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European engineering students' perception of learning and teaching activities

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ABSTRACT

STEM universities in Europe apply different pedagogical and didactic methods, which are reflected in the learning activities that are organised for the students. These activities provide students with different experiences in terms of handling their learning and in terms of achievement. There is great variation in terms of both semester structure and how teaching is carried out. A significant commonality is that besides technical domain skills and competencies, there are expectations (or demands) placed on students regarding acquisition of interdisciplinary skills and transversal competences.

The goal of this study is to illuminate students' perception of the various learning activities and teaching practices provided at STEM universities in Europe and to illuminate different perspectives of students' learning experiences. The goal is also to influence educators to implement increased use of student-centred learning approaches

The study was conducted through a survey disseminated through a European STEM students' network. Of the 349 respondents, 133 were determined as valid for extracting the conclusions. The survey included an open question where students were asked to describe a situation where they 'had significant learning accomplishment'. The survey also contained multiple-choice questions that aimed to create the profile of each respondent, based on their study structure and background. The answers were categorised according to contemporary learning theory. The profiles of the students were used to compare their experiences and draw conclusions based on students' perceptions of their learning experiences.

Based on the theoretical framework, the findings show that students' responses point to experiences of interaction processes (with peers or teachers) to a higher degree than experiences with acquisition processes (with content or with motivation). Recommendations point towards implementing a higher degree of student centred learning coupled with intensive teacher support. In addition, the development of students' reflective skills may improve their learning practices and thus increase their acquisition of skills and competencies.

Introduction

Engineering educations all over the world are currently experiencing new expectations and demands regarding the graduates' skills and competencies. In addition to the technical domain skills and competencies, there is an increased demand for interdisciplinary skills and transversal competencies (Passow, 2012; Beagon et al., 2021), not to mention the Industry 4.0 concept requiring, for example, digitisation competencies (Nørgaard & Guerra, 2018). In addition, the UN's 17 SDG goals provide a framework for sustainability in the entire field of technology, having a major impact on engineering education. From a competency level, however, there is an overlap of competencies needed for sustainability and Industry 4.0. Guerra and Nørgaard (2019) identify crosscutting competencies such as problem solving, communication, creativity, leadership, collaboration, lifelong learning, etc., which are crucial for future engineers.

Higher education institutions in Europe apply different pedagogical and didactic methods, which are reflected in the learning activities that are organised for the students. These activities provide students different experiences in terms of handling their learning and in terms of achievement. There is great variation in terms of both semester structure and how teaching is carried out, which indicates that the Bologna Process with the aim of unifying higher education in the European Union has clearly different degrees of implementation (Sursock, 2015; Gaebel & Zhang, 2018).

The goal of this study is to illuminate the following question: What are students' perceptions of the various learning activities and teaching practices provided at STEM universities in Europe? Moreover, through a theoretical lens, the goals is to illuminate different perspectives of students' learning experiences. The paper first presents the theoretical framework used to interpret the collected data, then we present the methodology used, and finally we go through the results and discuss them.

Theory on 'how we learn'

Today, the question of learning, both theoretically and practically, is placed high on the societal agenda. There are different understandings of learning among today's learning theorists but despite the differences, there are also significant common features that express something central about the understanding of learning today. There is an underlying understanding that the old notion, that learning can have the characteristic of being 'a filling up', what Paulo Freire (2009) in, *Pedagogy of the Oppressed*, named, the Banking Model, has been abandoned. Learning takes place in the interaction between new impulses and activities and the previously established knowledge, ability and experience (Kolb, 1984). Another common feature is that learning is not only an individual matter, but also a social and societal concern. That is, the setting in which learning takes place is not only an external framework, an environment, but always an integrated element in the learning process and in the resulting learning. In addition, individual learning is no longer considered a purely cognitive concern, but emotions and motivation, like social and societal concerns, are always part of the learning process itself and shaping its outcome.

