includes i.e. "New Interfaces <u>for Musical Expression</u>" since the interfaces will in the end be played by musicians, the experts for creating musical expression.

Looking at the NIME proceedings Website (https://www.nime.org/archives/) and searching in the titles of all NIME papers for the words "industry", "market", "company" and "selling" in parallel we do not get a single hit.

4.1.4 Target users of NIME Research Outcome

In asking the question of the target users in *NIME* developments we found a paper of Morreale and McPherson (2017) where it is analysed for a period of five years (2010-2014) how far new digital musical instruments (DMI) presented at the *NIME* conference were successful in being established. They asked 97 DMI makers to return data according to their concept of study and 70 answered.

Asking the question who the new devices were built for, 53 researchers ticked the answer that the instrument was built for them personally, 20 ticked the answer that the instrument was built for musicians generally (p. 193). Asking for the motivations of building the new instrument, 41 researchers answered that there was no instrument available allowing them to do what they wanted it to do and, therefore, they developed the new instrument. 34 were motivated because they wanted to complement their artistic practice with the instrument (p. 193). We can see here the relatively low number of developments built for the target group: other musicians than myself (only 20 out of 70, that is 28,57%).

Asking the question which role the music technology industry plays in this overview-paper and analysing the words used we see the following: the term “music technology” is found one time, the term “industry” is not found in the paper of Morreale and McPherson (2017). We conclude that the music technology industry does not play a subordinate role in the authors’ understanding of a DMIs longevity.

4.1.5 NIME Products on the market

Morreale and McPherson analysed the *NIME* proceedings 2010-14. We have no data for all of the *NIME* proceedings. However, in case we consider an average of 30% where researchers had in mind to address musicians generally with their research work, with 1867 papers (c.f. section 4.1.2) and a rate of 30% we would end up with 560 papers where the authors addressed musicians generally. Which papers or developments of those 560 that showed up in the *NIME* scene did get to the market to the knowledge of the authors?

Here is a list of such developments as far as we can see at present:

- The *reactable* (Jorda et al, 2005),
- The *Tenori-On* (Nishibori & Iwai, 2006); the Tenori-On was only on the market for a relatively short time
- The iPhone app *Magic Flute* (Wang, 2009)
- The iPhone app *Magic Fiddle* (Wang, 2011)
- The *bela platform* (McPerson, 2017; Sanchez et al., 2018)

With five out of 560 this is less than 1%. This seems to be a very low output for the world of musicians when looking at the scientific reputation (section 4.1.1) and research effort put into *NIME* research (section 4.1.2)

4.2 INNOVATIVE ACADEMIC RESEARCH OUTCOME COMING TO MUSIC TECH INDUSTRY

With respect to Wapner (2016, p. 14) the challenge to find interest at established companies for new developments of laboratories at universities is the task described here.

A first example is an at that time new method of sound-synthesis technique, the method of *Audio Signal Driven Sound Synthesis* (Poepel & Dannenberg, 2005). It was basically developed and the academic researcher wanted to bring it to the music technology industry. The development had been published and there was no patent a company had to pay licence fees for. The development was checked and approved by retired music technologist Robert Moog (inventor of Moog synthesisers, personal communication, June 2004 with first author). In addition, it was approved by the internationally respected academic music technology researcher Roger B. Dannenberg (Poepel & Dannenberg, 2005).

The following companies were contacted between 2005 and 2006 via email and phone: *Yamaha Music Europe GmbH*, *Roland Corporation*, *Steinberg Media Technologies GmbH*, *Native Instruments GmbH*. The result was: nearly no reaction, no interest. One answer from a phone call was that the researcher should go to *Musikmesse Frankfurt* (https://musik.messefrankfurt.com/frankfurt/de.html) with a presentation of the development. It was said that developers of the companies would be there at Musikmesse and would have time and be willing to check the new development.

However, the result of the visit at *Musikmesse Frankfurt* was similar: Again no time, no offer for communication. No interest was found to listen to any of the sound examples, no interest to read any of the already published papers.

Fifteen years later, and at a higher academic position, the researcher again tried intensively to contact local music industry companies, e.g. *Air Music Technology GmbH*, *Thomann GmbH*, *Ableton AG*, *Hohner Musikinstrumente GmbH* and *Karl Höfner GmbH & Co. KG*. *Ableton* invited him for a visit to Berlin. Sound examples were presented, the synthesis technology was explained. Since sound synthesis for string players was not their main field, they refused to cooperate. All other companies refused a meeting, except *Höfner*. Two zoom sessions with *Höfner* developers were done. They evaluated the development as good and useful, however, they didn't expect to be able to generate a product fitting to their product lines out of this synthesis method.

Meanwhile there are developments on the market using variants similar to the above-mentioned method. They are found in Guitar synthesisers e.g. the *BOSS SY-1000* or the *BOSS SY-200* (https://www.boss.info/us/products/sy-1000/ https://www.boss.info/us/products/sy-200/), or in products by the company *Electro-Harmonix* e.g. the *C9 guitar to organ machine pedal board* (https://www.ehx.com/products/c9/).

A second example presented here is an at that time new method of sound synthesis, the so-called FM (frequency modulation) synthesis (Chowning, 1973). "In 1967, Chowning realized that complex sounds could be generated using only two oscillators when the output of one oscillator is connected to the frequency input of a second oscillator." (Stanford, 1994, tenth section). It took until 1973 to develop FM synthesis at the laboratories of Stanford University so far that the basic principles of this sound synthesis method could be published (Chowning, 1973). Since the inventor John Chowning was convinced that the FM synthesis could be useful for the music technology industry, "... he took the idea to the [universities'] Office of Technology Licensing (OTL).

As a result, the university received a patent in 1977." (Stanford, 1994, 12th section). Further on, it was not Chowning himself who went to companies and offered his development. This was done by officers of OTL. They went to companies producing electronic organs.

While the development was refused by one company, a second one was interested, but the engineers did not have enough knowledge about digital signal processing and thus could not handle the development. Finally FM synthesis was offered to *Yamaha* and this company "... sent a young engineer named Kazukiyo Ishimura.". Inventor J. Chowning went on "I played the sounds and within 10 to 15 minutes he understood what I had done…" (15th section). Yamaha "... determined that FM synthesis dovetailed with their planning and applied for an exclusive licence, which Stanford granted." This technology lead e.g. to the famous Synthesizer *Yamaha DX-7* coming to the market in 1983 whose algorithms and sounds are still being sold today for example in the Native-Instruments software synthesiser *FM8* (https://www.native-instruments.com/en/products/komplete/synths/fm8/). The FM synthesis was furthermore implemented in several sound microchips and algorithms by Yamaha. The patent "... has brought Stanford [University] millions of dollars in patent licence fees" (Johnstone, 1994, p.1) and was - after a patent in biotechnology - the most lucrative patent of the university.

4.3 EXPERIENCE WITH A THIRD-PARTY FUNDING APPLICATION

The Death Valley, the "innovation grave" mentioned in Chapter 2, has also been recognised in politics. That is why funding lines were developed to help overcome precisely this Death Valley.

For an application of a *ZIM* - project (https://www.zim.de), such a funding line, the first author already had a team of a company willing to develop and sell a music and medicine technology product and another research team. The innovative technology for this new product was available. There was a technological risk in the development but already ideas how to deal with this risk. Taking the risk without funds was not possible for the company. With respect to Wapner (2016, p. 14) and the sentence "One of the greatest challenges for academic technology transfer is trying to interest either established companies or venture investors in our early-stage discoveries" (p. 14) we can state that this challenge had already successfully been accomplished.

While the project was approved by *ZIM* in a first draft handed in, the full application was not accepted by *ZIM*. The surveyor did not accept the proof of concept provided in the application. The surveyor, in contrast, wanted to have a peer-reviewed proof of concept in a scientific paper, where even the authors of the paper were not the authors of the *ZIM* application in order to believe that this technology would really work. The company and the developer of the new technology, however, did not want to publish or have published the innovation by other researchers because they wanted to keep it secret due to reasons of not giving their concurring companies this information.

The death of this innovation did not come from the industry, instead it came from the *ZIM* surveyor who wanted to have the above-mentioned proof of concept which was not going along with the needs of secrecy of the company.

4.4 EXPERIENCE AS A RESEARCH LEAD IN THE MUSIC TECHNOLOGY INDUSTRY

In this section the experiences as a lead researcher in an internationally leading music technology company and as a music technology consultant are described, which are relevant for this paper.

Contacts with academia happened mainly through reading papers and going to conferences, the latter also facilitating personal contacts. In the best case, these personal contacts led to longer term exchange and jointly applying for public funding or to regular student internships.

Essential difficulties are related to the different ideas of industry versus academic researchers as to which and how many people might be addressed by innovations. According to our experience, academic researchers are often mainly interested in basic research, not having in mind potential customers at all. In the field of applied research, beneficiaries of academic research are often composers, musicians and producers in very small musical genres which do not generate significant sales numbers. Sometimes only the researchers themselves use their innovations (c.f. section 4.1.4).

In nearly all cases when knowledge transfer actually happened during the time as a research lead, it was initiated by researchers and developers from the industry. An obvious reason for this one-sidedness is the confidentiality of companies' future research agendas. At the same time, academic researchers can get information about current products and underlying technologies from company websites. In principle, this makes it possible for them to learn about relevant topics, potential customer needs and subsequently to contact companies with suggestions for co-operations. However, from our personal experience this rarely happens.

One major input of knowledge and experience from the academic world is achieved by employing interns and graduates from research institutes and universities working in the area of technology for music creation. Personal relationships prove to be very helpful for general orientation and solving specific problems.

Publicly funded projects lead to regular exchange of requirements and ideas, so that both academic and industrial researchers better understand the other side. A potential problem is that, while academic researchers have rather stable and independent settings (typically Master and PhD thesis or research projects for post-docs), the companies' focus often changes more often and profoundly during the course of a collaboration. One reason is that companies often require the adaptation of research goals due to conflicting projects, in order to avoid high opportunity costs (by not realising the alternative project).

5. DIFFICULTIES IN COOPERATION BETWEEN ACADEMIA AND INDUSTRY IN MUSIC TECHNOLOGY RESEARCH

The present chapter 5 has the objective to answer question II (see section 3.1). In the following sections we refer to the sections 4.1, 4.2 … 4.4 which are in correspondence to the sections 5.1, 5.2 … 5.4.

5.1 NIME research scene and industry cooperation

If we assume that an artistic-scientific conference like the *NIME* does not have the aim of promoting cooperative research between academia and industry, it cannot be said that there would be disturbances that would hinder this transfer process between academia and industry. However, as the title of the conference suggests, and as a general mission of the sciences should include the benefit of humankind, we assume that the exchange of research outcomes is planned to include researchers from both fields.

While we see a huge body of papers that have been presented at NIME (4.1.2) where each one represents a research project, the question has to be asked where this research outcome could fruitfully be applied in new products in music technology. We are convinced that the number of five developments that have come to the market (4.1.5) is far too low with respect to the users of music technology given the immense amount of research effort put into this working field.

Where do we see factors disturbing the transferal process? It stands to reason to assume that the NIME community falls in a music technology world of its own that works self-referentially. The own artistic idea of authors is often in the foreground (58 out of 70 researchers build the new DMI for themselves) and the issues of the market, industry, companies, and selling the instruments play a subordinate role (quantified by the word count of industry related terms).

In conclusion a major disturbing factor for transferal and cooperative work is seen in the self-referential structure in this academic research scene. The peers who review the papers and who define the review-criteria are not the peers of the target groups in a collaborative academia-industry setting. While in the review process (the first author was many times reviewing NIME papers) the question is asked whether the present paper to be reviewed offers content relevant for the research scene, the reviewers are members of the academic research scene. Thus the perspective of developers from the industry does not play a sufficient role.

Even a feedback paper (evaluation 20 years of NIME,) which was peer-reviewed by NIME reviewers and accepted by them does not need to indicate in any way the number of products that have gone to the market of music technology, the financial turnover that has been created in music tech industry by the NIME research outcome, the feedback of persons in the world of musical expression who indicate that they are happy with the musical devices that came out of the NIME research or the new Music that has been possible thanks to developments **N**ew **I**nterfaces for **M**usical **E**xpression (NIME). Also, the missing words related to music technology industry as mentioned in section 4.1.3 can be seen as a sign of too little attention to the industry which usually is the field where developments are made ready to the target users.

Analysing the overall disturbing factor of self-referentiality in more detail according to sections 4.1.1 to 4.1.5 we identify a review system that is mainly oriented at academic research and has its focus mainly on the own artistic use of new developments. It hardly incorporates companies as research affiliations and a focus on the music technology industry is not found. These are in summary the main disturbing factors.

5.2 Innovative Academic Research Outcome Coming to Music Tech Industry

In the first example of section 4.2 (Audio Signal Driven Sound Synthesis) the main disturbing factor was lying in missing possibilities of communication. Due to the use in at present available synthesisers as described in section 4.2 it is clear that this technology has proven to be valuable. We conclude that the persons the developer had talked and mailed to either had no time or the topic did not fall into their working field or they did not understand the value of the development. In case a company would be interested to incorporate academic research results into their development area, it would be of help to have a communication channel and a person behind that channel that can deal with new developments with respect to both timewise and from the technological understanding. The barrier of an already patented development seems to play a less important role as long as the development has a bigger potential. We can see that in the second example.

The difference in the FM synthesis example we see in the effort of the officers of the OTL who can of course put more energy into going to companies with new developments as this is part of their main job. Secondly, Stanford University has a high reputation which can make it easier to make a company like *Yamaha* send an engineer to look at one new development.

The disturbing factors for the companies that were addressed from the OTL officers before *Yamaha* was asked to licence and use FM synthesis, were their inability to understand the potential of the development and their inability to technically understand and handle the new digital technology (or then to hire people that could do so).

In summary the disturbing factors we can find here are a lack of communication and a missing contact person for external developments, the inability to understand and to deal with a new development.

5.3 Experience with a Third-Party Funding Application

In this case the disturbing factor for developing the innovative product was the need of the already convinced industry partner and the academic researcher-collaborator not to publish the research outcome and the proof of concept in order to prevent concurring companies from knowing about this new technology.

According to the risk-problem described by Wapner (2016, p. 13 "... crossing the chasm between early innovation and readiness for licensing …") the disturbing factor was in this case the risk-estimation of the surveyor. The decision of the surveyor in the governmental innovation programme *ZIM* which was originally created to help companies to get over the "valley of death" (Wapner, 2016, p. 13) has in this case become the de facto death valley for this innovation.

ZIM applications need to have a technical risk in the development process of the innovation. If not, they will not be considered by *ZIM* for funding. But since surveyors also need to have success in the recommendation of applications that in the end turn out to be successful innovations on the market, it seems that in this case the *ZIM* surveyor did put his need for a safe success of the project higher than the need of confidentiality of the developer and company.

It may be asked how far a governmental program to overcome the death valley according to Wapner (2016, p. 13) shouldn't be structurally updated when reducing the technical risk of an applied project stands in conflict to the need for secrecy of the applicants.

5.4 Experiences as a Research Lead in the Music Technology Industry

Disturbing factors were the difference in research goals (e.g. good selling products vs. originality) and structural differences (frameworks/duration of research projects), leading to incompatibility in research strategies. While industrial researchers are usually well informed about the latest research in academia, academic researchers are very often not aware of current industry products and customers' needs.

A principal factor impeding alignment research objectives was the need to keep industrial research objectives and results secret while academic researchers need to publish.

6. SELECTED EXAMPLES OF DIFFERENCES IN ACADEMIC AND INDUSTRY DRIVEN RESEARCH

In the following section, opposing values, goals, and practices (industry vs. academia) in the same fields of research in music technology are presented. This shows the different frameworks the researchers are in and the consequences for the process of research.

6.1 Quality in Sound

The quality demands for certain aspects of developments (e.g. sound, performance, stability, parametrization…) in the music technology industry are on a very high level. Musicians want and need high quality sound results, thus the technology they buy must meet these needs.

In contrast, in scientific papers the main focus is on originality, scientific truth and new insight. This does not necessarily require a very high sound quality, except in the few cases when the topic of the paper is explicitly on the quality of sound. Thus, the industrial need of audio quality is rarely quantified in music technological papers and therefore often not of relevance in research.

6.2 Framework of Research

The goals and limitations of researchers and developers in companies are quite different from those in academia, sometimes not explicitly communicated, often not understood and rarely fully adopted by both sides. The need for making profit means, especially in bigger companies, addressing a large number of customers, with addressable markets in the order of hundreds of thousands to millions in total. New features have to be easy to operate and communicate, so that potential customers can grasp them without larger effort. In the perception of the customers, the products have to be better than competing ones, e.g., in terms of features, audio quality, sound aesthetics or ease of use.

One important quality topic are low CPU requirements and stability, which is often of secondary importance in academic research. Also ease of use and learnability are requirements that are specific to addressing mass markets and often not a focus in scientific work. A possible reason is that in academic context there are often no UX design experts working closely with the music DSP researchers. A product can be successful due to a low price, sometimes only possible due to low costs. Most of these aspects do not play a big role in the scientific discourse, meaning that publications mainly focusing on these issues do not fulfil scientific standards.

Technical innovation competes with other success factors, reducing the need for cooperation with academia. While it’s often easier to promote a product if it is innovative, it is only one of many aspects responsible for its success. Innovation doesn't have to be technical or requiring research, sometimes just a slightly new idea or good fit to customers’ needs is enough.

Internal communication of new technologies and ideas from developers to other departments such as product management, sound design, executive management is often challenging. Decisions are not easy to make, especially if new technologies are difficult to understand and a proof of concept does not yet exist. When trying to fit new ideas to products there can be possible deadlocks if the developer does not fully understand possible applications, while the product manager does not understand the risks and benefits of new technologies sufficiently. And sometimes the ultimate quality of potential developments cannot be evaluated since the effort even for a basic prototype is too high.

It’s worth mentioning that the motivation of decision makers in the industry can also be idealistic. Since many founders and employees of music technology companies are actually using their own products and are part of respective communities, they also have a genuine motivation to produce useful products of high quality for themselves and their peers. And they are curious about new technologies, giving them previously unknown experiences.

6.3 Interests and Values

We find different interests and goals in academia and industry. Following here, we want to show what is of high value and which reward and evaluation systems are found in both fields.

According to our experience and many conversations with academic research-colleagues we are convinced that the following values are of importance in the academic field for researchers:

- secure job and good salary (civil servant (Beamter), in case one is professor), even if salary is much lower than in industry,
- freedom of research,
- being able to do what one is really interested in and what one thinks is relevant for the world.

Many researchers have left financially lucrative jobs in industry because they wanted to do research in academic fields that really interest them. And, of course, they do not want to fall back by doing research for industry-interests at a lower salary that they did not want to do before at their former company.

Obvious reasons to work in the industry are typically a higher salary, ideally a permanent position and higher flexibility with respect to job roles. Many employees find a deeper meaning in creating work environments for musicians, ideally making a large number of customers happy. And often developers even use the products themselves as semi-professional musicians. Working on sound seems to be particularly satisfying for many employees in the music technology industry.

6.4 Evaluation Systems

With respect to evaluation systems in academic research we find for example:

- peer-reviewed publications, h-index, ranking in social media research platforms (e.g., researchgat.net)
- authorship in books,
- amount of received third party money,
- membership of committees, juries, editorial boards,
- governing organisations of research, professional and technical associations, standardisation institutions,
- number of supervised PhDs, Masters-theses,
- management of research institutes, laboratories and centres,
- development of research infrastructure,
- contributions to the internationalisation of research,
- significant contribution to interdisciplinary research,
- reviewer for research programmes, PhDs, scientific competitions,
- organisation or chairing of scientific meetings, workshops or conferences

(in parts from: HS Ansbach (2021))

In the music technology industry, evaluation systems for managers and researchers/developers differ strongly between companies. Measurement is less straightforward than in academia and often there is no formalised system in place. In general, efficiency and the contribution to company success are crucial.

6.5 Publications, Criteria and Development Tools

Peer-reviewed publications and citations are of big importance for the indication of scientific success in the academic world. While a researcher and the research community have no influence on the number of citations, the research community does have an influence on criteria how to evaluate publications. Here we list some of them:

- Originality: nobody has published the research outcome before
- The publications must meet scientific correctness and be clearly understandable, the content however, can be very complex
- Relevant academic research literature must be cited
- The research ideas and activities need to go along with current “hot stuff” according to the specific academic research scene (officially: relevant for the research field the publication is addressed to).

In contrast, the industry of music technology has often only low motivation to publish newest developments due to competition. Publishing is attractive for companies mainly in the form of patents. In rather rare cases there can be publications by the industry to give back to the academic community or to allow cooperation partners to share common research results (Parker et al. 2019, Zavalishin 2015).

Since even research goals are strategically relevant, confidentiality of industry demands makes matching processes to fitting research results difficult.

While researchers in the academic music technology world work with different development platforms such as *Matlab*, *C*, *C++*, *Python*, *Max*, *Pd*, *Super Collider* etc, the main language in the corresponding industry is *C++* due to performance aspects. That often makes transfers of research outcomes of academic projects difficult and costly to transform from e.g., *Max-Patches* to *C++* code.

We have seen in sections 6.1 to 6.5 many differences. Summarising, the disturbing factors to our insight often come from contrasting values, goals, methods of work and the incompatibility going along with this as described above.

7 PRESENTATION OF OUR IDEAS TO IMPROVE AND OVERCOME IDENTIFIED PROBLEMS

We have so far collected and presented several disturbing factors hindering collaborations and fruitful cooperations between academic and industrial research. To overcome these hindering factors, we propose some general ideas and ideas that are related to specific outcomes of the earlier described disturbing factors.

1. Industry, academia, and government must work together during the whole innovation process.
2. The gap between industry and academia is also a gap between basic research, early and late-stage technology development, ultimately leading to implementation into actual products. Already the identification of relevant research fields is not really coordinated between companies and academic researchers. We propose to explicitly focus this problem and find solutions.
3. With respect to differences in research strategies mentioned in chapter 6 we suggest workshops between industry players and academia on the basis of a non-disclosure agreement. It might be possible to take the risk to reveal more of the strategic needs of companies and the potential fit to research agendas in academia. Ideally, the presence of higher management would help authorise the revelation of sensitive information included in long term development strategies. The workshops should build the frame for an exchange in research know-how and should build trials of cooperative work which could at a later time be enlarged to longer time collaborations.
4. We further suggest the organisation of embedded research phases of academics in industry and vice versa beyond Bc. and Master's thesis work. We expect that this will have a strong impact. Personal contact would be more comprehensive than punctual meetings in publicly funded projects.
5. A big potential lies in UASs (Universities of Applied Sciences), which already have faculty personnel with industry experience and whose strength beyond applied research lies in transfer. We suggest obligatory internships in music research institutes potentially and expect that this leads to fruitful cooperative work.
6. To reduce the differing research goals, values and research strategies (chapter 6) we suggest longer term cooperations with flexibility in the research content. Identifying overlapping interests between academia and industry can ideally be solved by such longer cooperations.

7. Researchers and guest lecturers from companies should give talks and teach at universities for a better understanding of research strategies in the music technology industry. In addition, this would help students and researchers to get early and intense contact with companies.
8. The benefits for companies to contact many universities for collaborative work are critical since such activities cause significant effort. Our experience shows that this can best be achieved in long term relationships. Also, local connections between universities and companies make it much easier to cooperate.
9. Since Berlin has the highest concentration of music technology companies in Germany and maybe the whole world, it might be a good place to find a research institute on music production technology. Such an institute might be a hub for the integration between relevant research fields at universities, UASs, other relevant institutes and companies in the field.
10. In general, and with respect to sections 4.1, 5.1, and 6.4 we suggest improving rewards in academia for industry cooperation. For example, peer reviewed journals for publications about cooperations between academia and industry could give researchers impact points in the academic value point system. In such publications, standardised and efficient procedures and criteria for evaluation of research results such as (sound) quality, ease of use and performance of a product could be relevant evaluation criteria (c.f. section 6.2)
11. In research conferences (sections 4.1 and 5.1) we suggest incorporating a set of criteria of how the research, described in the publications, cooperates with research questions related to development in the music tech industry. Or one could add a track for papers that explicitly focus the exchange and collaboration with music technology and use in this track a specific set of criteria during the review process.
12. In conclusion from section 4.1.4 we suggest to ask in the review-process in music technology conferences: whom is the development built for? In case it is built only for oneself only the conference responsible persons could put such a paper in a special track which provides research not meant for a larger group of musicians and users.
13. With respect to section 5.1 we propose to develop specific journals that have in their topics applied research that has been done between industry and academia. Publications in those journals should describe the expected research outcome while academic research was done, and the real research outcome measured at products that have really gone to the market. In addition, they should describe user

experiences from selling companies. User experiences can be easily found in product ratings, sales rank etc.

14. Concerning the self-referentiality found in academic conferences we propose to do workshops at conferences that are led by a team of researchers from academia and industry. We now have at *NIME* and similar conferences e.g. workshops on specific technologies, or workshops and presentations of PhD work topics. We propose to have here categories of research projects (such that are already done and outcome is already patented) of collaborations between academia and industry as well.
15. In the evaluation systems used to assess the research strength of universities (c.f. section 6.4), there needs to be an evaluation structure that awards points for the value of direct collaboration between the university's research staff and companies. We propose to have a system in which this industrial research work can be positively included in the scoring systems WITHOUT being filtered by third-party funding providers. After all, the goal of politics and the activities of academic researchers guided by it should not be to convince reviewers from third-party funding institutions, but to enable, promote and positively evaluate industry-oriented research that both satisfies the interests of academic researchers and meets the needs of industry.
16. Similar to music bands who offered their fans to create music videos using the music of the band without risking lawsuits in the area of exploitation rights, we suggest to offer external persons to do research for the company including the promise that the research results will actually be looked at (c.f. section 4.2), that there will be appreciation, that employees of industry development departments will talk to external academic researchers about their developments.
17. With respect to the communication problem mentioned in section 5.2 we suggest installing a really reliable point of research contact to industrial companies. This point of contact could be in the simplest way an email address like external-research@company.com. The emails should go to the research lead or similar and be checked from time to time and to be appreciatively answered.
18. We recommend creating opportunities for external developers to present and sell their products on industry system platforms. An example can be found in the platform sold by *MOD-Devices* (https://moddevices.com/). At the pluginstore of *MOD-Devices* external developers can present and sell their plugins: https://moddevices.com/platform/plugin-store/

19. With respect to section 4.4 and 5.4 academic researchers should additionally be educated in becoming aware what fields of research are important for industry companies and they should learn methods to deal with them in first steps without coming into conflict with the necessary principles of secrecy.

8 FUTURE WORK

In addition to the implementation of the ideas and proposals listed in the previous chapter, we consider it important that more exchange between academia and industry about “how to work together” seems necessary, such as the current conference Business meets Technology. An international event specifically for the field of music creation software would potentially have a high impact in this field. Since many relevant research institutes and big companies are located in Europe, this would be an obvious place for such a conference.

A major part of this event could be dedicated to the problems, possibilities and potential fields of mutual cooperation, another part might be about the offers and requirements of academia and companies in this field. The outcome might be some helpful advice for potential partners.

Maybe even some further research along the lines of the questions and ideas of this paper could be established. A deeper research in existing literature on general cooperation between industry and academia would be a good starting point. In addition, qualitative interviews with research leads in music technology companies would add the domain-specific aspects.

A directory of music technology companies and academic researchers would make it easier to find the right match for any initiative such as research projects, internships and informal talks.

A crucial issue is the intended confidentiality of strategic research interests in both industry and academia. We are convinced that an understanding of each other's plans is a necessary starting point for any cooperation. Any step to master this challenge can be helpful for broader cooperation between the responsible persons in the different fields.

REFERENCES

Chowning, J. (1973). The Synthesis of Complex Audio Spectra by Means of Frequency Modulation. *Journal of the Audio Engineering Society*, 21(7), 526-534.

Fasciani, S; Goode, J. (2021). 20 NIMEs: Twenty Years of New Interfaces for Musical Expression. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME 2021)*, Singapore. http://doi.org/10.21428/92fbeb44.b368bcd5

Garousi, V.; Petersen, K.; & Ozkan, B. (2016). Challenges and Best Practices in Industry-Academia Collaborations in Software Engineering: a Systematic Literature Review. *Information and Software Technology*, 79, 106-127. https://doi.org/10.1016/j.infsof.2016.07.006

Gonzalez, V., Martin, C., Zelechowska, A., Bjerkestrand, K., Johnson, V., & Jensenius, A. (2018). Bela-Based Augmented Acoustic Guitars for Sonic Microinteraction. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME 2018).* 324–327. Virginia Tech. https://doi.org/10.5281/zenodo.1302599 Project Website: https://bela.io/

Grotjahn, M.; Plessing, T.; Tolkiehn, G.-U.; Vogler, T. (2018). Positionspapier des hlb zur Gründung einer Deutschen Transfer-Gemeinschaft (DTG) Ausgangssituation Motivation und Konzeptskizze für eine DTG. [Position paper of the hlb on the foundation of a German Transfer Association (DTG) Initial situation Motivation and concept sketch for a DTG.]. Bonn. hlb publications. Retrieved from: https://www.hlb.de/fileadmin/hlb-global/downloads/uber_uns/hlb-Positionspapier_Deutsche_Transfergemei^nschaft_fin.pdf

HS Ansbach (2021). Richtlinie zur Gewährung von Forschungsprofessuren (FP) und Forschungs- einstiegsprofessuren (FEP) an der Hochschule Ansbach [Guideline for the Granting of Research Professorships (FP) and Research Entry Professorships (FEP) at Ansbach University of Applied Sciences], internal document of Ansbach UAS, Ansbach

Johnstone, R. (1994). The Sound of One Chip Clapping: Yamaha and FM Synthesis. In *The MIT Japan Program*. Cambridge, MA, MIT Japan Program. Retrieved from: https://dspace.mit.edu/bitstream/handle/1721.1/17123/JP-WP-94-09-33434192.pdf

Jordà, S.; Geiger, G.; Alonso, M.; Kaltenbrunner, M. (2007). The reacTable: Exploring the Synergy between Live Music Performance and Tabletop Tangible Interfaces. *Proceedings of the ACM Conference on Expressive Character of Interaction,* 139-146. http://mtg.upf.edu/files/publications/reactable_tei2007.pdf Project Website: http://reactable.com/

McPherson, A. (2017). Bela: An Embedded Platform for Low-Latency Feedback Control of Sound. *Journal of the Acoustical Society of America, 141(5), 3618-3618.* https://doi.org/10.1121/1.4987761

Morreale, F., & McPherson, A. (2017). Design for Longevity: Ongoing Use of Instruments from NIME 2010-14. In *Proceedings of the International Conference on New Interfaces for Musical Expression* (NIME 2017) 192–197. Aalborg University Copenhagen.
Retrieved from: https://zenodo.org/record/1176218#.Yqt5AZDP00Q

Nishibori, Y.; Iwai, T. (2006). *TENORI-ON.* In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME 2006),* Paris, France
Retrieved from: http://www.nime.org/proceedings/2006/nime2006_172.pdf

Parker, J.; Esqueda, F.; Bergner, A. (2019). Modelling of Nonlinear State-Space Systems Using a Deep Neural Network. In *Proceedings of the 22nd International Conference on Digital Audio Effects*.
Retrieved from: http://dafx.de/paper-archive/2019/DAFx2019_paper_42.pdf

Perkmann, M.; Tartari, V.; Mckelvey, M.; Autio, E.; Broström, A.; D'Este; Fini, R.; & Geuna, A.; Grimaldi; Hughes, A.; Krabel, S.; Kitson, M.; Llerena, P.; Lissoni, F.; Salter, A.; Sobrero, M. (2013). Academic Engagement and Commercialization: A Review of the Literature on University-Industry Relations. *Research Policy*, 42(2), 423-442.
Retrieved from:
https://www.sciencedirect.com/science/article/pii/S0048733312002235

Poepel, C. & Dannenberg, R. B. (2005) (2005). Audio Signal Driven Sound Synthesis. In *Proceedings of the 2005 International Computer Music Conference*, 391–394, Barcelona, Spain

Schmid, H. (2013). *Barrieren im Wissenstransfer [Barriers to knowledge transfer]*. Wiesbaden: Springer

SPD, Bündnis 90/Die Grünen, FDP (2021). Mehr Fortschritt wagen. Bündnis für Freiheit, Gerechtigkeit und Nachhaltigkeit. Koalitionsvertrag zwischen SPD, Bündnis 90/Die Grünen und FDP [Dare more progress. Alliance for freedom, justice and sustainability. Coalition agreement between SPD, Bündnis 90/Die Grünen and FDP]. Berlin. Presse- und Informationsamt der Bundesregierung.

Retrieved from: https://www.bundesregierung.de/breg-de/suche/koalitionsvertrag-2021-1990800

Stanford, U. (1994). Music synthesis approaches sound quality of real instruments. In: *Stanford University News Service*, Stanford, CA
Online available at: https://news.stanford.edu/pr/94/940607Arc4222.html

Wang, G. (2009). Designing Smule's Ocarina : The iPhone's Magic Flute. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME 2009).* 303–307. https://doi.org/10.5281/zenodo.1177697

Wang, G., Oh, J., & Lieber, T. (2011). Designing for the iPad: Magic Fiddle. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME 2011)*. 197–202. https://doi.org/10.5281/zenodo.1178187

Wapner, J. (2016). The leap to industry. *Nature, 533,* 13-15, https://doi.org/10.1038/533S13a.
Retrieved from: https://www.nature.com/articles/533S13a.pdf

Zavalishin, V (2015). *The Art of VA filter design*. No statement of city: no statement of publisher. Retrieved from: https://www.native-instruments.com/fileadmin/ni_media/downloads/pdf/VAFilterDesign_1.1.1.pdf

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THE REASONS FOR DISTRESS OF FIRST-SEMESTER STUDENTS DURING COVID-19 PANDEMIC AND MITIGATION MEASURES

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ABSTRACT: Due to governmental restrictions in Germany regarding the Covid-19 pandemic, presential lectures were either just permitted under strict conditions or not at all. This led to a switch to an online format, which in turn had effects on the students and their perception of stress. This paper investigates the root causes of stress among first-semester students at a mid-sized university in southern Germany. In a quantitative-qualitative approach, 112 first-semester students (69,6 % female) participated in an anonymized survey that contained closed and open questions regarding the reasons for their perceived stress. In the end, the participants had the chance to give additional input on how they think the university can help to reduce stress levels. The most frequently reported reasons for stress were examination (69%), self-managed learning/ online format (57%), and social interaction (53%). The students expressed their wish for more information regarding the general operating procedure and the scope of coursework and exams. Furthermore, many felt overwhelmed with the manifold online tools of the university and were not able to manage their time efficiently. Easy-to-implement measures for the university to support the students are introductory courses to the platforms, a dedicated timetable for the study programs, and time management seminars. These and other measures are presented within this paper.

Keywords: *Stress; First Semester; Covid-19 Pandemic; Mitigation Measures*

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1. INTRODUCTION

Two years ago, in early 2020, the first infections of a new virus called SARS-CoV-2 – colloquial Covid-19 or Corona – were reported in Germany (Robert Koch-Institut, 2020). At this point, no one could barely imagine how this would turn into a global pandemic with curfews, travel restrictions, and commercial shutdowns. An economic crisis arose with many companies facing insolvency and high rates of unemployment (Statistisches Bundesamt, 2022). The health system was close to its limits and social distancing was statutory. Strict restrictions were prescribed by law; limitations of persons within a room, a distance of two meters, and wearing a mask became normal measures. These restrictions – of course – also affected the academic world. Due to the governmental ambition to avoid further spreading of the virus, gatherings of bigger groups were prohibited. This included presential lectures at universities. During the first waves up until October 2021, which were three full German semesters, almost all lectures had to be taken online (Hochschulrektorenkonferenz, 2022). So, for one and a half years – or half of the regular studying time for a Bachelor's degree, the students did not get to meet each other in person. Considering all the circumstances, several articles have shown that this time was stressful for everyone (e.g. Brooks et al. 2020; Mheidly et al., 2020; Pierce et al., 2020).

With the winter term of 2021, restrictions slowly have been relaxed, and presential courses were partially permitted again. A hybrid teaching model got the "new normal", but nevertheless, psychological after-effects of the previous lock-downs were and still are noticeable (Schlack et al., 2020).

The purpose of this paper is to deep dive into the winter term 2021 first-semester students' stress perception by analyzing the major root causes of their distress, and evaluating measures how to reduce the stress level. The target of this endeavor is to name explicit activities that a university can implement to facilitate the young peoples' start in university life and hence redirect their attention back to academic content. The findings of this paper are part of a longitudinal study about the development of stress and self-efficacy during one semester.

After a short theoretical introduction to stress, the methodology of the parental study will be described, followed by an explanation of the context to this paper. Next, the results are presented and practical implications are derived. A final discussion acknowledging the limitations of this study will close this paper.

2. STRESS

Hans Selye, a pioneer in the field of stress, once defined stress as the "nonspecific response of the body to any demand, whether it is caused by, or results in, pleasant or unpleasant conditions" (1985, p. 8). This definition puts stress in a neutral light. Contrary to the commonly perceived negative association with this word, stress in small amounts can be beneficial (Kouda & Iki, 2010; Minois, 2000). But as the circumstances of Covid-19 have increased the general stress level in society, the focus of the stress impact is on the negative effects within this paper (Haikalis et al.,2022; Riedel-Heller & Richter, 2021).

Stress symptoms may occur in miscellaneous forms that range from physical manifestations like headache or stomach ache to psychological disorders like anger or anxiety. Some people express the feeling of stress - consciously or unconsciously – in their behavior by starting to drink alcohol or eating unusual amounts of fast food or candy (Behere et al. 2011; Cohen et al, 2007).

In the academic setup, various studies have shown that stress has a negative impact on students' performance. High levels of stress are strongly linked to lower grades and a higher risk of health issues (e.g., Akgun & Ciarrochi, 2003; Zajacova et al., 2005). Especially, the first semester is considered to be particularly stressful for students, as many are moving away from home, family, and friends and have to adjust to college life and the academic requirements (Pitt et al., 2017; Zajacova et al., 2015). Based on these findings, the target group of this paper is first-semester undergraduate students. Goodman (1993) divided student stressors into the categories academic, financial, time or health-related, and self-imposed. As one objective of this paper is to name measures of how a university can support to reduce the stress, the focus will be on academic and self-imposed stress.

3. METHODOLOGY

As stated before, the content of this paper is part of an unpublished study about the development of self-efficacy and stress among first-semester students at the University of Applied Sciences in Ansbach, in the winter semester of 2021. This study aimed to investigate if and how the perceived stress level and self-efficacy are correlating over time. The present paper has its focus on stress, more specifically on the reasons for the perceived stress among the students.

All undergraduate students have been contacted in the first two weeks of their first semester at welcoming events, introduction lectures, and via messenger groups. After a short presentation about the background of the study, they were asked to participate in a three-part survey. The participation was voluntary and the students did not receive any credits or benefits for their participation. In the last run, an incentive in form of two shopping vouchers was announced to keep the participation rate on track. To take part in the survey, the students had to sign in by scanning a QR code or copying the link to the university's choice for surveys platform "Limesurvey".

The first part had to be filled at the beginning of the semester, the second one in the mid, and the third one after the final exams at the end of the semester. All three parts of the survey consisted of the same three scales to measure 1) the perceived stress level (Cohen et al., 1983), 2) the general self-efficacy (Chen et al., 2001) and 3) the academic self-efficacy (Chemers et al., 2001) besides the general demographic data retrieval. Students, who signed up for the first survey were reminded to participate in the other two runs, but participation rates dropped as expected. Of the 329 originally signed students, 198 completed the first survey, 148 filled as well the second, and 112 (69,6% female) the third one.

Whereas the parental study is purely quantitative, the present research is of a mixed nature. In the last part of the survey at the end of the semester, an additional question block was added, to capture the students' impressions and feelings in a retrospective. In the first part of this block, they were asked if specific factors – such as the search for housing or exams - were stressing them or not. The second part added a qualitative perspective by giving the students the chance to elaborate on their individual stressors and what support they would have liked from the university. This qualitative part was optional and in total, 48 of the 112 third-run participants shared their impressions.

4. RESULTS

Similar to other studies, the most relevant stressor for students was the examination and the related achievement pressure (e.g. Everly et al., 1994; El-Ghoroury et al., 2012). 77 out of the 112 respondents said that the exams stressed them. Figure 1 shows the perceived intensities of the seven stressors that were explicitly asked in the survey.

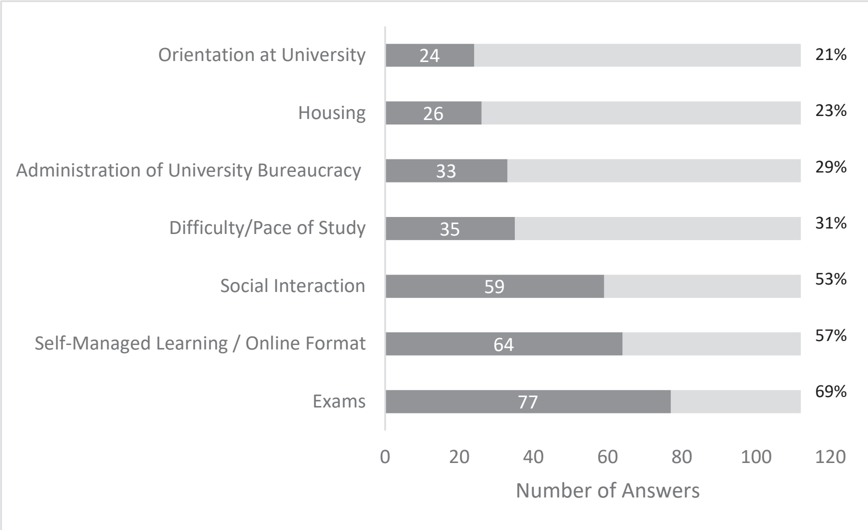

Figure 1. Perceived Intensities of Stressors

That the Covid-19 pandemic has a high impact on the students can be seen in the second and third rank of the stressors. 57% of the students reported that self-managed learning and the online format increased their stress levels. Besides the transition in the learning environment from school to university, the students also had to get used to the online format of lectures. Staying focused in a face-to-screen set up all day long is reported to be exhausting and hence it is a logical consequence that students frequently get distracted. Kemp and Grieve (2014, p.1) found in their study that - even though performance is similar between presential and online formats - students expressed “a strong preference for class discussions to be conducted face-to-face, reporting that they felt more engaged, and received more immediate feedback, than in online discussion”. This finding supports the fact that the students in this study feel stressed about online learning.

