The Influence of Learning Context on Engineering Students' Perceived Basic Needs and Motivation

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Research Paper

Abstract
Introduction: Learning context plays an important role in students' motivation to learn. Intrinsic motivation is important in order to foster students' deep learning, better performance and overall well- being. According to Self Determination Theory (SDT) of motivation, three basic needs should be satisfied for students to achieve intrinsic motivation: the need for autonomy, the need for competence and the need for relatedness. However, less attention has been given to what influences those basic needs for engineering students in different learning contexts. In this study we used the SDT framework to compare two different learning contexts: project-based courses and mixed courses (lecture based courses with group assignments) to explore whether students experience differences in the satisfaction of basic needs and motivation.
We aimed to answer the following research questions:
RQ1: What is the difference between students' perceived satisfaction of basic needs and motivation in mixed and project courses?
RQ2: Which factors are considered supportive for students' satisfaction of basic needs in each learning context?
Methods: Two studies were conducted in order to answer the research questions. A quantitative study was conducted across seven mixed courses and five project courses. Students completed questionnaires on basic needs and motivation at the end of the course. In addition, a qualitative study that focused on five of the courses was conducted, where focus groups with teachers and students were used to identify motivating and demotivating factors for each learning context.
Results: The students attending the project courses reported more satisfaction of autonomy, competence and relatedness, but no differences in motivation. The qualitative study revealed that among the most motivating factors for project-based courses were: real-life problems or involvement of real stakeholders, freedom to work in an interesting project, feedback, teamwork and relevance to major studies. However, in project-based courses students reported more uncertainty or lack of guidance that affected negatively their motivation. In addition, even though the project-based courses were more autonomy supportive, some aspects of them were considered quite restricting and thus, unmotivating. The balance between autonomy and structure was a major challenge for teachers especially in project courses.
Discussion: Project based courses do not guarantee higher students' motivation in learning. Even though students enjoy the autonomy of project-based courses, it is important that learning context address students' expectations and offer the right amount of autonomy and guidance in order to motivate them. SDT is a theoretical framework that Engineering Education can use in order to inform pedagogical interventions to foster motivation and thus improve students' learning.

Introduction

Students' motivation has received a lot of attention in the field of Higher Education. The learning context, that includes the educational approaches, cultural context, or physical setting

in which teaching and learning occur, can influence student motivation, which subsequently influences students'direction, intensity, persistence, and quality of the learning behaviors [1]–[3].

Within higher education, there is an increasing trend towards student-centred methodologies, such as project based learning (PBL). Literature states that PBL actively engages students in the learning process, leading to, among others, increased intrinsic motivation, effective problem solving skills, self- directed learning skills [4], [5]. That is because students in project based courses have more freedom to choose a topic to work on and responsibility to choose their way of working, while the role of teachers is to facilitate the learning process instead of directing it [3].

Self- Determination theory

Self Determination Theory (SDT) provides a useful theoretical framework for developing student centred learning contexts [6]. SDT differentiates between autonomous motivation (engaging in a behaviour that is driven by intrinsic goals and outcomes) and controlled motivation (engaging in a behaviour that is driven by the expectation of external rewards or the avoidance of punishment or feelings of guilt and shame).

Three basic needs are considered instrumental for motivation namely; autonomy, competence and relatedness. Autonomy refers to students' freedom of choice and agency. Competence refers to students' feelings of effectiveness and control over their learning. Relatedness refers to the students' experience of satisfying social connections with others (e.g. peers and teachers). Learning contexts that foster students' needs for autonomy, competence, and relatedness produce self-determined behaviours or intrinsic motivation, whereas learning contexts that neglect these needs result in non–self-determined behaviours or extrinsic motivation [6]–[9].

In this study, the aim is to explore students' perceptions of basic needs and motivation, in the context of Engineering Education. The purpose of this study is twofold. Firstly, to compare students' perceptions of basic needs and motivation in two different learning contexts (traditional courses with a mix of lectures and tutorials and project based courses). Secondly, to explore in depth which aspects of these learning contexts, students and teachers identify as motivating and fostering towards the basic needs of autonomy, competence and relatedness

Research questions

RQ1: What is the difference between students' perceived satisfaction of basic needs and autonomous motivation in mixed and project courses?
RQ2: Which factors are considered supportive for students' satisfaction of basic needs in each learning context?