One of the contributors to contemporary learning theories is Knud Illeris (2007) with his book, *How We Learn*, in which he explains his understanding of learning. Illeris believes that all learning involves two very different processes, both of which must be active in order for us to learn anything. As illustrated in Figure 1, one process 'is the **interaction** between the individual and the environment, which takes place throughout our waking time and which we can be more or less aware of . . . the other process, the **acquisition** takes place through the impulses and activities that the interaction entails' (Illeris, 2007, p. 22). The conditions that determine the interaction process are fundamentally of an interpersonal and societal nature (the external social and material world), whereas the conditions that determine the process of acquisition, on the other hand, are fundamentally of a biological nature. The two processes

thus relate to the outside world and inside the individual, respectively. The process of interaction is also referred to as the learning interaction dimension and it relates to an inter-personal and a societal level. The process of acquisition thus takes place exclusively at the individual level, but this process will always include both a '*content*' dimension and a '*driving-force'* dimension (Illeris, 2007, p. 23). The content is what is learned. There is always mention of *someone* having to learn *something*, and it is the acquisition of this *something* that is the element of learning. However, in order for acquisition to take place, there must be a driving force and it can be driven by desire and interests or by necessity or coercion, which will affect both the learning process and the learning outcome.

The basic structure of learning is thus comprised of two processes and three dimensions as shown in Figure 1.

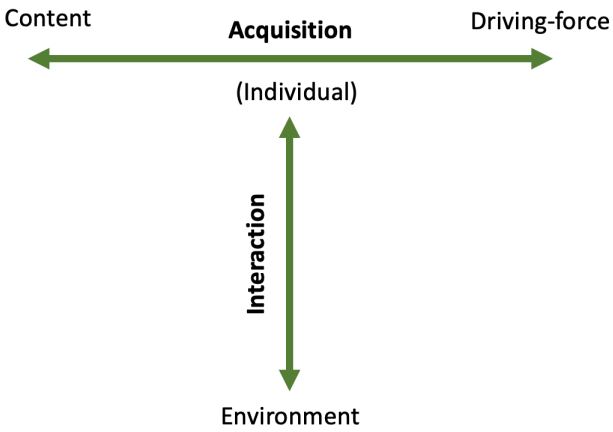

Figure 1: The fundamental processes of learning [adapted] (Illeris, 2007, p. 23)

In accordance with the aforementioned goals, this theoretical frame addresses learning as activities. Such activities are describable in everyday terms by students who normally have no theoretical knowledge of learning and its psychological mechanisms. This theoretical frame is also suitable for data obtained in ways that preclude further inquiry among respondents.

This theoretical frame will be applied to our data, and while going through the students' descriptions of their learning accomplishments, we will qualify Illeris' concepts. First, we will introduce our data collection methods.

Methods for collecting data and analysing students' perception on 'Best Learning Practice'

The data was collected as part of a research project on future engineering education, the A-Step 2030 (Lehtinen et al., 2020).The study was conducted through an online survey using the software, SurveyXact. It was approved by Aalborg University and disseminated through the Board of European Students of Technology (BEST) network. Of the 349 respondents, 133 were determined valid for the analysis. The validity was determined on the basis of respondents' answers to the open-ended questions. Unfortunately, a large number of students chose not to answer the open questions of the survey, but simply filled in answers where boxes could be ticked off. The analysis will mainly apply a qualitative approach using quotes that illustrate students' perception of learning. However, in order to exemplify the

number of students relating to each concept of the theoretical frame, a quantitative approach is used to show the diversity in percentage.

The respondents were STEM students, studying at European universities, including 26% non-European citizens; respondents were 56% female, 41% male and 3% non-binary. They are affiliated with a range of universities in Europe and there are differences as to how far they are in their studies.

The survey contained two main open questions where students were asked to describe a situation where they 'had significant learning accomplishment' and a situation where they 'had a low learning accomplishment'. The survey also contained multiple-choice questions that aimed to create a profile of each respondent, based on their studies' structure and learning activities.