The third major reason for distress in first-semester students is social interaction. 53% had difficulty in finding new friends and getting in contact with their peers. Due to the online lectures, the social interaction between the students was reduced drastically. As the survey was conveyed among first-semester students, many of them had not had contact before with other students in their new hometown.

Around one-third of the respondents reported being stressed by the pace of the study, as they had difficulties following the complex contents. Approximately the same amount named the administration of the university bureaucracy as a reason for their arousal. At the beginning of the first semester, students get overwhelmed by various tools, activities they have to do, and deadlines. What has been organized by the teacher at school, is now their own responsibility. The two least stressful factors were housing (23%) and orientation at the university (21%), but nevertheless still stressed one-fifth of the students. Additionally, in the free text field, the following stressors have been mentioned: finances/work besides university, moving away from friends and hobbies, and mental health issues.

As the qualitative part was in free text format as well, the results are bundled and rephrased according to their content. The students were asked what would have reduced their stress levels and what the university could do to support them. The answers are categorized in content and scope, information flow, time management, adoption of the online format, network, and housing.

Out of the 48 respondents, sixteen requested a more detailed provision of information on the scope of the coursework and the content of the exams. In case of uncertainties, the answering of questions via emails was considered time-consuming and cumbersome. More practical exercises, lecture notes, an overview of the study program, and study groups were mentioned as possible efforts to alleviate.

Information flow is the second most mentioned category with fifteen answers. Much important information gets lost in the flood of content in the first weeks of a study. Therefore, the students had difficulties in handling the different tools and fulfilling the requested tasks in time. The university's online platforms like Moodle, ILIAS, and Primuss are not self-explaining, and keeping an overview of the different purposes was considered tricky. As peer exchange was difficult with Covid-19, a more precise explanation was requested. Additionally, more reminders for general information like registration deadlines were desired.

The same amount of mentions (fifteen) has the third category network. Due to the pandemic circumstances, many students had difficulties making new friends and felt lonely. More freshman events, or course-internal events, would have helped them to meet new fellow students. Especially higher semester peers are of interest in order to exchange experiences and course requirements. Another answer included leisure activities or extracurricular engagements as a possible way to connect.

Eleven students rated time management as an important field for improvement. This self-imposed issue was very present due to the absence in the classroom. Students had to keep track of their online lectures and a structured daily routine. Distractions at home negatively impacted their concentration. Besides, the intervals between the exams were reported to be too short. One individual introduced the idea of an intermediate examination within the semester to collect credits for the final exam, but this wish might not represent the general consensus.

The adaption of the online format was named as a mitigation measure by nine students. Regularly, the lectures were held over a Zoom meeting and the content was not provided online afterward. Even when a student joined the original lecture, many questions remained open, because of the burden to reach out to the professor during an online class. The respondents requested recorded lectures to re-watch. If that is not possible, it would yet help to have the slide decks available. Also, the digitalization of the examination was mentioned. In case a student is corona positive - but feels well - an online exam would eliminate the issue to postpone the assessment to the next semester and re-study the course content. The majority of students named presential lectures as the best way to reduce the perceived stress, but the development of the pandemic is out of the university's control, unfortunately.

The last category is housing with four mentions. This issue is well known in the city of Ansbach. Every term, students have a hard time finding accommodation, as the housing market of the around 40.000 inhabitants city is continuously insufficient. The university already does its best by running a housing platform on its webpage with private offers.

5. PRACTICAL IMPLICATIONS

Based on these results, mitigation measures are recommended in this chapter. As the examination phase is and always will be a stressor to the majority of students independent of the visited institution and as there is no possibility to change the circumstance of the pandemic, the focus of the practical implications will be on the qualitative results of the study and structured accordingly and by their cost-benefit ratio.

Regarding the content and scope of course work and examination and the information flow, there are some easy-to-implement measures the university can take advantage of. As the students are overwhelmed by unstructured information in the beginning, the first proposal would be an overview of the operational model of the study program and the most important information summarized in a short form. This short summary should contain all important must-dos (e.g. choosing subjects, assignment of exams, re-registration next semester) and their deadlines, which tool to use for what activity, where to retrieve further information, and the overall structure of the study program. Additionally, every course should provide a one-pager about its focus, the main learning targets, the form of examinations, and deadlines if there are some. Some courses already share the slides with this content, but students sometimes need this information ahead of the first lectures, for the choice of compulsory elective subjects for instance.

The second proposal is the establishment of mandatory introductory courses for the various online tools. Just like for the library services in Ansbach, students should visit a course at the beginning of their studies where they get explained the handling and purpose of the university's IT structure. This measure would reduce confusion and as a consequence the workload of course secretaries and student support centers.

Another promising idea in this context is having additional reminders for important deadlines. If the period for exam registration is over and a student missed it, they have to wait until the following term to participate in the examination. The university already sends two email reminders, but some students do not check their university mail accounts regularly. Another form of reminder might be a possible solution. An app with all important data and push notifications would probably rather reach the students as they have their mobiles with them anytime. This app could also be used for overviews of events, tools and other university related information. Depending on the back-end requirements for the app, the IT subjects of the university might even be able to develop it themselves.

To address the social interaction issue, the university could implement a mentoring or buddy program. Every freshman should have an assigned higher-semester student as their mentor/buddy who they can contact if they have questions or doubts. It is important to pair them up beforehand because else introverted students would not reach out to participate. If the freshman does not need support, it is up to them to step out of the program anytime. Depending on the willingness of the higher semester students to take part in this program, an incentive might be necessary to consider to motivate them.

As time management was the biggest self-imposed stressor, the university could offer seminars on how to efficiently organize tasks and structure days. Such a time management course is an investment for the university that is not awarded directly, but indirectly as the students learn how to better focus on their tasks, hence are less stressed and hence are more likely to perform better (see also Häfner et al., 2014).

In a nutshell, the following mitigation measures are recommended to be implemented by the university administration.

1. Overview one-pager with most important information for study program and courses
2. Mandatory introductory courses for online tools
3. Additional reminders of important deadlines via app
4. Mentoring/Buddy Program with higher semester students
5. Offering time management seminars

The following further mitigation measures might be of interest but need to be discussed in detail because they are harder to implement or not compatible with all subjects. The first additional proposal is the implementation of question rounds every few weeks after a lecture, where students are given the time to ask questions without interrupting the flow of the professor. This might reduce the incoming flood of emails for the professors and give students the chance to easily address uncertainties.

Secondly, the intensity of the examination period might be reduced by either stretching the period or -if applicable – offering pre-tests during the semester to reduce learning content in the final exam. As the timing of the terms is not steered individually by the university but nationwide, the first option is rather unrealistic to implement. But, if subjects permit the second model of intermediate assessments, the workload at the end of the semester and with it the stress and pressure on the students would decrease. This model is time-intensive and requires a re-arrangement of the schedule and is therefore not easy to implement but under circumstances worth the effort.

Thirdly, the atmosphere and social feedback of face-to-face interaction are very different from the face-to-screen setup. Not all professors are well prepared for this format. Staff training focusing on online teaching and presentation skills might help everyone to adjust to the “new normal”. This measure is a win-win situation for both teacher and student, but is costly and does staff require to participate.

Other recommended measures are not the university administration’s responsibility but might be adopted by the student council. Some of the students asked for more freshman events like the orientation days at the beginning of the semester. Due to governmental restrictions, parties were prohibited for a long time, which is why there were fewer events in the term of this investigation. As Covid-19 is fading out, the student council will probably return to its usual activities. Additionally, it might be interesting to think about online or hybrid events for upcoming lockdowns to provide at least an option to get in contact with peers. Next to the open-to-all-students events, study course internal festivities or meetings could be arranged, since fellow students are not met physically in the classroom anymore at times of online lectures.

This circumstance also complicates the organization of learning groups. Possibly, the student council could set up the framework and provide the platform for students to form learning groups. Just like the housing exchange of the university, the student council could advertise learning groups on their page and interested students could inserate offers.

Another proposal that came up in the survey concerning networking is to get an overview of the leisure time activities in Ansbach. The student council’s webpage gives a broad insight into the extracurricular working groups of the university. However, if a student also wants to engage in clubs, associations, or other leisure time activities outside the university, information gets rare. It is obviously not the concern of anyone else what a person does in their spare time, but for some of the students, it might ease the start in a new town, if they have a rough overview of the offerings.

6. RESEARCH LIMITATIONS AND DISCUSSION

Besides the commonly known restraints and drawbacks of self-reported surveys, this study has a few other limitations. As this study is based on just one university, it may not be representative of generality but it can be seen as a pilot project. The mitigation measures are based on the individual perceptions of the survey participants and the measures might need to be adopted. Furthermore, the gender split of participants was not equal which might have impacted the results of the qualitative part. Due to this inequality and consequently low numbers of male respondents, no in-depth gender-based analysis was conducted that could have further differentiated the results.

Covid-19 is fading out again, so the impact of stress might be different now as presential meetings are permitted again. The results are still of interest, because 1) due to globalization, more pandemics will come up and lead to similar circumstances and lockdowns and 2) online and hybrid formats have been well established during the last two years. With this "new normal", more events will take place online even if face-to-face lectures are allowed. It is also interesting because 3) not all of the stressors were caused by Corona and hence are relevant at all times.

There have been mentioned a lot of measures the University of Applied Sciences in Ansbach could do to support, but in the end, it is still the students' responsibility to cope with their life, and sometimes it is best to be thrown in the cold water. The real world after school and university is hard and they have to be able to cope with their problems themselves. Nevertheless, the complete switch from presential to online format has been a tough transition for the institute as well, so it is recommendable for the university to take advantage of the low-hanging fruits and consider the easy-to-implement measures, as this is a win-win situation for the university, the staff, and of course the students. Less stress and confusion on the student side usually also means less workload for support staff and a better reputation for the university both performance-wise and recommendation-wise.

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Conflict of interests

No potential conflict of interest was reported by the authors.

AUTHOR CONTRIBUTIONS

The conceptualization of this paper was discussed between all of the authors because this research is part of Mrs. Oberst's Ph.D. program and Mrs. Hedderich, Mrs. de-Molina-Miguel, and Mr. Catalá Pérez are her supervisors. The investigation and writing were conducted by Mrs. Oberst. The other authors supervised, reviewed, and validated the research.

REFERENCES

Akgun, S., & Ciarrochi, J. (2003). Learned Resourcefulness Moderates the Relationship Between Academic Stress and Academic Performance. *Educational Psychology*, *23*(3), 287–294. https://doi.org/10.1080/0144341032000060129

Behere, S.P., Yadav, R. & Behere, P.B. (2011) A comparative study of stress among students of medicine, engineering, and nursing. Indian Journal of Psychological Medicine, 33 (2), 145–148.

Bohlken, J., Schömig, F., Lemke, M. R., Pumberger, M., & Riedel-Heller, S. G. (2020). [COVID-19 Pandemic: Stress Experience of Healthcare Workers - A Short Current Review]. *Psychiatrische Praxis*, *47*(4), 190—197. https://doi.org/10.1055/a-1159-5551.

Brooks, S. K., Webster, R. K., Smith, L. E., Woodland, L., Wessely, S., Greenberg, N., Rubin, G. J. (2020). The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *The Lancet, 395*(10227), 912–920. https://doi.org/https://doi.org/10.1016/S0140-6736(20)30460-8.

Chen, G., Gully, S. M., & Eden, D. (2001). Validation of a New General Self-Efficacy Scale. Organiza tional Research Methods, 4(1), 62–83. https://doi.org/10.1177/109442810141004

Chemers, M.M., Hu, L., & Garcia, B.F. (2001). Academic self-efficacy and first year college student performance and adjustment. *Journal of Educational Psychology, 93*, 55-64.

Cohen, S., Kamarck, T., and Mermelstein, R. (1983). A global measure of perceived stress. Journal of Health and Social Behavior, 24, 386-396.

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. JAMA, 298(14). 1685-1687.

El-Ghoroury, N.H., Galper, D.I., Sawaqdeh, A., & Bufka, L.F. (2012). Stress, coping, and barriers to wellness among psychology graduate students. *Training and Education in Professional Psychology, 6*(2), 122–134. doi:10.1037/a0028768

Everly, J. S., Poff, D. W., Lamport, N., Hamant, C., & Alvey, G. (1994). Perceived Stressors and Coping Strategies of Occupational Therapy Students. *The Ameri can Journal of Occupational Therapy*, *48*(11), 1022–1028. https://doi.org/10.5014/ajot.48.11.1022

Goodman, E.D. (1993). How to handle the stress of being a student. Imprint, 40,43.

Häfner, A., Stock, A., Pinneker, L., & Ströhle, S. (2014). Stress prevention through a time management training intervention: an experimental study. *Educational Psychology*, *34*(3), 403–416. https://doi.org/10.1080/01443410.2013.785065

Haikalis, M., Doucette, H., Meisel, M. K., Birch, K., & Barnett, N. P. (2022). Changes in College Student Anxiety and Depression From Pre- to During-COVID-19: Perceived Stress, Academic Challenges, Loneliness, and Positive Perceptions. *Emerging Adulthood*, *10*(2), 534–545. https://doi.org/10.1177/21676968211058516

Hochschulrektorenkonferenz (2022, Mar 31). Auswirkungen der COVID-19-Pandemie auf die deutschen Hochschulen – Aktuelle Hinweise und Nachrichten. https://www.hrk.de/themen/hochschulsystem/covid-19-pandemie-und-die-hochschulen/.

Kouda, K., & Iki, M. (2010). Beneficial Effects of Mild Stress (Hormetic Effects): Die tary Restriction and Health. *Journal of PHYSIOLOGICAL ANTHROPOLOGY*, *29*(4), 127–132. https://doi.org/10.2114/jpa2.29.127.

Kemp, N., & Grieve, R. (2014). Face-to-face or face-to-screen? Undergraduates' opin ions and test performance in classroom vs. online learning. *Frontiers in Psychology*, *5*. https://doi.org/10.3389/fpsyg.2014.01278

Mheidly, N., Fares, M. Y., & Fares, J. (2020). Coping With Stress and Burnout Associated With Telecommunication and Online Learning. *Frontiers in Public Health*, *8*. https://doi.org/10.3389/fpubh.2020.574969.

Minois, N. (2000). Longevity and aging: beneficial effects ofexposure to mild stress. *Biogerontology*, *1*(1), 15–29. https://doi.org/10.1023/A:1010085823990

Pierce, M., Hope, H., Ford, T., Hatch, S., Hotopf, M., John, A., Kontopantelis, E., Webb, R., Wessely, S., McManus, S., & Abel, K. M. (2020). Mental health before and during the COVID-19 pandemic: a longitudinal probability sample survey of the UK population. *The Lancet Psychiatry*, *7*(10), 883–892. https://doi.org/10.1016/S2215-0366(20)30308-4.

Pitt, A., Oprescu, F., Tapia, G., & Gray, M. (2018). An exploratory study of students' weekly stress levels and sources of stress during the semester. Active Learning in Higher Education, 19(1), 61–75. https://doi.org/10.1177/1469787417731194.

Riedel-Heller, S., & Richter, D. (2021). Psychische Folgen der COVID-19 Pandemie in der Bevölkerung. *Public Health Forum*, *29*(1), 54–56. https://doi.org/doi:10.1515/pubhef-2020-0121.

Robert Koch-Institut. (2020). Beschreibung des bisherigen Ausbruchsgeschehens mit dem neuartigen Coronavirus SARS-CoV-2 in Deutschland (Stand: 12. Februar 2020). *Epidemiologisches Bulletin*, *7*, 3–4.

Schlack, R., Neuperdt, L., Hölling, H., de Bock, F., Ravens-Sieberer, U., Mauz, E., Wachtler, B., & Beyer, A.-K. (2020). *Auswirkungen der COVID-19-Pandemie und der Eindämmungsmaßnahmen auf die psychische Gesundheit von Kindern und Jugendlichen*. https://doi.org/10.25646/7173

Selye, H. (1985) The nature of stress. The Best of Basal Facts, 7, 3-11.

Statistisches Bundesamt (2022, April 15). Wirtschaftliche Auswirkungen. Statistiken mit Bezug zu COVID-19. https://www.destatis.de/DE/Themen/Querschnitt/Corona/Wirtschaft/kontextinformationen-wirtschaft.html.

Zajacova, A., Lynch, S. M., & Espenshade, T. J. (2005). Self-Efficacy, Stress, and Aca demic Success in College. *Research in Higher Education*, *46*(6), 677–706. https://doi.org/10.1007/s11162-004-4139-z

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CROSS-CULTURAL COLLABORATION FOR INTERNATIONAL TRADE, AND MARKETS. CASE OF INDIGENOUS MANAGEMENT CONCEPTS

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ABSTRACT: The economic developments in the 21st century that are happening within the context of globalisation have increasingly set the focus on emerging markets. Moreover, it is expected that within the next twenty years, most of the world's growth will occur in the emerging markets (Cavusgil et al., 2013). Within this background, one market that particularly seems to gain increasing importance in the context of international trade is the People's Republic of China. Today, it is the world's second largest trading nation, and has emerged as the most important bilateral trade partner for many countries (Riccardi, 2016). Despite the unprecedented growth rates, and bi-lateral trade agreements, the importance and understanding of indigenous management practices unique to China remain largely unknown (Garg and Berning, 2017). The objective, therefore, of this paper is two-fold; the first objective is to explore the nature of culture and its role in the society. The second objective is to explore and investigate whether and how German companies' understanding of Chinese culture facilitates the trade negotiations. The paper seeks to contribute to the growing indigenous management research.

Keywords: *China; Cross-cultural collaboration; Indigenous management*

1. INTRODUCTION

The economic developments in the 21st century that are happening within the context of globalisation have increasingly set the focus on emerging markets. These markets are countries in a transition phase from developing to developed markets that are fostered by globalisation and, hence, have a rapid potential of growth. There is no specified list of

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countries that belong to emerging markets since growth indicators vary by year. In this context, the popular term 'BRIC' countries is used: Brazil, Russia, India and China - an association of major emerging markets, economically as well as politically (Cavusgil et al., 2013). Emerging markets provide many opportunities for investors of foreign countries. Since more than 80% of the world's population are located in emerging economies, they hold a massive market potential. Moreover, many emerging markets have promoted foreign investments by increased infrastructure de-velopment, the access to new technologies and support by the respective government. Within the next twenty years, it is expected that the majority of the world's growth will occur in emerging markets (Cavusgil et al., 2013). One market that particularly seems to gain increasing importance in the context of international trade is the People's Republic of China. Today, China is the world's second largest trading nation, following the United States of America, and also the world's leader in exports as well as the second in imports. It has always gained a high growth rate every year, as it is the most important bilateral trade partner for many countries (Riccardi, 2016). The Chinese market offers many chances and possibilities for foreign investors. In order to take those opportunities, it is essential to gain an understanding of the Chinese mindset (Granier, 2004).

2. STATE OF RESEARCH

Numerous publications have investigated the impact of culture on international business, especially in the context of emerging markets. There are several well-known models that measure various cultural dimensions in order to determine commonalities as well as differences between cultures. The most popular concepts include Hall's 3-Dimension model, Hofstede's 5-Dimension model, the GLOBE Study with its 9-Dimensions and Trompenaars' model with 7 Dimensions. The research will take selected dimensions of Hofstede's and Hall's models into account (Rothlauf, 2012).

In addition to concepts that merely identify cultural dimensions, there is also a vast selection of publications that consider the impact of culture on business. Many studies have investigated the impact of cultural characteristics and their implications for cross-cultural management and have covered the issue of intercultural problems in regard to Sino-German relationships in their respective publications, giving implications for German managers in regard to intercultural competence. Publications in the field of international management have also considered cultural factors and their impact on international business. In this context, several research have described the influence of culture on negotiation styles as well as customs in regard to social interactions with partners from other cultural areas.

This research builds not only on the existing models, but also incorporates two case studies to highlight the holistic perspective in this context. And after the analysis it was found that both practical cases indicate the strong influence of cultural differences on business. The behavioural patterns shown by the Chinese managers and employees allow conclusions to be drawn regarding the impact of Confucianism and the concepts of guanxi and mianzi. Also, the findings of Hofstede et al. (2010) and Hall (1976) regarding the cultural dimensions can be identified to have practical relevance that is reflected in the behaviour of Chinese. As having examined in the theoretical frame as well as in the analysis, Hofstede's dimensions power distance, collectivism vs. individualism and long-term vs. short-term orientation were found to have a considerable connection to Confucianism. The same finding applies to Hall's cultural factor of high-context vs. low-context communication. In consideration of the results, it can be confirmed that Confucianism exerts influence on the behaviour of Chinese managers and employees, and, hence, contributes to cross-cultural problems in regard to intercultural business activities.

3. RESULTS & DISCUSSION

The aim of this research was to investigate the impact of cultural differences on business between Chinese and German companies. In that regard, several sources of problems and their cultural background have been detected. The results are in accordance with the cultural dimensions that were identified in the researches of Hofstede et al. (2010) and Hall (1976). Also, a strong impact of Confucianism and its concepts guanxi and mianzi could have been demonstrated. In the analysis, not every aspect of the theoretical frame was covered due to the limited extent of the practical cases and the research project. Nevertheless, it has been found that culture has had a strong impact on the way business between Chinese and German partners had been conducted.

Furthermore, several characteristics and problems resulting from cultural differences have been examined in regard to the two practical cases. The most common problems that have been reported by the German managers particularly refer to differences in communication, conflict behaviour, decision-making as well as organising and planning. For differences in communication, the most frequent problems refer to disparities in high-context and low-context communication. Practical evidence for the preference of Chinese to use indirect and implicit communication rather than direct and explicit communication can be found. Additionally, the Chinese tendency to avoid conflicts and open criticism becomes apparent in the practical cases. In that respect, differences concerning the conflict behaviour of Chinese and German managers are demonstrated. Regarding the fields of decision-making as well as organising and planning, the sources of conflict mainly regard the different ways of allocation of responsibilities.

In this research, practical evidence for the influence of cultural differences on business has been found. The cultural differences that have been examined in the practical cases mostly resulted in conflict situations or misunderstandings between the Chinese and German partners. It can therefore be assumed that the cultural characteristics that have been presented have a practical relevance in the Chinese business environment. Confucianism, in particular, can be examined as a cultural factor with strong impact on the way Chinese do business. In that regard, the paper can confirm the assumption that culture has a significant impact on business activities between partners from different cultural areas. As having investigated in the two practical examples, there exists a practical relevance of understanding the characteristics of the partner's culture. Disregarding those cultural characteristics can lead to problems and misunderstandings between business partners, as the two practical cases confirm. Moreover, both business sides have stressed the importance of cross-cultural understanding in order to achieve successful business co-operations with Chinese partners. In this context, the importance of cultural sensitivity can be emphasised once again.

REFERENCES

Cavusgil, S. T., Ghauri, P. N. & Akcal, A. A. (2013). *Doing business in emerging mar--kets.* 2nd ed., Los Angeles et al.: Sage.

Garg, R., & Berning, S.C. (2017). *Indigenous Chinese Management Philosophies. Key Concepts and Relevance for Modern Chinese Firms.* In B. Christiansen and G. Koc (Eds.), Handbook of Research on Scientific and Technological Development in Asia: 43-57. IGI Global.

Granier, B. (2004). Gigantischer Markt? Gigantische Chancen? Gigantische Risiken? Sozio-kulturelle, wirtschaftliche, politische und rechtliche Rahmenbedingungen. In B. Granier & H. Brenner (Eds.), Business Guide China. Absatz, Einkauf, Kooperation – mit Erfahrungsberichten deutscher Unternehmer (11-47). 2nd ed., München et al.: Deutscher Wirtschaftsdienst.

Hall, E. T. (1976). Beyond Culture. Garden City, New York: Anchor Press.

Hofstede, G., Hofstede G. J. & Minkov, M. (2010). Cultures and organizations: software of the mind. Intercultural Cooperation and its importance or survival. 3rd ed., London et al.: McGraw-Hill.

Riccardi, L. (2016). Investing in China through Free Trade Zones. Heidelberg: Springer.

Rothlauf, J. (2012). Interkulturelles Management. Mit Beispielen aus Vietnam, China, Japan, Russland und den Golfstaaten. 4th ed., München: Oldenbourg.

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VIRTUAL ORGANIZATIONAL SOCIALIZATION – A STRUCTURED LITERATURE REVIEW AND RESEARCH AGENDA

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ABSTRACT: The literature on Organizational Socialization and Onboarding has assumed traditional work relationships located on-site in the company. Due to the Corona pandemic, remote work has gained tremendous importance. However, we do not yet know how the lack of physical presence affects organizational socialization. The research interest is to assess papers analyzing virtual organizational socialization systematically. The method used was a Systematic Literature Review (SLR). A protocol was made. In this, the search parameters were recorded. Literature relevant to the research question was identified and evaluated. This was examined and put into context. Key Findings: virtual organizational socialization represents a research gap. The literature is scattered; we only found a small number of relevant articles from different disciplines focusing on impediments of virtual organizational socialization. Research on onboarding practices that help overcome obstacles imposed by a higher degree of virtual work is needed.

Keywords: *Onboarding; Organizational socialization; SLR; Remote work; Virtual*

1. PURPOSE OF THE PAPER

Remote work was already rising over the last decade, but the covid-19 pandemic was a catalyst for working from home arrangements. In Germany, for instance, in 2021, half of

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all companies offered remote work for at least part of their employees (Bellmann et al., 2021). Whereas working from home before the pandemic usually wasn't daily and by choice (Delanoeije et al., 2019), due to Covid-19, working from home every day became mandatory for many knowledge workers (Waizenegger et al., 2020). The literature on organizational socialization refers to working environments with employees who work on-site in the companies (Ahuja & Galvin, 2003). However, during the pandemic, new employees started a job without being physically on-site. New contacts were made predominantly or even exclusively via digital communication media. This has implications for the nature of socialization in the company. This new type of collaboration significantly limits spontaneous communication and learning opportunities (Taskin & Bridoux, 2010). To compensate for this, structured new methods of onboarding are required. In this paper, we want to investigate what is known about virtual onboarding and the organizational socialization of new employees and develop a research agenda for this new field of organizational socialization research. We, therefore, chose to conduct a structured literature review (SLR). This methodology helps overcome the issue of a scattered field by synthesizing literature from authors with different backgrounds (Kraus et al., 2020).

2. RELATED WORK

2.1. Remote work

Research on remote work goes back to the 1980s (Olson, 1983). Remote work refers to situations where work is carried out outside the default place of work (International Labour Organization, 2020a). Telework is a subcategory of remote work that implies using information and telecommunications technology (ICT) (Taskin & Bridoux, 2010). Telecommuting refers to telework that is introduced as a substitute for commuter travel. Working from home generally means that work takes place in the employee's home. In the context of the covid-19 pandemic, it was used to describe temporary home-based telework (International Labour Organization, 2020b). Much of the literature on remote work investigates the benefits and disadvantages of teleworking for employees and companies (Waizenegger et al., 2020). Now, the question is not about whether a company should offer remote work but rather how this can be done to be effective. In our review, we used all the above terms to get a broad picture of onboarding and organizational socialization in remote work settings.

2.2. Virtual teamwork

Just like remote work has been on the rise even before the pandemic, virtual teamwork has increased over the last decades (Mak & Kozlowski, 2019). Virtual teams are defined as teams "of (a) two or more persons who (b) collaborate interactively to achieve common goals, while (c) at least one of the team members works at a different location, organization, or at a different time so that (d) communication and coordination is predominantly based on electronic communication media" (Hertel et al., 2005, p. 71). In its origins, virtual teams were contrasted to purely face-to-face teams. By now, a continuum between wholly virtual and face-to-face teams has evolved with information and communication technology's growing availability and functionality (Mak & Kozlowski, 2019). Purely face-to-face teams hardly exist anymore since most teams use communication technology to some extent, even when co-located. The Covid-19 pandemic increased team virtuality dramatically. Very abruptly and worldwide, many team members had to work from home using information and communication technology to collaborate (Klonek et al., 2022). Research on virtual teams shows that virtuality decreases communication frequency, knowledge sharing, satisfaction, and performance. However, these adverse effects tend to dominate short-term teams and disappear over time (Ortiz de Guinea et al., 2012). Virtuality is often experienced as a barrier to coworker multiplex relationships. Asynchronous work and not seeing coworkers' availability make it more challenging to connect quickly and regularly with colleagues (Schinoff et al., 2020).

2.3. Onboarding and Organizational Socialization

Although some authors use the terms onboarding and organizational socialization equally, in this paper, we understand that onboarding refers to "all formal and informal practices, programs, and policies enacted or engaged in by an organization or its agents to facilitate newcomer adjustment" (Klein & Polin, 2012, p. 268). Organizational socialization, as the broader term, describes the process by which an organizational outsider transforms into an organizational insider by learning and adapting to new jobs, roles, and the culture of their workplace (Bauer et al., 2021; van Maanen & Schein, 1979). The focus of onboarding is on the organization and its practices to help newcomers to adjust, whereas organizational socialization is a process occurring inside employees continuing over their working life, which they can influence through proactive behavior (Klein et al., 2015; Klein & Heuser, 2008; Klein & Polin, 2012).

In a Meta-Analysis, Bauer et al. (2007) investigated antecedents and outcomes of newcomer adjustment during organizational socialization. They showed that role clarity, self-efficacy, and social acceptance mediate the linkage between newcomer information seeking and organizational socialization tactics on the one hand and socialization outcomes such as newcomer performance, job satisfaction, organizational commitment, intentions to remain, and turnover on the other hand. Regarding the outcomes of organizational socialization, organizations should be interested in looking at how they can support this process. One starting point for many organizations is formal orientation programs. Attending those is linked to deeper socialization concerning goals, values, history, and the development of social relationships (Klein & Weaver, 2000). Onboarding practices such as a tour of company facilities, a personalized welcome by a senior leader, or the assignment of a “buddy” positively influenced organizational socialization (Klein et al., 2015). Socialization agents help newcomers adjust through various actions such as providing information, feedback, or resources. They can be supervisors, coworkers, team members, or mentors and play an essential role in organizational socialization (Klein & Heuser, 2008). Another aspect that has been studied in the organizational socialization literature is newcomer proactivity, i.e., information and feedback-seeking, or a proactive personality (Kammeyer-Mueller & Wanberg, 2003; Klein & Heuser, 2008). Proactivity in virtual environments may differ from proactivity in face-to-face settings. It might be easier to address colleagues and supervisors when seeing their availability. Still, some persons prefer to send an e-mail or ask questions in an online portal rather than address others directly. Working from home might demand even more proactive behavior on the side of the newcomers.

Bauer et al. (2021) examined which resources impacted newcomer adjustment. They found that especially personal resources such as a proactive and optimistic personality or organizational knowledge positively influenced early adjustment. In this regard, it will be valuable to investigate how prior experience with virtual teamwork and working from home, individual competencies such as virtual communication skills, and social and collaboration abilities (Cascio, 2000) improve newcomer adjustment to virtual or hybrid working arrangements.

2.4. The effect of the pandemic on organizational socialization

Many newcomers had to work from home during quarantine measures due to the Covid-19 pandemic. They had to work with colleagues working remotely, or if they were onsite, physical distancing obligations limited chances to observe their coworkers and interact with them (Saks & Gruman, 2021). Using computer-based programs for socializing with newcomers so far doesn’t seem to be an adequate substitution for social-based orientation sessions. These programs worked well for information-based content but negatively affected socialization and its distal outcomes, such as organizational commitment and job satisfaction (Rollag et al., 2005).

As we have shown, the literature provides various insights on onboarding and organizational socialization as well as on virtual teams and remote work. The first question we want to consider in this paper, therefore, is the following:

RQ1: What is the extent and coverage of virtual onboarding and organizational socialization in work-from-home arrangements?

Having identified studies of virtual onboarding and socialization methods, the following two research questions are:

RQ2: Which methods are used in this research?

RQ3: What are the main research themes studied?

To set an agenda for research in this area, we also want to assess what recommendations for future research the authors give:

Publication medium	Journal articles indexed in the Scopus and Web of Science (WOS) databases We also included articles in the conference proceedings.
Period	Published in any year (including in press), conference proceedings dating from 2018 onwards.
Languages	Writings in English
Research design	Empirical, conceptual, review
Content	Inclusion: • paper is concerned with onboarding in a virtual context • paper provides generalizable findings Exclusion: • paper is not related to at least one of the research questions • paper is not peer-reviewed (e.g. master's thesis)
Source	Scopus, web of science
Method	Boolean search in the title of the publication, abstract, and keywords

RQ4: What future research topics do the authors suggest?

Table 1. SLR protocol

3. METHODOLOGY

A systematic literature review was conducted as indicated in the following protocol to achieve our objectives.

The search was carried out in the databases Scopus and Web of Science since, in the fields of social sciences, those are considered to be the most extensive sources of academic articles (Chadegani et al., 2013). We searched for the keywords “organizational socialization” OR “onboarding” OR“new hire” OR “new employee” combined with the Boolean operator AND with the keywords virtual OR telework* OR "remote work" OR telecommut* OR "work* from home" OR "information and communication technolog*" OR videoconferenc*. As shown in the paragraph on remote work, the terms “telework”, “remote work”, “telecommuting”, and “work from home” are all used to describe the phenomenon of non-co-located working arrangements. All of these keywords were used to include all papers dealing with this subject. We also included the terms “virtual”, “information and communication technology”, and “videoconference” to make sure that articles that do not address remote work directly but deal with virtual collaboration or virtual teams are included. We searched for articles published in peer-reviewed journals and book chapters. We also included conference proceedings dating from 2018 onwards since articles referring to the effects of the pandemic might first appear in conference proceedings but have scarcely been found in journals so far. All steps taken in the research process were documented (Tranfield et al., 2003). Five articles could not be retrieved as the authors’ affiliated universities do not subscribe to these journals. The remaining full-length articles were thoroughly studied to decide about including them in the review, applying the inclusion and exclusion criteria indicated in the protocol.

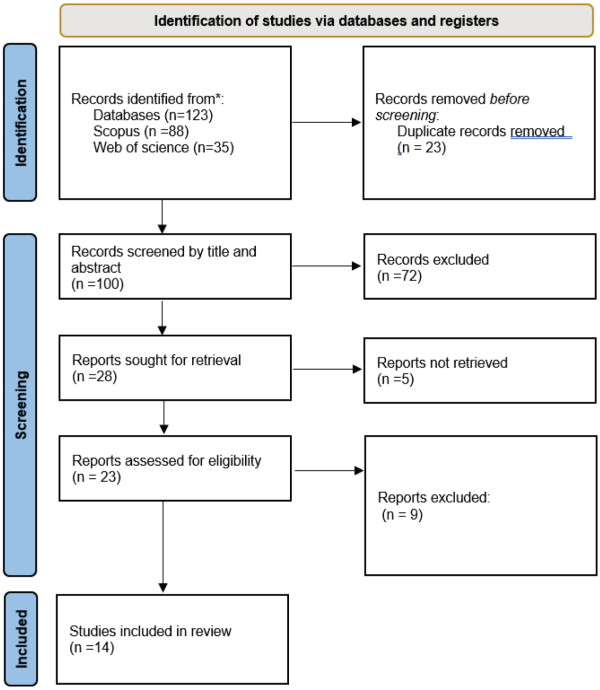

Figure 1. Flow diagram SLR

4 FINDINGS

In this section, the results are presented. A total of 123 articles initially could be found in the interrogated databases. After duplicate removal, the titles and abstracts of 100 articles were screened. This led to 23 full texts which were read. Nine of the retrieved full texts didn't meet the eligibility criteria. Finally, 14 articles were analysed in this study.

4.1. Bibliometric aspects of the selected articles

As Figure 2 shows, virtual onboarding and organizational socialization were hardly discussed before the Covid-19 pandemic. The sharp increase in 2021 suggests that research on these topics is growing.

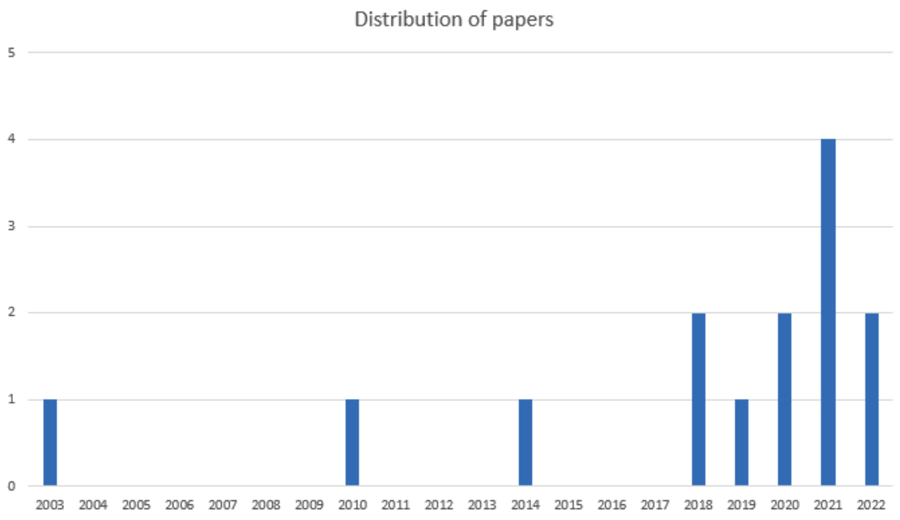

Figure 2. Distribution of papers across time

Of the 14 papers we found, four are case studies, four are qualitative studies, four are quantitative studies, and two are conceptual papers (see figure 3). This also shows that this research area is in its infancy, and researchers instead try to explore the field than test theory.

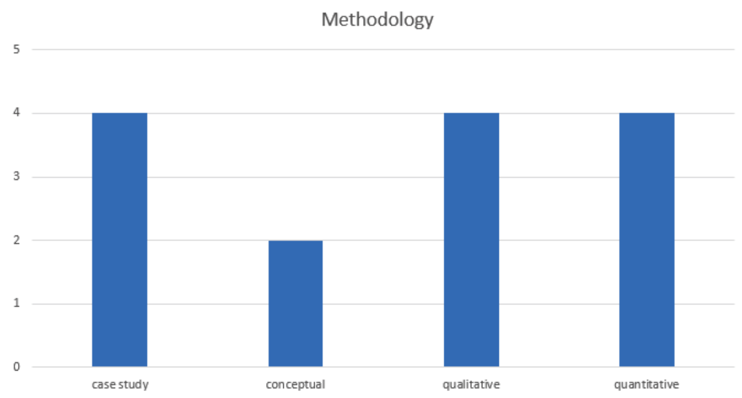

Figure 3. Methodology of the selected articles

4.2. Content of the selected articles

Both conceptual papers we found in the literature were published before the pandemic. Taskin and Bridoux (2010) theorize how different teleworking arrangements (high vs.

low frequency, working from home vs. neighborhood work centers, social legitimacy, and constraint vs. opportunity) affect organizational socialization and thus affect knowledge transfer. Gruman and Saks (2018) propose that the degree of virtuality moderates the effect of e-socialization, by which they understand digital socialization activities such as implementing virtual socialization agents or virtual socialization practices – on human and social capital, which then determines newcomer adjustment and, in turn, leads to distal socialization outcomes. Both papers argue that organizations should include face-to-face interactions to foster organizational socialization and its distal outcomes.

Three of the qualitative studies aim to determine the effects of working from home due to the pandemic on onboarding and relation building. Carlos and Muralles (2021) report that the lack of unspoken physical clues hinders socialization and that a deep investment in relationship-building is needed. Schreier et al. (2022) analyzed that frequent communication is essential to maintaining high levels of trust. They also found that supervisors were reluctant to recruit new employees because they thought working from home would hinder establishing well-functioning relationships. This is in line with Rodghero et al. (2021), who note that new hires struggle with communication and building relationships within their teams. This is the only paper that recommends remote onboarding, such as assigning an onboarding buddy, encouraging teams to turn on their cameras, or scheduling 1:1 meetings (Rodeghero et al., 2021). Another qualitative study looked specifically at social media use during organizational socialization, which enabled and constrained employees' socialization process (Lee et al., 2019).

Three case studies provide specific examples of organizations' efforts to implement measurements to foster organizational socialization in virtual environments. This can be through the construction of a digital organizational culture handbook (Asatiani et al., 2021), the installation of yearly summits, virtual "watercooler" chats (informal meetings via video chat), daily team calls, and regional co-working days (Choudhury et al., 2020), or, actionable items such as remote meet and greets, self-learning modules or, one to one check-ins (Goodermote, 2020). A case study with staff scientists during the covid-19 pandemic shows that managerial skills, including team development in digital environments and targeted orientation resources, are needed (Murphy et al., 2021).

Of the quantitative studies, two dealt with specific virtual teams. One looked at mentoring in virtual Open Source teams, which has a positive impact (Fagerholm et al., 2014). The other study found an intervention called "Wikipedia teahouse" – a virtual meeting of senior and new editors - effective at increasing new editor retention (Morgan & Halfaker, 2018). The oldest paper dealing with remote onboarding is a study by Ahuja and Galvin

(2003) that analyzed e-mails to investigate how newcomers in virtual groups differed in their communication. They showed that newcomers in virtual groups take a more active approach to acquire information, but they found e-mails inappropriate for inquiring about tacit and sensitive norms. Although information and communication technology nowadays offers much richer communication, the aspect that newcomers prefer to watch or listen to acquire sensitive information silently is still relevant.

A recent study from 2021 interrogated HR managers of 136 Portuguese companies about changes in their onboarding and other work and communication processes. Almost one-third of the respondents stated that induction and onboarding did undergo large significant changes due to pandemic-induced telework (Gonçalves et al., 2021).

These findings give some hints on practices that can be introduced to foster socialization in virtual environments, although research is needed to provide organizations with more generalizable results.

4.3. Propositions for future research in the selected papers

All authors conclude that more research is needed. It should be analyzed how knowledge-building and relationship-building work with teleworkers (Taskin & Bridoux, 2010). Besides testing the propositions outlined in their paper, Gruman, and Saks (2018) state that it should be determined which e-socialization methods are most suitable to reach the desired outcomes. It is also suggested to explore the impacts of individual and firm-specific factors such as IT literacy (Schreier et al., 2022). Rodeghero et al. (2021) propose to explore methodologies to improve virtual onboarding. They also suggest including the managers' views in the research.

5. FUTURE RESEARCH DIRECTION AND IDENTIFIED LIMITATIONS IN THE RESEARCH PROCESS

Considerably more work needs to be done to identify onboarding practices that work well in virtual work arrangements. It will be especially valuable to explore in qualitative research and case studies what practices new hires, and their managers describe as helpful in a virtual or hybrid socialization process. This is a gap in the literature since the practices described in the literature were somewhat fragmented and limited to a distinct group of employees, i.e., software engineers and library personnel.

