Multidisciplinary Journal for Education
Social and Technological Sciences

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

Analysis of the optimization of resources with Learning Analytics techniques

M-E. Torner[a*], C. Aparicio-Fernández[b], J-L. Vivancos[c], M. Cañada-Soriano [d]

[a]Department of Continuos Medium and Theory of Structures, Universitat Politècnica de València, 46022-Valencia, Spain. *Corresponding author: meutorfe@pvnet.upv.es
[b]Building Technology Research Centre (CITE), Universitat Politècnica de València, 46022, Valencia, Spain.
[c]Project Management, Innovation and Sustainability Research Centre (PRINS), Universitat Politècnica de València, 46022, Valencia, Spain
[d]Applied Thermodynamics Department (DTRA), Universitat Politècnica de València, 46022 Valencia, Spain

Received: 11 October 2022; Accepted: 15 March 2023; Published: April 2023

Abstract

This paper presents an empirical study based on the learning environment through different data analysis tools. The study is applied to the subject of Theory of Machines and Materials Resistance of the Chemical Engineering degree at the Universitat Politècnica de València (Spain), with the aim of being able to understand and optimize with greater knowledge the way of learning taught, to know what is more difficult for the students and to create a more personalized learning environment. In order to achieve this, it is important to have as much information as possible about the use and usefulness of the resources provided to the students as a teacher. Knowing this data will allow us to provide more efficient resources and to change those that, through data analysis, are not being useful to students. The results of this research show how, through applications such as Learning Analytics, greater performance can be obtained in both teaching and learning.

Keywords: learning environment, learning analytics, e-learning, big data

To cite this article: Torner, M-E., Aparicio-Fernández, C., Vivancos, J-L., Cañada-Soriano, M. (2023). Analysis of the optimization of resources with Learning Analytics techniques . Multidisciplinary Journal for Education, Social and Technological Sciences, 10(2), 46-58.https://doi.org/10.4995/muse.2023.18545

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

1. Introduction

Higher education has always been a step behind other educational levels when it comes to studies related to analytics and the learning environment (Rich et al, 2019). The search to offer academic excellence through more theoretical knowledge has been the line to follow for a long time in universities, leaving aside the more pedagogical part. Questioning as a teacher whether the resources provided have a good use by the students or whether they are sufficient have only been assessed through written tests, ignoring any data that is not a numerical assessment in these.

Given the events of recent years, especially the pandemic, the digitalization of both students and teachers has taken place in leaps and bounds, and the involvement of teachers in this situation has facilitated more direct contact with the reality of students and has served to update resources quickly and in a way that is more appropriate to the new technologies. This fact, although it has meant a great change in the way of teaching, has also opened the door to a multitude of data that would have been impossible before. All those platforms established in the pandemic have digitalized the obsolete system that was used in higher education, opening up a whole world of possibilities for studying all those movements on the part of both the teacher and the students which, being digitalized, are exposed so that they can be studied.

Learning analytics is a tool that allows us to use all the data from both students and their activities in different contexts and to obtain a clear picture of both individual and group learning. Having tools that can measure and evaluate both the resources provided to the students, the capacity of understanding that these have had and the use of these by the users together with the comparison of the results obtained can significantly improve the quality of learning.

Although, not enough relevance has been given to this type of learning analytics in higher education, there have been multiple developments of these tools that have been known under the term Big Data (Lloris et al, 2021). A tool that encompasses the collection of data from the different actors in the educational process in an evolutionary way, allowing statistics and interpretations of these (e.g., Dollar and Steif, 2012).

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

2. Material and Methods

In order to be able to understand the multiple benefits of this learning analytics, a specific case is proposed, the subject of Fundamentals of Machines and Strength of Materials. This subject is taught in the Chemical Engineering degree of the Universitat Politècnica de València (UPV), third year in the first semester and belongs to the common block of the industrial branch.