This study however, will solely analyse the individual descriptions of students' perceptions of a situation where they experienced significant learning accomplishments. They were asked:

> *Example of Best Learning Practice. Please describe in max. 300 words a situation where you had significant learning accomplishment. This may have been a situation where you were highly inspired and engaged, and experienced a key learning moment. Please outline the type and duration of the learning experience and include how it was initiated, supported and assessed.*

These descriptions were analysed using the software, Nvivo, and with inspiration from learning theories proposed by Illeris (2007). His understanding of learning and its two fundamental 'processes' and three 'dimensions' are described in the previous section. Illeris' understanding of 'how we learn' and his concepts are used as the theoretical frame for analysing students' perceptions of their 'Best Learning Practice'.

First, the descriptions were categorised using a deductive coding process as to whether respondents described processes related to 'acquisition' or the 'interaction' of learning. Then a second analysis where the descriptions categorised as 'acquisition' was analysed again, and again using a deductive coding, as to whether they relate to Illeris' predefined dimensions of 'content' or 'driving-force (incentive)'. The third and final analysis was using an inductive coding approach creating new categories (concepts) based on students' descriptions in relation to understanding students' perceptions of learning and teaching activities. The three analytical steps are illustrated in Figure 2.

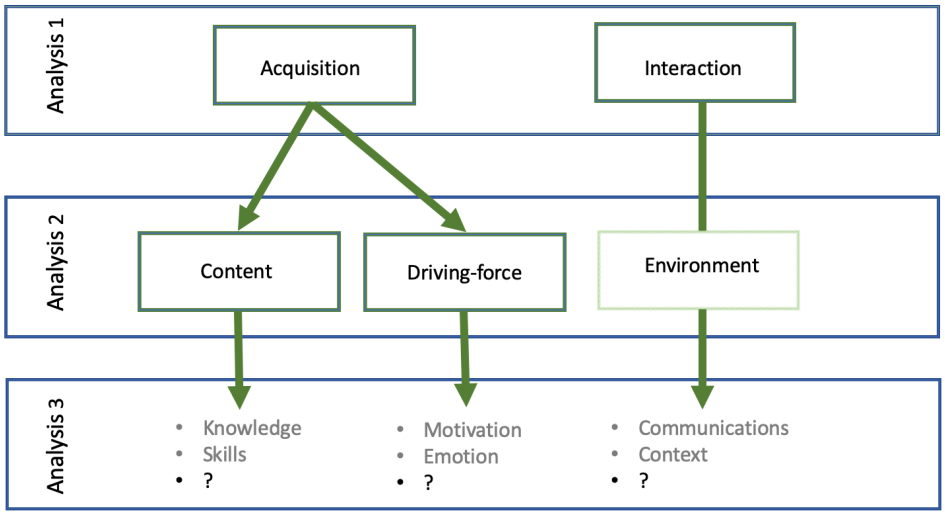

Figure 2: The analytical approach

Analysis of students' perception of 'Best Learning Practice'

The first step in the analysis of data was a deductive approach that categorised the students' descriptions into Illeris' two fundamental processes, acquisition and interaction. There is a clear difference in what practices the students described as being the main attribute to a significant learning experience. No less than 68% of the students described their learning experiences as a process related to interaction, and the remaining 32% described their learning with a process related to acquisition. Perhaps it is not surprising that students to a greater extent described their learning with attributes related to an interpersonal and societal nature than that of a biological nature. As anticipated, describing your context and world appears to be more straightforward than describing your inner processes. In any case, what primarily characterises the descriptions of the two processes is the distinction between the individual-oriented, where the student describes a motivation or an individual process for learning, and the interaction-oriented, where the student describes an environment or a relationship and interaction with peer students or with teachers.

The second step in the analysis is aimed entirely at the process of acquisition, thus the individual level. Again, a deductive process was applied and Illeris' two dimensions 'content' and 'driving-force' is used as the frame for categorising students' descriptions. The distinction here is whether the student described her/his 'best learning practice' with emphasis on 'what is learned (e.g., the element of learning), or with emphasis on the motivation and driving-force. Again, there is a rather large difference, as only 9% of the students described their learning based on elements associated with content – that is, a description of this '*something'* to be learned as a feature of a significant learning experience – whereas 23% accounted for their learning through driving-force and motivation.