Methodology

Participants and context of the study

Participants in this study were bachelor engineering students of a Dutch Technical University. All engineering students follow four "USE" courses as part of their curriculum. USE stands for Users Society and Enterprise, and it is a compulsory package of subjects that look at

engineering from a User, Society or Entreprise perspective. USE shows to students the context of technology in a wide range. During their Bachelor program, students take one basic course generally introducing them in normative and descriptive aspects of analysing technology and a USE-course sequence, which consists out of three courses. In these course, students analyse in depth the user-, society- and entrepreneurship aspects of a particular technology or a technological topic. Students can choose between 16 specific topics like 'Decisions under Risk and Uncertainty', 'Robots Everywhere', 'Future of Mobility', 'Technical Entrepreneurship' or 'Quality of Life'.

All USE courses differ in their content but they aim to achieve the same learning objectives. According to these students should be able: 1. to understand the interaction between technology, user, society and enterprise; 2. to understand the most important concepts, theories and methods used in the humanities, social sciences or management sciences; 3. to apply the user, society and enterprise aspects of technology in the design, development and evaluation of these technologies; 4. to formulate a well-argued opinion in a debate on user, society and enterprise aspects of technologies; 5. to reflect now on the responsibilities of professional engineers; 6. to work as members of multidisciplinary teams; 7. to communicate the results of their work to involved stakeholders; 8. to be motivated to take USE aspects into account when developing technologies.

Through the three courses of every USE trajectory, students are gradually exposed to the theory and practice of a given topic. The first course (exploration) is based mostly on lectures and students have to conduct only small cases studies. At the end of the course there is a final exam. In the second course (specialization), there is a mix between theory and practice. Students attend lectures on a weekly basis but they also have to conduct one or two small projects with a group of peers. Finally, in the third course (application), students work only on a project of their choice, with a group of peers. They do not have to attend lectures, they meet with their teachers for feedback on a weekly basis.

Thus, exploration and specialization courses represent traditional teacher directed courses where the main objective is the attainment of knowledge, whereas the application courses are student centred courses that are based on a project, where students are in charge of the learning process and the teachers have mostly a mentoring role.

Students' evaluation and motivation towards these courses appears to be mixed [10, 11]. Thus, exploring ways to make these courses motivating for students is a priority for the course teachers and curriculum designers.

Study design

To answer the research questions we used a multi method approach. To answer RQ1 we conducted a quantitative study. We invited students from 12 different USE courses to complete a survey study. The courses were grouped in 2 categories according to educational methods they adopted. The courses in the exploration and specialisation stages focused mostly on transmission of knowledge using a combination with lectures and group projects (in our analysis we call them mixed courses), whereas application courses focused on application of knowledge and were project based (in our analysis we call them project courses).

To answer RQ2 we conducted a qualitative study, using focus group with students and in-depth interviews with teachers. Table 1 summarises which courses were involved in the survey and qualitative study.

Table 1. descriptions of courses involved in the quantitative and qualitative study

Couse_setup		Survey study	Qualitative study
Mixed courses	Design for a Sustainable Future (exploration)	√	
	Decision under risk and uncertainty (exploration)	√	
	Robots Everywhere(exploration)	√	
	The Human in Technology (exploration)	√	
	Organizing Entrepreneurship (specialization)	√	√
	Human factors and Ethics (specialization)	√	
	Future of mobility		√
Project courses	Design for a Sustainable Future	√	
	Decision under risk and uncertainty	√	√
	Robots Everywhere	√	√
	The Human in Technology	√	
	Quality of Life	√	√
	Patents, Design Rights and Standards	√	

Quantitative study

The quantitative study included questions regarding students' perceptions of basic needs using the *Basic Psychological Need Satisfaction Scale – Work Domain* questionnaire [13]. Three questions were assessing satisfaction of autonomy (e.g. I feel like I could make a lot of inputs to decide how my tasks got done), three questions were assessing satisfaction of competence (e.g. *During the USE course, fellow students or tutors told me I am good at what I do*) and three questions were assessing satisfaction of relatedness *(I really like the people I worked with in the USE course)*.