It is compulsory and consists of 6 ECTS (European Credit Transfer and Accumulation System) of which 3 ECTS are theory and 3 ECTS are practical. Until the year of the Covid-19 pandemic (academic year 2019/2020), both theoretical and practical classes had been face-to-face in their entirety. In the academic year 2020/2021, the blended learning modality was introduced, where students could attend both face-to-face and online, where the increase of digital content and online resources on the online platform (UPV) was boosted. In addition, all face-to-face classes were recorded so that students had access to them throughout the academic year.

As the name of the subject indicates, it is made up of two different parts, each part belonging to a different department. Fundamentals of Machines belongs to the Department of Mechanical Engineering and is taught by a specialist professor of this department. This part of the subject corresponds to 50% of the total course. The other part of the subject corresponds to Resistance of Materials, from the department of Mechanics of Continuous Media and Theory of Structures and corresponds to the other 50%.

Given that the two parts are clearly differentiated, the object of this study will be the part of the Resistance of Materials subject, since the Fundamentals of Machines part has already been studied previously (Llopis et al,2021).

In the course analyzed, there are 76 students enrolled in the 2021/2022 course where the theory in the classroom is taught by two teachers while the practical part of the subject is taught by four teachers.

Below is a general description corresponding to the two different parts of the subject:

- Fundamentals of Machines: The aim is to introduce students to the analysis and design of machines, a basic discipline in all engineering degrees in the industrial branch. The

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

techniques for analyzing the movement of machines, being able to evaluate mechanical actions between their parts and mechanical actions to be supported, discovering the most common ones in this degree, are the fundamental pillars on which the syllabus of this subject is based.

This syllabus is complemented with the approach based on the use of computational techniques that exist for this task, its general aspects and the justified reasoning of the implications together with the numerical problem.

- Resistance of Materials: Introduction of the student to the study of the deformable solid, which is part of the basic principles of the Theories of Structures. Through the theories and fundamentals of elasticity, the concepts for understanding the behavior of the elastic solid when external forces are applied as well as the calculation of internal forces will be brought together. The knowledge of the different responses depending on the material, calculating and knowing the stresses that occur in the different existing structural systems, are part of the syllabus to be taught.

  The calculation of member elements (beams and columns) through their dimensioning is an important part of the subject.

In order to have the most complete investigation possible, it is necessary to name the different transversal competences (TC) defined by the UPV of which this subject consists. These are of great value in the student learning process as they are directly related to the skills and abilities of the professional field in which the subject and the degree are taught. Thirteen transversal competences are defined at the UPV (UPV,2020).

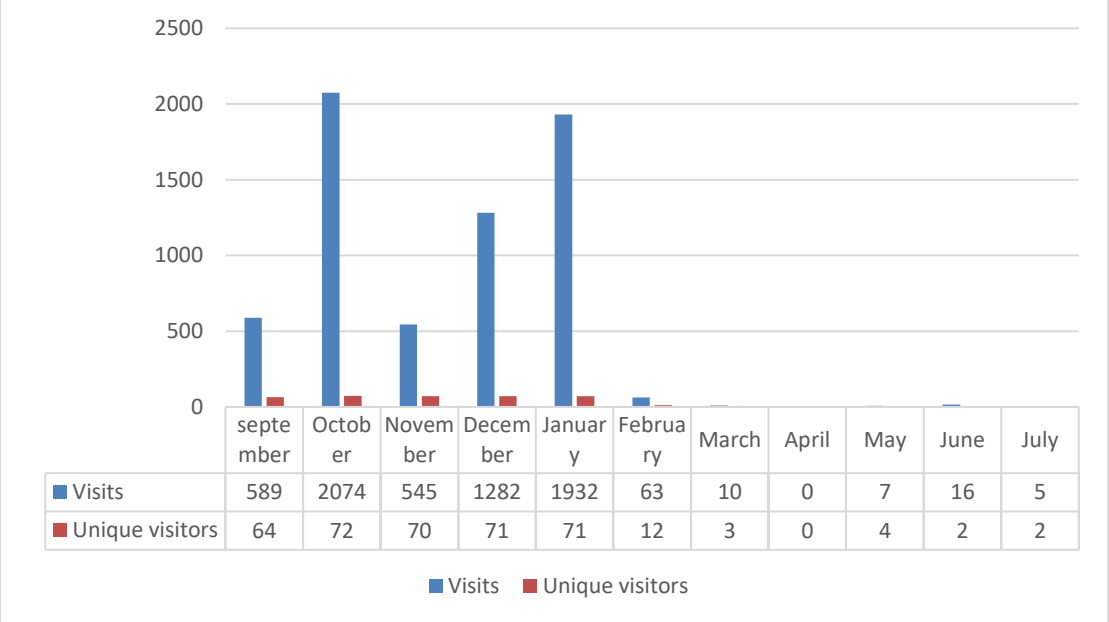
The three transversal competences (TC) belonging to this subject are set out below:

