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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 for Musical Expression" 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.

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