The SLR presented in this paper is limited by the small number of articles that meet the inclusion criteria, but it clearly shows the topic's significance.

6. VALUE OF THE PAPER

Our study shows that although a considerable body of literature exists in the fields of organizational socialization, virtual teams, and remote work, there is a research gap in bringing those subjects together to figure out how businesses can design their onboarding processes in a way that is suitable for a virtual or hybrid context.

Conflict of interests

No potential conflict of interest was reported by the authors.

AUTHOR CONTRIBUTIONS

Didion, Eva: Conceptualization; Methodology; Formal analysis; Writing - Original Draft, Writing - Review & Editing, Visualization. *Ambrosius, Ute, Perello-Marin, Maria Rosario, and Català Pérez, Daniel:* Conceptualization; Methodology, Writing – Review & Editing, Supervision.

REFERENCES

Ahuja, M. K., & Galvin, J. E. (2003). Socialization in virtual groups. *Journal of Management*, *29*(2), 161–185.

Asatiani, A., Hämäläinen, J., Penttinen, E., & Rossi, M. (2021). Constructing continuity across the organizational culture boundary in a highly virtual work environment. *Information Systems Journal*, *31*(1), 62–93. https://doi.org/10.1111/isj.12293

Bauer, T. N., Bodner, T., Erdogan, B., Truxillo, D. M., & Tucker, J. S. (2007). Newcomer adjustment during organizational socialization: A meta-analytic review of antecedents, outcomes, and methods. *The Journal of Applied Psychology*, *92*(3), 707–721. https://doi.org/10.1037/0021-9010.92.3.707

Bauer, T. N., Erdogan, B., Caughlin, D., Ellis, A. M., & Kurkoski, J. (2021). Jump-Starting the Socialization Experience: The Longitudinal Role of Day 1 Newcomer Resources on Adjustment. *Journal of Management*, *47*(8), 2226–2261. https://doi.org/10.1177/0149206320962835

Bellmann, L., Gleiser, P., Hensgen, S., Kagerl, C., Kleifgen, E., Leber, U., Moritz, M., Pohlan, L., Roth, D., Schierholz, M., Stegmaier, J., Umkehrer, M., Backhaus, N., & Tisch, A. (2021). *Homeoffice in der Corona-Krise: leichter Rückgang auf hohem Niveau*. https://www.iab-forum.de/homeoffice-in-der-corona-krise-leichter-rueckgang-auf-hohem-niveau/

Carlos, A. R., & Muralles, D. C. (2021). Onboarding in the age of COVID-19. *IFLA Journal*, *48*(1), 33-40. https://doi.org/10.1177/03400352211035413

Cascio, W. F. (2000). Managing a virtual workplace. *Academy of Management Perspectives*, *14*(3), 81–90.

Chadegani, A. A., Salehi, H., Yunus, M. M., Farhadi, H., Fooladi, M., Farhadi, M., & Ebrahim, N. A. (2013). A Comparison between Two Main Academic Literature Collections: Web of Science and Scopus Databases. *Asian Social Science*, *9*(5). https://doi.org/10.5539/ass.v9n5p18

Choudhury, P., Crowston, K., Dahlander, L., Minervini, M. S., & Raghuram, S. (2020). GitLab: work where you want, when you want. *Journal of Organization Design*, *9*(1), 1–17.

Delanoeije, J., Verbruggen, M., & Germeys, L. (2019). Boundary role transitions: A day-to-day approach to explain the effects of home-based telework on work-to-home conflict and home-to-work conflict. *Human Relations*, *72*(12), 1843–1868. https://doi.org/10.1177/0018726718823071

Fagerholm, F., Guinea, A. S., Borenstein, J., & Münch, J. (2014). Onboarding in open source projects. *IEEE Software*, *31*(6), 54–61.

Gonçalves, S. P., Santos, J. V. d., Silva, I. S., Veloso, A., Brandão, C., & Moura, R. (2021). COVID-19 and people management: the view of human resource managers. *Administrative Sciences*, *11*(3), 69.

Goodermote, C. (2020). Remote onboarding and training of new program coordinators into the medical education office during Covid-19 social distance quarantine: Process and recommendations. *Journal of Community Hospital Internal Medicine Perspectives*, *10*(5), 399–401. https://doi.org/10.1080/20009666.2020.1796055

Gruman, J. A., & Saks, A. M. (2018). E-socialization: The problems and the promise of socializing newcomers in the digital age. In Dulebohn, James H., Stone, Dianna L. (Ed.), *Research in Human Resource Management Ser. The Brave New World of eHRM 2.0* (pp. 111–139). Information Age Publishing Incorporated.

Hertel, G., Geister, S., & Konradt, U. (2005). Managing virtual teams: A review of current empirical research. *Human Resource Management Review*, *15*(1), 69–95. https://doi.org/10.1016/j.hrmr.2005.01.002

International Labour Organization (2020a). Defining and Measuring Remote Work, Telework, Work at Home and Home-Based Work.

International Labour Organization. (2020b). *Employers'guide on working from home in response to the outbreak of covid-19*. Bureau for employers'act.

Kammeyer-Mueller, J. D., & Wanberg, C. R. (2003). Unwrapping the organizational entry process: Disentangling multiple antecedents and their pathways to adjustment. *The Journal of Applied Psychology*, *88*(5), 779–794. https://doi.org/10.1037/0021-9010.88.5.779

Klein, H. J., & Heuser, A. E. (2008). The learning of socialization content: A framework for researching orientating practices. In *Research in Personnel and Human Resources Management* (Vol. 27, pp. 279–336). Emerald (MCB UP). https://doi.org/10.1016/S0742-7301(08)27007-6

Klein, H. J., & Polin, B. (2012). 14 Are Organizations On Board with Best Practices Onboarding? *The Oxford Handbook of Organizational Socialization*, 267.

Klein, H. J., Polin, B., & Leigh Sutton, K. (2015). Specific onboarding practices for the socialization of new employees. *International Journal of Selection and Assessment*, *23*(3), 263–283.

Klein, H. J., & Weaver, N. A. (2000). The effectiveness of an organizational-level orientation training program in the socialization of new hires. *Personnel Psychology*, *53*(1), 47–66.

Klonek, F. E., Kanse, L., Wee, S., Runneboom, C., & Parker, S. K. (2022). Did the COVID-19 Lock-Down Make Us Better at Working in Virtual Teams? *Small Group Research*, *53*(2), 185–206. https://doi.org/10.1177/10464964211008991

Kraus, S., Breier, M., & Dasí-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal*, *16*(3), 1023–1042. https://doi.org/10.1007/s11365-020-00635-4

Lee, S. K., Kramer, M. W., & Guo, Y. (2019). Social media affordances in entry-level employees' socialization: employee agency in the management of their professional impressions and vulnerability during early stages of socialization. *New Technology, Work and Employment*, *34*(3), 244–261. https://doi.org/10.1111/ntwe.12147

Mak, S., & Kozlowski, S. W. J. (2019). Virtual Teams. In R. N. Landers (Ed.), *The Cambridge Handbook of Technology and Employee Behavior* (pp. 441–479). Cambridge University Press. https://doi.org/10.1017/9781108649636.018

Morgan, J. T., & Halfaker, A. (2018). Evaluating the impact of the Wikipedia Teahouse on newcomer socialization and retention. In *Proceedings of the 14th International Symposium on Open Collaboration* (pp. 1–7). ACM. https://doi.org/10.1145/3233391.3233544

Murphy, M. M., Johnston, H. R., & Zwick, M. E. (2021). Staff Scientist Perspectives on Onboarding and Professional Development: A Case Study. *Journal of Biomolecular Techniques: JBT*, *32*(2), 74.

Olson, M. H. (1983). Remote office work: Changing work patterns in space and time. *Communications of the ACM*, *26*(3), 182–187.

Ortiz de Guinea, A., Webster, J., & Staples, D. S. (2012). A meta-analysis of the consequences of virtualness on team functioning. *Information & Management*, *49*(6), 301–308. https://doi.org/10.1016/j.im.2012.08.003

Rodeghero, P., Zimmermann, T., Houck, B., & Ford, D. (2021). Please Turn Your Cameras on: Remote Onboarding of Software Developers During a Pandemic. In *2021 IEEE/ACM 43rd International Conference 2021* (pp. 41–50). https://doi.org/10.1109/ICSE-SEIP52600.2021.00013

Rollag, K., Parise, S., & Cross, R. (2005). Getting new hires up to speed quickly. *MIT Sloan Management Review*, *46*(2), 35.

Saks, A. M., & Gruman, J. A. (2021). How do you socialize newcomers during a pandemic? *Industrial and Organizational Psychology*, *14*(1-2), 217–220. https://doi.org/10.1017/iop.2021.44

Schinoff, B. S., Ashforth, B. E., & Corley, K. G. (2020). Virtually (In)separable: The Centrality of Relational Cadence in the Formation of Virtual Multiplex Relationships. *Academy of Management Journal*, *63*(5), 1395–1424. https://doi.org/10.5465/amj.2018.0466

Schreier, C., Udomkit, N., & Matt, J. (2022). The effect of a mandatory work from home policy on respect, trust, and mutual obligations during the covid-19 pandemic in Switzerland. *ABAC Journal*, *42*(1), 237–257.

Taskin, L., & Bridoux, F. (2010). Telework: a challenge to knowledge transfer in organizations. *The International Journal of Human Resource Management*, *21*(13), 2503–2520.

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *14*(3), 207–222.

van Maanen, J. E., & Schein, E. H. (1979). Toward a theory of organizational socialization. *Research in Organizational Behavior*(vol 1), 209–264.

Waizenegger, L., McKenna, B., Cai, W., & Bendz, T. (2020). An affordance perspective of team collaboration and enforced working from home during COVID-19. *European Journal of Information Systems*, *29*(4), 429–442. https://doi.org/10.1080/0960085X.2020.1800417

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POTENTIAL USAGES OF VIRTUAL REALITY IN DESIGN RESEARCH AND PRACTICE – A REVIEW

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ABSTRACT: Besides application fields such as entertainment and marketing, the technology of Virtual Reality is also applied in research and practice, including domains such as automotive, architecture, and construction. Furthermore, VR has been utilized for several activities in design practice and design research. However, the impact of this technology on design as a profession remains to be investigated. Thus, in the present study, an integrative literature review is presented to investigate the potential impact of Virtual Reality on design research and design practice. The findings indicate potential advantages on different levels. VR has the potential to enhance problem identification due to laboratorial environments and to foster co-creation due to enhanced motivation and the establishment of synergies between the involved stakeholders. Furthermore, it supports prototyping activities due to its capabilities for realistic scaling and perspectives. And lastly, VR has proven to be advantageous for design evaluations and reviews due to its visualization and immersion potential. Drawbacks of using VR for design research and practice involve technical limitations such as restricted field of view, limited performance, but also aspects such as missing accuracy for prototyping and the absence of haptic feedback. Future work will involve an extended review involving further literature and application domains.

Keywords: *Virtual Reality, Design Practice, Design Research, Design Methods*

1. PURPOSE OF THE PAPER

Virtual Reality (VR) is defined as “the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.” (Oxford English Dictionaries, 2022).

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Eventhough the technology of VR already underwent a long way of development, it just entered the the end-user market less than a decade ago, with its majority applications in gaming and entertainment sector (Ivanova, 2018). Especially the COVID-19 pandemic had great impacts on digital domains such as the gaming industry and immersive technologies in a way that media and gaming consumption increased (Ellis et al., 2020). Still, VR is considered as a niche product but with great future potential both for consumers and enterprises (Deloitte, 2018).

Besides the entertainment industry, VR also finds its application in further domains such as marketing, military, healthcare and treatment, as well as industrial fields such as construction and automotive (Berg & Vance, 2016). In the automotive industry, for instance, VR is used among others for visualizations, driving simulation, design reviews throughout the product development, and ergonomic studies. One example for a marketing application in the automotive context is the “AUDI VR experience” that lets potential customers experience vehicles with any available specification and configuration with the help of head-mounted displays (HMD) (Audi, 2017).

Beyond that, VR already gained great releveance as research tool especially for exposure therapy, behavioural research and pedestrian research due to its advantages such as the conduct of experiments in safe and controlled environments, its flexibility in the creation of various scenarios, and great sense of immersion (Berg & Vance, 2016; Stadler, Cornet, & Frenkler, 2020b). Eventhough VR has already been utilized for creative tasks, participatory activities as well as tool for brainstorming, its impact on design research and design practice remains to be investigated. Thus, in the present paper, based on the analysis of a selection of 28 studies the potential impact of VR on design research and design practice is discussed.

2. KNOWLEDGE BASE

A knowledge base is shared to establish a basis for the literature review. The knowledge base covers and introduction to the topics of design practice and design research as well as an introduction to Virtual Reality and its distignuishement from other technologies such as Augmented Reality and Mixed Reality.

2.1 Design Practice

“Design is to design a design to produce a design.” (Heskett, 2002). This exaggeration from Heskett (2002) symbolizes the blurriness in defining the term “Design” as such. Moreover, the definition of the mentioned terminology including its goals, objectives, and application fields is not uniform and undergoes permanent changes (based on

Götzendörfer, 2014; Hauffe, 2008). In this context, Hirsch (2014) concludes that the blurriness of the term “Design” is a result of a missing uniform definition and its protection. Simon defines design as: “[…] courses of action aimed at changing existing situations into preferred ones” (Simon, 1996, S.111). Cross (2008) states that designers are usually confronted with very poorly defined problems (i.e., wicked problems or ill-defined problems) and that the task is to come up with a well-defined solution. In this paper, the term “Design” is defined as the activity a designer carries out to develop products, services, experiences and systems out of an underlying problem, need, or idea resulting in the fulfilment of user needs as well as the needs of all involved stakeholders. To achieve this, the designer must consider aspects such as technology, sociology, ergonomics, psychology, philosophy, finance, and ecology (based on Frenkler, 2020). While designing, designers usually follow a design process, however, there are various opinions on the definition of the design process with its stages and approaches, techniques, and operations (Archer, 1984; British Design Council, 2020; Bürdek, 2005; French, 1985; Heufler, 2004; Hirsch, 2014; Lawson, 2005; Pahl & Beitz, 1996; Stadler, 2021). Moreover, while going through the design process, designers usually execute activities such as researching, prototyping, evaluating, reviewing and presenting with the help of design methods (based on Gericke & Blessing, 2012; Martin & Hanington, 2012; Stadler, 2021; Wynn & Clarkson, 2018).

2.2 Design Research

There is no uniform understanding of the definition of the term “design research” (based on Cross, 2006; Dorst, 2008; Horváth, 2004; Koskinen et al., 2012; Sanders, 2008). For Cross (2006), design research means the development, articulation and communication of design knowledge. This design knowledge can be derived from the investigation of people, processes and products. Investigating people gives insight into design behaviour and design education. Examining processes is informative for design strategies, methodologies as well as tools. In this context, Cross (2006) explicitly states that due to advances of technologies, VR needs to be considered as a design tool in the future. Horváth (2001) also defines design research as "generating knowledge about design and for design” (p.2) (as cited in Blessing & Chakrabarti, 2009, p.5). Horváth (2004) further defines it as: "[…] the instrument of exploration, description, arrangement, rationalization, and utilization of design knowledge (Pugh 1990)”. *Figure 1* visualizes the understanding of the term design research for the current publication.

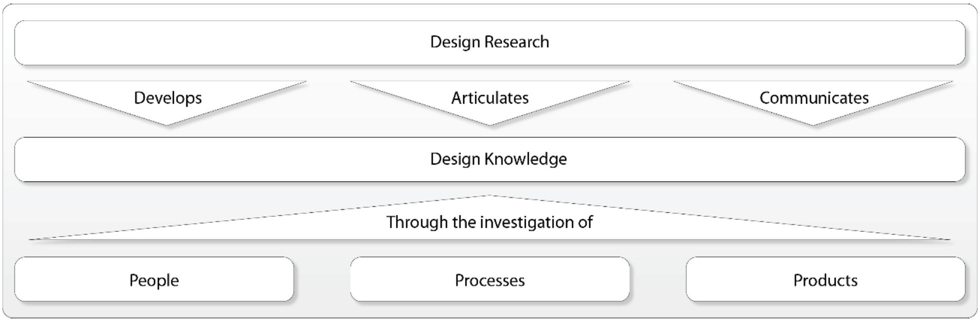

Figure 1. Design research (based on Cross, 2006)

Thus, in contrast to design practice that aims to create products, services, experiences, or systems, design research aims to develop, articulate, and communicate design knowledge that is derived through the investigation of people, processes, and products.

2.3 Virtual Reality

Considering the aforementioned definition of VR from the Oxford English Dictionaries (2022) as well as further definitions from (Cambridge Dictionary, 2022) that defines VR as “a set of images and sounds, produced by a computer, that seem to represent a place of situation that a person can take part in” and the definition of (Mihelj et al., 2013) who define VR as an interactive computer simulation that augments the user’s state in a way so that the user gets immersed in a virtual world, it becomes clear that there as a consensus of defining the term in many aspects. Based on a set of definitions of the term, for the present study VR is defined as “a computer-generated simulation that can be interacted with, consisting of images, videos, and/or sound that represents an environment that the view can experience by using electronic equipment”.

VR is considered as being part of Extended Realities (XR) that also comprise Augmented Reality (AR) and Mixed Reality (MR). While AR describes technologies that augment the visual field of users with digital information, MR is defined as a mixture between the real world and virtual world. Milgram and Kishimo (1994) defined a continuum for distinguishing the concepts of AR, VR, and MR (see Figure 2).

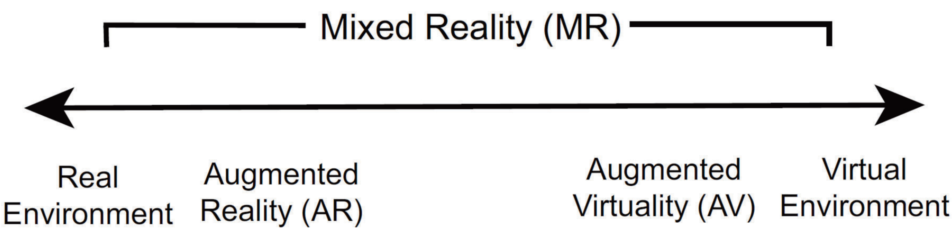

Figure 2. Relation of Extended Realities (Milgram & Kishimo, 1994)

In contrast to Milgram and Kishimo (1994), Rauschnabel et al. (2022) consider the letter "X" of the term XR as a placedholder arguing that VR does not extend reality but replaced it with digital content. *Figure 3* shows the definition of XR by (Rauschnabel et al., 2022), distinguishing the technologies into an AR-Continuum and VR-Continuum.

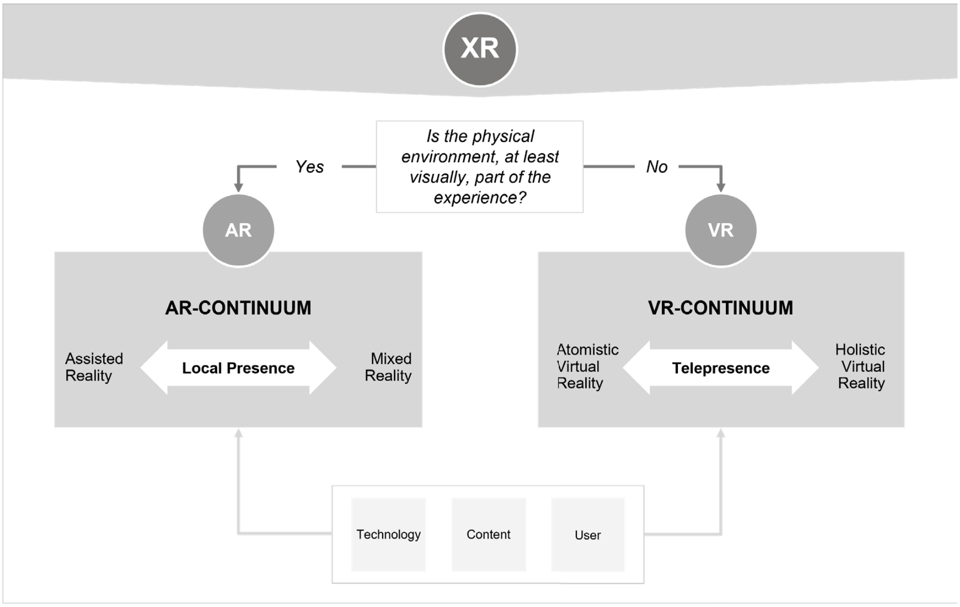

Figure 3. XR framework (Rauschnabel et al., 2022)

Especially in the last years, XR gets great attention since companies such as Meta Platforms (former Facebook), Microsoft and Apple are heavily investing in technologies such as Augmented Reality, Virtual Reality, and Mixed Reality (based on Boston Consulting Group, 2022). This fact shows the relevance and potential of theses technologies in our (near) future. However, especially considering the profession of design, the potential of XR technologies and especially VR is unclear yet. Thus, in the present paper, based on a review of literature in the domain of design practice and design research, the potential utilization of Virtual Reality will be assessed.

3. APPROACH

The methodology for the literature review is inspired by the model for integrative reviews of Snyder (2019) and Torraco (2005). Different research data bases such as scopus and google scholar were used in order to derive suitable literature. Inclusion criteria consisted of English language as well as the inclusion of the terms “design practice”, “design research”, “virtual reality” and further terms such as “co-creation”, “human-centred design”, and “design method”. Moreover, terms related to design activities, such as “ideation”, “prototyping”, “evaluating”, “design review” and “presentation” were included in the review. Criteria were defined in order to exclude literature not suitable for the present endeavour. The exclusion criteria included alternative definitions of the term “design” as well as the absence of a designerly nature of the publication (based on Cross, 2006). Overall 28 studies were included into the review. Based on the reviewed literature, core findings of using Virtual Reality in design research and practice are shared.

4. Findings

The findings are categorized in the activities that designers carry out during the design process and consist of problem identification, creative ideation, co-creation, prototyping, evaluation, as well as presentations and design reviews.

4.1 Virtual Reality for problem identification

There is a range of methods for identifying problems for existing products/systems, including interviews, questionnaires but also usability tests, heuristic evaluations, and cognitive walkthroughs. Especially for the identification of problems involving products with digital aspects, VR has already been utilized. Carlsson & Sonesson (2017) conducted VR user tests in the field of UX for automotive cockpits to evaluate UI concepts but also identify UI flaws/problems. The results indicate great advantages in the usage of VR due to its immersive and engaging experiences that could be visualized without physical prototypes. However, especially for problem identification activities in design research and design practice, literature is sparse, indicating that further research is needed to assess the impact that the technology of Virtual Reality can have on this specific design activity (based on Stadler, 2021).

4.2 Virtual Reality for creative ideation

Researchers already utilized Virtual Reality for creative activities such as brainstorming, creative three-dimensional sketching, designing moodboards, and conducting ideation workshops (Hamurcu et al., 2020; Israel et al., 2009). Rieuf & Bouchard (2017) developed a tool for designers in VR for creative sketching and the development of moodbards, two essential activities/methods during the development of design concepts. The researchers' findings suggest that VR in early stages of the design process can enhance emotional components of design activities and can lead to increased commitment of the involved designers regarding the task at hand. This also includes advantages related to VR such as experiencing 1:1 scales of 3D models and sketches, the ability to experience concepts out of various perspectives, as well as intuitive and natural interaction with the digital content. These results confirm implications drawn by Keeley (2018), who investigated sketching activities in Virtual Reality. The researcher also concludes that the technology allowed a greater sense of scales and perspectives when using VR.

Fromm et al. (2020) conducted a qualitative study consisting of VR brainstorming sessions in order to investigate the impact that the technology can have on negative group effects. The results show advantages of using VR for brainstorming sessions in terms of increased focus on the task as well as offering a relaxing digital environment to express ideas freely which led to a positive influence on idea generation. Another advantage of using VR in this context was the possibility to support geographically dispersed teams during the idea generation process.

4.3 Virtual Reality in co-creation

Current trends in designerly research and practices shift from company-centred activities towards user-centred approaches (Prahalad & Ramaswamy, 2004). Thus, instead of creating products for users designers increasingly design with users, resulting in advantages such as thorough understanding of user needs, increased efficiency as well as the establishment of synergies between users and designers (Prahalad & Ramaswamy, 2004).

In a co-creative design research study, researchers found out that by using VR, motivation and engagement of people was fostered. Furthermore, the technology of VR was advantageous over conventional methods in terms of feasibility of visualizing design concepts, and efficiency in terms of time and cost. Beyond that due to the usage of VR the roles of the involved designers shifted from being creators towards being coordinators and facilitators who helped people to express themselves and their needs (Stadler, Cornet, & Frenkler, 2020a). Furthermore, Bruno & Muzzupappa (2010) propose a participatory design approach for evaluating usability in the context of house appliances by allowing virtual interaction between the product and users in a virtual environment. The researchers conclude that VR is "[…] the best tool for satisfying the needs of a participatory design approach […]" that the usage of VR allows users to suggest interesting usability improvements during the design activity.

4.4 Virtual Reality for prototyping

Especially in the field of protoyping for hardware products, VR has already been utilized as an enhancements and sometimes even as a replacement for conventional Computer-Aided Design (CAD) applications such as Rhinoceros (2019) and 3ds Max (Autodesk, 2022). A range of researchers already investigated the impact of CAD and VR within the design process (Akca, 2017; Deb et al., 2017; Freeman et al., 2017; Stadler, Cornet, Mazeas, et al., 2020; Stark et al., 2010). The investigations indicate that the major advantages relate to the visualization and experience of 1:1 scales, realistic environments, engagement, and immersion. The major drawbacks of the technology of VR involve missing accuracy in the development of high-fidelity prototypes, restricted field of view, and the absence of haptic feedback (Berg & Vance, 2016; Bishop et al., 2001; Stadler, Cornet, Mazeas, et al., 2020).

By comparing commercially available CAD applications (desktop-based) with immersive applications for the creation of splines and volumes (VR), researchers found out that VR-based applications foster increased sense of scale, enhanced perspective when experiencing the volume models, as well as increased usability. Moreover, the usage of VR for the creation of volume models supported excitement and engagement while designing (based on Stadler, Cornet, Mazeas, et al., 2020).

4.5 Virtual Reality for evaluation

In order to evaluate design concepts, products or systems, VR has already been utilized as well, including methods such as usability testing, experience simulations, and user tests (Kumar, 2012; Martin & Hanington, 2012; Stadler, 2021; van Boeijen et al., 2014). Especially in application domains, in which physical prototyping is time-consuming and expensive, VR applications are frequently used for evaluating design concepts and design iterations.

Especially in the field of autonomous mobility, VR has been used in this context. In a range of studies, VR simulators were developed to evaluate communication concepts between autonomous vehicles and vulnerable road users such as pedestrians especially in ambiguous traffic situations such as at zebra crossings (Deb et al., 2017; Pillai, 2017; Stadler, Cornet, & Frenkler, 2019; Stadler, Cornet, Novaes Theoto, et al., 2019). In the domain of architecture, VR has been used. Kuliga et al. (2015) investigated the congruence in user experience between a real building and its digital twin. The researchers conclude that there are no significant differences in terms of user experience inside the real building and the immersive simulation, implying the suitability of using VR for such purposes.

4.6 Virtual Reality for design reviews and presentations

Due to its visualization potential, VR has already been used as a presentation and review tool of design concepts and products. Felip et al. (2020) compared product attributes of furniture presented in a real setting as well as in VR and investigated differences as well as equivalences. The researchers conclude that certain product attributes were better rated when being experienced in Virtual Reality, indicating the capabilities and potential advantages of using Virtual Reality for presentations and reviews.

Castronovo et al. (2013) evaluated immersive Virtual Reality systems for design reviews. The researcher conclude that aspects such as immersion and overall value of the VR system was rated high by the reviewers and that the usage of the technology for the design review allow users to interact with the virtual environment and its included objects in full scale and in a very intuitive way. In a patents and literature review, de Freitas et al. (2022) found out that VR is beneficial for design reviews and usability testings due to its enhanced capabilities to experience perspectives that stimulate insights, increased team engagement, improved and intuitive interactions, cost- and time- efficiency (especially for re-designs), but also increased safety for participants. Idenfitied limitations of using the technology for design reviews involved limited realism, latency issues, and communication challenges between the team members.

5. LIMITATIONS

The current investigation also involves a set of limitations. Firstly, a non-exhaustive selection of literature was reviewed and included in the study, preventing the derivation of robust results and generalizeability. Secondly, only few application domains for design activities were covered in the present study further limiting the generalization of the results.

6. CONCLUSION

In conclusion, the present literature review gives a small insight in potential usages that Virtual Reality offers for designers in design practice and design research, especially for activities such as problem identification, co-creation, prototyping, evaluation, as well as design reviews and presentations. As the review shows, the advantages of using Virtual Reality for design research and practice mostly lie in its capabilities to immersively visualize digital information which fosters motivation, engagement as well as understanding the products to be developed. Nevertheless, the utilization of using Virtual Reality in design also involves a set of limitations mostly related to technical disadvantages such as restricted field of view, limited resolution but also the absence of haptic feedback. Still, as long as these limitations are carefully considered and covered, VR has the potential to enhance a range of activities during the design process. Furthermore, as the technology of Virtual Reality matures, new application possibilities emerge for designers, implying that VR could become the next disruptive game changer for designerly activities. Future work will involve an extended literature review for using VR in design research and practice covering further application domains for designers.

REFERENCES

Akca, E. (2017). Development of Computer-Aided Industrial Design Technology. *Periodicals of Engineering and Natural Sciences (PEN)*, *5*(2), 124–127. https://doi.org/10.21533/pen.v5i2.86

Archer, B. (1984). *Systematic Method of Designers*. John Wiley & Sons Ltd.

Audi. (2017). *Audi startet Virtual Reality im Autohaus*. https://www.audi-mediacenter.com/de/pressemitteilungen/audi-startet-virtual-reality-im-autohaus-9270 (accessed 12.06.2022)

Autodesk. (2022). *3ds max - 3d modeling and rendering software for design visualization, games, and animation*. https://www.autodesk.com/products/3ds-max/overview (accessed 12.06.2022)

Berg, L. P., & Vance, J. M. (2016). Industry use of virtual reality in product design and manufacturing: a survey. *Virtual Reality*, *21*(1). https://doi.org/10.1007/s10055-016-0293-9

Bishop, I. D., Wherrett, J. A. R., & Miller, D. R. (2001). Assessment of path choices on a country walk using a virtual environment. *Landscape and Urban Planning*, *52*(4), 225–237. https://doi.org/10.1016/S0169-2046(00)00118-3

Boston Consulting Group. (2022). *The Corporate Hitchhiker's Guide to the Metaverse*.

British Design Council. (2020). *The Double Diamond: A universally accepted depiction of the design process*. https://www.designcouncil.org.uk/news-opinion/double-diamond-universally-accepted-depiction-design-process

Bruno, F., Mattanò, R. M., Muzzupappa, M., & Pina, M. (2007). Design for Usability in virtual environment. *Proceedings of ICED 2007, the 16th International Conference on Engineering Design*, *DS 42*(August), 1–12.

Bruno, F., & Muzzupappa, M. (2010). Product interface design: A participatory approach based on virtual reality. *International Journal of Human Computer Studies*, *68*(5), 254–269. https://doi.org/10.1016/j.ijhcs.2009.12.004

Bürdek, B. E. (2005). *Design - History, theory and practice of product design*. Birkhäuser – Publishers for Architecture.

Cambridge Dictionary. (2022). *Virtual Reality*. https://dictionary.cambridge.org/de/worterbuch/englisch/virtual-reality?q=Virtual+Reality

Carlsson, M., & Sonesson, T. (2017). *Using Virtual Reality in an Automotive User Experience Development Process*. Chalmers University of Technology.

Castronovo, F., Nikolic, D., Liu, Y., & Messner, J. (2013). An Evaluation Of Immersive Virtual Reality Systems For Design Reviews. *Proceedings of the 13th International Conference on Construction Applications of Virtual Reality, 30-31, December 2015*, 30–31.

Cross, N. (2006). Designerly ways of knowing. In *Designerly Ways of Knowing*.

Springer-Verlag London Limited. https://doi.org/10.1007/1-84628-301-9

Cross, N. (2008). *Engineering Design Methods: Strategies for Product Design*. John Wiley & Sons Ltd. https://doi.org/10.1016/0261-3069(89)90020-4

de Freitas, F., Mendes Gomes, M., & Winkler, I. (2022). Benefits and Challenges of Virtual-Reality-Based Industrial Usability Testing and Design Reviews: A Patents Landscape and Literature Review. *Applied Sciences*, *12*(3). https://doi.org/https://doi.org/10.3390/app12031755

Deb, S., Carruth, D. W., Sween, R., Strawderman, L., & Garrison, T. M. (2017). Efficacy of virtual reality in pedestrian safety research. *Applied Ergonomics*, *65*, 449–460. https://doi.org/10.1016/j.apergo.2017.03.007

Deloitte. (2018). *Digital reality: The focus shifts from technology to opportunity*. https://www2.deloitte.com/insights/us/en/focus/tech-trends/2018/immersive-technologies-digital-reality.html (accessed 12.06.2022)

Dorst, K. (2008). Design research: a revolution-waiting-to-happen. *Design Studies*, *29*(1), 4–11. https://doi.org/10.1016/j.destud.2007.12.001

Ellis, L. A., Lee, M. D., Ijaz, K., Smith, J., Braithwaite, J., & Yin, K. (2020). COVID-19 as ‘game changer’ for the physical activity and mental well-being of augmented reality game players during the pandemic: Mixed methods survey study. *Journal of Medical Internet Research*, *22*(12). https://doi.org/10.2196/25117

Felip, F., Galán, J., García-García, C., & Mulet, E. (2020). Influence of presentation means on industrial product evaluations with potential users: a first study by comparing tangible virtual reality and presenting a product in a real setting. *Virtual Reality*, *24*(3), 439–451. https://doi.org/10.1007/s10055-019-00406-9

Freeman, I. J., Salmon, J. L., & Coburn, J. Q. (2017). CAD Integration in Virtual Reality Design Reviews for Improved Engineering Model Interaction. *Proceedings of the ASME 2016 International Mechanical Engineering Congress and Exposition IMECE2016*, V011T15A006. https://doi.org/10.1115/imece2016-66948

French, M. (1985). *Conceptual Design for Engineers*. Springer Berlin Heidelberg.

Frenkler, F. (2020). *The Report. Industrial Design at the Technical University of Munich*. Technical University of Munich.

Fromm, J., Stieglitz, S., & Mirbabaie, M. (2020). The Effects of Virtual Reality Affordances and Constraints on Negative Group Effects during Brainstorming Sessions. *WI2020 Zentrale Tracks*, 1172–1187. https://doi.org/10.30844/wi_2020_k3-fromm

Gericke, K., & Blessing, L. (2012). An analysis of design process models across disciplines. *Proceedings of International Design Conference, DESIGN*, *DS 70*, 171–180.

Götzendörfer, M. (2014). *Untersuchung von Designprinzipien in Innovationsprojekten aus der Wissensperspektive*. Technical Unisersity of Munich.

Hamurcu, A., Timur, Ş., & Rızvanoğlu, K. (2020). An overview of virtual reality within industrial design education. *Journal of Engineering, Design and Technology*, *18*(6), 1889–1905. https://doi.org/10.1108/JEDT-02-2020-0048

Hauffe, T. (2008). *Design - Ein Schnellkurs [Design - A crash course]* (2nd editio). DuMont Buchverlag.

Heskett, J. (2002). *Design - A Very Short Introduction*. Oxford University Press.

Heufler, G. (2004). *Design Basics - From Ideas to Products*. Niggli Verlag AG,.

Hirsch, S. (2014). *Gestaltung und Umbruch - Industrie Design als Mittel sozioökonomischer Wertschöpfung*. Diplomica Verlag GmbH.

Horváth, I. (2004). A treatise on order in engineering design research. *Research in Engineering Design*, *15*(3), 155–181. https://doi.org/10.1007/s00163-004-0052-x

Israel, J. H., Wiese, E., Mateescu, M., Zöllner, C., & Stark, R. (2009). Investigating three-dimensional sketching for early conceptual design-Results from expert discussions and user studies. *Computers and Graphics*, *33*(4), 462–473. https://doi.org/10.1016/j.cag.2009.05.005

Ivanova, A. V. (2018). Vr & Ar Technologies: Opportunities and Application Obstacles. *Strategic Decisions and Risk Management*, *3*, 88–107. https://doi.org/10.17747/2078-8886-2018-3-88-107

Keeley, D. (2018). *The use of Virtual Reality Sketching in the conceptual stages of Product Design*. Bournemouth University.

Koskinen, I., Zimmermann, J., Binder, T., Redström, J., & Wensveen, S. (2012). *Design Research Through Practice - From the Lab, Field, and Showroom*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-385502-2.00001-8

Kuliga, S. F., Thrash, T., Dalton, R. C., & Hölscher, C. (2015). Virtual reality as an empirical research tool - Exploring user experience in a real building and a corresponding virtual model. *Computers, Environment and Urban Systems*, *54*, 363–375. https://doi.org/10.1016/j.compenvurbsys.2015.09.006

Kumar, V. (2012). *101 Design Methods*. John Wiley & Sons Ltd. https://doi.org/10.1007/s13398-014-0173-7.2

Lawson, B. (2005). *How designers think* (fourth edi). Elsevier/Architectural Press. https://doi.org/10.1016/0142-694X(81)90033-8

Martin, B., & Hanington, B. (2012). Universal methods of design: 100 ways to research complex problems. In *Develop Innovative Ideas*.

Mihelj, M., Novak, D., & Beguš, S. (2013). *Virtual Reality Technology and Applications* (S. G. Tzafestas (ed.)). Springer Science+Business Media. https://doi.org/10.1007/978-94-007-6910-6

Milgram, P., & Kishimo, F. (1994). A taxonomy of mixed reality. *IEICE Transactions on Information and Systems*, *77*(12), 1321–1329.

Oxford English Dictionaries. (2022). *Definition of Virtual Reality*. https://en.oxforddictionaries.com/definition/virtual_reality (accessed 12.06.2022)

Pahl, G., & Beitz, W. (1996). Engineering Design - A Systematic Approach. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9). Springer Science+Business Media. https://doi.org/10.1017/CBO9781107415324.004

Pillai, A. (2017). *Virtual Reality based Study to Analyse Pedestrian Attitude towards Autonomous Vehicles*. Aalto University.

Prahalad, C. K., & Ramaswamy, V. (2004). Co-creation experiences: The next practice in value creation. *Journal of Interactive Marketing*, *18*(3), 5–14. https://doi.org/10.1002/dir.20015

Rauschnabel, P. A., Felix, R., Hinsch, C., Shahab, H., & Alt, F. (2022). What is XR? Towards a Framework for Augmented and Virtual Reality. *Computers in Human Behavior*, *133*(May 2021), 107289. https://doi.org/10.1016/j.chb.2022.107289

Rhinoceros. (2022). *Rhinoceros*. https://www.rhino3d.com/ (accessed 12.06.2022)

Rieuf, V., & Bouchard, C. (2017). Emotional activity in early immersive design: Sketches and moodboards in virtual reality. *Design Studies*, *48*, 43–75. https://doi.org/10.1016/j.destud.2016.11.001

Sanders, L. (2008). An evolving map of design practice and design research. *ACM Interactions Magazine*, *XV.6*(Modeling Forum), 1–7. https://doi.org/10.1145/1409040.1409043

Simon, H. A. (1996). The sciences of the artificial, (third edition). In *Computers & Mathematics with Applications* (Third edit, Vol. 33, Issue 5). The MIT Press. https://doi.org/10.1016/S0898-1221(97)82941-0

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*(July), 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Stadler, S. (2021). *The Integration of Virtual Reality into the Design Process* [Technical University of Munich]. https://mediatum.ub.tum.de/?id=1612177

Stadler, S., Cornet, H., & Frenkler, F. (2019). Towards user acceptance of autonomous vehicles: A virtual reality study on human-machine interfaces. *International Journal of Technology Marketing*, *13*(3–4), 325–353. https://doi.org/10.1504/IJTMKT.2019.104601

Stadler, S., Cornet, H., & Frenkler, F. (2020a). Collecting People's Preferences in Immersive Virtual Reality : A Case Study on Public Spaces in Singapore ,. *Proceedings of the DRS2020*. https://doi.org/10.21606/drs.2020.308

Stadler, S., Cornet, H., & Frenkler, F. (2020b). Criteria Evaluation of a Virtual Reality Platform to Investigate People ' s Behaviour towards Autonomous Vehicles. *Driving Simulation Conference Europe 2020*.

Stadler, S., Cornet, H., Mazeas, D., Chardonnet, J.-R., & Frenkler, F. (2020). Impro: Immersive Prototyping in Virtual Environments for Industrial Designers. *Proceedings of the Design Society: DESIGN Conference*, 1375–1384. https://doi.org/10.1017/dsd.2020.81

Stadler, S., Cornet, H., Novaes Theoto, T., & Frenkler, F. (2019). A Tool, not a Toy: Using Virtual Reality to Evaluate the Communication between Autonomous Vehicles and Pedestrians. In M. C. tom Dieck & T. H. Jung (Eds.), *Augmented Reality and Virtual Reality*. Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-06246-0_15

Stark, R., Israel, J. H., & Wöhler, T. (2010). Towards hybrid modelling environments - Merging desktop-CAD and virtual reality-technologies. *CIRP Annals - Manufacturing Technology*, *59*(1), 179–182. https://doi.org/10.1016/j.cirp.2010.03.102

Torraco, R. J. (2005). Writing Integrative Literature Reviews: Guidelines and Examples. *Human Resource Development Review*, *4*(3), 356–367. https://doi.org/10.1177/1534484305278283

van Boeijen, A., Daalhuizen, J., & van der Schoor, R. (2014). *Delft Design Guide: Design Strategies and Methods*. https://arl.human.cornell.edu/PAGES_Delft/Delft_Design_Guide.pdf (accessed 12.06.2022)

Wynn, D. C., & Clarkson, P. J. (2017). Process models in design and development. *Research in Engineering Design*, *29*(2), 161–202. https://doi.org/10.1007/s00163-017-0262-7

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CONNECT.ME: A STEP TOWARDS HYBRID INTELLIGENCE

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ABSTRACT: Artificial Intelligence (AI) is drastically transforming the world around us. Rather than replacing humans, hybrid intelligence combines human and machine intelligence to leverage each of their individual strengths. We summarize different requirements and approaches identified to achieve hybrid intelligence and focus on conversational AI to build a cognitive agent that supports knowledge management within an organization. The agent automatically extracts knowledge from artifacts provided or published by the users. In addition, the knowledge base steadily grows while the agent talks to the users and the users provide feedback and the system is continuously learning to extract new types of entities and relations to answer more questions based on the knowledge graph and to access other sources of information. The first types of entities and relations extracted already support users in finding colleagues with relevant skills or interests. Based on information provided by the agent, collaboration among employees and, thus, knowledge sharing and transfer is encouraged. The collaboration between the cognitive agent as an AI artifact and employees combined with a system that learns and adapts while in use stressing explainability and trust in its answers entails a step towards hybrid intelligence.