- TC-03: Analysis and problem solving. Analyze and solve problems by applying the knowledge acquired in the classroom.
- TC-04: Innovation, creativity and entrepreneurship. Obtain the best way of tackling the problem that is presented to them,
- TC-05: Design and Project. Propose and carry out an idea in its entirety as well as how to direct and design it effectively.

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

3. Results and discussion

Once the relevant analysis and statistics of the data collected have been carried out with the aim of improving the teaching-learning process, the data obtained are shown below. Figure 1 shows the number of visits made by students to the resources provided in this subject via the UPV platform.



	septe mber	Octob er	Novem ber	Decem ber	Januar y	Februa ry	March	April	May	June	July
Visits	589	2074	545	1282	1932	63	10	0	7	16	5
Unique visitors	64	72	70	71	71	12	3	0	4	2	2

Figure 1. Online resources visits**.**

The number of visits by students were 6894, of which 75 students visited the Platform and only one student did not visit it. The average time spent per student was 42.1 minutes per visit. It should be noted that the platform is only accessible to those members enrolled in the subject and it contains all the materials necessary to take the course, as well as exams from previous years, the teaching guide and extra support material apart from that necessary to pass the subject.

It should be remembered that the subject is taught in the first semester, where classes start in September and the first mid-term takes place in October. Classes end in December and the exam of the second midterm takes place in January, as well as the recovery of these in February, the month in which the course ends with the delivery of the reports. As can be seen in the table and figure 1, the months with the most visits are October and January, coinciding with the subject exams, with a much

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

higher number of visits than the rest of the months. It should also be noted that despite the fact that February is the end of the course, apart from the month of April, where half of the month coincides with the holiday period, there are still visits to the course by students.

Within the Platform, there are different tools available. Of all of them, the resources tool is where all the content prepared for users can be found. If we make an analysis of the tools offered by the Platform, the most used by users are:

Table 1. Visits to online tools

Tool	Visits
Calendar	0.06%
Lessons	0.2%
Gradebook	0.5%
Web information	0.6%
Announcements	1.6%
Messages	1.8%
Assignments	1%
Resources	93.5%

As it is shown in Table 1, the most used tool is that of resources, with a much higher percentage than the others.

The resources tool contains 4817 files with all kinds of material for learning the subject. Of these files, 178 have been opened, the most opened file being the one containing the resolution of the exam of the second partial exam of the previous year of the Resistance of Materials part of the subject. The following figure shows the graph of the use of the resource tool by month.