Students were also asked to complete the validated 'Self-regulation questionnaire – Academics' questionnaire about motivation using 4 Likert-type items per scale [12]. It identified the following types of motivation: *Intrinsic* (I am highly interested in doing this.), *identified regulation* (This represents a meaningful choice to me.); *introjected regulation* (I would feel guilty if I wouldn't do so.), *external regulation* (others (parents, friends, teachers, etc.) oblige me to do so) and *amotivation* (Honestly, I don't know; I really feel that I am wasting my time in this course.).

Two composite variables were created, namely: autonomous motivation (combining intrinsic and identified regulation) and controlled motivation (combining introjected and external regulation). T-tests were conducted but no significant difference was revealed in students' motivation types.

Qualitative study

To answer the second research question, in-depth interviews and focus groups were conducted with students and teachers from 3 project courses and 2 mixed courses:

- Future of Mobility (specialization course)
- Decisions under Risk and Uncertainty (application course)
- Technological Entrepreneurship (specialization course)
- Robots Everywhere (application course)
  Quality of life (application course)

In this study we used the SDT theoretical framework to formulate questions about students' perception of autonomy, competence and motivation during the courses. Twenty group interviews and 6 individual interviews with students and 8 interviews with teachers were conducted in English for the qualitative study.

These five courses differed in terms of size and educational approach. The two specialization courses followed a traditional lecture based set up, with some additional individual and group assignments that students had to do. Table 2 summarises the differences of the courses included in the qualitative study in terms of: educational approach (project versus mixed course), assessment format, freedom to make choices (autonomy) and feedback opportunities that were considered important in promoting students' perception of competence.

Table 2. Courses involved in the qualitative study

Contextual factors	**Risks**	**Robots**	**QoL**	**FoM**	**TE**
Educational approach	Project- based course	Project-based course	Project-based course	Mixed course	Mixed course
Assessment format	Report	Report	Report	Assignment+ Multiple choice Exam	Assignment+ Multiple choice Exam
Freedom to make choices (autonomy)	Freedom To Choose From A List Of Cases	Freedom To Choose any topic of interest	Freedom To Choose From A List Of Cases	Limited	Limited
Feedback opportunities (competence)	Self Guided + Peer / Tutor Feedback	Weekly Tutor Meetings	According To Project Weekly Meeting	Self Guided Tutor Feedback In Lectures	Limited

	Peer Feedback Of Team	Peer Feedback

Data collection and data analysis

For the qualitative study, data were collected during the last week of each course, whereas the quantitative data of all courses were collected immediately after the end of the courses. Participation is both studies was voluntary. The survey data were analysed using the statistical package SPSS. For the comparisons between mixed and project courses in terms of students' motivation and basic needs, t-test were conducted.

The qualitative data collected from interviews and focus groups SDT was used as a framework for understanding students' and teachers' experiences and it was used to establish some a priori themes. Those themes included: perception of autonomy, competence and relatedness and through the interviews and focus groups the aim was to understand these themes in depth. Data saturation was achieved when no new themes were emerging from the interviews. According to Guest et al. [13] when exploring the experiences of a relatively homogeneous groups like in this case, 12 interviews are already enough. All qualitative data were transcribed and analysed thematically. After initial coding conducted by one researcher, a peer researcher also coded five of the transcripts to cross check the coding categories and ensure the trustworthiness of analysis.

Results

Quantitative study

Participants

In total, 535 students participated in the quantitative study. Those students participated in 12 different USE courses. Table 3 provides the frequencies of students from each course participating in the survey study. All students participating in the courses were 2 or 3 year bachelor engineering students. Demographics about students' gender, year of study or department were not collected as a way to ensure anonymity of students.