Keywords: *Hybrid Intelligence; Conversational AI; Knowledge Management; Collaboration*

1. PURPOSE OF THE PAPER

Who is the right colleague to ask about a specific issue? How do I find interested colleagues with the right skills to join a team and collaborate on a project? Unless you know all your colleagues in person, these seemingly simple questions are often hard to answer and require intensive search. However, much of the knowledge needed to connect to other colleagues is available within our brains and documents.

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Gaining access to implicit knowledge to foster knowledge exchange and transfer is a key knowledge management task (Probst et al., 2000). Especially when employees are retiring or leaving an organization, it is crucial to prevent brain drain (Hofer-Alfeis, 2008). Specifically, supporting employees to find colleagues with relevant skills and interests and connect with them is a simple form of knowledge management because it encourages collaboration and, thus, knowledge exchange. Yet, externalizing implicit knowledge through interviews and debriefings (Hofer-Alfeis, 2008; Ayele & Jonathan, 2018) is tedious and time-consuming. Therefore, it is often the bottleneck hindering successful knowledge management.

This paper aims to illustrate how cognitive agents grounded on continuously enhanced knowledge graphs constructed based on state-of-the-art AI solutions and appropriate feedback mechanisms for quality assurance can be used to support organization and domain-specific knowledge management. In addition, a first use case indicates how this approach helps users find the right colleagues and fosters collaboration. It thus serves very well as a foundation and is a step towards hybrid intelligence.

2. RELATED WORK

Hybrid intelligence is achieved by combining human intelligence and artificial (machine) intelligence to achieve a level of intelligence concerning problem-solving and decision-making that is out of reach for either one intelligence alone (Akata et al., 2020). The authors identify collaboration, adaptability, responsibility, and explainability as the key research challenges in achieving hybrid intelligence and discuss the respective state-of-the-art and open issues (Akata et al., 2020).

Unless we face a super intelligence that pursues its own goals, we may focus on two types of collaboration: supportive and participatory (Cummings et al., 2021). The most common type is supporting humans by weak AI systems that solve well-defined specific tasks. In participatory solutions, the AI system (agent) integrates into a team and acts as a teammate. This requires an interface for human-computer interaction based either on natural language or other forms of communication. However, supportive AI systems may also benefit from natural language interfaces.

AI systems with a natural language interface are called cognitive or conversational agents, assistants, or chatbots. Yet, while the primary purpose of a chatbot may be considered to just chat, cognitive agents are assumed to pursue or solve a specific task for their users either because they are asked to, or they decide to do so based on their perception of the environment. More generally, from an AI perspective, we are dealing with conversational AI (Kulkarni et al., 2019; McTear, 2020).

The application of big language models has vastly pushed the limits of natural language understanding and generation and achieved impressive successes. For example, the models of the GPT-family (Brown et al., 2020) or the OPT-family (Zhang et al., 2022) with their transformers and attention mechanisms appear to produce reasonable answers to arbitrary questions in natural language. Are these models ready to serve as end-to-end solutions for conversational agents? Are they the solution to our problem at hand?

The results are impressive: They sound good and are hard to tell apart from human answers (Brown et al., 2020, Zhang et al., 2022, Thoppilan et al., 2022). At a closer look, however, some cases reveal that there does not seem to be proper human-level understanding, and some answers provided are neither correct nor consistent with the context provided or with previous answers. Hence, we do not want to rely on these answers in most business situations. Furthermore, accessing the source of the information or some explanation from a large language model is not very straightforward.

A remedy to this problem is grounding conversational AI on knowledge bases—be them general and publicly accessible or domain-specific and private (Dinan et al., 2018; Chaudhuri et al., 2021; Fu et al., 2022). We will follow an approach based on an organization and domain-specific knowledge graph to support knowledge management.

3. APPROACH

In this section, we provide a detailed description of our approach. Figure 1 shows the main components of our cognitive agent within the application domain (López-Cózar et al., 2014). As grounding the cognitive agent on an organization and domain-specific knowledge graph is crucial to our approach, we first focus on the knowledge graph construction process. We then briefly describe the natural language processing (NLP) tasks (shown in blue) for understanding user intents, response generation, and extracting relevant knowledge from selected sources. We continue with a discussion of the dialogue and solution inference engines and the feedback mechanism to improve knowledge quality as another crucial part of our approach. Finally, we briefly sketch our first knowledge management use case that fosters employee collaboration. To lower the barrier of using the cognitive agent, it is integrated as a bot in a messaging client that is used organization-wide.

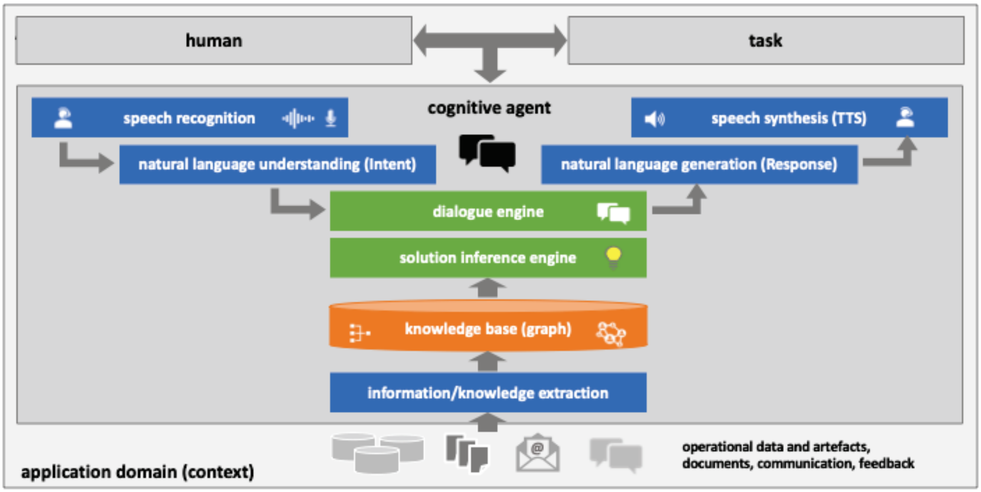

Figure 1. Main components of our cognitive agent and their interactions (based on López-Cózar et al., 2014).

3.1 Knowledge Graph Construction

The knowledge graph is the key component that stores and manages the externalized knowledge and, thus, the basis for answering any questions. There are two extreme ends to constructing knowledge graphs from data (Zhao et al., 2018): The top-down approach first defines an ontology consisting of schemata describing all relevant entity types and relation types. Subsequently, a knowledge graph is filled with entities and relations of the respective types extracted from relevant sources. By contrast, the bottom-up approach first extracts entities and relations as untyped objects and tries to identify appropriate types and structures in a follow-up step.

Initial experiments proved both extreme approaches to be infeasible for our application: Modelling an entire ontology upfront and ex-post integration and structuring of entities and relations are both very tedious and time-consuming. Furthermore, which entity types and relation types will be needed later at project kick-off is often unknown. There are parallels to data warehousing. A holistic modeling approach following the principles of Inmon (Inmon, 2005) is desirable but often infeasible in practice. By contrast, the approach following Kimball (Kimball & Ross, 2013) may have a higher risk of failing concerning schema integration. Hybrid strategies following the principle “think big, start small, grow step by step” are often successfully applied instead (SCN, 2013).

We follow this principle in our knowledge extracting and modeling process for constructing our domain and organization-specific knowledge graph, as shown in Figure 2. The goal is to create a fully typed knowledge graph with schemata for all relevant entities and relations. Rather than modeling the schemata upfront, they are iteratively identified and modeled. Thus, the knowledge graph is successively extended to cover entities and relations for further questions.

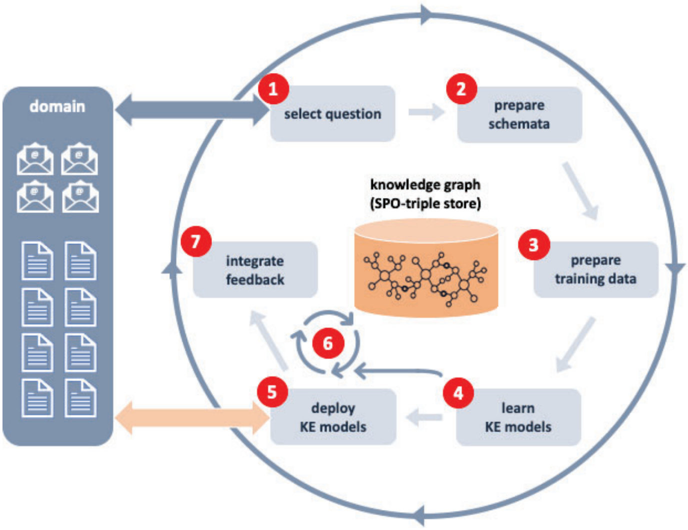

Figure 2. Iterative knowledge extraction and modeling process for constructing the knowledge graph.

In each iteration, a relevant question is selected (step 1), such as finding the right person to ask for an issue. Next, the entity and relation types required to answer the questions are identified and modeled appropriately (step 2). For any entity or relation type that does not already exist in the knowledge graph, a new knowledge extraction (KE) model must be constructed. This requires providing initial training data (step 3) and training or fine-tuning the model (step 4). Details regarding the NLP tasks involved in the KE models are described in the following section. The KE models are then deployed to extract entities and relations from existing data items (step 5). All KE models are continuously applied and monitored to extract entities and relations from new data items like ETL jobs in data warehousing (step 6). We assume that the extraction processes are error-prone and design the system to actively ask users for feedback based on confidence scores and deviations from expected content (step 7). The input is used to correct errors and fill missing values in the knowledge graph as part of the quality assurance loop. Finally, based on more and improved data, re-training of the KE models may be triggered (Shen et al., 2018). This allows early access to the results in any subsequent application and quick adaptation to changes in the data and the applications.

3.2 Natural Language Processing

Users may interact with the cognitive agent in written or spoken natural language. This requires several natural language processing (NLP) tasks to be addressed. For the sake of simplicity, we focus on text input and output. Standard pre-trained models for both text-to-speech recognition and speech synthesis work very well and will be added later. The remaining NLP tasks are understanding user intents, generating responses, and extracting knowledge from data sources in the knowledge graph construction process.

Given some examples for each intent, text classifiers to recognize intents can be fine-tuned based on pre-trained language models. The challenge is to define all relevant intents and trigger appropriate actions. The more intents that must be distinguished, the greater the risk of misunderstanding users. A feedback loop to assert correct understanding should be used to remedy this issue.

For specific intents that can be answered based on knowledge graph content, responses may be generated by following a set of rules. Natural language models conditioned on selected knowledge graph atoms may be used to get more response variability.

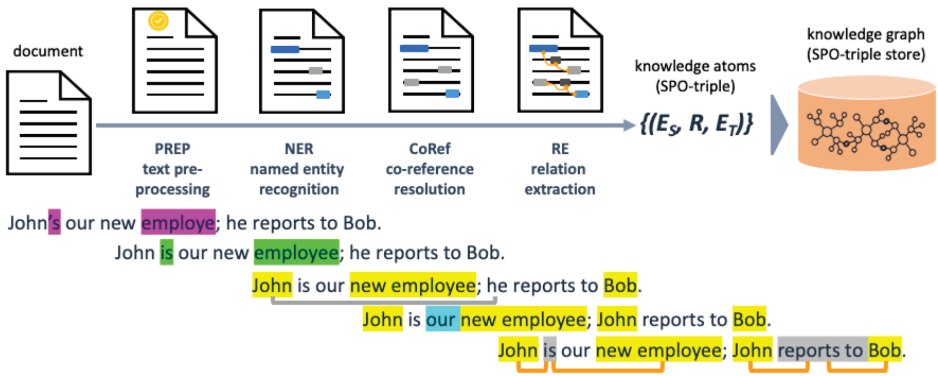

Figure 3. Knowledge extraction pipeline with relevant NLP tasks.

The knowledge extraction process heavily builds on different NLP tasks, as shown in Figure 3. Pre-trained models with fine-tuning for specific entities and relations are applied as described below. The goal of named entity recognition (NER) is to identify entities of a particular type, such as persons, locations, or organizations. For these generic entity types, numerous pre-trained models work well. However, fine-tuning to recognize domain-specific entities or adaption to specific entity types is required for domain-specific applications. The NER task is often tackled with deep learning approaches like bi-LSTM-networks or, more recently, with transformer-based networks in combination with a final conditional random field layer (Goyal et al., 2018; Panchendrarajan & Amaresan, 2018; Lothritz et al., 2020). Entity linking merges different entities if they refer to the same real-world object. Next, co-reference resolution (Co-Ref) attempts to substitute referencing words with the words they refer to. A well-known set of approaches mention pair models (Ng, 2017). Relation extraction (RE) identifies relevant relations between two entities. For this task, there are also well-known recurrent deep neural networks (Wang et al., 2021). All objects extracted are annotated with appropriate metadata such as recognition confidence, extraction timestamp, and source to enable quality assurance with user feedback.

3.3 Dialog and Solution Inference Engine

We follow the approach to ground the answers of the cognitive agent on knowledge bases to ensure more trustable and explainable responses. The primary source of information is the organization and domain-specific knowledge graph described above. Note, however, that it is not meant to be or remain the only source on which the cognitive agent is grounded. The solution inference engine may access different sources in a cascading schema of trust and decide if and how an answer is provided. As the initial agent is very limited in its abilities, it will tell its users if it cannot answer a question or lacks the required skill. Requests that cannot be handled well must be logged and trigger adaptation of the agent.

The dialogue engine glues together the communication with the users according to the perceived intents and context information provided and the solution inference mechanism. We currently use plain policy-based dialogue flows without the ability to learn conversation strategies. In addition to the communication triggered by users, the dialogue engine can initiate a conversation by itself to ask for feedback (see below).

3.4 Human in the Loop Feedback Mechanism

Typical usage scenarios of cognitive agents follow a pull strategy. Abstractly, users have an information need which they utter towards the agent. The agent recognizes the intent (NLU) in combination with context information, infers the answer, and creates a response. More advanced usage scenarios also have push strategies. On the one hand, this is relevant when the agent senses from the environment that a user needs help. On the other hand, we implement a feedback mechanism to engage the human in the loop to provide feedback. The agent keeps backlogs of entities and relations that should be checked. To create the backlog, each relevant object is assigned a quality score based on the recognition confidence of the knowledge extraction model, the age respectively last seen timestamp or the last queried timestamps, and the source. In addition, we plan to reduce any object's quality score in case appropriate anomaly detection or relation prediction methods flag the values observed as being suspicious. For entries in these backlogs, the agent actively requests user feedback used for quality assurance as described above. The KE models from the knowledge graph contraction process are reused to extract entities, relations, or attribute values uttered by users. Objects with a quality score below a predefined threshold are automatically put in their respective backlog at regular intervals. The dialog engine chooses items from the backlog based on the quality scores and specific users available for feedback at a given time. Finally, the quality is updated based on user feedback and may be removed from the backlog if the updated score is sufficiently large.

3.5 Knowledge Management Use Cases

The entire approach supports knowledge management by automatically extracting entities and relations stored to externalize implicit knowledge. In general, externalized knowledge is being used by the cognitive agent as a knowledge base to answer user queries. The content will also be used as input to other classical knowledge management approaches like expert interviews or debriefings.

The first selected question in the knowledge graph construction process focused on whom to ask for a specific issue. To answer this question, we extracted employees and their skills and interests from any available documents. First queries could be successfully answered based on similarity scores between the search phrases and the first knowledge atoms extracted. While the first results are promising, more content must be extracted and curated based on the quality assurance mechanism before an in-depth evaluation of the systems' capability to support further knowledge management tasks can be conducted.

Being able to recommend colleagues for specific issues or tasks is already a benefit. Even though a straightforward one, we already have an indirect form of knowledge transfer at this point. More importantly, direct knowledge transfer through collaboration among employees is encouraged by actively trying to connect them.

4. FINDINGS

When building organization and domain-specific cognitive agents, integrating individually constructed knowledge graphs helps provide an adaptive, explainable, and trustable solution. Especially for the latter, actively involving users to provide feedback is crucial to establish quality assurance with humans in the loop. Since both the vanilla top-down and bottom-up approaches to knowledge graph construction did not prove feasible, following the principle adopted from data warehousing to start small and grow step by step is also beneficial in our context. Addressing the problem of finding the right colleague for a given issue or joining a team enables direct knowledge transfer through collaboration and indirect knowledge transfer by externalizing formerly implicit knowledge in the knowledge graph.

5. RESEARCH IMPLICATIONS

The approach presented is only a first step towards hybrid intelligence and serves as an initial proof of concept on integrating and benefiting from cognitive agents, knowledge management, and humans in the loop for gaining feedback. However, bringing the right people together to solve single tasks or to form teams is a crucial challenge in organizations where not all members know each other in person. To achieve higher levels of hybrid intelligence, the agent will have to learn more skills such as accessing and providing context-specific information from different internal and external sources and, for example, actively participating in discussions or collecting current status information in daily project meetings. First, however, our focus is on extracting additional types of entities and relations as part of the iterative knowledge extraction and modeling process to support knowledge transfer among employees in an organization.

6. VALUE OF THE PAPER

We have presented a framework that indicates that the combination and orchestration of state-of-the-art NLP approaches together with explicit knowledge capture and appropriate actively triggered user feedback for quality assurance and data augmentation allows the construction of a domain-specific knowledge base on which cognitive agents should be grounded to provide more trustable and explainable answers.

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AUTHOR CONTRIBUTIONS

Both authors have contributed equally to the research and writing of the paper.

REFERENCES

Ayele, W. Y., & Jonathan, G. M. (2018). Debriefing for Knowledge Management. *BIR Short Papers, Workshops and Doctoral Consortium : Proceedings*, pp. 415–420. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-160463

Brown, T., Mann, B., Ryder, N., Subbiah, M., Kaplan, J. D., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell, A., Agarwal, S., Herbert-Voss, A., Krueger, G., Henighan, T., Child, R., Ramesh, A., Ziegler, D., Wu, J., Winter, C., Hesse, C., Chen, M., Sigler, E., Litwin, M., Gray, S., Chess, B., Clark, J., Berner, C., McCandlish, S., Radford, A., Sutskever, I., & Amodei, D. (2020). Language Models are Few-Shot Learners. *Advances in Neural Information Processing Systems (NIPS)*, 33, 1877–1901. Retrieved from https://proceedings.neurips.cc/paper/2020/file/1457c0d6bfcb4967418bfb8ac142f64a-Paper.pdf.

Chaudhuri, D., Rony, M. R., & Lehmann, J. (2021). Grounding Dialogue Systems via Knowledge Graph Aware Decoding with Pre-trained Transformers. ArXiv, https://arxiv.org/abs/2103.16289.

Dinan, E., Roller, S., Shuster, K., Fan, A., Auli, M., & Weston, J. (2019). Wizard of Wikipedia: Knowledge-Powered Conversational agents. ArXiv, https://arxiv.org/abs/1811.01241v2.

Fu, T., Gao, S., Zhao X., Wen J.-R., & Yan, R. (2022). Learning towards conversational AI: A survey. AI Open, Vol. 3, pp. 14-28, https://doi.org/10.1016/j.aiopen.2022.02.001.

Goyal, A., Gupta, V., & Kumar, M. (2018). Recent named entity recognition and classification techniques: A systematic review. *Computer Science Review*, Vol. 29, No. 1, pp. 21–43.

Hofer-Alfeis, J. (2008). Knowledge management solutions for the leaving expert issue. *Journal of Knowledge Management*, Vol. 12 No. 4, pp. 44-54, https://doi.org/10.1108/13673270810884246.

Inmon, W. H. (2005). *Building the Data Warehouse*. 4th Edition, Wiley Publishing.

Kimball, R., & Ross, M. (2013). *The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling*. 3rd Edition, John Wiley & Sons.

Kulkarni, P., Mahabaleshwarkar, A., Kulkarni, M., Sirsikar, N., & Gadgil, K. (2019, September). Conversational AI: An Overview of Methodologies, Applications & Future Scope. *In 2019 5th International Conference on Computing, Communication*, Control and Automation (ICCUBEA), pp. 1-7. IEEE.

López-Cózar, R., Callejas, Z., Griol, D., & Quesada, J. F. (2014). Review of spoken dia logue systems. Loquens, 1(2), e012. https://doi.org/10.3989/loquens.2014.012

Lothritz, C., Allix, K., Veiber, L., Bissyandé, T. F., & Klein, J. (2020). Evaluating Pre trained Transformer-based Models on the Task of Fine-Grained Named Entity Recognition. *In Proceedings of the 28th International Conference on Computational Linguistics*, pp. 3750–3760, Barcelona, Spain. Retrieved from https://aclanthology.org/2020.coling-main.334.pdf.

McTear, M. (2020). Conversational AI: dialogue systems, conversational agents, and chatbots. Synthesis Lectures on Human Language Technologies, 13(3), pp. 1-251.

Ng, V. (2017). Machine Learning for Entity Coreference Resolution: A Retrospective Look at Two Decades of Research. *In Proceedings of the Thirty-First AAAI Conference on Artificial Intelligence* (AAAI-17), pp. 4877–4884.

Panchendrarajan, R., & Amaresan, A. (2018). Bidirectional LSTM-CRF for Named En tity Recognition. *In Proceedings of PACLIC 2018*, S. 531–540.

Probst, G., Raub, S., & Romhardt, K. (2000). *Managing Knowledge: Buiding Blocks for Sucess*. 1st Edition, ISBN 978-0-471-99768-9, Wiley Publishing.

SCN Education B.C. (2013). Data Warehousing: The Ultimate Guide to Building Corpo rate Business Intelligence. Vieweg+Teubner Verlag.

Shen, Y., Yun, H., Lipton, Z. C., Kronrod Y., & Anandkumar, A. (2018). Deep Active Learning for Named Entity Recognition. *In Proceedings of the 2nd Workshop on Representation Learning for NLP*, pp. 252–256.

Thoppilan, R., Freitas, D., Hall, J., Shazeer, N., Kulshreshtha, A., Cheng, H.-T., Jin, A., Bos, T., Baker, L., Du, Y., Li, Y., Lee, H., Zheng, H., Ghafouri, A., Menegali, M., Huang, Y., Krikun, M., Lepikhin, D., Qin, J., & Le, Q. (2022). LaMDA: Language Models for Dialog Applications. ArXiv https://doi.org/10.48550/arXiv.2201.08239.

Wang, H., Lu, G., Yin, J., & Qin, K. (2021). Relation Extraction: A Brief Survey on Deep Neural Network Based Methods. *In Proceedings of the 4th International Conference on Software Engineering and Information Management* (ICSIM 2021), pp. 220–228.

Zhang, S., Roller, S., Goyal, N., Artetxe, M., Chen, M., Chen, S., Dewan, C., Diab, M., Li, X., Lin, X.V., Mihaylov, T., Ott, M., Shleifer, S., Shuster, K., Simig, D., Koura, P.S., Sridhar, A., Wang, T., & Zettlemoyer, L. (2022). OPT: Open Pre-trained Transformer Language Models. ArXiv, https://arxiv.org/abs/2205.01068v3.

Zhao Z., Sung-Kook H., & So I.-M. (2018). Architecture of Knowledge Graph Construc tion Techniques. *International Journal of Pure and Applied Mathematics* 118(19), pp. 1869–1883.

SPORTS MARKETING INNOVATION: INCREASING FAN ENGAGEMENT VIA INNOVATIVE STATISTICS FROM FACIAL EMOTION RECOGNITION

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ABSTRACT: Technology in football is increasingly used for decision making. Adoption, especially in Germany, has been slow. However, the benefits of data analytics for pre-, and post-match analysis have motivated decision makers to pay attention to the data science trend. Nowadays, football clubs from the third leagues or even amateur clubs are using technology to help them gain a competitive edge. Fan experience, both online and offline (home infront of the TV or at the stadium) is driving the next innovation stage in football. The study presented here is focused on testing and evaluation a facial recognition software on images from football coaches, just a few seconds after an important situation during the match has taken place (e.g., win, goal scored). We demonstrated that, in fact, emotion recognition software captures unexpected emotional reactions from coaches which could then be used to calculate interesting statistics and increase fan engagement and entertainment.

Keywords: *Emotion recognition; Football; Soccer; Ffan; Fan engagement; Sports marketing*

1. PURPOSE OF THE PAPER

"Football is a sport that is all about audience engagement" (Pearson, 2013, p. 1). Nowadays, football fans are used to get various statistical information (such as ball possession, passing accuracy or ball contacts) during a game broadcast. Broadcasters have been innovative in applying several technologies to add extra dimensions to the fans'

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TV experience in order to get them more engaged (Pearson, 2013). Since there is an increasing use of data analytics in football broadcasts as well as a rising demand for additional statistics by the spectators (Artmayr, 2002), experts seek to develop interesting new statistics in order to increase the fans' attachment (Engesser, 2016). Since most of the existing statistics are player-related, this study seeks to examine the possibility of providing entertaining new insights into the coaches' emotional states during the match to the spectators. Concerning this matter, especially the information that are surprising and unexpected to the spectators are interesting to them (Silvia, 2008). This means that particularly emotions that are unexpected in a specific game situation serve as a good basis for creating appealing statistical visualizations. Utilizing modern facial emotion recognition software, the relevant data can easily be captured in real-time during the match. Hence, the broadcaster can present the results to the TV spectators in the form of statistics to get them more engaged and offer a better overall experience (Parkinson, 2015).

The purpose of our study is the testing and evaluation of facial emotion recognition software in the context of football matches with a specific focus on the coaches. The evaluation focus is set on the capability of such software to deliver appealing data for producing statistics for entertainment and engagement purposes of football spectators.

To achieve our research goals, we test facial emotion recognition application with video material of football coaches in specific game situations. Afterwards, the application's results are compared to the emotions that are typically expected in that specific game situation to evaluate the system regarding its suitability for delivering interesting facts to the spectator.

2. RELATED WORK

Automatic facial recognition and emotion recognition systems find application in several areas. First, application areas of face recognition technologies are presented. One of the most important fields is *identity verification*. Especially in access control systems, face recognition is used to grant humans access to physical or virtual domains without the need of using physical keys or passwords. In contrast to such verification methods, which can be lost and/or forgotten, the face is always available and cannot be duplicated. Therefore, facial recognition experiences are increasingly used in e-banking and smart home systems (Joshi & Gupta, 2016). Automatic facial identity verification is also important for public security reasons and video surveillance systems. With its help, computer systems can automatically detect and identify potential criminals in a crowd of people as well as identify offenders on CCTV footage of crime scenes (Owusu, Zhan, & Mao, 2014; Zhao, Chellappa, Phillips, & Rosenfeld, 2003). One last example of face recognition software in identity verification purposes is video and image indexing (Hjelmås & Low, 2001) as it can be observed in iOS 10 (Wright, 2016). Other exemplary application areas of face recognition technology are digital cosmetics and gender classification (Yang, 2015), video conferencing systems (Hjelmås & Low, 2001) as well as marketing research (Dospinescu & Popa, 2016; Heuberger, 2016).

Secondly, application areas of facial *emotion recognition* are described. One important field is the development of smart Human Computer Interfaces (HCI). Hereby, the goal is to develop computer systems that can sense human emotions and adapt their reactions accordingly to the emotional state of the user (Brand et al., 2012; Pantic, 2015). Another important application area is medicine where emotion recognition technology can detect signs of pain in facial expressions, which is especially useful for patients being unable to express themselves verbally (Heuberger, 2016). It is also possible to capture pulse rates of patients via webcams (Keller, 2013; Poh, McDuff, & Picard, 2011), which tremendously supports modern Ambient Assisted Living concepts. Moreover, emotion recognition systems can ease interpersonal communication for handicapped people having difficulties to understand emotional states from facial expressions, such as persons with autism spectrum disorder (Smitha & Vinod, 2015). This technology is applied in customer research as well where knowledge about customers' emotions towards certain products can help companies prioritize their marketing investments. In the financial sector, this knowledge can be used to understand internal customer data, particularly in trading companies (Binali & Potdar, 2012). Other application areas are multimedia (e.g., gaming, music, and television), automobile safety (Bettadapura, 2012), as well as education (Binali & Potdar, 2012).

In summary, face recognition and emotion recognition technologies have a broad field of application. Nevertheless, their use in the field of sports has not been researched thoroughly. Therefore, our study tries to fill in this research gap.

3. METHODOLOGY

3.1 Formulation of hypotheses

As mentioned, situations are perceived as interesting when they are surprising or unexpected (Silvia, 2008). Our goal is to test whether a facial emotion recognition application delivers such unexpected results. Therefore, the following considerations are made.

Firstly, when a match develops in favor of the coach's team, for example, when his team scores a goal or wins the match, it is expected that the coach has positive emotions. When the software unexpectedly recognizes negative emotions, the results represent interesting facts to the spectators and can therefore be used as valuable statistics. Hence, hypothesis 1 (H1) can be stated as:

H1: There are cases where the software recognizes negative emotions (anger or sadness) on the coach's face even though there is a positive game situation (goal or win).

Secondly, the unexpected occurrence of positive emotions of a coach in negative game situations (e.g., goal against or loss) would also serve as an interesting statistic for the spectators. Thus, hypothesis 2 (H2) is declared as:

H2: There are cases where the software recognizes positive emotions (happiness or surprise) on the coach's face even though there is a negative game situation (goal against or loss).

The above mentioned situations are interesting for this study, as there is no added value by presenting facts to the spectators that are obvious to them. Thus, for example, the information that a coach is happy after his team scored a goal is quite natural to the fans and therefore perceived as rather boring. Statistical illustrations are valuable when they contain interesting data which would be the case if H1 and H2 are confirmed.

3.2 Research design

Our study follows the steps below:

1. Suitable video material was extracted from online sources, and videos were screened for positive game situations (goal or win) as well as negative game situations (goal against or loss).
2. Within a few seconds after the specific game situation, an image of the coach (with visible face) was captured using a screenshot tool. That way, 16 images of coaches' facial expressions in positive game situations and 16 images of coaches' expressions in negative game situations were captured, which serve as a basis for the emotion recognition analysis. Thus, the 32 image files were imported into the SHORE application, which recognizes the facial expressions and determines the emotional state of the coach.
3. The application's results were compared to the expected emotional state according to the game situation.

3.3. Tools

3.3.1. The SHORE software of Fraunhofer IIS

The software used for analysis is called SHORE, an acronym for Sophisticated High-speed Object Recognition Engine, and was developed by Fraunhofer IIS (Ruf, Ernst, & Küblbeck, 2011). In general, SHORE offers a flexible framework for detection tasks of objects consisting of a typical structure, whereby the focus lies on face detection and analysis, which is also used in this study (Ruf et al., 2011). SHORE offers robust, multiplatform-capable, real-time detection and tracking of in-plane (up to 60°) and out-of-plane rotated faces (up to 90°). Providing a face detection rate of over 90%, it represents a highly reliable technology (Heuberger, 2016).

Offering different engines, the software can be used for plain face detection or for more complex tasks such as gender classification, age estimation or emotion recognition (Ruf et al., 2011, p. 238). The latter engine is relevant for this work and is precisely called "Face + Eye Detection & Gender + Age + Expression Analysis". Working with still images, movies or live video streams, SHORE visualizes a bounding box of each face found in the specific frame as well as the location of the eyes. Most importantly, the software also calculates scores for four of the six basic emotions recognized on the face. These four recognizable emotional states are angry, happy, sad and surprised which serve as a basis for this research (Wagner, Andre, Lingenfelser, & Kim, 2011, p. 210).

3.3.2. Video material

The videos are from the UEFA European Championship 2016 in France and were obtained from the ZDF media library (ZDF, 2016). The reason behind choosing this source is that these so-called coachcam videos consist of three windows: one for each coach and one for the corresponding game situation. In this way, a clear assignment of the coach's facial expression and the specific game situation is possible, and the results are comparable because all videos are from the same tournament. The only problem that occurred in the video acquiring process was that the videos are not downloadable from the media library and are of really poor quality when acquired through other resources (if any). Thus, since SHORE can work with still images as well, a screenshot tool was used to capture the coaches' facial expressions in the particular game situation. The images were captured within a few seconds after the game situation, to ensure that the coach's emotion is related to the in-game events. Finally, around 40 videos were analyzed, which resulted in 32 images that were used for testing.

4. ANALYSIS

We tested two **positive situations**:

1) own team scoring a goal, and

2) winning the match;

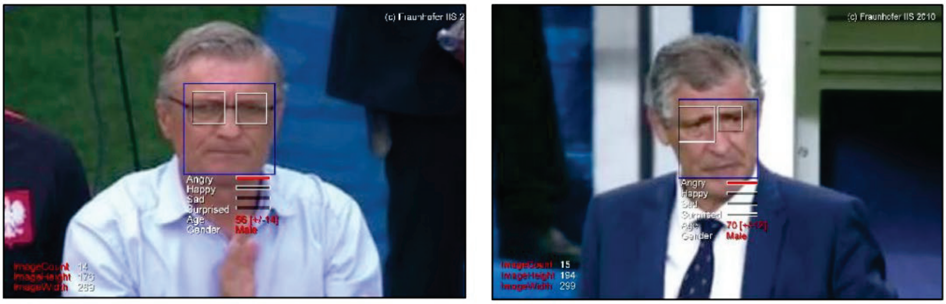
as well as two **negative situations**:

1) when a goal is scored against own team and

2) when own team loses the match.

For negative game situations, it is expected that the software recognizes negative emotions in the coaches' facial expressions, and vice versa.

An example of an unexpected emotion recognized by the SHORE application in the case of "own team scores a goal", is presented in Figure 1.



a) b)

Figure 1. Unexpected emotion (anger) when own team scores a goal

The results for all images analyzed for all four situations are presented in Table 1.

Table 1. Results of the testing

	Test image	Positive emotion (happy, surprised)	Negative emotion (angry, sad)
Positive game situation (goal)	1	X	
	2	X	
	3	X	
	4	X	
	5	X	

	6	X	
	7		✓
	8		✓
Positive game situation (win)	9	X	
	10	X	
	11	X	
	12	X	
	13	X	
	14	X	
	15		✓
	16		✓

Table 1. Results of the testing (continued)

	Test image	**Positive emotion (happy, surprised)**	**Negative emotion (angry, sad)**
Negative game situation (goal against)	17		X
	18		X
	19		X
	20		X
	21	✓	
	22	✓	
	23	✓	
	24	✓	
Negative game situation (loss)	25		X
	26		X
	27		X
	28		X
	29		X
	30		X
	31	✓	
	32	✓	

The grey shaded cells mark the unexpected outcomes which support the hypotheses, as described in section 3.1.

5. DISCUSSION

The software recognized four negative emotions in 16 examined positive game situations as well as six positive emotions in 16 negative game situations. Therefore, both hypotheses can be confirmed. With coaches showing unexpected emotions, our results show the potential of facial emotion recognition software to deliver interesting information to spectators, which can be visualized in the form of statistics by the broadcaster. The occurrence of unexpected emotions in specific game events could be a sign of unloading pent-up feelings. For instance, when a coach is angry about the playing style of his team, these emotions come up after a goal resulting in an angry facial expression. Another reason why unexpected emotions occur, might be that coaches try to overplay their emotions, for example when their team is outclassed by the opponent, they try to smile in order to hide their real anger. Interestingly, the results indicate that coaches rather tend to show positive emotions in negative situations than the other way around. This supports the idea that the coaches might try to put a good face on the matter. Visualizing such unexpected emotions in the form of statistical illustrations provides an opportunity for engaging the fans since they find surprising facts interesting (Pearson, 2013; Silvia, 2008). In this way, the fans can get an insight into the coaches' emotional states and therefore feel more involved into the match.

6. IMPLICATIONS

Research implications

Further research has to be conducted to validate the result of our study. More data should be tested, and several software applications should be compared. Since this testing used images of the game situations, experiments with real-time video streams have to be performed in order to realistically discuss options for usability during live matches. Furthermore, body language of coaches could be examined simultaneously. Future studies could consider the course of play to enhance the comparability of the results. Finally, market research should be carried out, to confirm the increasing demand for statistics of the coaches' emotional states.

Practical implications

The findings are useful for broadcasters of football matches because they propose a new technology to apply to increase fan engagement. Integrating such facial emotion recognition technology should be fairly easy and not especially costly for broadcasters. Interesting statistics can be calculated like, for example, the development of coaches' emotions during the game and present them to the TV audience. Another application area could be the support of the direction team, for example modified facial emotion recognition software could track the coaches' faces all game long and self-report striking emotional changes to the direction team, which they can then cut and show to the spectators. Since there are much viewed videos of coaches during the match, incorporating their emotions in real-time could make them more fascinating and entertaining. Certainly, the emotion recognition analysis can also be expanded to the players and thus information on their emotional development during the game can be collected and presented to the spectators. Furthermore, since sport gambling and betting has become an accepted part of the sport experience (Wann, Zapalac, Grieve, Partridge, & Lanter, 2015), bookmakers could use such statistics to develop a betting system based on coaches' emotions.

7. SUMMARY AND OUTLOOK

We investigated whether a facial emotion recognition application generates interesting data on the coaches' emotions in specific game situations. The idea is to present such data to the TV audience in the form of visualizations based on statistics for the purpose of increasing fan engagement. We found several unexpected results, with coaches showing positive emotions in a negative game situation and vice versa. Thus, facial emotion recognition technology can indeed be used in the context of sports marketing to increase fan engagement by providing interesting information about the coaches' emotions.

In the future, the use of technologies in football and sports in general will increase because the fans demand innovative entertainment approaches. Broadcasters have to rethink their technology portfolio in order to keep pace with their competitors. The importance of this issue is clarified by the emergence of more innovative technologies in football broadcasts, such as 360°-Streaming (Hoffmann, 2015) or Virtual Reality (Rentz, 2016). Facial emotion recognition applications might be the next big innovation in football broadcasts and might be indispensable in a few years. However, as with many other innovations, it remains open to see how the general audience would value it. This leads to future challenges for sports marketers, researchers, and computer scientists.

REFERENCES

Artmayr, J. (2002, December 26). Im Sport kommt es oft auf Zentimeter an. Der Standard. Online, from http://derstandard.at/1168711/Im-Sport-kommt-es-oft-auf-Zentimeter-an

Bettadapura, V. (2012). Face Expression Recognition and Analysis: The State of the Art (Technical Report). Georgia, US: Georgia Institute of Technology - College of Computing.

Binali, H., & Potdar, V. (2012). Emotion Detection State of the Art. In V. Potdar & D. Mukhopadhyay (Eds.), The CUBE International Information Technology Conference (pp. 501–507).

Brand, M., Klompmaker, F., Schleining, P., & Weiß, F. (2012). Automatische Emotionserkennung – Technologien, Deutung und Anwendungen. Informatik-Spektrum, 35(6), 424–432

Dospinescu, O., & Popa, I. (2016). Face Detection and Face Recognition in Android Mo bile Applications. Informatica Economica, 20(1), 20–28.

Engesser, S. (2016). Daten-Tool soll Fußball-Statistik revolutionieren. Online, from http://www.t-online.de/sport/fussball/id_78114264/packing-rate-fussball-statistik-sorgt-bei-em-2016-fuer-aufsehen.html.

Heuberger, A. (2016). SHORE - Pioneering Facial Analysis. Erlangen: Fraunhofer In stititute for Integrated Circuits. Online, from https://www.iis.fraunhofer.de/content/dam/iis/de/doc/il/bsy/bs/shore_pioneering_facial_ analysis.pdf

Hjelmås, E., & Low, B. K. (2001). Face Detection: A Survey. Computer Vision and Im age Understanding, 83(3), 236–274.

Hoffmann, M. (2015). Freed: Revolutionäre Streaming-Technologie erlaubt 360-Grad Rundumblick. Online, from Intel Deutschland GmbH: http://iq.intel.de/freed-revolutionare-streaming-technologie-erlaubt-360-grad-rundumblick/

Joshi, J. C., & Gupta, K. K. (2016). Face Recognition Technology: A Review. IUP Journal of Telecommunications, 8(1), 53–63.

Keller, D. M. (2013). Webcam captures pulse rates. Professional Engineering, 26(7), 8.

Owusu, E., Zhan, Y.-Z., & Mao, Q.-R. (2014). An SVM–AdaBoost-based face detection system. Journal of Experimental & Theoretical Artificial Intelligence, 26(4), 477–491.

Pantic, M. (2015). Automatic Analysis of Facial Expressions. In S. Z. Li & A. K. Jain

(Eds.), Encyclopedia of biometrics (2nd ed., pp. 128–134). New York: Springer.

Parkinson, G. (2015). 3 Sports Marketing Strategies To Engage Fans With Fresh Content. Online, from [3 Sports Marketing Strategies To Engage Fans With Fresh Content - Business 2 Community]

Pearson, I. (2013). The future of football. Futurizon & HTC.

Poh, M.-Z., McDuff, D. J., & Picard, R. W. (2011). Advancements in noncontact, multiparameter physiological measurements using a webcam. IEEE transactions on bio-medical engineering, 58(1), 7–11.

Rentz, I. (2016, August 26). Auftaktpartie wird in Virtual Reality übertragen - allerdings nicht in Deutschland. Horizont. Online, from http://www.horizont.net/tech/nachrichten/Fussball-Bundesliga-Auftaktpartie-wird-in-Virtual-Reality-uebertragen---allerdings-nicht-in-Deutschland-142314

Ruf, T., Ernst, A., & Küblbeck, C. (2011). Face Detection with the Sophisticated High-speed Object Recognition Engine (SHORE). In A. Heuberger, G. Elst, & R. Hanke (Eds.), Microelectronic Systems: Circuits, Systems and Applications (pp. 237–246). Berlin, Heidelberg: Springer.

Silvia, P. J. (2008). Interest - The Curious Emotion. Current Directions in Psychological Science, 17(1), 57–60.