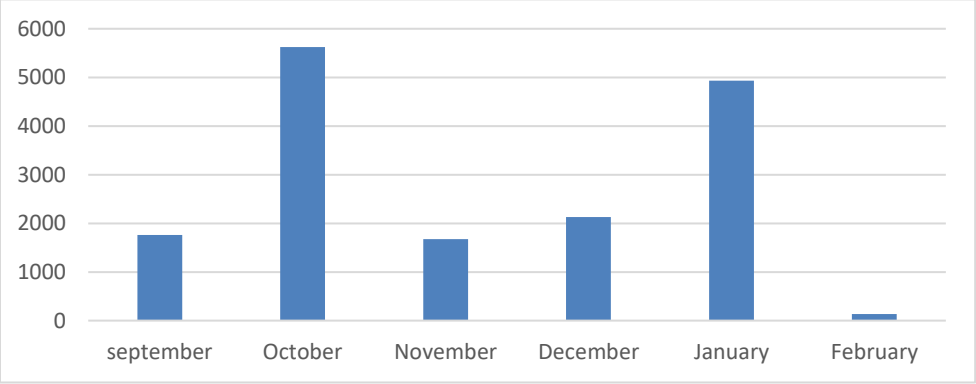


Figure 2. Online resources visits

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

October and January continue to be the months where the resources have been used the most. Within this data, we also have data for each student on how many times and in which months they have used the resources, giving us a more personalized and individualized idea that allows us to know the individualized learning process. For data protection reasons, this data is not shown.

Table 2 and Figures 3 and 4 show the final grades of the course of Theory of Machines and Strength of Materials and the practical grades of the practical part of Strength of Materials where you can see the percentage of students presented, the total percentage of what they represent as well as their classification obtained in the computation of the course. The students presented are 71, which represents a total of 97.26 %.

Table 2. Final grades of the subject Theory of Machines and Strength of Material

Grade	Students	Exam attendance	Total
Distinction (Merit with distinction)	2	2.82%	2.74%
Merit	0	0.00%	0.00%
Good	22	30.99%	30.14%
Pass	41	57.75%	56.16%
Fail	6	8.45%	8.22%

Average	Standard deviation	Max. note	Min. Note
6.29	1.68	9.40	0.50

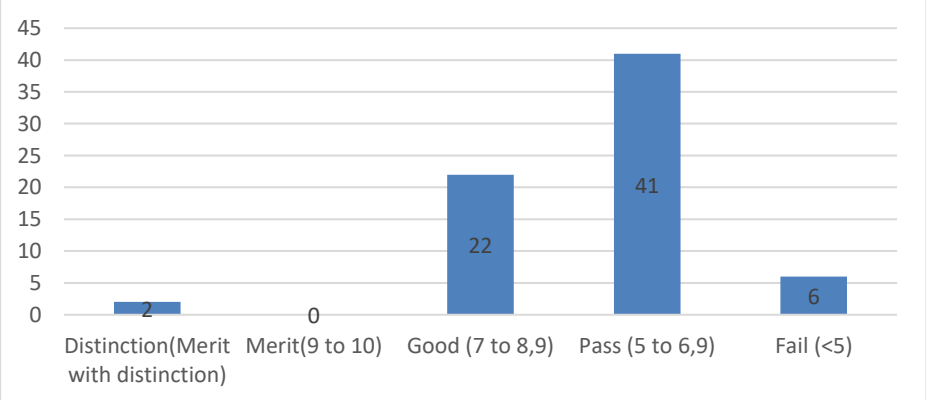


Figure 3. Final grades of the subject Theory of Machines and Strength of Materials