The third step, in the analysis, takes an inductive approach conceptualising Illeris' three dimensions of learning: content, driving-force and environment. The findings from this analysis will be presented in the following sections highlighting concepts with the supporting quotes.

Acquisition: Content

The content dimension was described by only 9% of the students exemplifying their experience of a significant learning accomplishment. The examples mostly relate to a subject that the student particularly likes:

> '*my course of Introduction to Programming in first year of my bachelor's'*
>
> and
>
> '*when I switched from Civil Engineering to Computer Science I got a pretty big boost'*

or explain how content is acquired such as

> '*Understanding complex physical phenomena is a difficult challenge which I faced several times during my studies. What I found useful is to try and understand everything from the basics'.*

The content descriptions are in general superficial and not very concrete in relation to what made these examples a best learning practice.

Acquisition: Driving-force

The driving-force dimension can be conceptualised as extrinsic and intrinsic motivation (Deci & Ryan, 1985), as emotions and as willpower being the predominant concepts.

The extrinsic motivation examples point in the direction of exams, for example,

> '*learning for an exam, I started early and learned from flashcards with spaced repetition and was able to remember a lot of the topic, even after the exam'*
>
> or
>
> *'I ended up with a bad result and the exam also went bad. Because of this, I was motivated and dedicated to doing a better project on my second semester, which means I worked really hard, and ended up with a good result and the best grade possible'*.

Another student was motivated by freedom:

> '*a reason was that I had a lot of freedom to try out new stuff and come up with creative solutions to the posed problem'*.

In addition, some students are motivated for studying by future employment or even future earnings such as,

> '*when I see the real purpose of the subject. How to convert that knowledge into money and profit. That is when it get really interested'.*

A few students gave examples of intrinsic motivation through a learning practice:

> '*I like to colour code my subjects and also each lesson. So keeping this short and simple, colours help me learn and I'm always inspired and motivated when my material is organized in that manner'.*

Students also gave examples of emotions in relation to their best learning experiences. Most of them were related to psychological study environment such as,

> '*it helps me feel that I can rest and really learn something'*
>
> and
>
> *'to be in a psychological mood that favors studying: not being too stressed, sad or nervous'.*

Students also explain that

> *'a comfortable environment and to know the people around them, in order to be more open to the experience of sharing and learning'*

are very important for their learning.

Finally, students mentioned willpower as being part of an experience of significant learning accomplishment. A student described a learning situation as

> *'Calculations. Copy an example, after that try as many times as I am able to do it without help. Repeat it on the next day as well'.*

In general, students were less exact in describing their learning process related to acquisition. The individual processes in achievement of learning appears to be not as obvious or to be harder to describe. Content, what is learned, was especially not the focal point of any description of a best learning practice. Motivation, however, is for some students and in some situations seen as a driver for a learning practice.

Interaction: Environment

Students frequently described the interaction dimension, on the other hand, as a process for a good learning practice. According to students' descriptions, interaction can be conceptualised as practice/laboratories, project-work, team/peer-student, the teacher, and a material world.

Practice and laboratory

Several students defined significant learning accomplishment through practice or laboratory work with hands-on experiences:

> '*I would have to say that hands-on experiments and discussing the results with a supervisor immediately after have had the most "oh, hey, I understand something" moments'*
>
> and
>
> '*during the laboratories, we were given a task and I could ask at any point for help. It was important for me because it is really valuable when you get stuck to ask for help'.*

Also engaging with practice seems to be a highly valued learning practice:

> '*the most significant learning accomplishment for me was when we had 3-day workshop with representatives of company related to my field of studies'*
>
> and
>
> '*The best learning practice I had was through a practical project all the quadric-mester long. I was able to test the theoretical lectures through this project each time one ended. Therefore my knowledge of the courses was better'*
>
> and
>
> *'In the first year, we created a plane motor in 3D on our computer. We have never done something like that before'.*

Project-work and problem-oriented learning

Another very frequently described best learning practice is project-work, both as an individual learning practice:

> '*Working with project based learning and getting to experiment and testing your own hypotheses during the writing of my bachelor project has been a situation where I had a significant learning experience'*

and in teams of students, project-work is highly appreciated:

‘*one example are real-life projects that we, at xx are obliged to accomplish. Together with a team, each individual works on comprehensive and complex problems from real-life, throughout the duration of course (ca 3 months)’.*

Some students described their process of learning relating not only to project-work but also to the process of solving a problem

‘*In my opinion, I’ve learnt very efficiently during group project. It was an IT project and working at 4 we were supposed to solve a problem*

or engaging in a project with poorly defined and poorly supported projects.