Smitha, K. G., & Vinod, A. P. (2015). Facial emotion recognition system for autistic children: a feasible study based on FPGA implementation. Medical & Biological Engineering & Computing, 53(11), 1221–1229.

Wagner, J., Andre, E., Lingenfelser, F., & Kim, J. (2011). Exploring Fusion Methods for Multimodal Emotion Recognition with Missing Data. IEEE Transactions on Affective Computing, 2(4), 206–218.

Wann, D. L., Zapalac, R. K., Grieve, F. G., Partridge, J. A., & Lanter, J. R. (2015). An Examination of Sport Fans' Perceptions of the Impact of the Legalization of Sport Wagering on Their Fan Experience. UNLV Gaming Research & Review Journal, 19(2), 21– 40

Wright, A. (2016). Inside iOS 10: Examining the new smart Photos features. Retrieved December 04, 2016, from appleinsider: http://appleinsider.com/articles/16/09/22/inside-ios-10-examining-the-new-smart-photos-feature.

Yang, M.-H. (2015). Face Detection. In S. Z. Li & A. K. Jain (Eds.), Encyclopedia of biometrics (2nd ed., pp. 447–452). New York: Springer.

ZDF (2016). ZDF Mediathek: Coach-Cam Videos. Online, from ZDF: https://www.zdf.de/suche?q=coach+cam&from=&to=&sender=alle+Sender&attrs%20=#searchappendhttps%3A%2F%2Fwww.zdf.de%2Fsuche%3Fq%3Dcoach%2Bcam%2%206from%20%3D%26to%3D%26sender%3Dalle%2BSender%26attrs%3D%26page%3D2

Zhao, W., Chellappa, R., Phillips, P. J., & Rosenfeld, A. (2003). Face Recognition: A Literature Survey. ACM Computing Surveys, 35(4), 399–459

THE DIAS PROJECT – DEVELOPMENT OF AN INTELLIGENT DIGITAL ASSISTANT IN HIGHER EDUCATION ENVIRONMENTS

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ABSTRACT: The following paper will introduce the DIAS project (Digital Intelligent Assistant for Studying and Teaching) hosted at the University of Applied Sciences Ansbach, Germany. In this research project, a digital study assistant based on conversational Artificial Intelligence will be developed. To meet the multi-faceted needs of students in their day-to-day studies, the assistant will have four components: communicator, for answering questions, for conversation, and for mentoring; a planner, for performing time management and course planning; a motivator, for actively managing learning success; and an analyzer, for providing the necessary information about the student's study progress.

Keywords: *Digital study assistant; Digital education; Chatbot; Conversational AI*

1. PURPOSE OF THE PAPER

An efficient study organization serves as a basis for a successful study. However, during the Covid-19 pandemic, the procurement of information and support becomes more difficult for students. Moreover, most universities lack appropriate digital offers to continue to provide students without face-to-face teaching a full educational experience with the individual support they need.

A growing research interest in the field of digital assistants in recent years (Maedche et al., 2019), especially concerning the usage of conversational Artificial

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Intelligence (AI), opens up new possibilities to apply in the educational domain. Building on the promising opportunities, the DIAS project aims to develop a digital intelligent assistant for studying and teaching based on conversational AI. In this current German university research project, the digital assistant will have four main application areas: communicator, for answering questions, conducting conversations, and mentoring; a planner, for performing time management and course planning; a motivator, for actively managing learning success; and an analyzer, for providing the required information about the student's progress in the program. Overall, the AI-based assistant will accompany students, inform them, motivate them and enable them to better organize and successfully complete their studies. The open source-based development will be available for other universities and educational institutions.

The purpose of this paper is to summarize the DIAS project including its different components and to shed light on the planned integration into the existing university system. The rest of the paper is organized as follows. Section 2 reviews related work, whereas section 3 outlines the rationale for developing such a digital student assistant. Afterwards, the DIAS itself and its four components as well as the architecture are presented in detail in section 4. Finally, approaches for future work are illustrated in section 5.

2. RELATED WORK

Digital assistants are increasingly being used in educational contexts (Maedche et al., 2019). Universities expect the offer of such systems, especially due to the growing use of distance learning settings, to improve communication and the general learning experience between lecturers and students as well as to provide administrative support (Song et al., 2019). In general, an intelligent assistant can be understood as an AI system that is capable of conversing with users in natural language (Windiatmoko et al., 2020). They can respond to instructions and complete certain tasks or answer queries by finding and providing information (Chandraa & Suyanto, 2019).

Recent developments in the education domain have produced innovative digital assistants with different components and purposes. The majority of assistants focus on the communication components, which means that there are numerous chatbots that only focus on providing information by answering questions about various topics like application deadlines, exam results or general information about the university [e.g. Windiatmoko et al., 2020; Chandraa & Suyanto, 2019; Ranoliya et al., 2017). These systems require large amounts of data, which are available e.g. by connecting to a domain-specific database (e.g. collected FAQs of the university) (Galko et al., 2018) or by connection to the university website (Ait-Mlouk & Jiang, 2020). The creation of a knowledge graph (a network that represents relationships between real-world entities) is also conceivable (Tamayo et al., 2020). Moreover, assistants exist to support the execution of selected processes, e.g. in the application process or in the registration of courses (Chandraa & Suyanto, 2019; Hien et al. 2018). Another project investigates how students can be supported in achieving individual educational goals by processing data from e.g. learning management systems and data on individual learning and work behavior (Weber et al., 2021). In the future, the data-driven environment will be able to provide situation-appropriate hints, reminders, and recommendations, including local as well as externally offered courses and Open Educational Resources (OER) (Weber et al., 2021). In addition, there are also systems that support teaching. These include, for example, intelligent tutoring systems that impart knowledge through peer support modules and content quizzes (Song et al., 2019; Lai, 2011).

3. REASONS FOR A DIGITAL STUDY ASSISTANT

The reason for developing and implementing a digital student assistant at the university is conditioned by the following circumstances.

More than a quarter of all Bachelor students in Germany do not successfully complete their studies (Autorengruppe Bildungsberichterstattung, 2020). According to a recent study by the DZHW, students with a lack of motivation to study and a wait-and-see attitude are particularly at risk of dropping out (Heublein et al., 2017). This group of people in particular, but also other students, would benefit from assistance that supports and motivates them to actively self-manage and organize their studies.

In addition, the situation is changing due to the growing proportion of digital courses, such as in blended learning courses (a combination of personal instruction and computer-based learning), or currently due to the pandemic. Students have fewer opportunities to exchange ideas with each other and with their professors. In a study conducted in 2020 by the university's own Service Center for Digital Teaching and Didactics (SDL) on digital teaching at HS Ansbach, many professors complained that they can no longer address and motivate students in this setting as individually as before. It is to be feared that individual problems will be recognized later than before and that students are more likely to drop out.

Furthermore, students do not always clearly recognize which information can be found where. Sources that can be accessed around the clock are e.g. the student portal, learning platforms like Moodle and Ilias as well as the IT service portal and the university's homepage. For further questions or in case of individual difficulties, there is the possibility of counseling - in person, by e-mail or by telephone. An evaluation of the

2020 enrolment and application process at the HS Ansbach shows that students already have difficulties in obtaining information at the beginning of their studies (Hochschule Ansbach Studierendenservice, 2020). Specifically, a low level of comprehensibility and coordination of the various communication channels was criticized.

The Assistant is also intended to relieve advisors by answering routine questions with easy-to-find information that are frustrating for advisors and cost valuable consulting time. These questions should be answered more quickly by the Assistant in the future. Students have such questions around the clock, but until now it has often taken days to receive a mail response or professorial advice.

Against this background, Ansbach University of Applied Sciences would like to use an innovative, digitally-supported approach to better integrate its information and counseling services for students, make them clearly available, and further expand them.

4. INTRODUCTION TO DIAS

The assistant will be built in the form of a virtual assistant. It is generally designed to be open, so that different output channels ("frontends") can be integrated and users can access it on a website or through an app, for example. The back-end is equally open, so that the institution providing the service can integrate its individual information sources and channels. Although the service is initially designed for use in universities, it can in principle also be used by other education providers and in other scenarios.

The assistant is being developed in close cooperation with all stakeholders and tested as a model in two degree courses at the University of Applied Sciences Ansbach. An app and an information terminal which is intended to be installed on the campus are to be implemented as exemplary output channels After the project has been successfully completed, it is planned to implement it throughout the entire university.

The four key components of the DIAS (planner, communicator, analyzer and motivator) will help students as well as teachers and the administration in their daily study and working life.

Following shows supporting factors for the students:

- interactive and intelligent information assistance on the course of studies and teaching content
- identification of learning content, creation of learning plans, learning progress forecasts and evaluations
- guidance system for course and exam registration
- learning motivation with reminder and reward functions (success-coins)

- answers to individual questions, if necessary connection to the right advice/application office
- study progress forecast and early warning system

Further the supporting factors for the teacher and the administration:

- interactive and intelligent information assistance on study process, administrative procedures and documents.
- anonymous evaluation of learning progress and learning behavior
- efficient medium of information transfer by stored standard answers and content
- support of learning motivation through anchoring of learning objectives
- relief of email traffic and more time for individual support

By providing these various functions, DIAS will assist students in successfully completing their studies. It gives support for the key factors of information availability and interaction and tackles the too many barely coordinated communication channels. Implemented within different touchpoints (f.e. app or the university website) an additional implementation throughout a hologram is planned. Therefore an interactive construction will be placed at the university itself to increase the awareness at first and the active usage at second.

4.1. Components of DIAS

a) Communicator

The communicator component of DIAS basically refers to the function of a chatbot (see fig. 1). A chatbot should provide students with quick answers to routine questions at any time. For this purpose, teachers and administrators store quality-assured standard answers in advance. Therefore, a rule-based answer generation approach will be followed in the beginning. In a second expansion stage, the chatbot will be expanded to include AI-based answer generation in order to provide answers to individual questions. For this purpose, the bot makes use of various frameworks and methods from conversational AI, including Spacy, a library for programming tasks in Natural Language Processing (NLP) using Python and the RASA framework that is used to develop the assistant's infrastructure. If necessary, students will be connected to the relevant advice or application center. The chatbot is the communication hub between students, teachers, administration and the four modules of DIAS. In principle, the chatbot can be integrated into various communication channels in order to pick up the participants at familiar communication points. For example, it can be implemented on campus in a hologram or an info terminal to provide information on the spot. To create a personal connection, two- or three-dimensional avatars are envisaged as chat partners. An integration of the chatbot into WhatsApp, telegram or university websites is also conceivable. Regardless of this, the information procurement is always based on the same, uniform and quality-checked information pool.

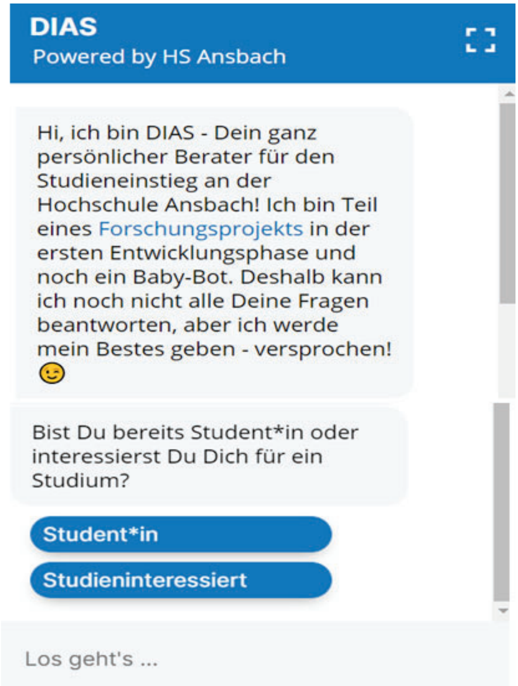

Figure 1. Communicator component

b) Planner

DIAS as a Planner will actively support students in their study planning and serve them as a versatile, interactive, and intelligent information assistant on the study process and course content. Students will be using the Planner to identify course content, create learning plans and register for courses and exams with the help of a guidance system. It is also planned to provide the student with a to-do list, a learning journal, and a goal tracker. Teachers and administrators will use the service to streamline processes, actively "feed" it with information and make documents available. On this basis, DIAS reminds students individually, for example, of the need to apply for a disadvantage compensation or of re-registration deadlines or of own defined goals and tasks. In its function as a planner and study organizer, DIAS also provides an AI-based question and answer system. With the help of intelligent search algorithms, students can ask DIAS content-related questions about the lecture, the course schedule, and their own status in the course.

c) Motivator

DIAS will be equipped with a motivating function based on gamification elements. Gamification elements are already known from various application contexts. Self-motivation apps are for example being used successfully in the areas of sports and health, but they are also increasingly used in education, for example in the form of platforms like Kahoot or in apps like Bubble or Duolingo. "Gamification of education is a developing approach for increasing learners' motivation and engagement by incorporating game design elements in educational environments." (Dichev & Dicheva, 2017). DIAS will provide the students with reward and success points that illustrate the achievement of learning objectives. If teachers anchor such learning objectives in the DIAS motivator, they can be treated like levels in games to encourage students to learn in a playful way. Push messages can be used to remind students to complete a unit, and success coins are credited when the unit is activated, or the goal is reached. Rank names similar to online communities, can also be introduced by marking progress with awards such as Ambassador, Super User, Special Matter Expert, etc.

d) Analyzer

Learning Analytics is an educational technology which can be used by students and by teachers. It collects the information of the learner and uses them to improve the learning by either helping the student to reflect on the learning progress or offering the teacher an actionable feedback function towards their students (Wollny et al., 2021).

Therefore, the DIAS is intended to enable as well a voluntary, AI-based determination of study and subject progress forecasts. The forecast should realistically show students risks in their study progress and act as an early warning system if necessary. For example, the usage for the students could be the receiving of an early warning if they are unlikely to achieve the required ECTS by the end of the semester if their performance remains unchanged. Such developmental analyses could help to reduce failure rates in the short term. However, the analyzer should also support teachers directly. The usage for the teacher can be, for example, to have an anonymous evaluation of the learning progress of the course participants to track the current learning status, optimize their courses or offer supplementary learning paths and materials in the sense of constructive alignment. The AI can also give them recommendations for this. In the future, support for agile forms of teaching is also conceivable.

To implement these functions a connection towards different databases will be made. In order to obtain the information about each student's progress and grades, it is necessary to connect to a university database that contains the relevant data about each student. Collecting this information can reveal, for example, missing ECTS and missing courses.

In addition, the connection to the learning platform "Moodle" is made in order to connect the different courses and the existing course content. Moodle offers a platform which is used by students and teachers equally to provide and access course material and course tasks. It can be used as a learning environment and to offer different tasks and learning objectives (Moodle, 2022). Using this function data can be received about the learning progress and therefore the probability of success within the course. Therefore further functions are already existing, e.g. tasks with a grading system can be included to monitor the study progress as well as additional plugins are available which includes softwares that provide tools like flashcards or a documentation tool (H5P, 2022). Which tools and plugins are the most relevant to use still needs to be determined but promising options seem to be available.

4.2 ARCHITECTURE

The following figure (fig. 2) shows the planned architecture of DIAS. The data collection is based on the connection to existing systems such as the grading system Primuss, a student eFile, module handbooks as well as the existing administration system. The architecture is based on Data Privacy by Design which means data protection by technical design. The idea behind this is that data protection is best observed in data processing operations if it is already technically integrated when they are designed (Cavoukian, 2022). As mentioned, DIAS will have the four components communicator, planner, motivator and analyzer which will mainly offer services as a digital assistant for study process and execution, for learning content and motivation, for an early warning system and study progress forecast, for study management and for provision of information. The underlying technologies of these services will be Machine Learning and Artificial Intelligence including a question answering system, a knowledge-based rule system, Natural Language Processing and Understanding as well as Blockchain as an incentive system. The recipients of these services will be students as well as lecturers and study program directors. But it also reduces the workload of academic advisors, for example through the communicator who handles routine questions of students. Possible communication channels include messenger services such as Telegram and WhatsApp, a degree program or university app, teaching and learning systems such as Moodle, and the university website.

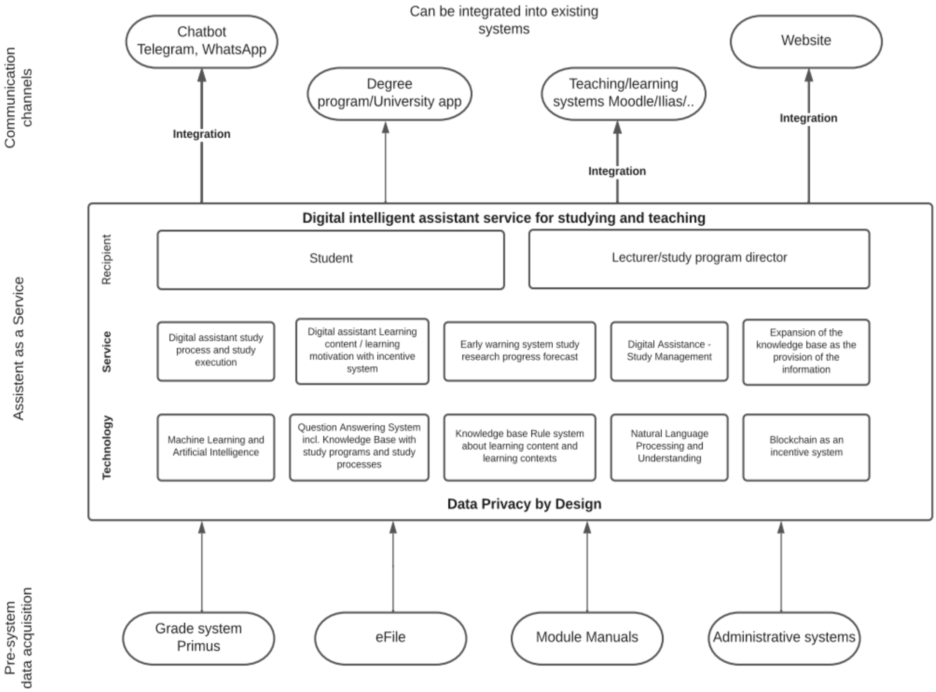

Figure 2. Architecture of DIAS

5. FUTURE WORK

The project is guided by the CRISP-DM process model with its six phases/work packages. Within the individual work packages, an agile approach based on SCRUM is used. The goal is to create a minimum value product in each of the defined SCRUM sprints (time-defined work phases). The approach of developing such a minimum usable product for the stakeholders per iteration cycle ensures rapid usability and evaluation.

At this stage several work packages are simultaneously in process to ensure constant development and improvement. Therefore, the work packages which include business understanding, data understanding, data preparation and modeling are not finished yet and will be developed further in future.

This is connected to the evaluation phase of the constructed models which is processed hand in hand with the modeling, for the effectiveness and accuracy. The evaluation of the AI methods is based on effectiveness indicators such as the accuracy of forecasts and the error rate of the results based on historical data. It contains the core of the DIAS system and its artificial intelligence.

The future will be the deployment, where an exemplary implementation of a frontend by an iOS or Android app, an exemplary integration into a chatbot of the student service or into a teaching or learning system such as Moodle is created. Furthermore, processes will be developed for the creation of a service and a support environment as well as the establishment and definition of further development and adaptation activities. The deployment approach is step-by-step as well as agile and iterative. The effectiveness of the overall system will be evaluated during the three-semester trial phase. Feedback will be collected in a biannual survey and various key figures will be defined and evaluated, such as the dropout rate, the failure rate, and the student satisfaction scale.

At last a preparation for the university-wide implementation and transfer will be intended. For this purpose, a guideline for the implementation of DIAS in different environments will be developed. Project results will be presented at appropriate events, e.g. scientific congresses and working meetings of Bavarian universities.

REFERENCES

Ait-Mlouk, A.; Jiang, L. (2020). KBot: A Knowledge Graph Based Chat Bot for Natural Language Understanding Over Linked Data. *IEEE Access*, *8*.

Cavoukian, A. (2022, April 20). Privacy By Design. https://privacysecurityacademy.com/wp-content/uploads/2020/08/PbD-Principles-and-Mapping.pdf.

Chandraa, Y.; Suyanto, S. (2019). Indonesian Chatbot of University Admission Using a Question Answering System based on Sequence-to-Sequence Model. *4th International Conference on Computer Science and Computational Intelligence, Procedia Computer Science*, *157*.

Dichev, C., & Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education*, *14*(9).

Galko, L.; Porubän, J.; Senko, J. (2018). Improving the User Experience of Electronic University Enrollment. *2018 16th International Conference on Emerging eLearning Technologies and Applications (ICETA)*.

H5P. (2022, April 20). Examples and Downloads. https://h5p.org/content-types-and-applications

Heublein U.; Ebert, J.; Hutzsch, C.; Isleib, S.; König, R.; Richter, J.; Woisch, A. (2017). Zwischen Studienerwartung und Studienwirklichkeit. *DZHW Forum Hochschule*.

Hien, H.; Cuong, P.; Nam, L.; Nhung, H.; Thang, L. (2018). Intelligent Assistants in Higher- Education Environments: The FIT-EBot, a Chatbot for Administrative and Learning Support. *Ninth International Symposium on Information and Communication Technology*.

Hochschule Ansbach Studierendenservice Abt. 1-Imma (2020). Immatrikulation und Bewerbung 20202-BA.

Hrsg. Autorengruppe Bildungsberichterstattung (2020). Bildung in Deutschland 2020. wbv Media, Bielefeld 2020.

Lai, K.-W. (2011). Digital technology and the culture of teaching and learning in higher education. *Australasian Journal of Educational Technology*, *27*(8).

Maedche, A.; Legner, C.; Benlian, A.; Berger, B.; Gimpel, H.; Hess, T.; Hinz, O.;

Morana, S.; Söllner, M. (2019). AI-Based Digital Assistants: Opportunities, Threats, and Research Perspectives. *Business & Information Systems Engineering*, *61*.

Moodle. (2022, April 20). Lernerfolg mit Moodle. https://moodle.de

Ranoliya, B. R.; Raghuwanshi, N.; Singh, S. (2017). Chatbot for university related FAQs. *International Conference on Advances in Computing, Communications and Informatics (ICACCI)*.

Song, D.; Rice, M.; Oh, E. (2019). Participation in Online Courses and Interaction with a Virtual Agent. *International Review of Research in Open and Distributed Learning*, *20*(1).

Tamayo, P.; Herrero, A.; Martin, J.; Navarro, C.; Tránchez, J. (2020). Design of a chatbot as a distance learning assistant. *Open Praxis*, *12*(1).

Weber, F.; Schrumpf, J.; Thelen, T. (2021). Development of a Digital Goal Setting Companion for Higher Education. In: Kienle, A., Harrer, A., Haake, J. M. & Lingnau, A. (Hrsg.). *DELFI 2021*. Bonn: Gesellschaft für Informatik e.V., (109-114).

Windiatmoko, Y.; Hidayatullah, A.; Ahmadi, R. (2020). Developing FB Chatbot Based on Deep Learning Using RASA Framework for University Enquiries. *ICITDA Conference Batch 3*.

Wollny, S., Schneider, J., Di Mitri, D., Weidlich, J., Rittberger, M., & Drachsler, H. (2021). Are We There Yet? - A Systematic Literature Review on Chatbots in Education. *Frontiers In Artificial Intelligence*, *4*.

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A REVIEW OF THE USE OF MACHINE LEARNING TECHNIQUES IN ECO-INNOVATION RESEARCH

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ABSTRACT: Machine learning is a powerful tool used across research all over the world. Machine learning algorithms are a form of artificial intelligence that allows more accurate predictions of causal conditions of all kinds, being able to analyze complex data samples beyond what a human could do. Machine learning mimics human reasoning by creating a neural network, and this has proven to be a useful technique to solve complex problems.

The thread of climate change is one of the most complex problems that humanity is currently facing. On one hand, we need the industries and the market to continue to function to guarantee covering the needs of the population, and its continued development. On the other hand, this development must guarantee the conservation of the planet and its habitability conditions, which are essential for the continued existence of a world to be left to future generations. Reducing the harmful effects that business-related activities have on the natural environment is key to guarantee a sustainable future, and this done, among other elements, through eco-innovation techniques.

Therefore, both machine learning and eco-innovation are striving topics across researchers nowadays, but: Are these two topics linked to each other? Is machine learning used as a tool to support a better understanding of eco-innovation (i.e., environmental innovation)?

This review aims to understand what is the role that machine learning has in the context of eco-innovation.

Results show that machine learning is not a widely used technique in the field of eco-innovation research and that there is a wide spectrum of research in which machine learning could be used in the future alongside the increasing research linked to eco-innovation.

Keywords: *Machine learning; Sustainability; Innovation; Eco-innovation; Environmental innovation*

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1. PURPOSE OF THE PAPER

The purpose of this paper is to better understand how machine learning is used in the context of research linked to eco-innovation through an analysis of bibliometric results.

Eco-innovation and environmental innovation practices are those that meet the demand of quality and sustainable products and services, using innovations, and while protecting the environment (Martínez-Pérez, García-Villaverde, and Elche, 2015).

Eco-innovation (i.e., environmental innovation) is key to be able to reach the sustainable development goals set out by global leaders. Nevertheless, sustainability comes along in many dimensions and through the entire value chain of processes and products. Depending on factors such as the economic sector, the geographical location, the characteristics of the infrastructure, the availability of resources or the R&D budget environmental orientation may be approached differently by each specific firm. As the saying of Ortega y Gasset goes, “I am myself and my circumstances”: Each company has a specific situation and its orientation towards environmental practices may defer depending on the company’s external and internal factors. Environmental innovation of companies comes through many perspectives and may be done differently for each firm, presenting complex datasets where many characteristics and potential causal conditions to trigger or block eco-innovation practices are present, with a high difficulty to analyse the firms’ characteristics, external and internal factors.

On the other hand, machine learning is defined as leveraging on artificial intelligence and statistics among other topics, is designed to emulate learning from evidence and “train” algorithms so that they learn from the dataset automatically (Jordan and Mitchell 2015, El Naqa and Murphy, 2015). It is therefore useful to analyse bid datasets with numerous factors, which would be impossible to analyse manually by humans.

In consonance with this, we propose to research whether machine learning is used as a tool to support a better understanding of eco-innovation (i.e., environmental innovation). In principle, the high complexity of eco-innovation research including a wide range of external and internal factors, and the complex datasets, suggests that machine learning may be a viable tool to address eco-innovation research.

This paper aims at understanding what is the current use of machine learning to promote a better understanding of the triggers, barriers, and characteristics of eco-innovation. The paper will provide clarity regarding the who researchers may use machine learning algorithms in the context of environmental innovation and eco-innovation research.

2. RELATED WORK

Machine learning is one of the key methodologies used across wide scope of sectors and economic activities. Machine learning are computational methods, where past information is analyzed to make accurate predictions or improve performance (Mohri, Rostamizadeh and Talwalkar, 2018; Wang et al., 2016) and a data sample is studied to develop a set of algorithms to make accurate predictions of the future. In order words, machine learning can also be defined as an "evolving branch of computational algorithms that are designed to emulate human intelligence by learning from the surrounding environment" (El Naqa and Murphy, 2015). As discussed by Jordan and Mitchell (2015), overall, machine learning allows computers to improve by-themselves, without requiring human intervention, through their own experience. It aims at improving decision making across industries (e.g., manufacturing, healthcare etc.) based on the analysis of evidence.

As described by Mohri, Rostamizadeh and Talwalkar (2018), the larger the sample, the easier the task is. It is key to understand the complexity of the topic and to collect the information accordingly. Without having sufficient data, the learner cannot properly analyze the solutions and would make an arbitrary choice among several options as they all seem like good solutions. On the other hand, it is also possible that over complex models may lead to complicated boundaries, entangling the analysis for the learner (Wang et al., 2016).

One use case for analysis employed in machine-learning is "basket analysis", which is, for example, finding associations between products bought by customers. As described by Alpaydin (2020), machine learning can be used to study the conditional probability of the form $P(X|Y)$ where Y is the product, for example in the case of a supermarket, and X are the products that the customers have already purchased (e.g., how many of the customers who buy wine also buy cheese). Machine learning can be used in a similar way to study the characteristics of a company with X characteristics to understand what the conditional probability for Y is, for example in this case, integration of environmental considerations into innovation. Also, it would allow the study of the association between product (good or service), process, organizational or marketing innovation and their related environmental characteristics. Additionally, the relationship between the factors driving environmental innovation and the types of innovation.

Also following the guidelines presented by Alpaydin (2020), it is possible to introduce a third element to showcase the characteristics of the company (i.e., company size, sector etc.), to integrate company's attributes into the association analysis. In this case, the form would $P(X|Y, D)$, where D is the set of company attributes.

3. METHODOLOGY

The database Scopus was used to explore the application of machine learning techniques to study eco-innovation.

Scopus is the world's largest abstract and citation database, and it can be used to monitor and measure research since it contains a wide scope of peer-reviewed literature such as papers of scientific journals, conference proceedings, and scientific books. (Baas, Schotten, Plume, Côté, and Karimi, 2020; Schotten, Meester, Steiginga, and Ross, 2017).

Several queries were performed to understand the role of machine learning in the context of eco-innovation research based on the publications' combinations of keywords. The method used is presented in Figure 1.

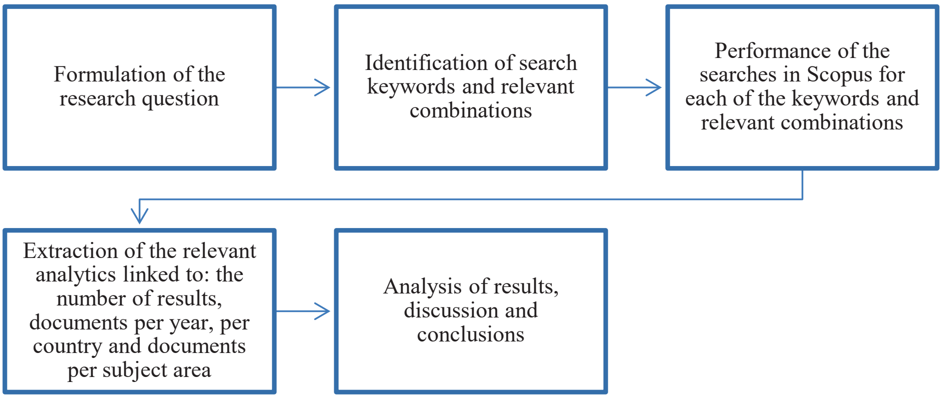

Figure 1. Research methodology

Regarding the formulation of the research question, the key element of this study is to understand whether machine learning is used in the context of eco-innovation research. Since, as described in the previous sections, eco-innovation research having often a complex set of parameters and large scope of elements to analyse, at first glance, make machine learning an ideal tool for this type of research.

Within this context, the research question of this paper is: Is machine learning used as a tool to support a better understanding of eco-innovation (i.e., environmental innovation)?

The key words selected for the search aimed at understanding the existing literature where one or several topics were present.

Table 1. Keywords used for the search

Keyword(s)	Rationale
Machine learning	Understand the total volume of literature linked to "machine learning", where "machine learning" is material to the published research as it is included as a keyword. Please note, terms such as "artificial intelligence" or "AI" were not included in the search as "machine learning" is a type of AI (Allegra et al., 2022) and therefore all article linked to machine learning is by definition also linked to artificial intelligence.
Innovation	Understand the total volume of literature linked to "innovation", where "innovation" is material to the published research as it is included as a keyword.
(Environmental innovation) OR Eco-innovation	Understand the total volume of literature linked to "eco-innovation" or "environmental innovation", where "eco-innovation" or "environmental innovation" is material to the published research as it is included as a keyword and are both terms used interchangeably referring to innovation with environmental considerations
Environmental innovation	Understand the total volume of literature linked to "environmental innovation", where "environmental innovation" is material to the published research as it is included as a keyword.
Eco-innovation	Understand the total volume of literature linked to "eco-innovation", where "eco-innovation" is material to the published research as it is included as a keyword.
Innovation AND Machine learning	Understand the total volume of literature linked to "innovation", and "machine learning", where both "innovation" and "machine learning" are material to the published research as they are both included as a keyword.
Environmental innovation AND Eco-innovation	Understand the total volume of literature linked to "environmental innovation", and "eco-innovation" to understand the use of these terms across literature.
(Environmental innovation OR Eco-innovation) AND Machine learning	Understand the total volume of literature linked to "environmental innovation" or "eco-innovation", and "machine learning", where "environmental innovation" or "eco-innovation", and "machine learning", are material to the published research as they are included as a keyword.

Environmental innovation AND Machine learning	Understand the total volume of literature linked to "environmental innovation" and "machine learning", where both "environmental innovation" and "machine learning" are material to the published research as they are both included as a keyword.
Eco-innovation AND Machine learning	Understand the total volume of literature linked to "eco-innovation" and "machine learning", where both "eco-innovation" and "machine learning" are material to the published research as they are both included as a keyword.

This allows the understanding of the current use of machine learning through the analysis of bibliometric figures.

4. FINDINDS

Machine learning is definitely a key research topic, with almost 300,000 publications having "machine learning" as a keyword. The highest volume of research regarding machine learning is published in United States, China, Indica, United Kingdom, Germany and Canada.

Results displayed in Table 2 show that machine learning, even though it is widely used for other topics (showing more almost 300,000 results in Scopus) is not a popular technique, rarely appearing for eco-innovation (i.e., environmental innovation) research.

Results of the search by keywords (without any filter per year, document type, source type or topic) show that among 1,037 results of publications containing the keyword "eco-innovation", only 2 contain as well the keyword "machine learning", representing less than 0.2% of results, with one article published in Spain (Peiró-Signes, Segarra-Oña, Trull-Domínguez and Sánchez-Planelles, 2022) and other in South Korea (Moon, Park and Woo, 2021). The latter included the term "machine learning" as part of the keyword "unsupervised machine learning approach", specifying that research leveraged on an unsupervised learning technique, K-means clustering method. Regarding the keywords "environmental innovation" and "machine learning" appearing together, a total of 21 results appear, whereas environmental innovation by itself has a total of 9,786 results. Thus, machine learning is used in ~0.21% of the total of research linked to environmental innovation.

Table 2. Number of results

Keyword(s)	Number of results
Machine learning	299,960
Innovation	206,469
(Environmental innovation) OR Eco-innovation	10,350
Environmental innovation	9,786
Eco-innovation	1,037
Innovation AND Machine learning	778
Environmental innovation AND Eco-innovation	473
(Environmental innovation OR Eco-innovation) AND Machine	22
Environmental innovation AND Machine learning	21
Eco-innovation AND Machine learning	2

The total of 22 results linked to machine learning and eco-innovation (i.e., environmental innovation) showed the following characteristics (please note the paper published by Moon, Park and Woo (2021) is duplicated appearing in both results for "Environmental innovation AND Machine learning" and for "Eco-innovation AND Machine learning"). Overall, 50% of documents are articles, 36.4% are conference papers and 13.6% reviews, where the different authors have only one publication on the topic.

Regarding their publication year, Figure 2, shows the breakdown of documents per year, with 2021 and 2020 being the two most relevant years so far in terms of publications, and a similar proportion will be followed in 2022 considering that the search was performed in May 2022. This shows that there is a growing interest in the use of machine learning techniques for eco-innovation research.

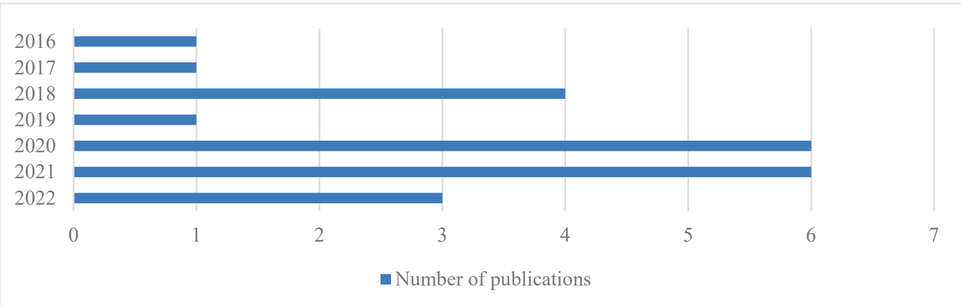

Figure 2. Documents per year

Figure 3 shows the breakdown of documents per country, with the highest being China, United States and the European countries. Results show that the research concerning both eco-innovation and machine learning is spread across regions and that there is a limited number of publications across the different countries, finding a maximum of 3 papers per country, which is a surprisingly low amount considering that both eco-innovation and machine learning are both popular terms striving today in terms of research interest.

Figure 3. Documents per country

Concerning the split per subject area, Computer Science, Engineering an Environmental Science and the three predominant ones as shown in Figure 4. This is aligned with the fact that machine learning, as it is artificial intelligence and based on algorithms, has a strong link with areas such as computer science, mathematics and engineering, and of course, more specifically, linked to decision sciences. Other subject areas such as environmental science, earth and planetary sciences are linked to the environmental aspects of eco-innovation. Additionally, other research areas appear linked to innovation having a strong link to business, such as business, management and accounting or economics.

Figure 4. Documents per subject area

5. DISCUSSION AND CONCLUSIONS

Approximately 1 in 20 papers (~5.0%) dedicated to innovation are linked to environmental innovation (or eco-innovation), whereas only 1 in 35 papers (~2.8%) dedicated to innovation and machine learning, are linked to environmental innovation (eco-innovation). This shows that the overall tendency to use machine learning in eco-innovation studies is lower than in the case of general innovation. Machine learning is linked to innovation research almost twice as often than it is linked to eco-innovation research. This suggests a lower maturity in the analysis of causal conditions and use of machine learning techniques for environmental innovation than for general innovation. Overall, results also suggest that eco-innovation is studied following other tools and that machine learning is not a widespread approach in the context of eco-innovation.

Overall, the number of publications using machine learning for eco-innovation related research is 3.14 documents per year, which is quite limited considering the high volume of machine learning publications and the high volume of eco-innovation research.

Also, research on this topic is relatively recent. The first research including machine learning and environmental innovation was published in 2016. This year is aligned with the overall main-stream use of machine learning techniques, considering that the 2010s came with the deep learning interest (Molnar, Casalicchio, Bischl, and 2020), but yet still this yearly average of 3.14 publications per year suggests that there is a research area still to be further developed and knowledge niche for the time being.

Regarding the countries, looking into Scopus publications on machine learning, also United States and China are the two key country publishers. Nevertheless, no country is publishing more than 3 papers per year addressing environmental innovation or eco-innovation and machine learning.

Also, these numbers do not reflect the global trends in the use of machine learning. In the overall number of publications of machine learning, India is in the top 3 of key publishers with over 29,000 documents, whereas there is no research published linked to eco-innovation and machine learning by any Indian research institution. This suggests that maybe the eco-innovation topic is less developed in this country, which also confirm when looking into the number of publications linked to eco-innovation and environmental innovation in the area, where India does not make the cut for the top 10, and China, United States, United Kingdom, Italy, and Spain are the leading countries in eco-innovation / environmental innovation research. In other words, supports the idea that the development of machine learning in other fields does not necessarily represent a development of machine learning techniques linked to eco-innovation research. And the development of eco-innovation studies does not necessarily trigger an interest in a machine learning approach.

Overall, the fact that machine learning present only in 0.2% of eco-innovation publications suggests that machine learning is not a widely used tool in eco-innovation research. This may suggest that the field of understanding causal conditions linked to eco-innovation may be a subject still to be developed, on which for the time being the analysis has not required powerful tools such as machine learning. Potentially eco-innovation use cases and data may be feasible to be processed manually or through simpler methods than the machine learning algorithms, at least for the time being. This also suggests an overall low maturity in the topic, as machine learning is one of the preferred alternatives when an exhaustive analysis identifying a wide scope of characteristics needs to be analysed.

6. RESEARCH LIMINATIONS/IMPLICATIONS

The key limitation of this research is to better understand what the alternatives to machine learning are and to what extent there are other tools to study causal conditions for the integration or preventing the integration of eco-innovation practices in firms.

7. ORIGINALITY/VALUE OF THE PAPER

This paper providers and overview of the use of machine learning in eco-innovation (i.e., environmental innovation) research, which, as per the results of the analysis, seems to be a field yet to explore by researchers in the eco-innovation field.

REFERENCES

Allegra, A., Tonacci, A., Sciaccotta, R., Genovese, S., Musolino, C., Pioggia, G., & Gangemi, S. (2022). Machine Learning and Deep Learning Applications in Multiple Myeloma Diagnosis, Prognosis, and Treatment Selection. Cancers, 14(3), 606.

Alpaydin, E. (2020). *Introduction to machine learning*. MIT press.

Baas, J. ; Schotten, M. ; Plume, A. ; Côté, G. ; Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. Quantitative Science Studies, 1(1), pp. 377-386.

El Naqa I.; Murphy M.J. (2015) What Is Machine Learning? In: El Naqa I., Li R., Murphy M. (eds) *Machine Learning in Radiation Oncology*. Springer, Cham. https://doi.org/10.1007/978-3-319-18305-3_1

Jordan, M.I.; Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. Science, 349(6245), 255-260. DOI: 10.1126/science.aaa8415

Martínez-Pérez, A.; García-Villaverde, P; Elche, D. (2015) Eco-innovation antecedents in cultural tourism clusters: external relationships and explorative knowledge, Innovation: Management, Policy & Pract., 17, pp. 41-57, https://doi.org/10.1080/14479338.2015.1011058

Mohri, M.; Rostamizadeh, A.; Talwalkar, A. (2018). Foundations of machine learning. MIT press.

Molnar, C.; Casalicchio, G.; Bischl, B. (2020). Interpretable machine learning–a brief history, state-of-the-art and challenges. In Joint European Conference on Machine Learning and Knowledge Discovery in Databases (pp. 417-431). Springer, Cham.

Moon, H.; Park, S.; Woo, J., (2021). Staying on convention or leapfrogging to eco-innovation?: Identifying early adopters of hydrogen-powered vehicles. Technological Forecasting and Social Change, 171, p.120995. https://doi.org/10.1016/j.techfore.2021.120995

Peiró-Signes, Á.; Segarra-Oña, M.; Trull-Domínguez, Ó.; Sánchez-Planelles, J. (2022). Exposing the ideal combination of endogenous–exogenous drivers for companies' ecoinnovative orientation: Results from machine-learning methods. Socio-Economic Planning Sciences, 79, p.101145, https://doi.org/10.1016/j.seps.2021.101145

Schotten, M.; Meester, W. J.; Steiginga, S.; Ross, C. A. (2017). A brief history of Scopus: The world's largest abstract and citation database of scientific literature. In Research analytics (pp. 31-58). Auerbach Publications.