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

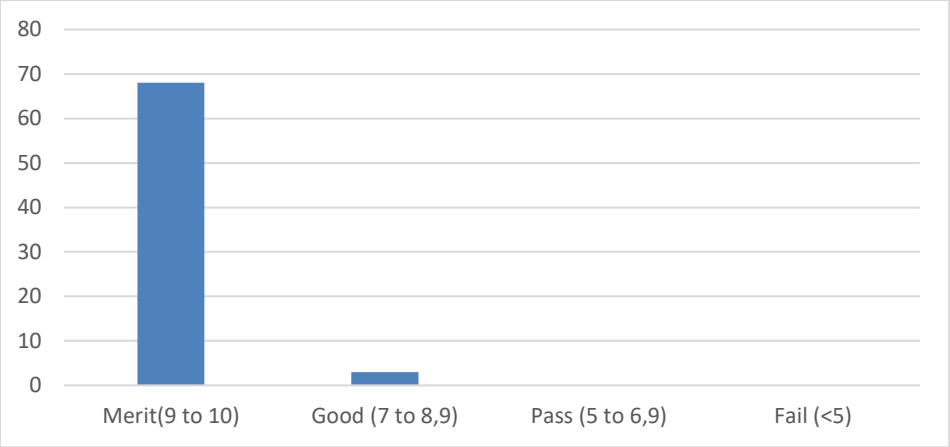


Figure 4. Final grades of practices of the part of Strength of Materials

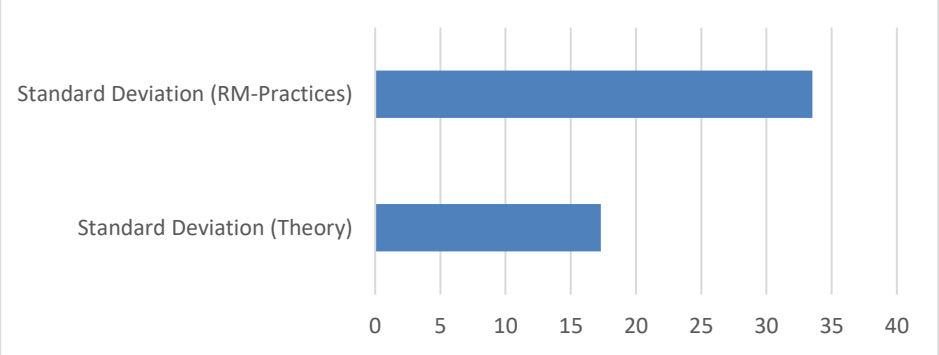


Figure 5. Standard deviation of the marks of the theory and practical lessons

Figure 4 shows the marks of the practical groups of the Resistance of Materials part of the course. It can be seen that the practical part of the subject has much higher averages than those shown in the exam marks for the theoretical part of the subject. The practical part of the course is easier for them, as the students are divided into 4 working groups, and they receive more personalized help from the teachers. In this practical part, three exercises with experimental set-ups are carried out where, through working groups, they apply theoretical knowledge to practical cases which they can relate to their everyday environment more easily.

Figure 5 shows the standard deviation of the subject in terms of the practical part and the theoretical part. It can be seen that the standard deviation of the subject is lower in the theoretical part than in the practical part.

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

After having taught the subject for several years and with the experience acquired during these years and the data analyzed, it can be said that the teaching-learning process is quite positive, there is room for improvement on many points though:

- Although the percentage of failed students is very low, 8.22%, it must always be the objective of any teacher to eliminate the failure rate through tools that motivate dropout, so the results indicate that work must be done on this point in order to achieve total success in the group.
- There is a big difference between the marks of the theoretical and practical part which should be correctable. Although the ratio of students cannot be controlled by the teaching staff, it has been shown that it influences the performance of the academic group, as in this case. It is difficult in a theory class where all the students are present to give more personalized attention. The motivation of the students in the practical classes is also due to the fact that the cases are studied through experimental set-ups where they can apply the theoretical knowledge to reality, perceiving the interest that this awakens in them.
- It should be noted that class attendance tends to be around 75%-80%, a fairly high percentage if we take into account that there is a very low percentage of students who are unable to attend either because they have dropped the subject or because it overlaps with other subjects from previous years.
- Given that it has not been possible to publish the graphs of the students who have made most use of the platform's resources due to data protection reasons, it can be affirmed that those students who have made most use of the resources are those students who have obtained the highest marks in the whole subject.
- In the case of the Resistance of Materials section, the resources that have had the most visits are those contained in previous years' exams. This means that the resources that enter the least are the theoretical ones and that, as the exams folder is fully resolved, the students again prefer the practical part to the theoretical part, although it is incomprehensible to carry out the former without knowing the latter. Given this fact, a new approach to the theoretical notes should be reconsidered. The material should be

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

more oriented towards short videos and linked to cases that they can see in their daily lives.