‘*Project work where we had some orientation, with some defined objectives but with different possible approaches. The project lasted for 2 months’*

and

‘*The better learning experiences I had were through (often) poorly initiated and poorly supported projects, where the assessment was often done fully at the end of the project through a report, without much transparency regarding what was expected beforehand’.*

One student simply described the best learning practice as

‘*learning by doing – with a project.*

Team and student-peer

The interaction with student peers is most frequently among students descriptions. Students seem to prefer collaboration with student peers in different learning processes, or in project-work:

‘*we had to do a group project (3-4) associated with the class that was very inspiring and interesting that made me learn more and engage me more to this specific class’*

and

‘*learning together with fellow colleagues was most effective for me, interacting in small groups with professors in solving the problem task*’

and also while studying:

‘*I guess the best learning practice was when me and my friends just sat at some cafe and studied together. I think co-working and group studying is the key to successful learning’.*

The Teacher

The teacher and the interaction with the teacher is also often described as part of the students’ experience of significant learning accomplishment.

‘*I highly inspired and engaged, when the teacher explains the material interestingly and engages the students in the subject, shows how much he likes this subject and deliver the material in a light and interesting way’*

and

‘*we had a great professor in physical chemistry who was really engaging. He had great examples from everyday applications for something that can be quite tricky to understand. And thus visualising very theoretical concepts’.*

It seems very much to be the engagement of the teacher:

‘*university courses that I enjoyed the most were the ones where the professor was passionate about the subject they were teaching us about. When you see someone’s passion about something – you start to like that thing too. Now there are some subjects that I study with enjoyment and I plan to do my master studies in those areas’*

and also when it is fun to learn:

‘with my favorite teacher ever. The subject was about Java programming, but she made it fun by creating a project about Game of Thrones’.

Material world

A few students described their learning practice based on a material context:

‘*in the library with decent light and during the day’*

and

‘*need my headphones and all study materials’.*

Only a handful of students indicated their material world or study environment as having an impact on their best learning practice.

We saw from this analysis that the students’ s of their learning experience can be explained within the analytical framework of the three dimensions presented earlier.

Conclusion and Recommendation

The analysis of students’ descriptions of their best learning practice was initially categorised into the processes acquisition and interaction. As Illeris (2009) accounts for in his understanding of learning, a learning process consists of two fundamental processes – acquisition and interaction – and both processes need to be active in order for learning to take place. Even so, it is interesting to see how students are able to articulate their best learning practice reflected in these processes. That is, whether it is a description justified by individual achievement or whether the description is justified in collaboration and context – in other words, a distinction between the individual and the outside world. Even though students are better at describing their interaction processes, this does not mean that acquisition does not take place. According to Illeris (2014, p. 16), there may be a time shift in the two processes in which reflection takes place. But then again, perhaps it is not surprising that students largely describe their learning with attributes related to an interpersonal and societal nature than that of a biological (e.g., mental or emotional) nature. Describing your context and material world apparently is more straightforward than describing your emotions and reflective processes. However, from the data collected, we are merely able to make these assumptions.

The analysis also categorises students’ descriptions of their learning experience into Illeris’ three dimensions – content, driving-force and environment. This analysis was purely an analysis of descriptions categorised as acquisition in the first step, but here they were further categorised as content and driving-force. From this analysis, we see that there is less

awareness of content than of driving-force when describing best learning practices. We see that students more often describe their motivation or emotions rather than the content – for example, what they are actually learning as part of the best learning experience.