Wang, H. ; Lei, Z.; Zhang, X.; Zhou, B.; Peng, J. (2016). Machine learning basics. Deep learning, pp. 98-164.

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WHO ATTENDS OUR FOREIGN LANGUAGE COURSES? A PRELIMINARY LOOK INTO THE PROFILE OF LEARNERS OF CHINESE

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ABSTRACT: This article takes a look into the profile of students enrolled at elective foreign language (FL) courses at German universities. Two surveys on their study biography show that learners of Chinese have on average learned more previous foreign languages than learners of Spanish. As more experienced FL learners, they draw on more FL learning strategies and more sources for transfer, a psycholinguistic process observed in FL learning. Based on contrastive theories, possible sources for transfer into and out of Chinese are suggested to contribute to the successful teaching of Chinese.

Keywords: *Chinese; Foreign language learning; Learner biography; Transfer*

1. INTRODUCTION

Chinese has become an established elective subject at many German universities and enhancing China competence is a declared target for education and research in Germany since the MERICS report (Stepan et al. 2018) came out in 2018 (Frenzel and Godehardt 2021). The purpose of this paper is to contribute to a more successful teaching of Chinese based on a better understanding of learners' background and previous knowledge, which will help building up more China competence in Germany. Although some basic information on the state of Chinese as a subject at schools (Guder 2005, Guder et al. 2021, Shahar-Büchsel and La Mela 2019) and universities (Klöter 2016) are available, there are to our knowledge no detailed analyses of these learners' profiles that would contribute to improving the teaching of Chinese for a certain target group.

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The article briefly touches upon key findings of studies into transfer in foreign language learning since this is a common process extensively investigated (Angelis and Selinker 2001, Reinfried 2017). Two surveys into learners' foreign language learning strategies and their study biography are presented that shed light on the profile of students learning Chinese, here in contrast to learners of Spanish. Taking a thorough study of transfer between Romance languages as basis (Eibensteiner and Müller-Lancé 2021), some contrastive thoughts on European languages commonly offered at universities offer possible areas for transfer into and out of Chinese, which ultimately leads us to suggestions for future research.

2. TRANSFER IN ADDITIONAL FOREIGN LANGUAGE LEARNING AND ITS ROLE FOR LEARNING CHINESE

Language systems of one and the same speaker influence each other. The first language, possible second languages and additional foreign languages show these effects of influence in all linguistic areas such as phonology, morphology, lexicon, syntax, pragmatics, and others. Influence can be seen during the process of language production and in the resulting produced language.[1] Since it looks highly unlikely that no effects of transfer will be observed in foreign language learning, a quest for possible sources for positive effects in learning Chinese is certainly promising. Transfer naturally has an interfering effect, and this can also be explained to learners so as to avoid negative effects or at least to raise awareness of this possible negative influence.

There was a long debate over whether the first language (Na Ranong and Leung 2009) or the first foreign language (Bardel and Falk 2007) plays a dominant role in transfer. Sources for transfer may generally be found among psycholinguistically related languages (Rothman 2010), and learners might perceive genetically unrelated languages as typologically related. These psycholinguistic relations seem to be highly individual at might be difficult to investigate on a broad basis. Typologically related previously studied languages (that are genetically related) are unlikely to be available for German learners of Chinese. A possible source of transfer might be found in whatever language shares a comparable structure with the one to be learned (Westergaard et al. 2017). The Spanish preposition "de" indicating possession might evoke comparisons with the Chinese possessive particle 的 due to orthographic, semantic, and also phonetic similarities, in this case most likely resulting in negative transfer due to the syntactic differences (where the possessor and the possessed are used exactly in the opposite positions). Questions for ongoing investigations into the matter include whether transfer is holistic (as a complete

[1] The reader shall be referred to (Angelis 2010) for further literature.

language system being transferred), whether it may be positive and/or negative, and what the sources of transfer may be (Puig-Mayenco et al. 2020).

Foreign language instruction in the field of Romance language has long asked for the application of the concepts of multilingualism in the classroom (Meißner and Reinfried 1998). This is based on the possibility to develop receptive competences very quickly and easily between closely related languages. Is there no way to accelerate learning distant languages based on phenomena of transfer? To help answer this question, we need to understand these learners' language learning profile.

3. SURVEYS ON THE NUMBER OF PREVIOUSLY STUDIED FOREIGN LANGUAGES

In an intervention study to be published elsewhere, participants gave details about their study history. 187 students enrolled in Spanish and Chinese courses at universities mainly in northern Bavaria indicated, how many foreign languages they had studied before enrolling in the current course. The results are presented in table 1.

Table 1. Number of previously studied languages (intervention study)

Language currently studied	N	Mean	SD
Chinese	51	2.76	1.210
Spanish	136	2.12	0.826

A Levene Test for homogeneity of variance shows that variances are not homogeneous: $F(185)=14.791$, $p<0.001$. A Welch-Test for independent samples shows that there is a significant difference between the two groups ($T(68.420)=3.524$, $p<0.001$). Students of Chinese enrolled in elective courses at German universities had on average learned more foreign languages previously than students of Spanish.

Supplementary figures are drawn from an investigation into foreign language learning (FLL) strategies. In an online survey, learners of Chinese at German educational institutions were asked to give insight into their FLL strategies. Participants were recruited through the Association for Teaching Chinese as a Foreign Language in German-speaking countries. An email was sent to all the members of this association who teach Chinese. Their learners thus include students at secondary schools, universities for applied sciences, universities, Confucius Institutes, and other institutions. The target group is fundamentally different, yet to our knowledge there are no other data on learners' biographies available at this point. Purely for comparison, we will investigate these data as well. In this survey, learners were also asked to indicate how many foreign languages they had studied before studying Chinese, giving them single-choice options. The responses are summarized in table 2.

Table 2. Number of previously studied languages (strategies study)

Number of languages studied previously	N	%
One	7	8.8
Two	36	45.0
Three	20	25.0
More than three	11	13.8
No reply	6	7.5

The great majority had studied two or more than two languages before Chinese. It must be kept in mind that these learners studied Chinese at different types of educational institutions. The information on where they learned Chinese is given in table 3.

Table 3. Institutions where learners studied Chinese (strategies study)

Institution	N	%
Normal University	31	40.0
University of Applied Sciences	8	10.0
Secondary School	31	38.8
Other type of institution	4	5.0
No reply	5	6.3

The relatively high number of learners at secondary schools as well as a number of learners at other institutions and missing replies may have contributed to a comparatively low number of respondents who indicated that they had studied more than two foreign languages before, since at German secondary schools it is extremely rare that students would learn more than three languages at all, and because “other types of institutions” may not require entrance qualifications as tertiary educational institutions do and thus receive a relatively high number of learners with a lower educational degree and a less profound foreign language learning background in general. At German secondary schools, almost exclusively “Gymnasien”, Chinese can be chosen as second, third or so-called “late” foreign language, the latter including it as a third foreign language several years after the second foreign language or as a fourth, additional foreign language that may substitute the first or second foreign language. To our knowledge, there are no figures on how many students in Germany learn Chinese as a fourth language at grammar school. A probably not very representative study (Guder et al. 2021) shows that out of 40 teachers of Chinese at state schools, two teach it at primary schools, two at fifth grade, four at sixth grade and another four at seventh grade, where it is no more than the second foreign language (30%). Furthermore, eight teach Chinese at eighth grade, three at ninth grade, eight at tenth grade and nine al eleventh grade, where it might be the third or fourth foreign language (70%).

Taken together, these figures show that at secondary schools, Chinese may be more than the second foreign language and that with 38.8%, the participants in the survey on FLL strategies who had studied more than two foreign languages previously also tend to show a profile of more experienced foreign language learners. This shows that they generally have a variety to “choose”[2] from as a source of transfer, and that as comparatively experienced FL learners, they might have more FL strategies to apply when they start learning this distant language.

4. TRANSFER INTO AND OUT OF CHINESE: WHERE TO LOOK

To mention just one investigation into its usefulness, Eibensteiner and Müller-Lancé (2021) show how German secondary school students transfer knowledge about aspect between Romance languages. It does not seem too unlikely that based on an identification of difficult structures of Chinese for German learners, analogous strategies can be identified and tested to see how active transfer into a typologically distant language (Guder 2008) may show effect. Contrastive analysis (Lado 1957) or rather the identification of marked structures in contrast (Eckman 2008) as well as error analysis (Gebhard 2016, 2020) will show where to transfer, and a comparison of Chinese with widely studied foreign languages at secondary schools and universities will show from where to transfer. Furthermore, a look at other foreign languages will show where to transfer from Chinese as a source.

[2] Transfer is mostly silently understood to be an unconscious psycholinguistic process (cf. assumptions in Rothman et al. 2019), although some authors conceive it as a conscious targeted strategy (Eibensteiner and Müller-Lancé 2021), at least to some extent (Oxford 1989).

At first glance, the Chinese script, lexical tones, and some grammar features such as its aspect system or relatively flexible word classes and the use of adjectives as predicates may come to mind as challenges for German learners. There are some heritage languages spoken among German students that use other, but alphabetic scripts, such as Russian, which is also a subject at secondary schools, or Arabic. Transfer possibilities seem limited, given the structural differences between phonologically based scripts and those that show more morphological traits[3]. Lexical tone as a category itself may only be found among rare heritage languages. However, a look at phonetically similar structures in the native language or any previously learned foreign language at sentence level might be worth a thorough analysis since negative influence from these sources have already been observed (e. g. Jin 2013). Furthermore, adjectives ("tired") can serve as predicates without a copula ("be") in Chinese, a trait shared with some heritage languages (Turkish, Russian, Arabic and some Southeast Asian languages). A grammatical peculiarity of English, conversion (the change of word class without formal changes, e. g. the use of color adjectives as nouns in "the green" or nouns as verbs in "to microwave sth.") might serve to show learners that the lack of morphology so typical of Chinese has its (albeit remote) similarities in well-known languages.

With English and Romance language being well established at secondary schools and universities, the topic of aspect (a grammatical category of the verb system that may express how something is seen in or over time but independent of tense) shall be focused on in the following.

Eibensteiner and Müller-Lancé (2021: 69ff) show how different aspect systems in previously learned languages show different effects in the target language, depending on whether the form and meaning of aspect are consciously noticed. Transfer may happen between languages that share similar aspect systems but will be inhibited if differences are too big or remain unnoticed. It is true that the categories of say Spanish imperfective and perfective past tenses do not map the Chinese categories of aspect particles such as 了 le (perfective), 过 guo (experimental), and that the English progressive form (-ing) is different from the Chinese continuous particle 着 zhe. However, the topic of aspect as a grammatical category of Chinese itself may well be introduced in a focus-on-forms approach using these examples from previously studied languages.

Some suggestions for the application of transfer from Chinese into other languages concern Chinese characters (transfer into Japanese), lexical tones (into Vietnamese and other Chinese languages such as Cantonese), isolating traits (into Indonesian and Malaysian), to name just a few interesting foreign languages from the point of view of

[3] See Guder 2009 on phonological traits of the Chinese script.

Economy/Business and Globalization. Especially lexical similarities in highly frequent items (such as numbers) might offer interesting insights into related Chinese languages and dialects and even other East Asian languages.

The above are merely suggestions based on lose comparisons of some language structures quite apparent to the learner's eye.

5. CONCLUSION

The study found that students who learn Chinese at German educational institutions, mainly universities, have learned more foreign languages previously than learners of Spanish, so they are more experienced in foreign language learning. This means that their language learning strategies may be further developed and actively applied for successful learning. Since these learners have a broader basis of previously learned foreign languages and thus sources for transfer, active transfer methods seem to make for a good contribution to successful learning of Chinese. Possible language structures for this transfer might be conversion (from English), grammatical aspect (from Romance languages), non-Latin scripts (from Russian and other languages), and non-copula predicates (from Turkish, Russian, Arabic and Southeast Asian languages such as Vietnamese). Further suggestions for the application of transfer from Chinese into other languages concern Chinese characters (transfer mainly into Japanese), lexical tones (into Vietnamese and other Chinese languages such as Cantonese), isolating traits (into Indonesian and Malaysian).

Suggested opportunities for transfer will be confirmed through research in the form of intervention studies and interviews with successful learners. Furthermore, with a more thorough look into the study biography of learners of Chinese and their awareness of transfer, we will have a better understanding of this target group to better cater for their needs and develop methods and media suitable to support their successful learning.

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Conflict of interests

No conflict of interests can be reported.

AUTHOR CONTRIBUTIONS

Christian Alexander Gebhard is wholly responsible for the whole paper.

REFERENCES

Angelis, Gessica de; Selinker, Larry (2001): Interlanguage Transfer and Competing Linguistic Systems in the Multilingual Mind. In: Britta Hufeisen, Jasone Cenoz und Ulrike Jessner (Hg.): Cross-linguistic influence in third language acquisition. Psycholinguistic perspectives. Clevedon, UK, Buffalo: Multilingual Matters (Bilingual education and bilingualism, 31), pp. 42–58.

Bardel, Camilla; Falk, Ylva (2007): The role of the second language in third language acquisition: the case of Germanic syntax. In: *Second Language Research* 23 (4), pp. 459–484. DOI: 10.1177/0267658307080557.

Eckman, Fred (2008): Typological Markedness and Second Language Phonology. In: Jette G. Hansen Edwards und Mary L. Zampini (Hg.): Phonology and second language acquisition. Amsterdam: Benjamins (Studies in bilingualism, 36), pp. 95–115.

Eibensteiner, Lukas; Müller-Lancé, Johannes (2021): Transfer im schulischen Drittspracherwerb des Spanischen. Wie L2-Kenntnisse des Englischen, Französischen und Lateinischen den L3-Erwerb von perfektivem und imperfektivem Aspekt im Spanischen beeinflussen. Tübingen: Narr Francke Attempto (Romanistische Fremdsprachenforschung und Unterrichtsentwicklung).

Frenzel, Andrea; Godehardt, Nadine (2021): Mehr Chinakompetenz für eine strategische Chinapolitik. Ein systemischer Ansatz beginnt bereits in der Schule. Bundeszentrale für Politische Bildung. Online verfügbar unter https://www.bpb.de/shop/zeitschriften/apuz/326887/mehr-chinakompetenz-fuer-eine-strategische-chinapolitik/, zuletzt geprüft am 12.04.2022.

Gebhard, Christian (2016): Häufige Fehler erwachsener Lerner des Chinesischen im Anfängerstadium 31, pp. 30–50.

Gebhard, Christian (2020): An Error Analysis of Beginners' Oral Exams of German learners of Chinese. In: Ute Ambrosius und Patrick Gröner (Hg.): Ansbacher Kaleidoskop 2020. Aachen: Shaker Verlag (campus_edition Hochschule Ansbach), pp. 64–81.

Guder, Andreas (2005): Chinesisch und der Europäische Referenzrahmen Einige Beobachtungen zur Erreichbarkeit fremdsprachlicher Kompetenz(en) im Chinesischen. In: *CHUN Chinesisch Unterricht* 20, pp. 63–78.

Guder, Andreas (2008): Was sind distante Fremdsprachen? ein Definitionsversuch am Beispiel des Chinesischen. In: Eva Burwitz-Melzer, Wolfgang Hallet, Michael Legutke, Franz-Joseph Meißner, Joybrato Mukherjee und Miriam Kämmerer (Hg.): Sprachen lernen - Menschen bilden. Dokumentation zum 22. Kongress für Fremdsprachendidaktik der Deutschen Gesellschaft für Fremdsprachenforschung (DGFF) Gießen, 3. - 6. Oktober 2007. Baltmannsweiler: Schneider-Verl. Hohengehren (Beiträge zur Fremdsprachenforschung, 10), pp. 69–78.

Guder, Andreas (2009): Sinographemdidaktik. Aspekte einer systematischen Vermittlung der chinesischen Schrift im Unterricht Chinesisch als Fremdsprache ; mit einer Komponentenanalyse der häufigsten 3867 Schriftzeichen. Zugl.: München, Univ., Diss., 1998. unveränd. Nachdr. der 1. Aufl. Tübingen: Groos (SinoLinguistica, 7).

Guder, Andreas; You, Wenhao; Frenzel, Andrea; Willems, Ariane pp. (2021): Macht mehr Chinesisch! Wirklichkeiten und Möglichkeiten des Schulfachs in Deutschland. Bildungsnetzwerk China. Online verfügbar unter https://bildungsnetzwerk-china.de/fileadmin/user_upload/download-bereich/08_macht_mehr_chinesisch_2021.pdf.

Klöter, Henning: Chinese as a Foreign Language, Linguistics and Pedagogy. In: Rint Sybesma (Hg.): Encyclopedia of Chinese Language and Linguistics. Online verfügbar unter https://referenceworks.brillonline.com/entries/encyclopedia-of-chinese-language-and-linguistics/chinese-as-a-foreign-language-linguistics-and-pedagogy-COM_000184.

Klöter, Henning (2016): Chinesisch-Sprachkurse in BA-Studiengängen an Hochschulen in Deutschland, Österreich und der Schweiz: Ergebnisse einer Erhebung. In: *CHUN Chinesisch Unterricht* 31, pp. 51–62.

Lado, Robert (1957): Linguistics across cultures: Applied linguistics for language teachers. Ann Arbor: University of Michigan Press.

Meißner, Franz-Joseph; Reinfried, Marcus (1998): Mehrsprachigkeit als Aufgabe des Unterrichts romanischer Fremdsprachen. In: Franz-Joseph Meißner (Hg.): Mehrsprachigkeitsdidaktik. Konzepte, Analysen, Lehrerfahrungen mit romanischen Fremdsprachen. Tübingen: Narr (Giessener Beiträge zur Fremdsprachendidaktik), pp. 9–22.

Na Ranong, Sirat; Leung, Yan-kit Ingrid (2009): Null Objects in L1 Thai-L2English-L3 Chinese: An Empiricist Take on a Theoretical Problem. In: Yan-kit Ingrid Leung (Hg.): Thid Language Acquisition and Universtal grammar. Bristol/Buffalo/Toronto: Multilingual Matters, pp. 162–191.

Oxford, Rebecca L. (1989): Language learning strategies. What every teacher should know. Boston, Mass.: Heinle & Heinle.

Puig-Mayenco, Eloi; González Alonso, Jorge; Rothman, Jason (2020): A systematic review of transfer studies in third language acquisition. In: *Second Language Research* 36 (1), pp. 31–64.

Reinfried, Marcus (2017): Transfer. In: Carola Surkamp (Hg.): Metzler Lexikon Fremdsprachendidaktik. 2. Aufl.: J.B. Metzler, pp. 348–349.

Rothman, Jason (2010): On the typological economy of syntactic transfer: Word order and relative clause high/low attachment preference in L3 Brazilian Portuguese. In: *International Review of Applied Linguistics in Language Teaching* 48 (2-3), pp. 245–273.

Rothman, Jason; González Alonso, Jorge; Puig-Mayenco, Eloi (2019): Third Language Acquisition and Linguistic Transfer: Cambridge University Press.

Shahar-Büchsel, Ulrike; La Mela, Verena (2019): Chinesisch als Schulfach in Deutschland: Potenzial und Gelingensbedingungen. Eine qualitative Studie zur Zukunft des schulischen Chinesischunterrichts. In: *CHUN Chinesisch Unterricht* 34, pp. 58–81.

Stepan, Matthias; Frenzel, Andrea; Ives, Jacqueline; Hoffmann, marie (2018): China kennen, China können. Ausgangspunkte für den Ausbau von ChinaKompetenz in Deutschland. Mercator Institute for China Studies. Bonn (MERICS China Monitor, 45). Online verfügbar unter https://www.merics.org/sites/default/files/2018-05/MERICS_China_Monitor_45_China_kennen_China_koennen.pdf, zuletzt geprüft am 13.06.2020.

Westergaard, Marit; Mitrofanova, Natalia; Mykhaylyk, Roksolana; Rodina, Yulia (2017): Crosslinguistic influence in the acquisition of a third language: The Linguistic Proximity Model. In: *International Journal of Bilingualism* 21 (6), pp. 666–682. DOI: 10.1177/1367006916648859.

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HAVING A REAL PROTOTYPE OF YOUR OWN PRODUCT DESIGN – SMALL EFFORT; BUT BIG EUREKA MOMENT FOR STUDENTS

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ABSTRACT: This paper presents a project-based product design course, which is the only course on product design in our curriculum. We noticed that the building of a prototype is often omitted in academic teaching. However, students benefit from building a prototype of their design. Hence, we reduced the theoretical content to give students time to design and build a prototype. To illustrate the course two student projects are shown. We want to motivate lecturers to introduce prototyping to courses, since our experience is that the benefits of building a prototype outweigh the decrease in theoretical knowledge.

Keywords: *Design education; Project management; Project-based learning; Sustainable design*

1. PURPOSE OF THE PAPER

Product development comprises all the steps and activities in the computer-aided development of a technical product, starting with the initial idea and ending with the first virtual prototype as a 3-dimensional computer-aided-design model (CAD model).

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Actually, a holistic approach to teaching would go one step further by realizing the virtual prototype through manufacturing and assembling its individual parts. This would allow the students to experience and test the real prototype as well as to identify design modifications to finally optimize the virtual CAD model (Berglund and Grimheden, 2011).

Unfortunately, it is precisely this last step - the first realization of a prototype - that is often skipped in established courses in academic teaching at universities. The reasons are manifold and obvious. We see the following three most significant reasons as our challenges to overcome:

- Teaching students to design and develop products is extremely time-consuming. Since only limited courses on product development and product design are available in the (already packed) curricula of universities, the real prototype - as the last step - is omitted due to time constraints.
- The building of a prototype requires further demanding competences (Jensen et al., 2016), which are hardly taught within established product development education. These include a well-founded use of software interfaces, knowledge on interrelations between product and process, reflection on and evaluation of change requirements, and responsibility in terms of safety.
- Prototypes are always unique. Hence, the required supervision of students during manufacture and assembly goes hand in hand with high teaching expenses (lab time, teaching load, etc.). Intensive bilateral coordination between lecturers and students (often 1:1) is essential.

It is becoming obvious that there is an undeniable gap between the importance of a real prototype and the actual implementation of this significant step in academic teaching.

In this paper, we detail a project-based product design course, which is a mandatory course in the 6th term of the bachelor program on Sustainable Engineering at the University of Applied Sciences Ansbach (Germany). The course allows students to design a product and to gain individual experience in design. However, this is the only course focusing on product design in the curriculum of the bachelor program. As a consequence, our students have only had a quick and superficial taste of product design in the past and not had the chance to build prototypes of their designs. We decided to reduce the scope of theoretical content (and thus the number of lectures) to give the students time and resources to really do an individual product design project by themselves - starting with the first idea, including manufacture, assembly and finally the testing of a real prototype. The response of the students revealed that the realization of a prototype helps them to strengthen the acquired competences and to gain a better and more holistic view of product design. With our work we want to motivate colleagues and lecturers to introduce the building of a prototype into product design courses. Obviously, this goes hand in hand with a decrease of time to teach theoretical knowledge. However, we found that the benefits of building a prototype (Lande and Leifer, 2009) outweigh the decrease in theoretical knowledge on product design.

The paper is structured as follows: First, we present the structure and implementation of the course (Section 2.1). Afterwards, the design challenge is stated and explained (Section 2.2) and in Section 2.3 the available resources and machinery in the "creative prototyping" lab are detailed. Section 3 then presents two product design projects carried out by students in the summer of 2020. The students designed and finally built a wooden toy tractor (student #1, Section 3.1) with its garage (student #2, Section 3.2). Furthermore, each student developed and prepared a 90-minute workshop, in which the designed product can then actually be designed and/or manufactured and/or built by children from different age groups (Section 3.3). The paper closes with a conclusion and an outlook on further improvements to the course (Section 4).

2. THE COURSE ON "PROJECT-BASED PRODUCT DESIGN"

The course on project-based product design for bachelor students is a mandatory course in the 6th term of the bachelor program on Sustainable Engineering at the University of Applied Sciences Ansbach, Germany. This is the only course focusing on product design in the curriculum of the bachelor program. Hence, our aim is to provide a comprehensive experience of relevant aspects of product design in just one course with five credit points (ECTS). In addition, there is no separate course in the students' curriculum that focuses on the fundamentals of project management. Therefore, we merged those two topics and designed a course that both satisfies the demands on product design education and provides an adequate first experience of project management for the students (Mills and Treagust, 2003).

This section details the basic structure and the content of the course on project-based product design (Section 2.1). In Section 2.2 the project challenge is presented and the general conditions for all projects are defined. Additionally, relevant information on the available tools and machines (Kriesi et al., 2014) in the "creative prototyping" laboratory are presented in Section 2.3.

2.1 Structure and implementation of the course

The course includes two 90-minute slots in the weekly curriculum over 14 weeks during each summer semester. The course is structured in two main parts, each spanning the entire semester (Figure 1):

- The **theoretical part** is assigned to the first 90-minute slot each week. It includes seven lectures and five workshops that provide the content on relevant aspects of project management and product design, which are seen to be essential for the students and the success of their design projects. A listing of the topics and content of these lectures and workshops is given in Figure 1.
- The **practical part** is assigned to the second 90-minute slot each week. During these time slots, the lab (Section 2.3) is open to all students to discuss their projects and designs with colleagues, the lecturer as well as the lab engineer. Furthermore, the students can get to know the available manufacturing machines and tools in the lab, take part in safety training and (usually rather later in the project) manufacture and assemble their prototypes.

Once the students have achieved some progress in their projects, a short pitch is given by a student at the beginning of each 90-minute slot. No requirements are set for these pitches other than recommending a duration of seven minutes. Finally, the evaluation of the projects and the course is based on i) a presentation by each student at the end of the semester and ii) a short report that documents the project and provides reflection on the project, the individual progress and the lessons learned.

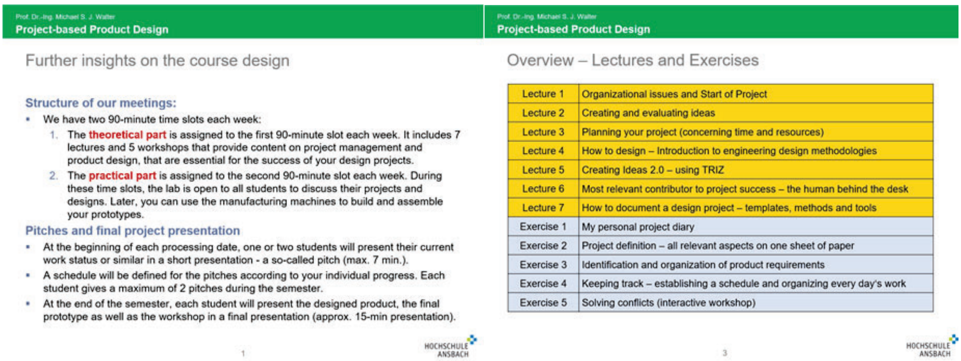

Figure 1. Slides with organizational issues (left) and topics of lectures and workshops (right)

2.2 Defining the project challenge

The students face a challenge to **design** and **build a first prototype of** a wooden product for children (age: 3+) or a useful wooden product for teenagers (up to 16 years). They are free to decide on the target group for their product. To give a first orientation for the students, they are motivated to get inspiration from agriculture, agricultural technology, farm life and work, etc. However, the scope of designs is not limited to these fields. A wooden toy tractor (made by the lecturer, Figure 2) is shown to the students to illustrate a sustainable product design (Soomro et al., 2021) and to stimulate the creative flow of project ideas. In addition, each student must develop and prepare a 90-minute workshop, in which the product can actually be designed and/or manufactured and/or built by the children (of the previously defined target group) themselves in the laboratory. This additional assignment achieves student reflection on their products, the projects' process, as well as communicating their lessons learned to others (Balve and Albert, 2015). The final project challenge, however, is stated very simply:

Plan and perform your product design project!

Figure 2 shows the slide presenting relevant information on the design project as well as the available CNC carving machine in the lab.

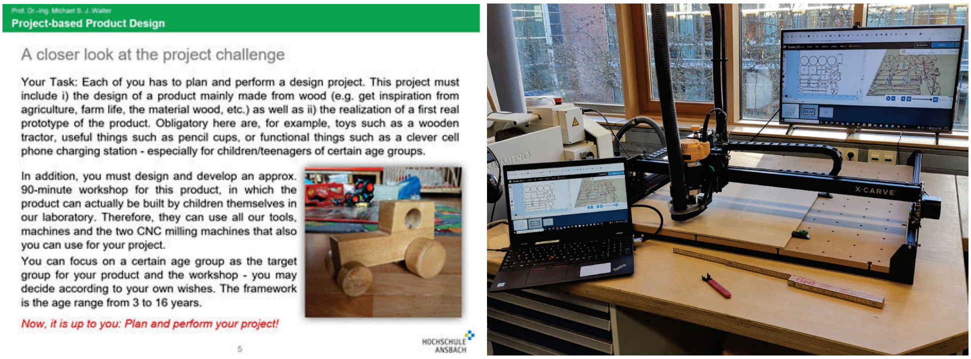

Figure 2. Presentation slide with the definition of the project challenge (left) and available open-source CNC Carving machine X-Carve (right).

2.3 AVAILABLE RESOURCES AND MACHINERY IN THE "CREATIVE PROTOTYPING" LAB

As many meetings and lectures as possible are taking place in the lab, to allow the students easy and low-threshold access to the machinery and thus to counter hesitant approaches of the students during their projects. The first meeting of the course always takes place in the lab. It includes an introduction to all the required organizational information as well as the project challenge (as detailed in Section 2.2). Furthermore, the students are also introduced to the main manufacturing machines (in particular, the CNC carving machines) and the available tools in the lab (from the workbench and screwdriver, to the hand planer and palm sander, surface finishes, etc.). Figures 3 and 4 show the lab and highlight the resources and machinery.

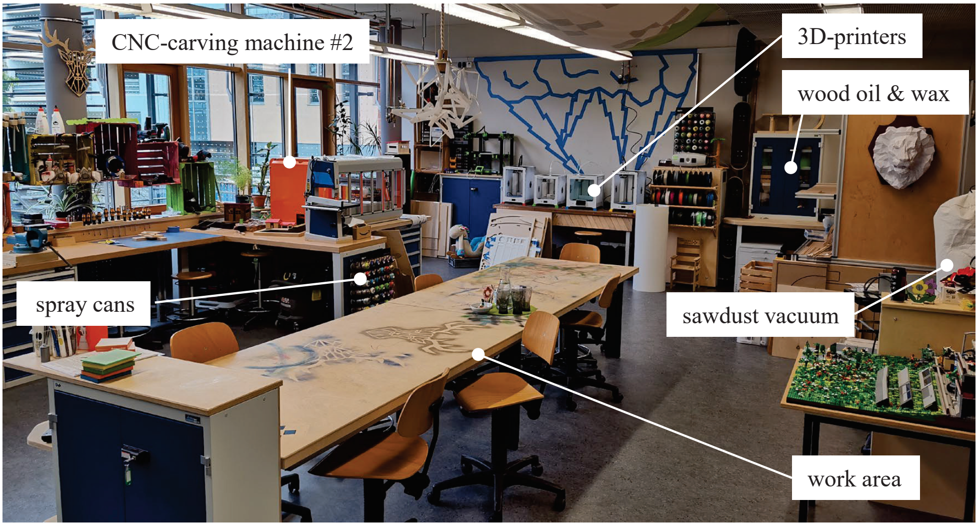

Figure 3. Resources and machinery in the "creative prototyping" lab (view from left corner).

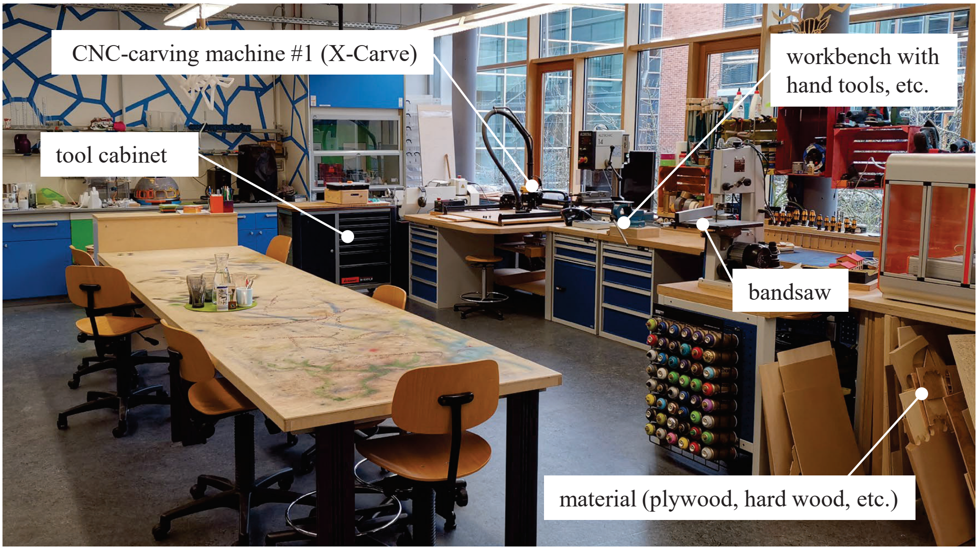

Figure 4. Resources and machinery in the "creative prototyping" lab (view from right corner).

3. BEST PRACTICE – TWO DESIGN PROJECTS BY STUDENTS

This section details the design projects of two students carried out in the course from April 2020 to July 2020. Both students attended the course in their sixth semester and had no experience or knowledge of product design aside from the basic application of 3D-CAD (from the lecture on engineering design in their second semester). Both students collaborated and came up with the idea of designing two individual products that were "connected" in a certain way to force both students to adjust and synchronize their own projects. The students decided to design a wooden toy barn (project #1) and a wooden toy tractor (project #2). Furthermore, they defined the connecting requirement that the tractor must be able to drive into the barn and that the barn door can be completely closed when the tractor is parked inside. The final prototypes of the tractor and the barn are shown in Figure 5.

Figure 5. Final prototypes of the toy barn (project #1) and the toy tractor (project #2).

3.1 Design project #1 – The barn

The student aimed for the toy barn to be a design made of single wooden parts that are assembled only by stacking, thus being suitable for children of younger ages. Furthermore, the barn must have an opening to allow the tractor to enter and leave. Therefore, movable doors were required to open/close the barn entrance. Finally, a nice spot to attach a wooden sign (for a logo or the children's name) was an essential requirement set by the student. To gain information about alternatives for the joint design, the student studied existing 3D wooden puzzles for children by measuring the dimensions of the single parts and evaluating the effects on the assemblability and the resulting stability of the finalized puzzle.

The student then focused on defining her project, prepared her project definition and progressed to the development of the time schedule. The eight work packages (WP) and three milestones (MS) are shown in the Gantt diagram in Figure 6. To document her project and her progress, she kept a project diary, developing a one-page template for each day to document her work, working times and to structure and organize achievements and "To Do" list. Overall, she spent ~58.5 hours on her project - starting with the first thoughts about the project until the first prototype of her barn design was completed.

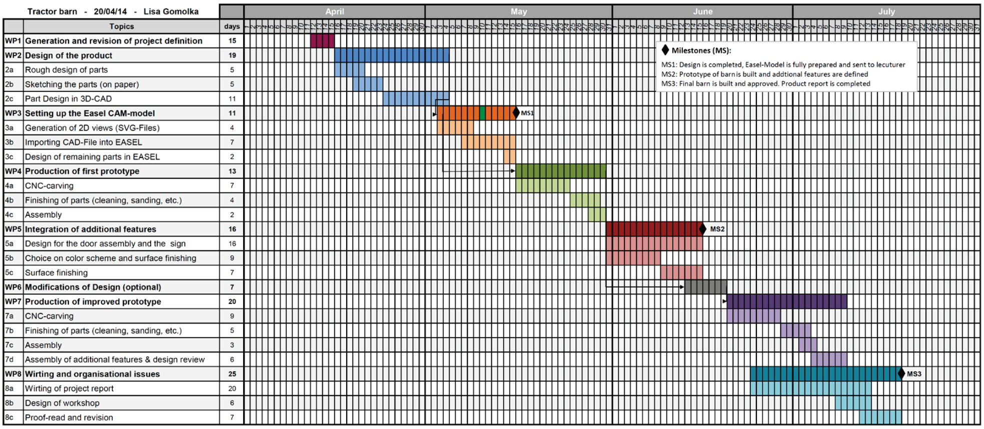

Figure 6. Gantt diagram of the design project #1.

The Gantt diagram already provides plenty of time (several weeks) to plan, set up and finally do the manufacturing of the single parts of the wooden barn. Therefore, the student designed the barn assembly using the CAD system SolidWorks and exported two dimensional, vector-based SVG files for all single parts. Then the SVG files were imported into the browser-based CAM freeware EASEL (Inventables, Inc., 2021) that is used to set up the carving process and to control the CNC carving machine in the laboratory. After setting the parameters of the carving process (such as feed rates, bit dimensions, material properties, plywood dimensions, etc.), the parts were carved from sheets of plywood. All these steps were done by the student, supported and supervised by the lecturer and the lab engineer to ensure safety. Figure 7 shows two pictures that were taken during the carving of the parts of the barn wall (made from 8 mm plywood) and the roof (made from 10 mm plywood). Finally, the barn walls and the roof were assembled, and the doors were mounted to the barn.

Furthermore, the student attached a small wooden plate engraved with the abbreviation *HS Ansbach* of the University of Applied Sciences Ansbach. To visually upgrade the final barn assembly, the student decided to paint the roof parts with a red acrylic color (that is also approved for use by children). After a final presentation of the barn to the lecturer, the prototype got the status "approved".

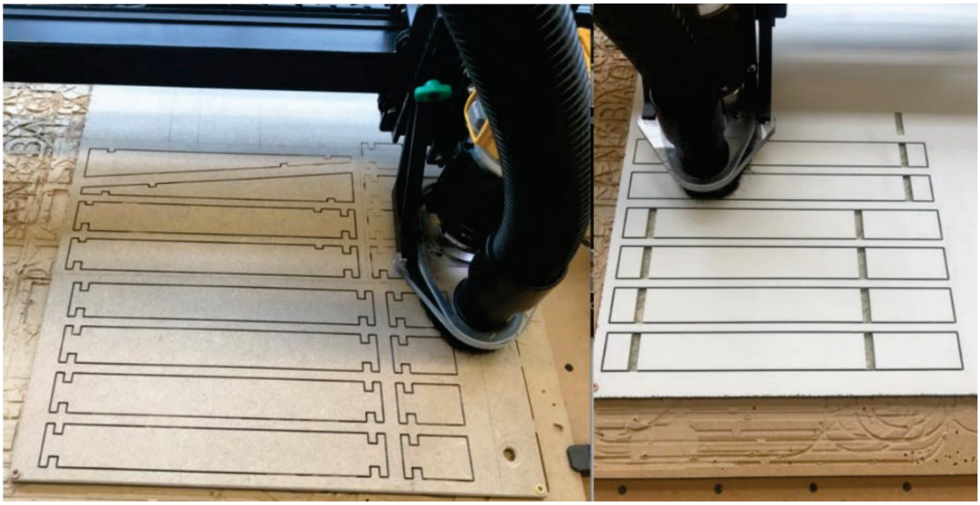

Figure 7. CNC carving the parts of the barn walls (left) and the roof (right) out of plywood.

Figure 8. Front and rear view of the completely assembled toy barn.

3.2 Design project #2 – The Tractor

The second student's design project focuses on the design and building of a wooden tractor, a scale model of a real tractor. Therefore, he had to face a different variety of challenges from the first student. One major aspect is the reduction of the original tractor's complex shapes for a wooden model without losing the unique visual features and elements. After writing the project definition, the student developed a Gantt diagram to organize and structure the available time for each task. At this stage, he was already aware that the design of the joints would be a major challenge for his project. Therefore, he focused immediately on the analysis and evaluation of different approaches on "joining the individual wooden parts". While low-cost wooden puzzles are often assembled by key/slot connections (see Figure 9), the student finally decided on the assembly technique of "rectangular pin/hole" joints, which can be precisely carved with the available X-Carve (Inventables, Inc., 2021).

Figure 9. Comparison of three different approaches on assembly joints.

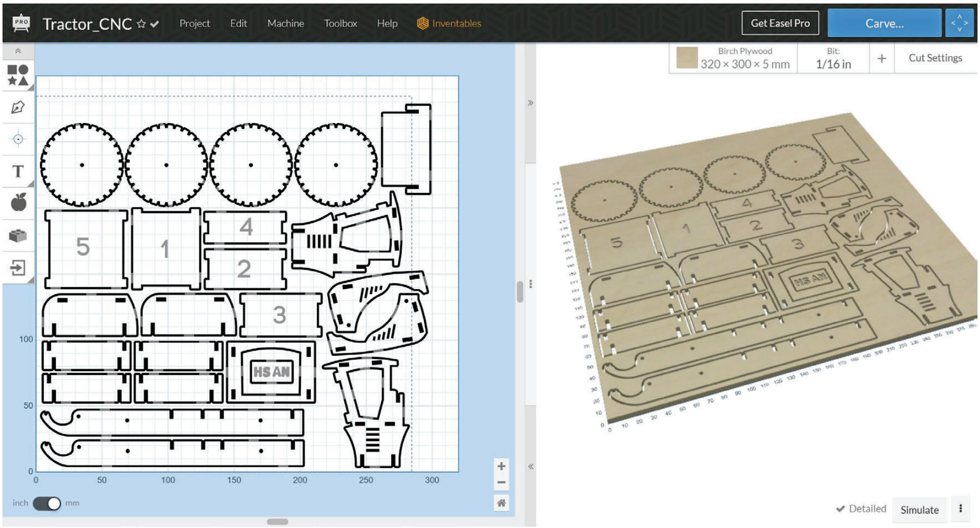

Figure 10. Screenshot of the tractor model in the CAM software EASEL (left: working area; right: preview of final carving).

The student's next step included the CAD design of the parts using SolidWorks. Therefore, he took several photos of a real CLAAS tractor and imported these into the software's sketch environment to trace the main shapes as well as relevant geometrical features (such as the ventilation grille of the hood). After the final assembly of the parts in a 3D CAD assembly, the quantities and positions of all the required pin/hole-joints were defined. Based on the 3D model, the 2D sketches of all parts were saved to vector-based SVG files, which were later imported into the EASEL software. Figure 11 shows the screenshot of the final EASEL model. All the tractor parts were carved with the X-

Carve using birch plywood (thickness: 5 mm) and a router bit (diameter: 1/16 inch). Finally, the parts were sanded and painted, the prototype was assembled and driven into the barn to test the students' requirements on their products. The tractor got the status "approved".