- The study carried out on the visits to the platform shows that most students do not do continuous work on the subject, which is highly recommendable. The months that coincide with the exams are those in which the resources are most used, the most open being the second part of last year with almost 300 visits. In the theoretical part the most viewed topic is topic 3 of elastic behavior with a total of 255 entries. It is logical that this is the most viewed theoretical topic as it is the topic that contains the most formulation as well as basic examples to be able to solve the elasticity exercises.
- It is striking that the Platform of the subject receives visits even after the end of the course. This is not a very high number, but it does repeat the pattern followed during the first semester. In the second semester, the months with the highest number of visits are those that coincide with the exams. This gives us a clue that students are happy with the resources posted on the platform and even use them for other subjects in which basic concepts are shared.
- With respect to the practical part, number 3 is the one that, although the marks are very high in general, compared to the other two practical parts, it is the one with the lowest marks. This is due to the fact that it is the most complex practical part of the subject and it also coincides with the fact that it is delivered during the holiday period, which often leads to a lower level of involvement, and this point should be corrected by trying to modify the type of exercise.
- Through various student surveys, the results show that the students are happy with both the teaching staff and the resources offered by them.
- Given that the whole subject consists of two distinct parts as explained above, it can be seen that higher marks are obtained in this part of the subject than in the Fundamentals of Machinery part, although the difference is very small. This is mainly due to the practical part of the subject rather than the theoretical part. As a future approach this should be changed by setting joint objectives that unify this point through the coordination of the teaching staff.

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

4. Conclusion

Higher education has fallen behind other levels of education in the study and analysis of learning. Although there are many tools available today that have been augmented by the rapid incorporation of these tools by the pandemic, few studies have yet been based on them.

Therefore, in this study we wanted to show how these analyses provide a complete picture of the results as well as the quality of learning and academic performance.

The results have shown those points where the subject should be improved and how the student receives the knowledge and resources offered by the teaching staff of the subject.

Being able to know each and every one of the different aspects of the process means that although the results of the students are very satisfactory, it is possible to draw lines for the future in order to always offer the best education to the students. It has also provided us with an individualized study of each pupil and the comparison with the group, obtaining conclusions for improvement.

Author Contributions: All authors have contributed equally.
Funding: This research received no external funding.
Conflicts of Interest: The authors declare no conflict of interest.

References

Alba-Linero,C., Moral-Sanchez,S.N.,& Gutierrez-Castillo,P. (2020). Impacto f COVID-19 on education in a Spanish university: What should we change? In I. Sahin & M.Shelley (Eds.), Educational practices during the COVID-19 viral outbreak:International perspectives (pp.81-106). ISTES Organization. ISTES Organization. https://eric.ed.gov/?id=ED608253.

Araújo-Vila, N., Cardoso L., Toubes D.R. & Fraiz-Brea J.A. (2020). Digital Competence in Spanish University Education and Its Use by Students. Publications,8(4), 47. https://doi.org/10.3390/publications8040047.

Aslam,S., Saleem,A., Akram,H., Parveen, K., Hali,A.U. (2021). The challenges of teaching and Dollár, A., Steif, P. S. (2012). Web-based Statics Course with Learning Dashboard for Instructors. *Computers and Advanced Technology in Education*. https://doi.org/10.2316/P.2012.774-025.

Chang,H.S. (2020). Online Learning in Pandemic Times. *Revista Romaneasca pentru Educatie Multidimensionala*.12(2Sup1), 111-117. https://doi.org/10.18662/rrem/12.2Sup1/296

Dollár, A., Steif, P. S. (2012). Web-based Statics Course with Learning Dashboard for Instructors. *Computers and Advanced Technology in Education.* https://doi.org/10.2316/P.2012.774-025

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

Ferguson, R. (2012). Learning analytics: Drivers, developments and challenges. *In International Journal of Technology Enhanced Learning,* 4, (5–6), 304–317. https://doi.org/10.1504/IJTEL.2012.051816.

Hernandes-Melis, C., Fenning, P., & Lawrence, E. (2016). Effects of an alternative to suspension intervention in a therapeutic high school. *Preventing School Failure*, 60(3), 252–258.