However, as one digs deeper into the three dimensions, we see trends in preferences in learning practice, and some clear concepts emerge. The overall concept is project-work. This is what students most often refer to in their description of a best learning practice, while several further describe the project-work as organised in a problem-oriented way. Another concept that appeared frequent is learning practices being organised as laboratories, assignments or exercises, and practice. Students describe their learning experiences as hands-on, and several highlighted the importance of a teacher being present and available during the session for support and help. This, however, is different from the descriptions of project-work, where students describe poorly designed and loosely structured project-work as the best learning experience. The data does not provide any evidence for why a teacher is required in hands-on sessions and not in project-work; what we see, however, is a difference in the duration of these learning activities where laboratory exercises are very short exercises counted in hours as opposed to project-work being counted in weeks or often months. This time difference might explain the importance of a teacher being present while students navigate poorly defined and loosely organised learning activities. These poorly defined and loosely structured learning exercises could indicate that students aim for more student-centred learning method.

The concepts of teamwork and student-peer work is also dominant in the interaction processes. It seems as if students in general find learning to be a social process, as pointed out by Vygotsky (1962). The described examples of teamwork are very often related to some kind of project-work and it appears that project-work and teamwork, in many students' understanding, work hand-in-hand.

As mentioned earlier, students abstain from describing best learning practices based on acquisition processes. We saw only a few and those were mainly content related to, for example, a specific subject, rather than grounded in the students' acquisition processes. This could indicate that students do not have the knowledge, language and insight into reflection processes, for example, and therefore are unable to describe acquisition processes as best learning processes. Thus, students might need to gain more knowledge on reflection processes and how they acquire knowledge and skills. In general, students might improve learning by gaining more knowledge on 'how we learn'.

References

Beagon, U., Kövesi, K., Tabas, B., Nørgaard, B., Lehtinen, R., Bowe, B., Gillet, C., & Spliid, C. (2021). Preparing engineering students for the challenges of the SDGs: What competences shall they need? *European Journal of Engineering Education*

Deci, E., & Ryan, R. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior.* New York: Plenum.

Freire, P. (2009). *Pedagogy of the Oppressed. 30th Anniversary Edition.*

Gaebel, M., & Zhang, T. (2018). Trends 2018: Learning and Teaching in European Universities. European University Association. www.eua.eu

Guerra, A., & Nørgaard, B. (2019). Sustainable Industry 4.0. Complexity is the new normality: Proceedings SEFI 2019. SEFI: European Association for Engineering Education, s. 501-510 10 s

Illeris, K. (2007). *How We Learn: Learning and Non-learning in School and Beyond*. Routledge.

Illeris, K. (2009). *Læring* [learning]: Roskilde Universitetsforlag.

Illeris, K., Jarvis, P., Wenger, E., Engeström, Y., Mezirow, J., & Ziehe, T. (2014). *Læringsteorier; Seks aktuelle forståelser.* [Learning-theories: Six contemporary understandings] Roskilde Universitetsforlag, Denmark.

Kolb, David A. (1984) *Experiential Learning. Experience as the Source of Learning and Development.* Englewood Cliffs: Prentice-Hall.

Lehtinen, R., Piironen, A., Kövesi, K., Cantrel, M., Beagon, U., Nørgaard, B., & Schrey-Niemenmaa, K. (2020). The Prioritization of Skills and Competences Required by Future Engineers as part of A-STEP 2030 project. https://www.astep2030.eu/en/project-reports

Nørgaard, B., & Guerra, A. (2018). Engineering 2030: Conceptualization of Industry 4.0 and its implications for Engineering Education. *7th International Research Symposium on PBL: Innovation, PBL and Competences in Engineering Education* Aalborg Universitetsforlag

Passow, H. J., "Which ABET Competencies Do Engineering Graduates Find Most Important in their Work?," J. Eng. Educ., vol. 101, no. 1, pp. 95–118, Jan. 2012

THE 17 GOALS. United Nations; Department of Economic and Social Affairs, Sustainable Development. Retrieved July 17, 2021, from https://sdgs.un.org/goals

Sursock, A. (2015). Trends 2015: Learning and Teaching in European Universities. European University Association. www.eua.eu

Vygotsky, L. S. (1962). Thought and language. Cambridge, MA: MIT Press

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