

# Why are we Here? Student Perspectives on the Goal of STEM Higher Education

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**Abstract**—A key component of the tertiary education system is the negotiation of common expectations in terms of pedagogy and the manner in which learning is scaffolded in the learning context. This paper addresses this interplay of perspectives by drawing on two elements of our previous work, a longitudinal study of student identity development [1] and a study contrasting project course students' experiences with teachers' expectations [2]. The paper develops a model of student interaction with teachers and the higher education system, which contributes to a better understanding of the consequences of recent changes and trends in higher education, e.g. demands for activating students, increased level of detail in course specifications, and examination of "non-core subject content". This is an immensely complex area and we approach this challenge with a focus on the issue of students rejecting learning opportunities. Through this lens we will identify and illustrate some essential aspects of how to adapt educational settings to better accommodate how students behave and view the goal of their education.

**Keywords**—professional competencies; intellectual alignment; student learning

## I. INTRODUCTION

Effecting change in STEM education has emerged as a recent focus in disciplinary centred higher education research in science and technology over the last few years. One of the central questions in this research is to understand factors which might explain the slow pace of change in teaching and learning at university which has been experienced over the last two decades. Tremendous investment and related efforts over the past few decades have built up a substantial knowledge base about STEM learning and many effective pedagogies and interventions [3]–[5]. Yet prestigious organizations such as the National Research Council, ASEE and Royal Academy of Engineering are increasingly expressing dissatisfaction with the rate of implementation, adoption, and scale-up of research-based instructional strategies [6]–[8].

A number of the factors that inhibit innovation and systemic change have been discussed in the works of Borrego and Henderson, among others. Factors such as collegial conservatism, quality assurance processes [9], and curriculum structure have been the major focus of much prior work. Curriculum and learning outcomes are also strongly linked to the pedagogical approach applied to the learning situation. The far reaching impact of student agency in the change process has been

discussed by Barker [10], and in particular the sensitivity of educational systems to student criticism.

We have observed a recent increase in mismatches between teachers intentions with educational settings and student behaviour. This ranges from students using course specifications, often outdated, to avoid learning activities, to students increasingly avoiding engagement in learning activities they consider not being needed in order to pass a course. The increased use of student active pedagogy has, in our opinion, been an important factor in creating this mismatch, and perhaps also a reason for seeing an already existing mismatch more clearly. This will be discussed later further on in the paper.

A key component of sustainable change is the negotiation of common expectations among players in an educational system, e.g., in terms of pedagogy and the manner in which learning is scaffolded in the learning context. Conservative expectations can have a negative impact on the STEM change process [1]. A better understanding of the interplay between expectations and recent changes and trends in higher education, e.g. demands for activating students, increased level of detail in course specifications, and examination of "non-core subject content", is one key to how educational settings can be adapted to better accommodate how students behave and view the goal of their education.

In this work, we develop new theories and models that can be used to reason about the interplay between different players' motivation in educational settings. We present a number of cases where teachers have observed unexpected student behaviours and discuss these from the perspective of interplay and alignment of motivation using the proposed theories and models.

Our vision is to create a framework that will facilitate pedagogically sound changes in STEM higher education. The effect on students should be the focus for change. We see student attitude towards their study time as an essential factor in this endeavour. Students should, in a successful educational setting, view the time allotted for learning associated with a course as something to fully use. That is, a student with a solid previous understanding regarding the learning associated with a course should cover a larger "area" of learning than a student not as prepared. Both these students should feel at home in the educational system. Well functioning alignment

between students, faculty, and the higher education structures are at the core for this to happen. The following quote from Brophy [11] captures this dilemma.

”Especially needed are strategies for helping students come to value what they are learning for its perceived self-relevance and potential life application (not just to enjoy the activities in which they are engaged). Second, even those aspects of the school curriculum that are well worth learning may not become valued as such by students unless their exposure to them is designed to connect with their motivational zones of proximal development and is mediated in ways that scaffold not only their learning but their appreciation of what they learn.”

The remainder of this paper is structured as follows. We commence with a survey of the field as background to the work presented here. Then we introduce our proposed framework for understanding the major players in higher education, followed by an overview of the theoretical underpinning for the framework. The framework is then applied to some cases of poor alignment between players. Some final remarks are given in the conclusion.

## II. SURVEY OF THE FIELD

This trend towards student-centric and student active learning, is building on an increasingly influential body of work in the higher education research literature [12]–[15]. Research has shown that implementing a student-active curriculum clearly has many advantages for student performance in individual courses [16], but also that there are potential pitfalls associated with widespread use of some common student-active classroom techniques affecting the students’ experience of their education [16]. Understanding the role of motivation in this evolving area is essential for exploiting the potential of student active pedagogy.