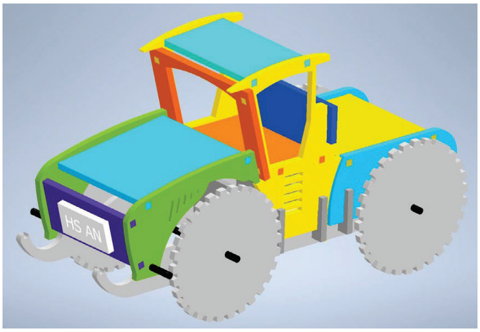

Figure 11. Screenshots taken from the design process in SolidWorks: final virtual assembly of the tractor.

3.3 Development of workshops for children

The project challenged the students with two main tasks: on the one hand, the design and its realization as a first real prototype (as shown by the example of both students); on the other hand, each student must develop and prepare a 90-minute workshop, in which the product can be designed and/or manufactured and/or built by children in the "creative prototyping" laboratory. This additional challenge prompts the students to reflect on their products, the development processes, and the communication of the lessons learned. Furthermore, the students had to switch perspectives (from learner to teacher). This leads to a different view of things and uncovers misunderstandings in the simplicity of the design and/or the complexity of carrying out a project and/or an adequate presentation and documentation of the project. In addition, didactic skills are acquired by the students. The students developed their workshops for children aged 5+ (barn) and 10+ (tractor). Both students took into account that the preparation of workshops would be time-consuming, including the manufacture of individual parts in sufficient quantities, as well as setting up the workspace. As part of the preparation, selected parts and sub-assemblies (whose manufacturing and/or assembly were too time-consuming and/or too complex and/or required patience and thus might cause frustration) had to be done in advance. For instance, the barn door sub-assembly had to be pre-assembled. Moreover, small parts such as nameplates were prepared in their basic form and finished during the workshop (such as carving a child's name into the plate).

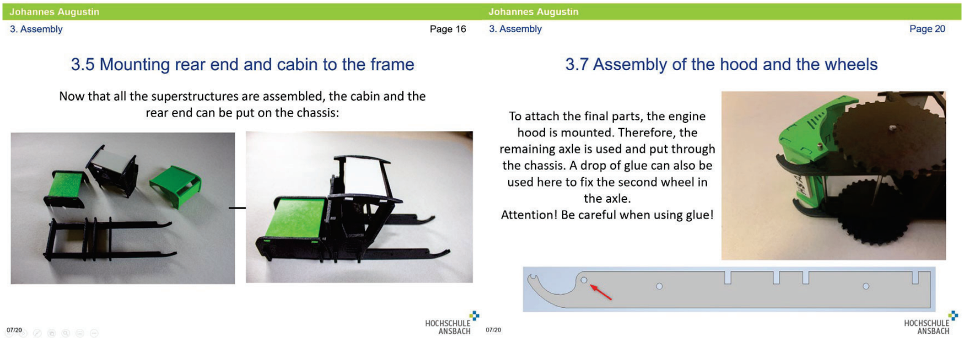

Figure 12. Presentation slides providing instructions on the tractor assembly.

Nr	Name	Bauteil	Stückzahl
1	Bodenplatte		1 x
2	Seitenteil lang (26 cm)		4 x
3	Seitenteil lang oben		2 x
4	Seitenteil schräg		2 x
5	Bogen		1 x
6	Hinten (20 cm)		4 x
7	Hinten / Mitte oben		2 x
8	Mittelteil Dach		1 x
9	Seitenteil kurz (5 cm)		4 x
10	Vorne (4 cm)		**8 x**
11	Dach (30 cm)		**7 x**
12	Tor		**2 x**
13	Namensschild	HS ANSBACH	**1 x**
14	Farbe + Pinsel		**Rot 1x** **Blau 1x** **Grün 1x**
15	Magnete		**Magnet-band** **Magnet 1x**
16	Passstifte		**4 x**

Figure 13. Bill of materials for the “barn” workshop (in German)

The younger the participants, the greater the additional focus on occupational safety. The nature of edges, chemicals (such as paint) and tools must be adapted accordingly, which makes the complexity vary. Furthermore, the number of supervisors also depends on the participants and their ages. Each student prepared a presentation (visualising step-by-step), a bill of materials and a guideline and checklist to allow a thorough preparation of the workshop. The presentation slides in Figure 12 give instructions on the assembly of the tractor's cabin, rear end, front axle and hood. Figure 13 details the bill of materials for the "barn" workshop of student #1.

4. CONCLUSION AND OUTLOOK

Our aim is to motivate colleagues and lecturers to introduce the building of real prototypes to product design courses and to increase active elements such as setting up individual projects. At first sight, this may raise concern that the loss of time for teaching theoretical knowledge will have negative effects on the students' competencies. However, we found that the benefits of carrying out a design project and building a prototype outweigh the decrease in theoretical knowledge on product design. Furthermore, the students' feedback on the course was very positive, stating that it is "*fun"* to do a product design project, and

> *"It was the first time in my studies that I had to use and apply all the stuff I learned".*

However, problems also became obvious during the course. The holistic documentation of the product design process (from the idea to the real prototype) is always unique. Moreover, this includes digital content (CAD models, manufacturing data, etc.) and non-digital content (sketches, the product itself, haptic feedback, etc.) in valid versions. Students currently struggle to document the project and acquired competencies and skills in a holistic, consistent, and traceable manner. From a didactic point of view, "analog" documentation hardly reflects the competencies and skills acquired by the students and is therefore not suitable for a well-founded assessment of the acquisition of competencies and the contents of the course. In consequence, we emphasize the future use of e-portfolios for documenting and evaluating product design projects. This can be a possible next step to provide the students with a significant improvement in the quality, transparency and traceability of their activities, decisions, results (e.g. digital CAD models), etc. when documenting them as part of their project.

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REFERENCES

Balve, P.; Albert, M. (2015). Project-based learning in production engineering at the Heilbronn Learning Factory. Procedia CIRP, Vol. 32, pp. 104-108.

Berglund, A.; Grimheden, M. (2011). The importance of prototyping for education in product innovation engineering. ICORD 11: Proceedings of the 3rd International Conference on Research into Design Engineering. Research Publishing and Indian Institute of Science. pp. 737-745.

Inventables, Inc. (2021). *EASEL World's Easiest CAD/CAM Software*. Retrieved April 25, 2022, from https://www.inventables.com/technologies/easel.

Jensen, L.S.; Özkil, A.G.; Mortensen, N.H. (2016). Prototypes in Engineering Design: Definitions and Strategies. DS 84: Proceedings of the DESIGN 2016 14th International Design Conference. Faculty of Mechanical Engineering and Naval Architecture; Design Society. pp. 821-830.

Kriesi, C.; Steinert, M.; Meboldt, M.; Balters, S. (2014). Physiological Data Acquisition for Deeper Insights into Prototyping. DS 81: Proceedings of the NordDesign 2014. Aalto Design Factory; Design Society. pp. 580-589.

Lande, M.; Leifer, L. (2009). Prototyping to learn: Characterizing engineering students' prototyping activities and prototypes. DS 58: Proceedings of ICED'09, the 17th International Conference on Engineering Design. Design Processes. pp. 507-516.

Mills, J.E.; Treagust, D.F. (2003). Engineering Education; Is Problem-Based or Project-Based Learning the Answer?. Australian Journal of Engineering Education, Vol. 3.

Soomro, S.A.; Casakin, H.; Georgiev, G.V. (2021). Sustainable Design and Prototyping Using Digital Fabrication Tools for Education. Sustainability, Vol. 13 No. 3, p. 1196.

BMT22
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SUSTAINABLE RECRUITMENT AND DEVELOPMENT OF QUALIFIED PROFESSORIAL STAFF AT UNIVERSITIES OF APPLIED SCIENCES

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ABSTRACT: Due to the double qualification of a PhD and five years of professional experience outside of higher education, it is very difficult for universities of applied sciences to recruit good professors in specific areas such as certain areas of computer science. Since such a shortage of qualified professors can lead to considerable deficits in higher university development, the present structured personnel recruitment procedure for universities of applied sciences was developed.

Keywords: *Professorial staff, Talent management, Human resources development.*

1. PURPOSE OF THE PAPER

The aim of the project was to contribute to the promotion of the recruitment and development of academic staff at universities of applied sciences and thus to strengthen the economic and social development of the region around the respective university of applied sciences. To this end, suitable measures were to be found to improve the current personnel situation, in particular the advertisement, staffing and appointment of new professors. A concept was developed that is adapted to the location-specific initial situation and the university-specific needs.

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2. CURRENT PROBLEMS IN RECRUITING PROFESSORIAL EMPLOYEES

For universities of applied sciences, the recruitment - especially the recruitment of professors – is one of the most strategically important tasks. Professors determine the quality of the academic education system with their research profile (Bayerisches Hochschulpersonalgesetz, 2020). Successful recruitment requires the aspirants to have multiple qualifications in the form of a doctoral degree, practical experience and pedagogical aptitude (Bayerisches Hochschulpersonalgesetz, 2020). In addition to the formal requirements for appointment, there are currently many factors that hinder the successful appointment or the specific development of qualified young professors:

- Opportunities for a professorship at a university of applied sciences are insufficiently known to potential candidates
- Poor research opportunities due to the extensive number of courses compared to universities
- Low pay compared to the private sector
- PhD students at universities of applied sciences often do not have non-discriminatory access to cooperative doctorates at universities
- Due to the academization of the working environment, in some areas there are no PhD candidates for professorial positions
- As women are the main caregiver for children in Germany, the double qualification required for a professorship at a university of applied sciences acts as a kind of double filter, especially for women

This situation creates a considerable strategic barrier to further development. In addition to similar causes throughout Germany that make it difficult to recruit professorial staff at universities of applied sciences, the conditions are further exacerbated by the location in rural, rather structurally weak areas.

3. RECRUITMENT AND DEVELOPMENT OF ACADEMIC STAFF

In order to counteract the problems mentioned above, a structured and plannable career concept for professors at universities of applied sciences was developed. The aim is to qualify a limited number of young researchers specifically for vacant professorial positions and at the same time to strengthen the research culture at the university of applied sciences. The offer is directed explicitly at candidates who do not yet fulfill all formal appointment requirements for a professorship (Art.7 Par.3 BayHSchPG; Hochschulallianz für den Mittelstand, 2016). They should acquire the missing qualifications in the course of the program and be supported by " academic mentors", who bring research and transfer projects into the programme for joint work.

Accordingly, the following qualification paths could counteract the lack of qualified professors (Lay & Ruf, 2019; Wissenschaftsrat, 2016):

- Doctoral graduates without work experience in the private sector (e.g. research assistants at universities) work with an extramural partner at least 60% of the time for three years during the pro-gramme
- Professional practitioners with at least three years of work experience in the non-university sector but without a PhD complete a cooperative doctorate in the programme with a university

During the qualification phase, each junior professor should be supported by a academic mentor as team partner. The academic mentor's task is to integrate and further develop the junior academics in all relevant fields of work at the university of applied sciences (teaching, research, transfer, didactics, acquisition of thirdparty funds, academic administration, team building).

In addition, the two conduct research or transfer projects (Lay & Ruf, 2019; Wissenschaftsrat, 2016) jointly and participate in the digital innovation cluster that will be created in the project (see Figure 1). During the entire qualification phase, academic mentors receive a reduction of six teaching lessons per week (Wissenschaftsrat, 2016). The respective junior candidates will teach these courses; the academic mentor will ensure the quality of the teaching. During this period of reduced hours, the mentor has the chance to realize applied research projects, in which the young academics are also involved. Accordingly, there is no structural deficit in the teaching activity, while the university profile can improve through applied research projects. The junior professors can take advantage of the “Service Centre for Digital Teaching and Didactics” to hone their didactic skills via training courses.

If the junior researcher (temporary position) has acquired all the necessary formal requirements during the programme and has also demonstrated his/her potential, he/she should be awarded a tenured professorship without having to reapply. However, the legal conditions have not been created yet.

On the one hand, this would make it possible to open up a completely new highly qualified target group for professorships at universities of applied sciences. On the other hand, the working conditions would be much more attractive for existing professors via the applied research projects.

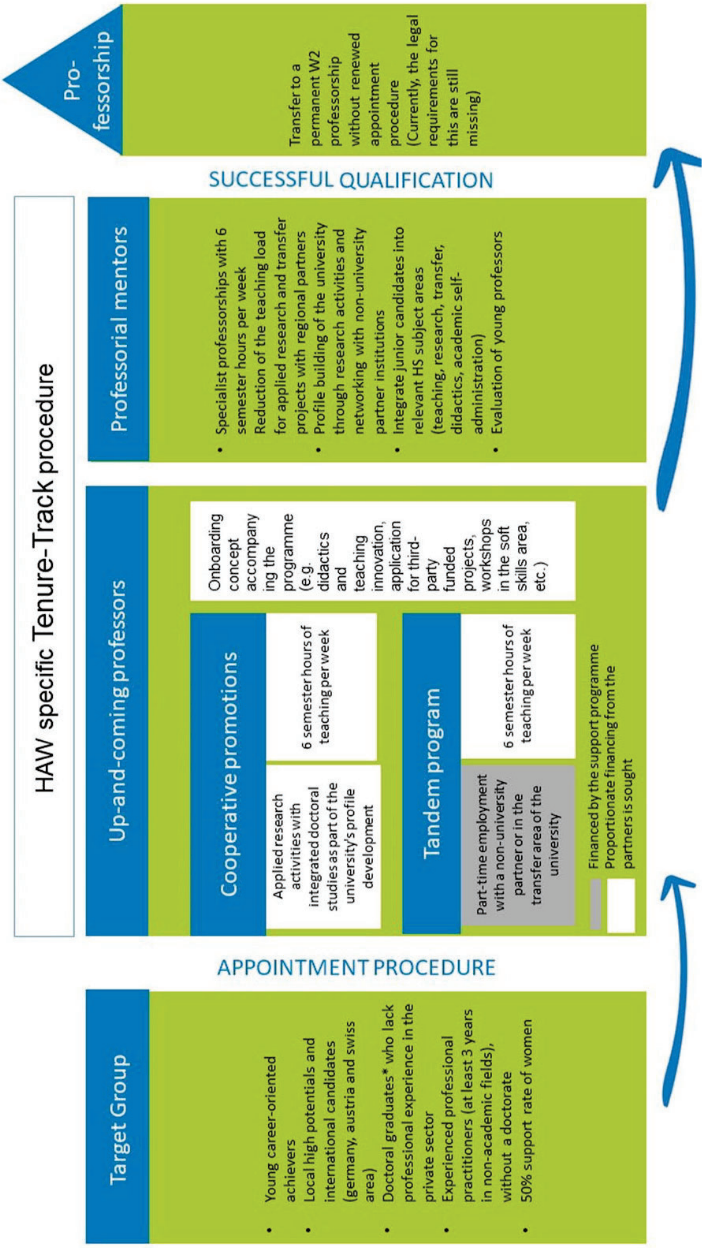

Figure 1. Structured and plannable career opportunities for professors at universities of applied science

4. CONCLUSIONS AND OUTLOOK

Funds from the Federal Ministry of Education and Research (BMBF) allow on the one hand to strengthen some marketing measures for attracting qualified personel. On the other hand four candidates can be preparer for a professorship at a university of applied sciences. Should the experience with this kind of qualification be positive it might lead to an institutionalization of this kind of process.

AUTHOR CONTRIBUTIONS

Patrick M. Gröner: Conceptualization, Investigation, Writing, Project Administration, Supervision.
Lena Dittrich: Conceptualization, Investigation, Writing.
Barbara E. Hedderich: Academic consultation and presentation of the results.

REFERENCES

Bayerisches Hochschulpersonalgesetz (2020). Artikel 7 Abs. 3 Bayerisches Hochschulpersonalgesetz (BayHSchPG). Available: https://www.hs-ansbach.de/fileadmin/Redaktion/Hochschule/Einstellungsvoraussetzungen_Prof_Artikel_7_Abs._3_BayHSchPG.pdf (Last called: 05.04.2022).

Hochschulallianz für den Mittelstand (2016). HAW-Professorinnen- und Professorennachwuchs durch eigene neue und innovative Karrierewege Ein Positionspapier der Hochschulallianz für den Mittelstand. Available: http://www.hochschulallianz.de/fileadmin/dateien/Positionspapier_innovative_Karrierewege.pdf (Last called: 05.04.2022).

Lay, M., & Ruf, M. (2019). Nachhaltige Personalbeschaffung – *Am Beispiel der Stellenbesetzung von Professoren an Hochschulen für angewandte Wissenschaften*. In W. Wellbrock & D. Ludin (Eds.), Nachhaltiges Beschaffungsmanagement Strategien – Praxisbeispiele – Digitalisierung (P. 149 – 164). Wiesbaden: Springer.

Wissenschaftsrat (2016). Empfehlungen zur Personalgewinnung und entwicklung an Fachhochschulen. Available: https://www.wissenschaftsrat.de/download/archiv/5637-16.pdf?%20__%20blob=publicationFile&v=3 (Last called: 05.04.2022).

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WE'RE MORE EQUAL ON ZOOM: INCLUSION AND PERSONAL RELATIONS IN THE VIRTUAL CLASSROOM. WHY WE SHOULD NOT ABANDON WHAT WE HAVE LEARNED DURING THE PANDEMIC

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***ABSTRACT*:** Foreign language teaching as well as courses on culture and civilization have had to switch to an online format during the pandemic. During this time, instructors had to defend their teaching methods against reproaches that these course contents could only be adequately taught in a face-to-face setting in a physical classroom. This article shows how online tools create inclusion and closeness in virtual settings and explains that for some learners, online teaching might generally be the better option. Based on our own opinion poll, a brief literature review and a presentation of our best practice examples, we argue that before, during and after the pandemic, online teaching has its advantages that can be applied in a meaningful, targeted way.

Keywords: *Online teaching; Inclusion; Virtual classroom; Closeness; Social anxiety disorder*

1. INTRODUCTION

Online courses have been in demand for several reasons even before the pandemic. We are now in a situation where teaching on-campus is possible, yet some learners choose online classes. Online teaching has generally been accused of being aloof and uncommunicative since personal contact is missing, blocked by the screens between people.

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The purposes of this paper can be divided into three main points. First, we would like to understand whether the majority of students really wants to go back completely to on-campus teaching after the pandemic and what the rationale behind their choice might be. Second, we want to explain that online courses have advantages for a certain type of students, namely what we call anxious learners. Third, we wish to show how online tools can create direct communication on an individual level in virtual classrooms and this way overcome distance between course participants as well as between these and their teacher in foreign language and culture and civilization courses. By doing so, we suggest guidelines for future formats of communicative teaching in a volatile situation during and after a pandemic that creates uncertainty among institutions, teachers, and learners.

The remainder of this paper is structured as follows: Chapter two presents the methods applied in this paper. In Chapter three we outline the main results of our own opinion poll on the preference of online or on-campus courses. Chapter four takes a brief look at literature from the fields of Psychology and Neurodidactics to describe the needs of learners in general and anxious learners in particular. Chapter five is a collection of our own best practice examples to create closeness and inclusion in online courses. Chapter six summarizes the main findings and suggestions and offers an outlook.

2. METHODS

We carried out an opinion poll at a university in northern Bavaria on an internet platform to find out what students' current preferred form of instruction is: online or on-campus. All enrolled students at this university were sent a link to the online poll about courses in all fields of study by e-mail. The poll comprised four short questions to keep it as brief as possible and thus obtain the highest number of complete replies possible. Preliminary results are presented here and a more thorough analysis will be published elsewhere.

Through a brief literature review we collected basic facts about two topics relevant for teaching in general, and for teaching groups of anxious young adults in particular: Emotion and learning, and anxiety and learning. We chose these topics because we consider them highly relevant for the groups of students we have been teaching in the recent years, namely young adults in foreign language and culture and civilization courses. The reviewed papers were chosen from encyclopedia for the general academic public and standard literature on foreign language teaching. It should be stressed at this point that the findings can be applied to teaching in general and are not limited to foreign language teaching.

Drawing on our own experience as teachers of foreign language courses and courses on communication skills, we compile some best practice examples to show how anxiety can be reduced and closeness can be created in online courses.

3. OPINION POLL: DO WE ALL WANT TO GO BACK INTO THE PHYSICAL CLASSROOM?

Our poll was carried out at the beginning of the summer term of 2022 on an internet platform. All students of one Bavarian university were invited by email to take part. The fact that roughly one thousand students took part within the first 24 hours shows how relevant the topic must be for them. The first question was about participants' spontaneous preference: online or on-campus courses. Out of the 1323 participants, 710 (53.63%) voted for online courses, 549 (41.47%) for on-campus courses.

Participants were then asked, "Do you see advantages in online courses?" and "… in on-campus courses?" and several advantages were suggested based on personal communication with students in a multiple-choice menu, all starting with "Yes, because…". They might have been influenced by the suggested reasons but had the chance to add further advantages, deny all of them and comment on any of them in a text field right next to the indicated advantage. The following reasons to see advantages were suggested, figures are listed in table 1. Advantages for online courses: It gives me more flexibility on learning location; I am afraid of an infection with the Coronavirus; I feel more comfortable than in the classroom; I see other advantages (please specify); No, I don't see any advantages. Offered reasons to see advantages for on-campus courses: Personal contact is important; One can use university infrastructure such as the cafeteria and library; There are less technical problems; I see other advantages (please specify); No, I don't see any advantages.

Table 1. Example table

Online courses	%	On-campus courses	%
Flexibility on location	73.49	Personal contact	61.03
Fear of Covid infection	29.00	University infrastructure	39.50
Comfort	25.91	Less technical problems	20.69
Others	29.91	Others	16.54
No advantages	8.01	No advantages	16.39

The main reason for a preference of online courses is local flexibility, the main reason for on-campus courses personal contact. Only 8 % see no advantages in online courses whereas twice as many participants, 16.39%, say they do not see advantages in on-campus courses. It is obvious from these figures that not everyone wants to get back into the physical classroom.

Next, a question was included whether their personal preference was based on their individual character. Again, several justifications were suggested that could be commented on or denied, and further reasons and comments could be added. This part of the poll was conditioned, so that participants who had chosen online courses as their preferred mode were asked if the reason for this preference was connected to any, several, or none of the following attitudes (shares given in brackets): I am open for modern media (32.25%); I am rather shy (11.18%); Yes, for another reason (5.21%); No (9.74). Participants who had chosen on-campus courses as their personal preference were given the following possible justifications for their choice: I enjoy being with others (25.00%); I don't like spending time on the computer (5.06%); others (3.85%) or No (8.91%).

Finally, the chance to comment on the combination of online with on-campus courses was given. For reasons of space, only a rough summary of responses is given in brackets. Participants were asked to rate the following formats as positive ("+") or negative ("-"): Hybrid courses, in which a part of the students meet on-campus and another part takes part online (overwhelmingly positive); Blended learning, in which a part of course contents has to be dealt with online and another part on-campus (mainly positive); A flexible change between online and on-campus (clear positive tendence). No further choices were included to keep the poll short, but participants had the chance to comment on these two formats and suggest further ones. A more detailed analysis of responses and comments will be published elsewhere.

As can be seen, online formats are welcome as a modern way of learning and in some cases due to shyness. One should keep in mind, however, that there might be a bias since the poll was carried out online and less digitalized students might have felt inclined not to take part because of this form. A reviewer points out that another bias might be found in the fact that recent experience could only be made online, particularly affecting beginning students. We believe, however, that a minimum of 12 years of in-class teaching at school would certainly level that out.

4. ANXIETY IN THE CLASSROOM AND WHY WE NEED TO REDUCE IT

We have been observing growing numbers of shy learners at smaller universities in southern Germany and elsewhere. Whether learners suffer from social phobia, social anxiety disorder (SAD) as a pathology or are simply shy, introverted or generally anxious is not up to us to judge, so we will use the term "anxious learners" to refer to them. School anxiety is known to affect around fifteen percent and this number is growing (Florin 2022), and a lifetime period of this anxiety is estimated to affect around seven percent (Sartory 2021). School psychology has identified anxiety as one of the contributors to rejectionist attitudes (Florin 2022). One of the manifestations of this shyness is the phenomena of black tiles on Zoom. Who has not experienced situations that might lead to slightly frustrating situations for teachers as this one: Well prepared and enthusiastic about modern online teaching, the teacher starts their online meeting—and faces a dull mosaic of black tiles. Hardly any participant seems to be willing to show their face and accompanying your learners along their way to success becomes talking to a mainly black screen. Even when asked to turn on their camera, many students claim to find themselves in an "unpresentable state" and prefer to leave their camera off, even without displaying a picture instead. Having talked to many of our students, we believe that one of the reasons for this behavior is (classroom) anxiety. Another reason might be the estrangement due to the perception of the own presence in the physical space and simultaneously on the screen.

We take for granted that it is not the medium itself, but the instructors' attitude and technological as well as didactic competence that contributes to creating inclusion, closeness, and a reduction of anxiety in the classroom. Using the right tools is a question of learner and teacher personality, and certain tools can contribute to an anxiety-free learning setting. Ever since the Affective Filter theory was suggested in the late 70s (Dulay and Burt 1977), the importance of this type of setting has been generally acknowledged as a necessary starting point to make learning possible: "Low anxiety appears to be conductive to second language acquisition, whether measured as personal or classroom anxiety." (Krashen 1982). Negative emotions, such as fear and anxiety, are depicted as a filter that keeps the learner's brain from absorbing input and learning. One of the teachers' goals is, therefore, to create a low filter learning environment. Pennington and Richards (1986: 217) point out that anxiety and stress also affect performance. As we know from neurodidactics investigations, emotion plays a role in (foreign language) learning and especially for language and culture courses appropriate teaching methods that foster communication skills are paramount, since linguistic actions imply emotion as part of expression (cf. Donnerstag 2010). Experiencing authentic real-world linguistic acts may well form the center of foreign language learning, and this can be achieved through methods based on virtual or drama pedagogy. The roots of drama pedagogy reach back to the 18th century, as considerations were already made for an action-oriented foreign language teaching in connection with theater methods (Sambanis 2013). The PDL-method (Psychodramaturgy for Language Acquisition, abbreviated after French

Psychodramaturgie Linguistique) is an approach to foreign language learning, initiated in 1977 by Bernard Dufeu, that takes its origin both from the Psychodrama of J. L. Moreno as well as from dramaturgy and theater pedagogy. Dufeu describes his approach as a “pedagogy of being”, in which language is a means of communication and encounter, as opposed to a “pedagogy of having”, in which linguistic structures are the object of the learning process and instructors are purely mediators of knowledge (Baudracco-Kastner 2022).

Our suggestions are supposed to help teachers understand these reasons and reduce these frustrating moments: For some students, it may feel embarrassing or even threatening to show their face in a group and “hiding” behind a screen is not to be interpreted as a lack of interest. Could a certain adjustment of the setting and methods lead to a more positive teaching and learning situation, in which both parts feel more comfortable?

5. REDUCING ANXIETY AND CREATING CLOSENESS FOR ANXIOUS LEARNERS IN ONLINE COURSES

It has been shown that online courses are the preferred mode of instructions for many learners. Anxiety is a hinderance in the learning process, and a growing number of students are facing challenges in connection with anxiety. We consider it paramount to offer an anxiety-free virtual learning environment in order to reach out to our students and suggest the teaching methods described in the following.

5.1. How to contribute to an anxiety-free virtual learning environment

Foreign language courses can touch upon at least two methods used in therapy (Gordon and Wong 2014): Social Skills Training, since socializing is a part of communication, and Relaxation Techniques, since taking part in a course from home, the comfort zone, contributes to being less tense. Furthermore, aspects of Mindfulness-Based Therapies can be incorporated by using portfolios as performance records that take out the pressure of exams (cf. Gebhard 2020). Online courses may present a safe learning environment since it provokes less anxiety than real-life interaction according to a study of 2,348 college students (Yen et al. 2012). This explains why some people opt for online courses even after the pandemic and it explains black tiles, since these offer anxious learners the protection they are looking for. Black tiles should not be seen as the long-term solution for these learners though. In fact, it might appear even counterproductive to offer this kind of “hideout”. As Andersson et al. conclude, internet-based cognitive therapy is a “promising new treatment option” and “effects seem to be stable over long-term follow up" (p. 581). We certainly do not suggest turning teachers into therapists but rest assured that internet-based instruction serves as a mean to reach out to anxious learners and offers them a first step into an anxiety-free learning environment. An announced invitation to turn on the camera only for a quick salutation after some time (or even lessons) showed effect in several courses taught by one of the authors of this article: half of the students left their camera on. With due patience, anxious learners can be led to get out of their comfort zone step by step. One of the later steps should be communication with native speakers of the target language or culture. Doing this through tandem apps (such as *Tandem, HelloTalk*, etc.) again gives anxious learners the chance to start this journey from the safe setting of their comfort zone.

Online courses offer direct private communication between teachers and students. Receiving corrective feedback in front of fellow students is certainly more face-threatening than receiving a private chat message within one's comfort zone. They also offer the chance to participate in small groups (breakout sessions on Zoom) in which the perceived threat by "the public" is reduced due to the small group size.

Furthermore, hypersensitive learners only have the chance to reduce the amount of sensory input in virtual classrooms, thus reducing their level of tension.

After these brief introductory suggestions, we would like to give some more detailed examples on how to create closeness and overcome physical distances in digital formats in the following section.

5.2. How to reach out: Closeness and distance in the virtual classroom

"Imagine sitting in a room full of people, and nobody is there". "Imagine sitting in your living room and being together with people in Australia, Spain and Mexico at the same time". These seemingly contradictory statements perfectly describe the paradox of closeness and distance (Krauskopf 2021) caused by video conference formats.

In the following, the terms closeness and distance with regard to relationships in a group setting will be shortly outlined. We differentiate between emotional closeness and physical closeness, whereby these influence each other in the context of physical presence. The need for closeness and distance differs individually, depending on culture, situation, and personality structure. For describing group structures and actions, the personality model by Fritz Riemann, described in its book *Basic forms of anxiety* (1961), and the resulting "Riemann-Thomann Cross" are often referred to. This model describes the contrasting orientations of humans (closeness/distance, continuity/change) in their individual manifestations as expressions of their underlying personality structures (schizoid, depressive, compulsive, hysterical). The structures originally described as pathological are adapted in this model for the description of “normal-neurotic” characters (Stahl 2007). For instance, the need for closeness correlates with characteristics such as people orientation, extroversion, the need for recognition and harmony. The need for distance, on the other hand, correlates with factual orientation, rational thinking, and the need for detachment. The orientation of individual group members towards the four basic needs influences communication and social behavior. Rules also contribute to establishing a relation between closeness and distance in any situation. Moreover, cooperation in a didactical context is influenced by shared notions and expectations related to social roles (Krauskopf 2021: 219). It stands to reason that individual needs and behavior towards closeness and distance and the commonly acknowledged social rules affect the dynamics (and hence, the ability to work and learn) of a group.

These reflections seem particularly interesting when observed from the perspective of online meetings through video conferences. They emphasize the paradox of feeling close despite being distant and raise questions concerning the perception of our virtual activities. Besides the aspect of reduction, apoint frequently used to argue against online classes, virtual participation might also offer a sense of protection (familiar domestic surroundings) and advantages such as the comfort of not having to move or commute. This enables anyone to easily connect with anybody around the world. Anxious learners can particularly benefit from a virtual classroom that facilitates integration and participation by all.

For all these reasons it strikes us as plausible to free the digital learning space from its reputation as being just a workaround. We should establish it as a distinct, complementary, or alternative format. The question is how the benefits of the format can be optimized and how downsides can be minimized to enable interaction and group dynamics to develop. The aim is to develop a virtual learning space that incorporates and adjusts the relations in the new medium. This way, it is possible to achieve and sustain a positive, fostering atmosphere within a secure and trustful frame. In the following, we will particularly elaborate on the reduction of perception caused by the absence of physical presence and the simultaneous presence in two dimensions in the online formats. The mentioned methods and activities refer to the context of online teaching, but also apply to other areas of digital cooperation (e. g. in management training, team, and project work) with some adjustments.

All humans experience the world in a spatial way and constantly face the choice of either being close to other humans and things, or seeking distance. Our freedom of choice, however, is limited. No matter how hard we try to distance ourselves from the external world (emotionally and physically), we cannot just escape it. In a group situation such as classes, we continuously question our place in the group and try to balance closeness and distance. In the context of presence classes, it first happens in a physical way: We enter a room at our own pace, we receive signals such as glances, postures and movements that guide us to our choice between consciously involving ourselves in a situation or just observing it. At the same time, we are part of a group and find ourselves exposed to a situation. If we do not feel comfortable, we cannot just escape and avoid being seen. We may not even be free to choose who we want to be close to or distance ourselves from. Entering the room at the beginning of a group process, but also at the beginning of every meeting, is a demanding situation that can create different levels of stress, depending on individual personalities. This situation requires a "frame" that acts like a protective film and provides space for every individual. In the context of classes, it is the task of the teacher to create this frame. If classes are conducted with physical attendance, this frame consists of distribution and equipment of rooms where the work will take place, as well as procedures and rituals such as joining up in front of the classroom, having a coffee together or greeting rituals. People connect with each other, and this contributes to everybody joining in and making themselves comfortable with the group before the start of the actual work. In the course of the classes, this frame connects the group members with each other and with course contents and provides orientation and security.

What does the phase of arrival look like in the digital environment? This topic implies different questions related to closeness and distance, but also to the axis of continuity and change of the "Riemann-Thomann Cross", namely how we experience closeness and distance in a room that we can only perceive two-dimensionally on a screen; which dynamics develop when somebody is at home and at the same time participates in a virtual group; how continuity-oriented people deal with the uncertainty of a new setting; how much trust or skepticism people show towards technology; and whether they understand it as a chance or a threat.

The lack of three-dimensionality and sensory impressions makes it impossible to arrive in a group in the known and socially accepted way. The virtual setting also features a lack of orientation that presence situations usually provide in the form of social and interactive rituals. But for individuals as well as the group itself, the same identification phase takes place. We choose more or less consciously between closeness and distance, search for our comfort zone and either feel good or not. Online formats should also be designed in a way that allows all participants to arrive within a secure frame. This is the requirement for active participation in a fostering atmosphere.

When comparing the arrival at a virtual room to the arrival at a class on site, it appears that this happens very fast in videoconference. Our choice between physical closeness and distance disappears. We find ourselves in a group and feel the pressure to say something and break the silence, which can be unpleasant. We do not choose who is going to appear in the tile next to us. Mutual and simultaneous eye contact does not take place. Even seeing one' own image can be irritating: how do the others perceive me? Am I on screen or in my own room? Which private information do I reveal through showing a particular background? From this perspective, it seems comprehensible that anxious learners often leave their tiles black. The immediate appearance on screen can overwhelm these learners and trigger them to stay invisible in order to avoid an unpleasant situation. A purposeful approach to entering the virtual room can reduce the hesitation to turn on the camera and encourage the group members to participate. When starting a meeting, teachers can share an image on screen or play music to make the silence less uncomfortable. This also enables the participants to observe and estimate what to expect from others. Every individual can choose when to turn on their camera. Images and music may connect to the contents of the subsequent lesson. In language classes, for instance, it can be a song in the foreign language. To create a relaxed and informal atmosphere, teachers can choose to stay in the background until all participants show up, and just welcome everybody in the chat. From this observing position, the teacher can also analyze how the group comes together, what moods they show and what conversations arise and thus prepare for the lesson.

The arrival in the virtual classroom can be mentioned and designed explicitly. This makes sense when the group includes members who refuse to participate with image and sound and leave their tiles black. A short explanation of how social dynamics in a group take place and how they are perceived differently by every individual shows learners that they receive attention. Subsequently, teachers can invite individuals to experiment what the arrival in the online group feels like and which possibilities are at hand to design it. At the beginning of the "experiment", everybody is asked to turn on their cameras when they feel ready to start. Learners can stand up, leave the camera image, regulate their distance to the screen and find their own pace and position. As a sign of arrival, learners can be asked to adopt a posture or to say a short welcome sentence (in language classes, in the foreign language). After this conscious arrival, it is relatively likely that all cameras will stay on. Through observing the arrival of the other group members, learners can discover similarities in behavior that strengthen group cohesion and the emotional closeness between them.

A further step is integrating sensory impressions and three-dimensionality in the virtual environment. In the "real" world, we are constantly exposed to sensory impressions. These influence our behavior, our well-being and our choices of closeness or distance. During the initial phase of a group situation, we "sniff" at the room we are in and the others around us. Body language and postures allow us to inspect our fellow people, their character traits and status in the group. This contributes to us finding our place and interacting with others adequately. Furthermore, it provides security and stability because we can see what is going on. In the virtual realm, we see as many settings as there are participants in the group. These settings have their own circumstances and mostly remain hidden. This crucial factor can complicate the creation of a trustful group atmosphere and a secure frame. It is important to reflect on the circumstances of online formats and their impacts to understand ways of behavior. Some activities can contribute to establishing mutual trust and integrating the "realities" of individuals in the group process. At the beginning of an online session, walking through the room can help individuals to focus on the two dimensions of the physical and virtual room and their presence in both rooms. The learners are invited to move mindfully within their surroundings and to gather sensory impressions (looking out of the window, colors and sounds in their room). Impressions like images or sounds can be brought back to the digital experience. In an initial plenum, everybody can imitate a sound or describe an image and thus reveal their experience in the physical room to the others. The technique of role reversal, originating in the psychodrama of J. L. Moreno, can create an introductory plenum that at the same time includes the surroundings and let people share information about them with the group. One popular activity is the role reversal with a "familiar object". With this method, learners are asked to display an item in their room that would tell something about them if it could speak. Subsequently, learners act as the chosen item and tell something about themselves ("I am X's coffee cup, and we spend a lot of time together when X studies"). In language classes, this activity not only strengthens perception, but also becomes an oral expression exercise. The role reversal itself provides a sense of shelter for anxious learners because they speak through an item and feel less exposed. Revealing their domestic surroundings can make some people feel uncomfortable. But by leaving it up to participants if and how much they would like to show, nobody is forced to strip off their privacy.

These are just some methods to tackle the new and unfamiliar ways of being together in the virtual environment and to handle the new perspective on closeness and distance. The aims are:

- To support members to find their place in the group,
- To provide the basis for regulating the tension between closeness and distance that is different from physical settings,
- To encourage everybody to consciously perceive themselves and their presence within the group in two dimensions,
- To involve sensory impressions in order to use more channels than just speaking,
- To create a shared realm of experience where individuals can get together as a group,

- To introduce the learners to the virtual setting and its rules, enabling them to discover it,
- To offer security and orientation and satisfying the need for structuring the new situation.

So far, we have mainly put our focus on overcoming distance in the digital setting. We asked ourselves the question: how can we handle the reduction that we experience in the virtual realm and how can we integrate processes of group dynamics? Concluding this paper, we would also like to address the question of how the novel properties of digital media can contribute something new to the learning process.

From our point of view, digital settings, besides being a new form of togetherness that still requires further research and the establishment of social rules, also provide a protective function. This sense of protection can particularly be understood as a chance for successful integration into the group for anxious learners. Coming back to the Riemann-Thomann Cross, introverted people and anxious learners rather have an orientation towards distancing themselves. They need room for themselves, distinction, and individuality. Participating in classes from their own domestic surroundings can mean a sense of protection missing in physical settings. As a consequence, they can reduce stress and develop a positive attitude. The twofold presence on the screen and in their own room might seem awkward at first, but also constitutes a frontier that cannot be trespassed by others. Some learners in language classes reported that it was easier for them to express themselves in the foreign language because of the sense of “shelter” in front of the screen. Instead of being in the midst of the attention of a group, they can act out of a familiar position and pose in their known surroundings, which contributes to spontaneous expression. This can be more uncomfortable when being exposed to the reactions of a group physically present. One of the main techniques of the didactics method of Psychodramaturgy for Language Acquisition by Bernard Dufeu uses symbolical, neutral, and blind masks that also provide a sense of shelter for beginners of foreign languages. It allows the learners to focus on listening and expressing linguistic utterances in an individual exercise. In the digital realm, this effect gets amplified by the familiarity of the surroundings. We furthermore offer the learners to turn off their camera image when working on individual exercises, in order to assure their focus.

Considering some characteristics of our target group, it is also vital to mention the “democratic” character of a video conference. In an analog setting, personalities reveal and produce information physically, in how they occupy space: Anxious learners mostly have a rather secluded attitude (shoulders inbound, head and sight downward) and move in a smaller radius. Extroverts, in contrast, tend to have a solid erect posture and attract attention with their verbal, nonverbal and paraverbal behavior. Unlike introverts, they are seldomly overlooked. In physical classrooms, there is a particular danger of introverted students receiving too little attention, falsely assuming that their performance and participation are insufficient. For these learners, the tile in a digital surrounding provides the chance to be on equal footing with everybody else, to be granted the right to be equally present and important. They receive more attention without doing anything proactively, just by turning on their camera. This can strengthen their confidence and, consequently, their willingness to learn, and their performance. Instructors might want to focus on treating everyone in the same way as far as participation in class, turn taking and the like are concerned, for example with apps that display a countdown on screen for equal speaking time, going through the list of participants in a foreseeable way so that learners can get prepared when to speak, etc.

As opposed to the aforementioned reduction of closeness that the virtual realm brings with it, it is also important to look at the chance of overcoming physical distances. Through reducing the logistical requirements, there are more possibilities of participating in virtual meetings and less limitations regarding the composition of groups. This also promotes the inclusion of people with handicaps, who have the chance to participate in groups without logistical difficulties or physical restrictions.

At the same time, it may also contribute to an increased diversity of backgrounds and nationalities in the groups, because it does not matter where participants are. We would also like to mention a recently conceived voluntary project to improve the linguistic integration of Ukrainian refugees with free German lessons on Zoom. The participants are spread all over Germany and other countries. Under the title "Internationalization at home", Gebhard (2018) deals with the independence of space and time provided by the digital realm. He describes different methods for digital language classes that have proven successful at Ansbach University of Applied Sciences, such as the communication with native speakers in chats and video tandems with partner universities. These methods also make it easier for students who have little affinity for traveling and communication with foreigners to get to know a foreign language and culture.

Viewing closeness and distance through the perspective of digital media offers completely new perspectives and, at the same time, poses many research questions. We find it important to investigate the new and distinct qualities of virtual settings and to cast a positive light on them, freeing them from being seen as a mere replacement for traditional concepts and emphasizing their own dynamics.