L., Proshkin V., & Hlushak,O. (2020). High school teachers' competence development by means of digital technologies.Information Technologies and Learning Tools, (4),298–314.Awan, R.H., Afshan, G., &Memon, A.B. (2021) Adoption of E-Learning at Higher Education Institutions: A Systematic Literature Review. Multidisciplinary Journal *for Education, Social and Technological Sciences*, [S.l.], 8(2), 74 –91. https://doi.org/10.4995/muse.2021.15813.

Llopis-Albert, C. Rubio, F., Valero, F. (2018). Optimization approaches for robot trajectory planning. *Multidisciplinary Journal for Education, Social and Technological Sciences*, 5(1), 1-16. https://doi.org/10.4995/muse.2018.9867.

Llopis-Albert, C. Rubio, F. (2021). Application of Learning Analytics to Improve Higher Education. *Multidisciplinary Journal for Education, Social and Technological Sciences*, 8(2), 1-18. https://doi.org/10.4995/muse.2021.16287

Llopis-Albert, C., Rubio, F. (2021). Methodology to evaluate transversal competences in the master's degree in industrial engineering based on a system of rubrics and indicators. *Multidisciplinary Journal for Education, Social and Technological Sciences*, 8(1), 30-44. https://doi.org/10.4995/muse.2021.15244

Maag, J. W. (2003). Behavior management: From theoretical implications to practical applications. Independence, KY: Cengage Learning.

Maag, J. W. (2012). School-wide discipline and the intransigency of exclusion. Children & Youth Services Review, 34(10), 2094–2100.

OEI (2019). Learning analytics and education. Revista iberoamericana de educación. *Organización de Estados Iberoamericanos para la Educación, la Ciencia y la Cultura (OEI).* Monográficos, volumen 80(1), 217 pages. https://rieoei.org/RIE/issue/view/Learning%20Analytics/vol%2080%281%29

Parsons, B. (2015). The way of the rod: The functions of beating in late medieval pedagogy. Modern Philology, 113(1), 1–26.

Pohl, B. (2013). The moral debate on special education. New York, NY: Peter Lang.

Purpel, D. E., & McLaurin, W. M. (2004). Reflections on the moral and spiritual crisis in education. New York, NY: Peter Lang.

Rich, P.J., Browning, S.F., Perkins, M., Shoop, T., Yoshikawa, E., Belikov, O.M. (2019). oding in K-8: *International trends in teaching elementary/primary computing.* TechTrends,63, 311-329. https://doi.org/10.1007/s11528-018-0295-4

Robinett, D. (2012). Alternatives to student suspension. Leadership, 42(1), 32–36.

Sales, D., Cuevas-Cerveró, A. y Gómez-Hernández, J.-A. (2020). Perspectives on the information and digital competence of Social Sciences students and faculty before and during lockdown due to Covid-19. *Profesional de la Información*, 29(4). https://doi.org/10.3145/epi.2020.jul.23Khoruzha

Shah, N., & McNeil, M. (2013). Discipline policies squeezed as views on what works. Education Week, 32(16), 4–11

UNESCO. (2020). Starting digital divides in distance learning. https://en.unesco.org/news/startling-digital-divides-distance-learning-emerge

https://doi.org/10.4995/muse.2023.18545
e-ISSN: 2341-2593

UPV, 2020. Proyecto institucional competencias transversales. Universitat Politècnica de València (UPV). Valencia. Spain. https://www.upv.es/entidades/ICE/info/Proyecto_Institucional_CT.pdf

Yucesoy-Ozkan,S., Kaya,F., Gulboy,E., Altun,D.E., & Oncul,N. (2020). General and special education practices during the COVID-19 viral outbreak in Turkey. In I.Sahin & M.Shelley (Eds.), *Educational practices during the COVID-19 viral outbreak: International perspectives*(19-62). ISTES Organization. https://eric.ed.gov/?id=ED608253