Table 3. Frequencies of students participating the survey study

		Survey study	
Couse setup		Frequency	Percent
mixed courses	Design for a Sustainable Future (exploration)	65	15.3
	Decision under risk and uncertainty (exploration)	82	19.3
	Robots Everywhere(exploration)	82	19.3

	The Human in Technology (exploration)	35	8.3
	Organizing Entrepreneurship (specialization)	154	36.3
	Human factors and Ethics (specialization)	6	1.4
	Total	424	100.0
project courses	Design for a Sustainable Future	14	12.6
	Decision under risk and uncertainty	23	20.7
	Robots Everywhere	30	27.0
	The Human in Technology	10	9.0
	Quality of Life	16	14.4
	Patents, Design Rights and Standards	18	16.2
	Total	111	100.0

Differences between the two learning contexts

Students' scores in Basic Needs and autonomous and controlled motivation
T- tests revealed that students participating in project-based courses evaluated significantly higher their perceived autonomy, competence and relatedness. Two composite variables were created for motivation, namely: autonomous motivation (combining intrinsic and identified regulation) and controlled motivation (combining introjected and external regulation). T-tests were conducted but no significant difference was revealed in students' motivation types between mixed and project courses

Table 4. Differences in students' scores in Basic Needs and autonomous and controlled motivation in mixed and project courses

	Couse setup	N	Mean	Std. Deviation	t	sig
Autonomy	mixed course	385	3.52	.710	-4.208	.000
	project course	97	3.85	.643		
Competence	mixed course	385	2.87	.693	-3.872	.000

	project course	97	3.19	.838		
Relatedness	mixed course	389	3.76	.722	-2.981	.003
	project course	96	4.01	.693		
Autonomous Motivation	mixed course	386	2.98	.738	.111	.912
	project course	95	2.97	.768		
Controlled Motivation	mixed course	382	2.17	.724	-.637	.525
	project course	100	2.22	.657		
Amotivation	mixed course	393	2.26	.918	-1.046	.296
	project course	100	2.37	.957		

Qualitative study

The qualitative study aimed to identify facilitators and constraints on students' perception of basic needs of autonomy, competence and relatedness.
Autonomy and competence were the major themes that teachers and students discussed while, relatedness received much less attention. With regard to relatedness, students' mentioned the ability to formulate their own groups as a positive aspect. Students mostly enjoyed working with their peers from their own major as they shared more commonalities. However, the theme of relatedness of was not elaborated further by the students in any of the two learning contexts.

Perceived autonomy of students in mixed courses

Students in mixed courses, despite having ''less autonomy'', viewed the structure of the course and the guidance of the teachers as important factors that did not hinder their sense of autonomy. They were satisfied with the freedom to:

a) Choose a topic for their assignment

"I think in general worked well. The topics for the assignments were interesting"

b) Choose their group members.

"I haven't worked with the other group members before, but the group work was really enjoyable"

c) Define their own study time and meetings with group members

"The setup of the course was really good. We knew what we were expected to do"

Perceived competence of students in mixed courses

For the mixed courses students, reported as key factors for sense of competence:

a) The enthusiasm and communication skills of the teachers to transfer their knowledge.

The enthusiasm and involvement of the lecturers. Having motivated lecturers always helps me to be interested in the course as well and be actively engaged in it. Also, it simply makes me happy to see happy people, so thanks for that.

Furthermore, the lectures were mostly fun to attend. Lastly, what was remarkable was that the professors really wanted to improve what they did. This was done by asking feedback from students more than once

b) The acquisition of knowledge relevant to their major.

The part I liked most of the course was the reader because it taught me some concrete concepts on how to assess sustainability. We study at a [name of institution], I think most people like to learn concrete/technical things

c) The connection between theory and practice with the combination of lectures and small group assignments.

A USE package can add something to your study, but it should connect to your major and it should be challenging

d) The use of real life scenarios and experiences that teachers shared with them during the course, which highlighted the link with their future work as engineers.

This is an example of a real-life situation which requires full analysis of the situation in a business content. The best part of the course is getting to know how companies actually work and how they are built

Perceived autonomy of students in project based courses

For students, in project courses, being autonomous meant to be free to make choices during the course. For project courses, autonomy was inherited in the design of the course, as students had to initiate and accomplish a project by themselves, where teachers played a mentoring role. However, not all choices mattered in the same way for students. The most important choices that students felt that increased their perceived autonomy were:

a) Autonomy over the choice of topic for the assignment and the project,

"You have the freedom to work on whatever interest you and that is really motivating"

"I thought you had enough freedom to choose which way you would approach the problem, free enough to come up with solutions to the problem"

b) Autonomy over organizing teamwork and distribution of workload (e.g. defining their own timing and deadlines).