6. SUMMARY AND OUTLOOK

The three questions raised at the beginning of this paper were: Do students really want to go back to on-campus teaching? What role play anxiety and emotions in the learning process? And how do we contribute to an anxiety-free learning virtual environment and reach out to our students in online courses? They can be answered as follows.

According to our opinion poll summarized in chapter three, a majority of students prefer online courses, mainly due to the flexibility this offers. At the same time, personal contact matters to most of them. Anxiety was identified as a main hinderance of learning in chapter four, that also found that emotions play an important role, at least in courses in which expression and communication skills are to be acquired. Online tools can be used in ways to reduce anxiety and create closeness in online courses as described in our best practice examples in chapter five.

Most of us have become acquainted with tools for online teaching. Many teachers embrace the idea to turn back to on-campus teaching and some institutions seem to rule out any alternatives to this mode of instruction. It is our believe that the lessons learned during the pandemic should guide us into a future of flexible modern language teaching with a plethora of methods targeted at diverse groups of students. There is no need to force anyone to any kind of method. We hope to have shown that some reservations against online teaching are groundless and that it certainly has its advantages for many learners.

A further look into how anxious learners develop their communicative skills and work on their readiness to actively approach others, thus reducing inhibiting factors of their shyness may well be worth a longitudinal study.

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No conflict of interests can be reported.

AUTHOR CONTRIBUTIONS

Christian Alexander Gebhard is mainly responsible for chapters two through four. Monica Baudracco-Kastner is mainly responsible for chapter five. All other responsibilities and chapters were equally shared.

REFERENCES

Andersson, Gerhard; Carlbring, Per; Furmark, Thomas (2014): Internet-Delivered Treatments for Social Anxiety Disorder. In: Justin W. Weeks (Hg.): The Wiley Blackwell Handbook of Social Anxiety Disorder. 1. Aufl. s.l.: Wiley-Blackwell, S. 569–587.

Baudracco-Kastner, Monica (2022): Online-Sprachunterricht mit der PDL (Sprachpsychodramaturgie): Wege zu einer virtuellen Begegnung. In: *Z Psychodrama Soziom*. DOI: 10.1007/s11620-022-00657-w.

Baudracco-Kastner, Monica (2020): Psychodrama goes online. Möglichkeiten virtueller psychodramatischer Arbeit für Training und Beratung. München: GRIN Publishing GmbH.

Donnerstag, Jürgen (2010): Emotion. In: Carola Surkamp (Hg.): Metzler-Lexikon Fremdsprachendidaktik. Ansätze - Methoden - Grundbegriffe ; mit 15 Graphiken und Tabellen. Stuttgart, Weimar: Verlag J.B. Metzler (Metzler-Lexikon).

Dulay, Heidi; Burt, Marina (1977): Remarks on Creativity in Language Acquisition. In: Marina Burt, Heidi Dulay und Mary Finocchiaro (Hg.): Viewpoints on English as a second language. In honor of James E. Alatis. Unter Mitarbeit von James E. Alatis. New York: Regents Publ, S. 95–126.

Florin, Margaretha (2022): Ängstliche Kinder in der Schule. Ein personzentriertes Verständnis und Handlungsempfehlungen für Lehrpersonen. In: Susan C. A. Burkhardt, Beatrice Uehli Stauffer und Susanne Amft (Hg.): Schüchterne und sozial ängstliche Kinder in der Schule. Erkennen, verstehen, begleiten. 1. Auflage. Stuttgart: Verlag W. Kohlhammer, S. 103–123.

Gebhard, Christian (2020): Das Lernportfolio als Leistungsnachweis im Chinesischunterricht. In: *CHUN Chinesisch Unterricht* 35, S. 86–102.

Gebhard, Christian (2018): Praxisbericht: Interkulturelles Video- Tandem an der Hochschule Ansbach. In: Zeitschrift für Interkulturellen Fremdsprachenunterricht. Didaktik und Methodik im Bereich Deutsch als Fremdsprache (23), 149-154.

Gordon, Dina; Wong, Judy (2014): Cognitive-Behavioral Therapy for Social Anxiety Disorder. The State of the Science. In: Justin W. Weeks (Hg.): The Wiley Blackwell Handbook of Social Anxiety Disorder. 1. Aufl. s.l.: Wiley-Blackwell, 477-.

Krashen, Stephen D. (1982): Principles and practice in second language acquisition. Oxford: Pergamon Press (Language teaching methodology series).

Krauskopf, Karsten (2021): Wenn die Kamera dunkel bleibt – Psychodramatische Überlegungen zur Rolle digitaler Medien beim Lehren und Lernen. In: *Z Psychodrama Soziom* 20 (2), S. 209–222. DOI: 10.1007/s11620-021-00602-3.

Sambanis, M. (2013). Fremdsprachenunterricht und Neurowissenschaften. Tübingen: Narr Francke Attempt Verlag GmbH + Co. KG

Sartory, Gudrun (2021): Phobische Störungen. In: Friedrich Dorsch und Markus Antonius Wirtz (Hg.): Dorsch - Lexikon der Psychologie. 20., überarbeitete Auflage. Bern: Hogrefe, S. 1351–1352.

Stahl, E. (2007). Dynamik in Gruppen. 2., vollständig überarbeitete und erweiterteAuflage. Weinheim, Basel: Beltz Verlag

Yen, Ju-Yu; Yen, Cheng-Fang; Chen, Cheng-Sheng; Wang, Peng-Wei; Chang, Yi-Hsin; Ko, Chih-Hung (2012): Social anxiety in online and real-life interaction and their associated factors. In: *Cyberpsychology, behavior and social networking* 15 (1), S. 7–12. DOI: 10.1089/cyber.2011.0015.

Poster Session

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PROJECT: DIAS – DIGITAL INTELLIGENT STUDY ASSISTANT

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ABSTRACT: A successful study requires an efficient study organization. Not all students succeed in this, especially in distance learning scenarios. In the DIAS project, a digital intelligent assistant for studying and teaching is to be developed. The AI-based assistant will accompany students, motivate them and enable them to better organize and successfully complete their studies. It serves as a planner, communicator, analyzer and motivator. The assistant is being developed in close cooperation with all stakeholders and tested as a model in two degree courses at the University of Applied Sciences Ansbach. An app and an information terminal are to be implemented as exemplary output channels at Ansbach University of Applied Sciences.

Keywords: *Digital assistant; Distance learning; Chatbot; Education*

1. INTRODUCTION

During the Covid-19 pandemic universities needed to provide distance learning resources, but most universities lack appropriate digital assistants to provide students without face-to-face teaching a full educational experience. Innovations in the field of digital assistants with the usage of AI are offering a promising opportunity for new supporting systems in the educational domain. Since October 2021, the DIAS project has been running at Ansbach University of Applied Sciences with the goal of accompanying, motivating, and empowering students to better organize and successfully complete their studies. Therefore a **D**igital **I**ntelligent **A**ssistant for **S**tudying and teaching (**DIAS**) is to be developed.

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2. RELATED WORK

An intelligent assistant can be defined as an artificial intelligence system which is capable of talking to users in natural language (Windiatmoko, Rahmadi & Hidayatullah, 2021). They are able to respond to instructions and to help with certain tasks or queries by finding and providing information (Chandra & Suyanto, 2019). Reviewing related literature, different potential application areas for a digital study assistant can be identified. However, it can be stated that the majority of digital agents in this context are chatbots. One study represents therefore a comprehensive literature review demonstrating use cases of chatbots in education (Wollny et al., 2021). But the DIAS project aims to take a different approach to a digital assistant. To cover the various needs of students multiple components shall be developed in addition to the communication component. Therefore a planning, analysis and motivation component is also foreseen for the DIAS.

3. METHOD

The project comprises three central measures that are interlinked through feedback. The first step is the conception involving all stakeholders and data protection issues. For this purpose, among other things, a target group-specific needs analysis is drawn up on the basis of a preceding persona analysis. Their experiences, needs and requirements are queried and recorded in the form of a specification sheet. Since DIAS mainly collects personal data of the students, the implementation of appropriate data protection is necessary and planned from the beginning ("privacy by design").

The second step is the technical development. Agile development of the underlying, central AI service is planned according to the CRISP-DM (Cross Industry Standard Process for Data Mining) procedure model.

The third step is the testing and scientific evaluation. In the project, a model implementation and testing will initially take place over the course of three semesters in two model study courses.

4. RESULTS

The DIAS shall consist of these components in more detail:

- Communicator: Chatbot for quick answers to questions related to studying and teaching
- Motivator: Reward and gamification elements to illustrate learning objectives
- Planner: Active support in study planning and self-organization
- Analyser: Voluntary, AI-based study analysis and progression forecast

Additionally following key features of innovation are ensured:

- Student-centeredness: Students and their needs are the center of the project. The overarching goal is to improve their motivation to study and their success in their studies.
- Benefit for other stakeholder groups: Teachers, course directors, advisors and administrative units also benefit. The digital assistant brings f.e. together data sources and information platforms already used by students, teachers and the administration, which ensures greater efficiency and clarity.
- Making available and using in other contexts: The DIAS is being developed as open source software, so it can be implemented not only at Ansbach University of Applied Sciences, but also at other universities.

5. CONCLUSION

Ansbach University of Applied Sciences wants to overcome the digital resource gap and enhance its information and counselling services for students with an innovative, digitally-supported approach summarized in the DIAS project. Therefore DIAS takes on various functions as a planner, motivator, analyzer, and communicator in the form of an AI-based chatbot. Students can interact with DIAS via various messenger services, the learning management system Moodle, the university's homepage, a hologram, and terminals on the university campus. It shall not only help students but also support additional stakeholders like teachers and administration. The results of the DIAS project is implemented university-wide for all study programmes and shall be made available as an open source solution for further usage.

REFERENCES

Chandra, Y., & Suyanto, S. (2019). Indonesian Chatbot of University Admission Using a Question An-swering System Based on Sequence-to-Sequence Model. Procedia Computer Science, 157, 367-374. doi: 10.1016/j.procs.2019.08.179

Windiatmoko, Y., Rahmadi, R., & Hidayatullah, A. (2021). Developing Facebook Chatbot Based on Deep Learning Using RASA Framework for University Enquiries. IOP Conference Series: Materials Science And Engineering, 1077(1), 012060. doi: 10.1088/1757-899x/1077/1/012060

Wollny, S., Schneider, J., Di Mitri, D., Weidlich, J., Rittberger, M., & Drachsler, H. (2021). Are We There Yet? - A Systematic Literature Review on Chatbots in Education. Frontiers In Artificial Intelligence, 4. doi: 10.3389/frai.2021.654924

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INFLUENCE OF VIRTUAL REALITY ON THE FEELING OF HUNGER AND THE CONSEQUENCES FOR THE FEELING OF SATIETY AND FOOD CRAVINGS

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ABSTRACT: The influence of virtual reality on the feeling of hunger was investigated. The test with a total of 61 participants showed that virtual reality via the eyes and hand movements can partially influence the feeling of well-being and satiety as well as strongly influence the desire to eat. A statement about the influence on the feeling of hunger cannot be made, because the answers from different questions give contradictory results. Further more detailed investigations are necessary to be able to make a clear statement about the influence on the feeling of hunger.

Keywords: Virtual reality; Influence; Hunger; Satiety; Cravings

1. INTRODUCTION

While newborns eat only to satisfy basic needs listening solely to their body sensation, most adults have exchanged this sensation for cultural eating habits. Also cultural eating habits have probably made every adult eat at least once even though they were not hungry at all. A familiar example scenario of this is the dinner invitation among acquaintances. Because social etiquette demands it everyone eats even if it does not taste good or they are not hungry. Among other things, because of these socially imposed constraints people forget to pay attention to their body-controlled hunger sensations as early as childhood (Gniech). In addition to societal eating triggers advertising also drives many people to eat on a regular basis. Especially in this day and age everyone is constantly surrounded by food advertisements that unconsciously evoke food cravings and make one believe that they have to eat something very specific and cannot do without this taste experience

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(FRANK, 2010). This not only remotely controls the pleasure center but causes many common diseases such as diabetes as a result of obesity. First studies show that therapies for weight loss can be supported by virtual reality (Coons, 2011). However, is it also possible to satisfy elicited cravings and the hunger often initiated only by the brain with Virtual Reality or even to cause a feeling of satiety without the body absorbing the calories? To find out the following research question is investigated. In which direction can the feeling of hunger before taking the lunch break meal (in the cafeteria) be influenced by virtual reality for students and employees of Ansbach University of Applied Sciences?

2. METHOD

To investigate this, a group of three students created an experimental setup in virtual reality. First, the setup of the food scene was determined. It was decided to arrange the food selection buffet-like on three extra tables in a semicircle in front of the test place. A clear overview of the food without influencing factors was considered important and the most practical usability. The next step was to determine the food selection. Since there should be a mixed selection of healthy and unhealthy dishes. Attention was also paid to the selection process to ensure that the food was photogrammetry suitable. For the test environment the 3D laboratory and the cafeteria of the University of Applied Sciences Ansbach were available. Due to the proximity to the students and employees, the proximity to the food and thus the supposedly easier recording of the eaten food after the test run, as well as the somewhat quieter environment, the back room of the cafeteria of the University was chosen as test location. For the test time the dining hall's food service served as a guide. After the initial planning was completed, the Unity project was set up and the photogrammetry of the food was started. For the photogrammetry process it was important to freeze the food beforehand, otherwise it would have melted. A photobox, two light boxes and a Sony a6300 camera with a 30mm fixed focal length (APSC) with a fixed aperture of f.14 were used for photgramming. After the photos were converted into a 3D object via Agisoft Metashape, they were then post-processed and optimized in 3DsMax. The tables and chairs were modeled with as little polygon as possible in Maxon Cinema 4D and then imported into Unity as an .fbx file. Version 2021.3.3f1 was used for the Unity project along with the Pro-Builder and Meshbaker plugins. For the test subjects to interact with the scene, various scripts were programmed that cause the following. The food dish is cloned by pressing a button directly in front of the test person, when another food is selected the current one is deleted, if cutlery is needed for the food a fork or knife appears and if eaten up the object is destroyed. In addition, a total of five questionnaires were created via google forms for the test run. These were used to pre-select the test subjects, to record the feeling of hunger and cravings before and after the test, to track the mealwishes and the food eaten after the test. After a trial run with four test persons and subsequent small optimizations, the test phase was started. Eleven pre-registrations for the test were registered. In order to find test subjects, students and employees were approached and selected on site near the cafeteria. Before the test began, the research project was briefly explained to the test subjects. Afterwards, the questionnaire was filled out on a tablet before the test. After answering the questionnaire, the application in the virtual reality glasses was started (see figure 1). The test subjects decided themselves how long they wanted to eat and could end the test themselves by clicking on the exit sign. At the end of the test the post-test questionnaire was completed. Finally, a final questionnaire was sent to the participants by mail which was to be answered after the next meal consumption.

3. RESULTS

The majority of the tested persons are students between the ages of 16 and 27. Of a total of 63 tests, 61 valid tests are included in the evaluation, because the test subjects were only interested in the technology and lost sight of the test scenario. The response rate of the questionnaire to record the amount of food actually eaten and the type of dish was so

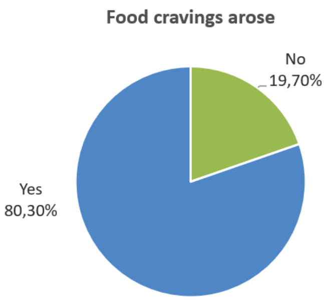

Figure 2: Diagram of food cravings, Janine Riemann

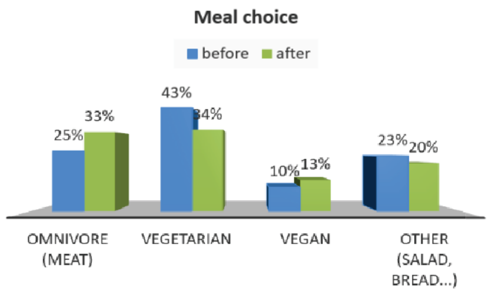

Figure 3: Diagram of meal choice, Janine Riemann

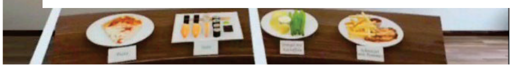

Figure 1: VR-scene setup, Janine Riemann

low at 23 responses, that it cannot be taken into account further due to the low representation. The evaluation of the subjective questionnaires shows a slight improvement in well-being after the test run. Thus a total of three people state that they feel better after the test than before the test. On average, the hunger score on a scale of 0 (not hungry) to 10 (very hungry) increased from 5.5 to 5.8 after the test. The average hunger score increased by 0.3 units. 50.8% of respondents report coming out of the test hungrier. 68.9% do not feel a sense of satiety after the test. Thus 31.1% feel satiated. 19.7% do not feel any food cravings after the test, while 80.3% feel cravings for a particular food (see figure 2). Before the run 42.6% say they want to choose the vegetarian dish in the canteen, 24.6% the meat dish, 9.8% the vegan dish, and 23% other such as salads or sandwiches. After the test run 34.4% want to choose the vegetarian dish, 32.8% the meat dish, 13.1% the vegan dish, and 19.7% other. There is choice, while the vegetarian meal and other meal choice decreases after the test (see figure 3).

The most eaten dishes in the virtual reality environment have been sushi and the fruit basket consisting of apples and peaches, closely followed by the pizza and fries.

4. CONCLUSION

With the described test setup it is not possible to clearly deduce from the results and make a clear statement as to whether the feeling of hunger can be influenced with virtual reality or not. The results show reasons that speak both for and against an influence. At this point, further and more precise investigations must be carried out which ideally focus exclusively on the feeling of hunger. Thus test subjects could be accompanied for a week and as soon as hunger arises the test could be carried out. Finally it would have to be asked exactly whether the feeling of hunger is more or lesser afterwards. A study over a longer period of time could also produce a clearer result, as influencing factors could be balanced out due to more frequent testing. An influence on the feeling of well-being and satiety seems to be given, but the influence on the feeling of satiety can be dependent on the individual imagination. Also at this point more exact research could be done in the future to find out the dependencies. Food cravings can also be influenced by virtual reality. The test subjects not only felt cravings for certain dishes afterwards, but in some cases also changed their choice of food in the cafeteria. For the exact reasons, psychological examinations must be carried out in addition to the experimental setup to find out the correlations.

REFERENCES

Coons, M. J. (2011). *The Potential of Virtual Reality Technologies to Improve Adherence to Weight Loss Behaviors.* Journal of Diabetes Science and Technology.

FRANK, S. e. (2010). *Processing of food pictures: influence of hunger, gender and calorie content.* Brain research.

Gniech, G. (kein Datum). *Essen und Psyche: Über Hunger und Sattheit, Genuss und Kultur.* 2013: Springer-Verlag.

Hayes, R.H.; Wheelwright, S.C. (1979). Link Manufacturing Process and Product Life Cycles. Harvard Business Review, Vol. 57, No. 1, pp. 133-140.

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SUSTAINABILITY AT THE UAS ANSBACH

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ABSTRACT: Sustainability at the Ansbach University of Applied Sciences was investigated. The survey with a total of 323 participants showed how much students and employees of the university pay attention to sustainability in various areas of their private lives and how they see the sustainability of the university. The results of the survey help the sustainability office with further measures and show in which areas the university needs to do more for its sustainability.

Keywords: Sustainability; UAS Ansbach

1. INTRODUCTION

The purpose of this data collection was to find out, to what extent the students and employees of Ansbach University of Applied Sciences pay attention to sustainability in their private lives and how they assess the current sustainability performance of the University. In this way, information was collected on the participants' understanding of sustainability. This gives the University's sustainability team the opportunity to be as transparent as possible in the area of sustainability information and to make the necessary changes as efficiently as possible.

Therefore, the following research question was posed: "To what extent do students and employees of Ansbach University of Applied Sciences pay attention to sustainability in their private lives and how do they rate the University's current sustainability performance?”

2. RELATED WORK

There’s no related work on the sustainability of our University.

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3. METHOD

The method of data collection was a digital questionnaire using an online survey application called "LimeSurvey". The link to the survey was distributed to all students and staff via the university email distribution list. Regarding the characteristics of the participants, the inclusion criteria for data collection was enrollment or employment at Ansbach University of Applied Sciences. Thus, the desired participants included all students and employees of the university who could be reached by e-mail. Age and gender did not play a role.

Other questions in this context were as follows:

"What suggestions/ideas do participants have for improving sustainability at the

university?" (free text response)

"Is there a relationship between age and understanding of sustainability?"

The research hypotheses were as follows:

1. more than half of students and staff pay close attention to their own sustainability in their private lives

2. students rate the university's current sustainability record lower than employees

4. RESULTS

Grades were awarded in a range of 1-6, with 1 being the best and 6 being the worst.

There were 323 participants in total, 209 of them students and 114 employees.

Average grade self-evaluation students: 2,58

Average grade self-evaluation staff: 2,47

Average grade for the sustainability at UAS Ansbach students: 2,88

Average grade for the sustainability at UAS Ansbach employees: 2,97

5. CONCLUSION

The following results emerge with regard to the research hypotheses.

1. more than half of the students and employees pay very close attention to their own sustainability in their private lives.

For a confirmed hypothesis, more than 50% of the respondents must state that they pay very close attention to their own sustainability.

Since only 17.10% of the respondents pay very strong attention to sustainability in their private everyday life, the hypothesis is considered to be refuted.

2. "The students assess the current sustainability balance of Ansbach University of Applied Sciences worse than the employees."

For the hypothesis to be confirmed, the average grade given by students and staff to the university in terms of sustainability must be better for staff than for students. Since the average grade of the students was approx. 2.88 and that of the staff only approx. 2.97, the following applies was only approx. 2.97, this hypothesis is also considered to be refuted.

More than half of the participants in this survey pay very strong to strong attention to to their own sustainability in their private lives. And with 41.18% of the free text answers, the internal processes at UAS Ansbach are the area where sustainability needs to be improved the most.

REFERENCES

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PUBLIC PERCEPTION OF NONPHARMACOLOGICAL INTERVENTIONS FOR COVID-19-PANDEMIC CONTAINMENT

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ABSTRACT: Since the end of 2019, the COVID-19 pandemic has been weighing heavily on countries worldwide. Different measures have been taken in Germany to combat this pandemic. In addition to nonpharmacological measures, vaccination strategies have been used to contain the pandemic. A retrospective survey was conducted to get a snapshot of what the population thinks about these measures and how they prefer to be informed. It collected attitudes of the inhabitants of Ansbach towards the COVID-19 situation in June 2020, June 2021 and December 2021. The survey shows that there was a change of opinion regarding the measures and the behaviour on the part of the government as the pandemic progressed. While occupational restrictions decreased, the positive opinion of the undertaken measures decreased. The fear of infection is steadily decreasing. After a sharp rise of the fear of economic consequences in June 2021, it decreases again in December 2021.

Keywords: *COVID-19; Nonpharmacological measures; Germany; Opinions; Population*

1. INTRODUCTION

COVID-19 has been considered a pandemic since March 11, 2020. This disease is caused by the SARS-CoV-2 virus and is a severe respiratory disease.(Bundesministerium für Gesundheit, 2022) Infection occurs from person to person via droplet infection and aerosols (released e.g. when breathing, coughing and speaking). A number of hygiene and protective measures were taken during the pandemic due to the high risk of infection.(Bundeszentrale für gesundheitliche Aufklärung, 2022a) These include the AHA+A+L rules and the G-rule. To reduce the risk of infection, the AHA+A+L rule recommends keeping at least 1.5 m away from other people and washing your hands frequently. Furthermore, according to this guideline, one should only sneeze into the crook of one's arm or into a handkerchief when facing away from other people. Protective face

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coverings should be worn. In addition, this regulation recommends ventilating rooms regularly and using the COVID-19 warning app, which warns of encounters with infected people. The G-rule defines admission to public places (e.g., movie theaters, restaurants, etc.) by vaccination status.(Bundeszentrale für gesundheitliche Aufklärung, 2022b) In addition to hygiene regulations, vaccine research has had success since December 2020 (Paul-Ehrlich-Institut, 2022). The vaccines reduce the risk of falling ill. If a person still falls ill, the risk of a serious course of the disease is minimized. In addition, the chance of infection is reduced.(Robert Koch-Institut, 2022)

2. Method

In order to obtain data, a retrospective survey was conducted in December 2021. The sample size for this survey was n = 67. All of the participants were from Ansbach and varied in age. Approximately 40% were younger than 40 years old when the survey was conducted. Approximately 60% of the participants were female. More than half (approx. 55%) of the participants report that their highest school-leaving qualification was the "mittlere Reife" (intermediate school leaving certificate). The survey collected data related to the information channel used, professional constraints and fears, as well as personal opinions about the nonpharmacological measures taken and about the vaccine.

3. Results

The COVID 19 pandemic resulted in professional restrictions. In the course of the survey, however, fewer and fewer of the participants were affected by those restrictions. Above all, contact restrictions, mask requirement and home office were named as professional restrictions. This also applies to opinions about the nonpharmacological measures taken (see figure 1).

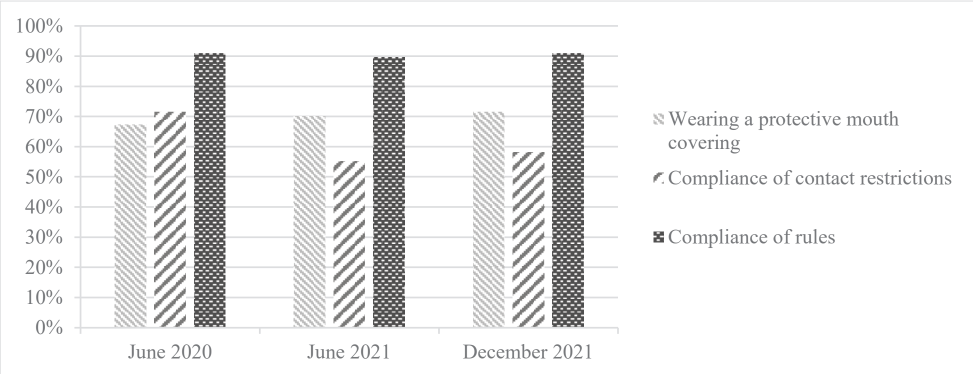

Figure 1: Compliance of the measures

In December 2021, less than half of the respondents consider them appropriate. While COVID-19 compliance increases in June 2021, it decreases again in December 2021 (see figure 2). More than half of the respondents are generally following the regulations. For half (approx. 46%) of the respondents, a change of opinion took place in the time period surveyed. This was mainly triggered by the knowledge gained about COVID-19 (approx. 27%) and in the opinion of the respondents, inappropriate or bad measures (approx. 27%).

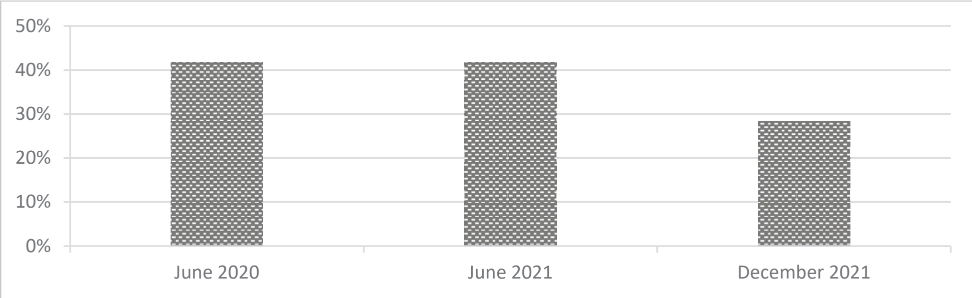

Figure 2: Positive evaluation of the measures

Figure 3 shows that the fear of infection is constantly decreasing among the German population. Fear of economic consequences decreases after a previous steep rise from June 2021.

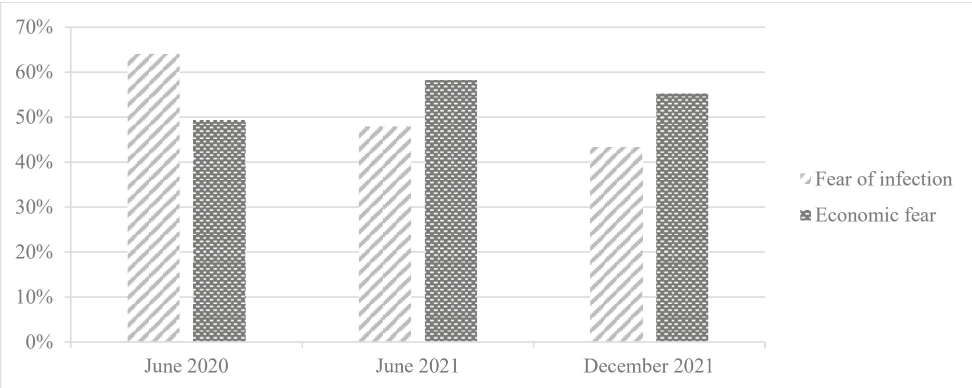

Figure 3: Fears due to COVID-19

The internet (ca. 76%) was the most frequently used source of information about COVID-19. Television (approx. 66%) and radio (approx. 61%) were also important sources of information for the respondents. More than half of the participants reported that they critically question the information they obtain. The majority seek a second opinion. Almost the entire respondent group has been vaccinated or is planning to be vaccinated. Information about vaccination is mainly obtained from the media (approx. 70%). With one single exception, the participants consider vaccine and drug research to be useful. Above all, the respondents consider the weakened course of the disease achieved by vaccination to be an advantage. However, some of the participants believe that the lack of research is a disadvantage of vaccines. The increased chance of a (faster) recovery argues mainly in favour of a COVID-19 drug. However, the lack of long-term research is also criticised here.

REFERENCES

Bundesministerium für Gesundheit. (2022, May 10). Corona-Virus kurz erklärt. *Zusammen gegen Corona*. https://www.zusammengegencorona.de/faqs/covid-19/coronavirus-kurz-erklaert/ (accessed June 4, 2022)

Bundeszentrale für gesundheitliche Aufklärung. (2022a, May 25). Ansteckung und Übertragung. *Infektionsschutz.de. https://www.infektionsschutz.de/coronavirus/fragen-und-antworten/ansteckung-und-uebertragung/ (accessed June 4, 2022)*

Bundeszentrale für gesundheitliche Aufklärung. (2022b, April 4). *Aktuelle Corona-Regeln. Infektions-schutz.de. https://www.infektionsschutz.de/coronavirus/wie-verhalte-ich-mich/aktuelle-corona-regeln/ (accessed June 4, 2022)*

Paul-Ehrlich-Institut. (2022, April 29). *COVID-19-Impfstoffe. https://www.pei.de/DE/arzneimittel/impfstoffe/covid-19/covid-19-node.html (accessed June 4, 2022) Robert Koch-Institut. (2022, June 7). COVID-19 und Impfen: Antworten auf häufig gestellte Fragen (FAQ). https://www.rki.de/SharedDocs/FAQ/COVID-Impfen/gesamt.html;jsessionid=55EAD07D427DA8F6216CD0941A3924E7.internet061 (accessed June 8, 2022)*

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PATTERN RECOGNITION PROGRAMMING TO PREDICT PRODUCTIVITY OF YARROWIA LIPOLYTICA DSM 3286 FOR CITRIC ACID PRODUCTION.

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[a]*Ansbach University of Applied Sciences, Germany*

ABSTRACT: The non-conventional yeast Yarrowia lipolytica is attracting increasing attention due to its potential to produce large amounts of organic acids from hydrophobic substrates. Due to the steadily increasing demand for citric acid in the industrial sector, the aim of this scientific work was to develop a predictive model of the citric acid productivity of the strain Yarrowia lipolytica DSM3286. As a basis for this, the optical density, pH, cell number and citric acid were determined in 18 identical mixtures.

The citric acid concentration (mean values of the measured concentration over time) follows a linear increase. Based on this, the mathematical calculation operation of linear regression was selected for modeling the prediction model in Python. The following coefficients were determined for the variables used in the learning algorithm:

- time: $6{,}104 * 10^{-4}$
- OD: $-1{,}224 * 10^{-1}$
- pH value: $-4{,}043 * 10^{-1}$
- Cell count: $1{,}749 * 10^{-8}$

In final validation of the program, a result accuracy of 86.5% was obtained. The result obtained in the present scientific work shows that by means of simple linear regression, over a cultivation period of 13 days, a prediction of the citric acid productivity of strain Yarrowia lipolytica DSM3286 is possible.

Keywords: *Yarrowia lipolytica; Citric acid; Predictive model; Python*

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1. INTRODUCTION

Yarrowia lipolytica belongs taxonomically to the ascomycetes and is an obligate aerobic, apatho-genic, heterothallic and oleaginous yeast (Fickers et al., 2002; Barth et al, 2003). Fat- and protein-rich substrates represent the natural habitat (Barth et al. 2003), but the obligate aerobic yeast *Y. lipolytica* can also grow on substrates such as glucose, fructose, ethanol, or acetate.

Y. lipolytica is of biotechnological interest mainly because under certain culture conditions the apathogenic strain can secrete various organic acids, such as citric acid or isocitric acid, into the medium in high concentrations of up to 200 g* L^{-1}. Due to these properties and the simple procedural cultivation of the strain, it represents an ideal microorganism for the biotechnological production of citric acid (Gonçalves et al. 2014). Citric acid is the most consumed organic acid in the world and is mainly used as an acidifier, preservative, and antioxidant in various industries (Morgunov et al., 2018).

More and more scientists are also turning to self-learning algorithms and artificial intelligence (AI) in the natural sciences to do their work more efficiently and effectively. The use of self-learning algorithms and artificial intelligence to optimize processes is therefore becoming increasingly important in the natural sciences. Python is one of the most popular languages for scientific programming. Python is an object-oriented, open-source, universally interpretable programming language that is well suited for standard programming tasks. (Millman und Aivazis 2011; Dubois 2007)

Based on the previous studies on citric acid production in *Y. lipolytica* DSM 3286, the present scientific work aimed to create a Python programming to predict productivity from a total of 18 identical cultivation approaches. For this purpose, the data of optical density, pH, cell number and measured citric acid concentration were first documented and evaluated at regular intervals in each batch. This was followed by the programming of the learning algorithm in Python, the preparation of the training data sets and the evaluation of the program.

2. METHOD

The test execution as well as the programming was done as shown within the following flowcharts.

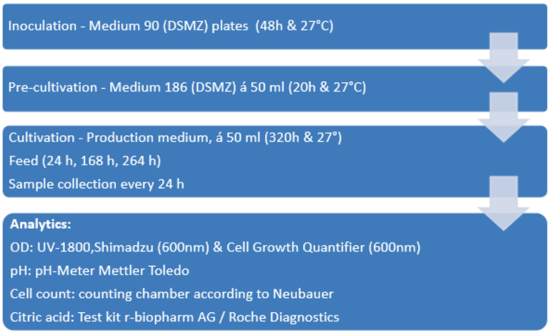


Figure 1: Execution of the experiment shown as a flowchart

Multiple linear regression was used to program the citric acid prediction in Python and implemented as follows.

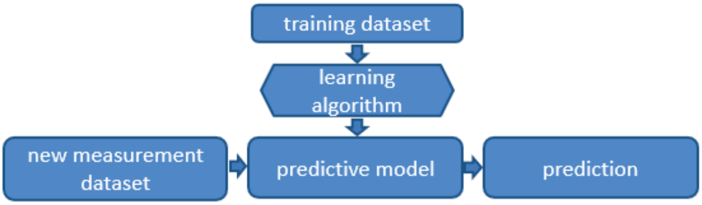
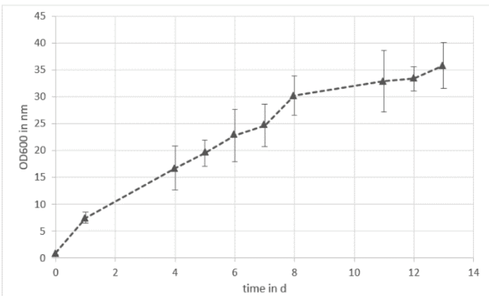


Figure 2: The learning algorithm is programmed from the training data. Via the input of new measurement data into the prediction model, the prediction of the unknown value takes place. (Raschka 2017)

3. RESULTS

For comparability, the mean values from the respective samples with the same sampling times were calculated and illustrated in the following graphs.



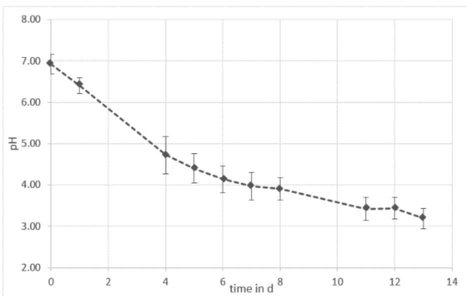
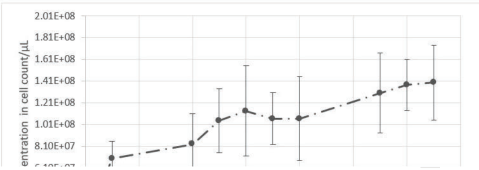


Figure 3: The average optical density and its standard deviation as well as the average pH value and its standard deviation over the cultivation period of 13 days; N=18.

Figure 4: The average cell number/µL with standard deviation as well as the average citric acid yield with standard deviation over the cultivation period of 13 days; N=18.

The following figures show the programming results.



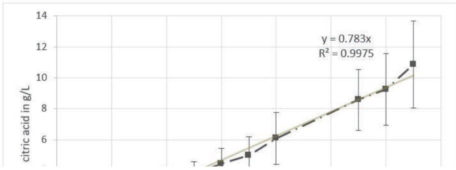
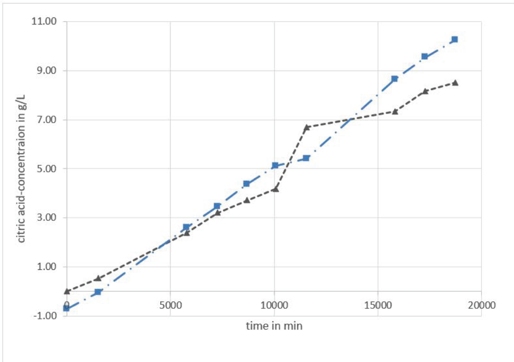


Figure 6: Multiple Linear Regression source code used, which was developed in Python.

*Figure 5: Course of measured (triangle/ grey) and predicted (quadrilateral/ blue) citric acid concentration of batch 7.1 (no part of the training data sets). The average result accuracy of these two runs is **92%**.*

```
#Multiple Regression

import pandas as pd

from sklearn import linear_model

data = pd.read_csv("./excelfiles/Datensatz1-10.csv")
x = data[['mins', 'OD', 'pH', 'cells']]
y = data['cs']

regr = linear_model.LinearRegression()
regr.fit(x, y)

#Probeneingabe:
#predictedCS = regr.predict([[Zeit in min,OD,pH-Wert,Zellzahl]])
predictedCS = regr.predict([[1440,8.18,6.39,76800000]])

print("Citronensäure-Konzentration: ")
print(predictedCS)
print("--------------")
print("Koeffizienten: ")
print(regr.coef_)
print("--------------")
print("Ergebnisgenauigkeit:")
print(regr.score(x,y))
print("--------------")
```



4. CONCLUSION

Considering the result accuracy of the programmed model of 86.5 %, this can be rated as good compared to other biological models, which show a result accuracy of close to 90 %.(An, 2019). To increase the accuracy, more test data sets should be incorporated into the model. Considering the exclusion of individual variables and the resulting accuracy of results, it is recommended to measure all four variables in future approaches and to include them in the program. In conclusion, the model for predicting citric acid production in strain Y. lipolytica works within the cultivation period of 13 days.

REFERENCES

An, J.; You Z.; (2019). Sequence-based Prediction of Protein-Protein Interactions Using Gray Wolf Opti-mizer–Based Relevance Vector Machine.

Barth, G.; Beckerich, J. M.; Dominguez, A.; Kerscher, S.; Ogrydziak, D.; Titorenko, V.; Gaillardin, C., (2003). Functional genetics of Yarrowia lipolytica. In: de Winde, J. H. und S. Hohmann, Functional Gene-tics of Industrial Yeasts.

Dubois, P. F. (2007): Python: Batteries Included,. In: Computing in Science & Engineering (9).

Fickers, P.; Le Dall, M. T.; Gaillardin, C.; Thonart, P.; Nicaud, J. M., (2003). New disruption cassettes for rapid gene disruption and marker rescue in the yeast Yarrowia lipolytica.

Gonçalves, F. A. G.; Colen, G.; Takahashi, J. A. (2014): Yarrowia lipolytica and its multiple applications in the biotechnological industry. In: TheScientificWorldJournal 2014, S. 476207.

Millman, K. J.; Aivazis, M., (2011). Python for Scientists and Engineers. In: Comput. Sci. Eng. 13 (2), S. 9–12. DOI: 10.1109/MCSE.2011.36.

Morgunov, I. G.; Kamzolova, S; Lunina, J. N.; (2018). Citric Acid Production by Yarrowia lipolytica Yeast on Different Renewable Raw Materials.

Raschka, S.: Machine Learning mit Python. Das Praxis-Handbuch für Data Science, Predictive Analytics und Deep Learning. 1. Auflage. Frechen: MITP (mitp Professional). Available online at https://www.ciando.com/img/books/extract/3958454240_lp.pdf, 2017, last tested on 01.08.2021.

BMT22
4th International Conference
Business Meets Technology.
Ansbach, 7th to 9th July 2022

BUSINESS MEETS TECHNOLOGY

4TH INTERNATIONAL CONFERENCE

Barbara Hedderich, Michael Walter, Sebastian Stadler, Eva Didion, M. Rosario Perelló Marín, Daniel Catalá-Pérez (Eds.)

The 4th International Conference "Business meets Technology" took place from 7th to 9th July at the University of Applied Sciences of Ansbach, Germany.

The 3rd International Conference "Business meets Technology" took place on September 23rd and 24th at the Universitat Politècnica de València (UPV), Spain.

The first and second edition of the Conference were held at the University of Applied Sciences of Ansbach in 2018 and 2020, respectively.

The theme of the conference is «Business Meets Technology». By suggesting such a broad topic, we aim to invite researchers with a variety of interests in theory and research in various areas of science, commerce, and arts related to business and technology. By providing a general motto, we emphasize that contributions from all areas of science are welcome.

From its multidisciplinary approach, the event's objective is to allow generating and contributing valuable knowledge to face the significant social challenges established as political priorities by the program's European science, research and innovation framework.

The international focus of the event, with the participation of leading experts from European universities, both in the scientific committee and in the scientific program as invited speakers, enriches the exchange of knowledge for all attendees.

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