> *"…I like the way it's set up, cause it fits exactly with what the rest of the course is…the rest of the course is free and open , so the ..the contact hours should also be free and open, so.."*

Both of those pre-conditions for perceived autonomy were accompanied with a challenge. With regard to the freedom to choose their own topic, students the experienced increased insecurity for their choice. The lack of structure and concrete guidelines made them often doubt about whether they were on the right direction in the project.

> *"At first we had a… a bit too simplistic subject, so we had to change to completely different subject and that was kind of hard to, that was a really hard part to find a good subject, cause when you have a good subject, it's way more fun to work on it and … and then yes it's going pretty well I think"*

In addition, even though the project courses ''advertised'' the freedom of students, students were bounded to several limitations in terms of project planning, externally imposed deadlines and mandatory feedback meetings.

> *"I think if you, we go very often to these meeting, because we think they are important and we want to ask questions and it's nice to have time that we all sit together, however if it's not necessary ,then I feel that it's not really useful..if you have to go, so that's why I like the freedom"*

Perceived competence of students in project based courses

For students in project course, sense of competence was a result of being equipped with adequate knowledge in order to apply it to real life problems.

Working on a case and being required to provide a consultation report to a stakeholder was a challenge for students but also a motivating aspect. Making use of a decision theory to solve a real life decision problem was mentioned as a very interesting component of the course. Students' in project courses mentioned as important factors for perceived competence:

a) The ability to work to a real life project involving real clients of stakeholders

> *"I think it's helpful that you look and define a real life problem. And when you are given a description of something that you can turn into a.. to find a real and complex problem and you are able to solve it."*

> *"Translating a real life problem to a problem you can analyze effectively"*

b) Thinking as engineers and apply knowledge previously acquired

> *"but um… I would say that the project does allow me to implement and use my knowledge that you learn"*

For them the sense of competence was strengthened by the thought that the project course was a good preparation of being an engineer in the future.

However, students in project courses experienced also constraints in their perception of competence. This had to do with the openness of the project course and the lack of clear guidelines. On the one hand, several groups of students felt competent enough to accomplish their project. They designed a project in an area of interest where they could use their skills

and knowledge. However, several groups doubted their ability to complete the project. The lack of clear expectations from the teachers was considered as a main barrier to competence satisfaction.

> *"It is hard to start, to see what is expected from them (the teachers). The early feedback should be important."*

> *"Maybe they could at the beginning of the course…eh… give some examples of previous projects. Like what would have to deliver first. We don't know really what to expect, to… to deliver at the end"*

Teachers view on students' motivation

Keeping the lectures interesting

For teachers in mixed courses their main challenge was to keep the lectures interesting and engage students in active learning. For achieving his, they used videos and dialogue during lectures as well as groups discussion in classroom.

> *"I try to make my lectures ''less dry''. I incorporate examples that they might find interesting or videos from people they admire, like Elon Musk"*

Balancing the provision of freedom and guidance as teachers in project based courses

For teachers supervising project courses, achieving the balance between autonomy for students and enough guidance was a hard task. There were some realistic constraints that posed some barriers to the autonomy of students such as limited time of the courses that required that some strict deadlines were imposed;

> *"So, what I like is that again there is uh.. freedom within limits so to say..relatively broad limits and I like the structure that is student directed learning..I am trying to provide as much support as possible, but in this case it's the students who do the work and they learn from each other and that's also something I have tried to stress during the presentations, so all groups learn from the other groups and not only from the peers within their groups, but also from each other..I think that the time span is a little short, because we have about eight weeks to our disposal, so I think a few more weeks could have been beneficial, especially if you want to integrate bigger ethics component to it.."*

> *"We could say that students want autonomy in content and guidance in the process and structure".*

According to teachers, students who could not handle the openness of the project course, remained at a superficial level in their work as they were not able to understand and produce a rigorous and good quality product.

> *"Like if you don't give them a specific task they think superficial is ok and I think I didn't give them any guidelines for rigor, …, so I think I would probably change that, to make some kind of standards of depth, rigor like number of citations you have, inclusion of the literature you uhm…"*

Discussion

This study used the framework of Self-Determination Theory and examined the differences in students' motivation and satisfaction of basic needs of autonomy, competence and relatedness, in two different learning contexts [6], [14], [15]. More specifically, students participating in project courses were compared to students who attended mixed courses that combined lectures and group work. In contrast to our expectations, no differences were found between the project based and mixed learning contexts under study, on students' autonomous, controlled motivation and amotivation. However, students in project courses reported significant more satisfaction of autonomy, competence and relatedness. To explain these results, we looked at the results of the qualitative study.

Supporting elements in students' experience of autonomy was students' ability to make choices over the topic of assignment and group. Other elements such as strict deadlines, or mandatory presence to tutorials were considered controlling elements and were not motivating for students. Even though our findings support current literature that PBL is more supportive towards students' basic needs, our study did not show any difference in students' motivation. SDT states that the basic needs influence motivation. We measured significant differences between mixed and project courses in basic needs and we would therefore expect differences in motivation as well, but we did not find such a difference.

Based on the results of the qualitative study, two explanations could be provided, why no differences were found between project and mixed courses effect on students' motivation.

Firstly, students in project based courses, despite reporting autonomy over their learning process during the project, they also described several controlling elements in the learning environment, such as fixed deadlines for project deliverables and students' mandatory presence in tutorials. It is possible that these elements might have affected the overall motivation of students. If some restrictions in the project based courses cannot be avoided, it is important that teachers communicate to students why those restriction are necessary. According to Assor [16] providing students a rationale for performing a task when choice is limited, can positively enhanced autonomous motivation.

Secondly, focus group results showed that students experienced uncertainty and insecurity about making right choices when working in project based courses. This insecurity even if students did not consider it as a lack of competence could diminish students' autonomous motivation. The findings of our study suggest that it is important that teachers communicate clearly the goals and objectives of the course and the project to students so they have a better understanding of what is expected from them.

In addition, providing mechanisms, where students can ask questions to improve their understanding of expectations can support them to feel more competent. In this case, an important implication for project based learning contexts is providing students with the right amount of structure as a way to foster motivation [3], [11], [17].

Conclusion

This study contributes that the claim that project based courses are intrinsically motivating [4], [11], [17]–[19]is not completely justified. Even though students in project based courses, rated their perception of autonomy, competence and relatedness higher compared to peers in mixed courses, this difference was not reflected in their self- reported motivation. Our qualitative study suggests that the existence of controlling elements in an autonomy supportive environment as well as the perceptions of educational activities as being very

difficult without enough guidance from the teachers, can be both affecting students' motivation. A learning context needs to be autonomy-supportive and competence-supportive by offering to students challenge and at the same time guidance to accomplish their objectives [7]. The challenge remains for educators how to achieve this when courses need to accommodate students with different learning needs, learning styles and attitudes [20].

Limitations

This study has several limitations. The survey study had a cross- sectional character and such a design prevents from assessing causal relationships between examined variables. All survey questionnaires were based on self- report. The qualitative study was conducted with students who self- selected possibly affecting the generalizability of outcomes. In addition, current mixed learning contexts in this study did not exclusively rely on lectures, but also include some active learning techniques, such as work groups. The use of active learning strategies, such as workgroups could have affected our study findings. Nevertheless, the project based courses under study did give students significantly more opportunities for active learning than the mixed courses and they are undoubtedly more student-centered.

Recommendations for future research and practice

Future studies should adopt a longitudinal design to examine the relationships between students' basic needs, characteristic of the learning environments and motivation. A more in-depth analysis could also focus on differences between mixed courses and differences between project courses. The relationship between proving the right amount of autonomy and guidance to students seemed to perplex both teachers and students in project based courses, suggesting that this is still an important topic for further investigation.

With regard to recommendations for practice Kusurkar et al. [21] summarized some advice for curriculum designers on how to use SDT theory to foster motivating learning environments. Those advices emphasize the important of identifying and nurturing students' learning needs; encourage students' active participation in the course as well as emphasizing students' responsibility for their learning; provide structured guidance and constructive feedback; provide tasks that are challenging enough but not impossible for students to tackle; acknowledge and deal with students' frustration and emphasizing the value of uninteresting activities that are important in the learning process.

To sum up, SDT provides a useful framework for analyzing learning contexts and identifying barriers and facilitators to students' motivation by focusing on the basic needs of autonomy, competence and relatedness. In addition SDT is also a useful framework for pedagogical innovation that curriculum developments can use for the development of motivating and students centered learning contexts.

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