A number of studies investigate the effects of teacher and student motivation on behaviours and quality of student experience and performance. For example, Schiefele [17] establishes that students’ interest in the topic and achievement motivation predict both their experience of the learning situation and their achievement, independently of their ability. Bolkan et al. [18] show that students that are motivated to process the learning material perform better than less motivated students, regardless of clarity of instructions. Kunter [19] investigates how teachers’ enthusiasm correlates to choice of instructional methods and students’ perception of the learning situation. Schiefele et al. [20] developed a model where teacher interest is described as consisting of subject, didactic and educational interest. The model is then used to investigate the effects on student motivation [21]. The study finds that teachers’ educational interest is a strong predictor of the characteristics of the teachers’ classroom setting. Structure, and actively monitoring classroom rules, help to structure the learning environment and thus increase student learning time, which in turn shows strong effects on student motivation.

None of these studies take into consideration the effect that educational structures have on student and teacher behaviour and motivation. Neither do they investigate the effect student motivation may have on teacher performance. Our proposed framework complements and extends these earlier results by providing a structure that permits researchers to gain a more holistic understanding of motivations and behaviours present in an educational system, and an understanding of the impact of these factors on terms of the development of professional competencies.

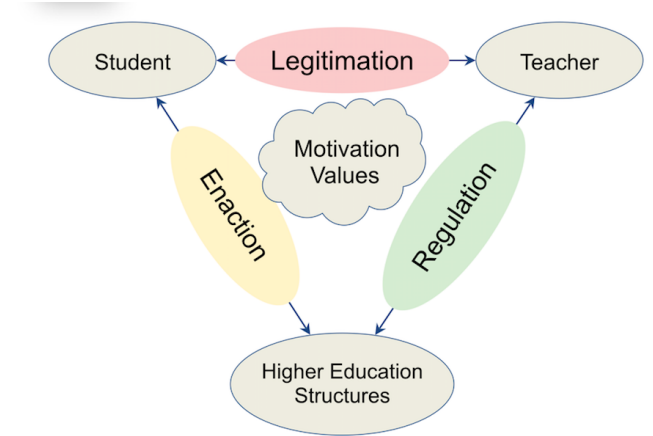


Fig. 1. The Educational Value Model

## III. FRAMEWORK

Our proposed framework is intended to support reasoning about the motivations and behaviour patterns of staff and students engaged in higher education (Figure 1). We link several other theories with the framework to support new approaches to reasoning about motivation and behaviour, and especially how they align with student activities which deal with learning of, and development of, professional competencies.

Our point of departure draws on ideas from Variation Theory [22] to theorise that experiences of motivation, and the resulting learning behaviours of engagement and disengagement, are negotiated within a broader academic system the major actors and interrelationships of which are illustrated in Figure 1. Using this approach we argue that motivation, values and derived behaviours in the learning context are being negotiated in interaction between these major actors. Each arrow represents a tension and a scope for experience, communication and negotiation of relevance. For instance students and teachers interact during the learning process in ways that reinforce or undermine self-esteem. The processes associated with this relationship can be viewed as consisting of actions that are involved in legitimization of both the learner and teacher in their roles, and in the context of the learning situation.

Similarly the other two arrows represent symmetric relationships between the other two major elements of the

educational system visible in our model. We view the interaction between the student and the educational system as one of “enaction” where the student through engaging with the curriculum and higher education system try to understand their role and objectives in relation to that system. For teachers the relationship with the higher education structures is more characterised by the regulatory and quality assurance nature to these structures as they are experienced from an academic teaching perspective.

#### IV. ANALYSIS: THEORY AND METHOD

##### A. The Theory of Planned behaviour and the Reasoned Action Approach Extension

The proposal also leverages the Reasoned Action Approach (RAA, see Figure 2) developed by Fishbein and Ajzen [23], which is an extension of the Theory of Planned Behaviour (TPB) [24], [25], as a means to capture behaviour coupled with beliefs. The approach considers beliefs as strong predictors of behaviours and is used here to give a structure for investigating factors underlying an observed behaviour. TPB has been used to investigate human behaviour in different areas, where perhaps healthcare [26] is the closest to our proposal. Both TPB and RAA are well established theories regarding understanding human behaviour, and provide the necessary link between the systems view presented in Figure 1, and the empirical data collection and analysis. RAA provides direct support for the analysis of our two qualitative data pools. This theory is not further expanded on in this paper. It is only included to give a holistic picture of the framework.

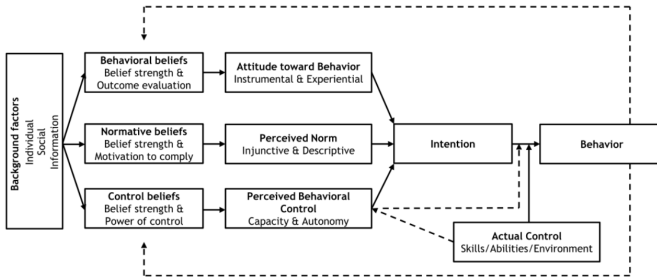


Fig. 2. A Structural View of the Reasoned Action Approach [23]

##### B. Intellectual Alignment Linking the Envisioned, Enacted, and Lived Aspects of Learning

When viewed from the variation theoretical perspective learning environments link the Envisioned, Enacted, and Lived aspects of learning, but can be experienced differently by learners (with their major focal awareness in the Lived) and teachers (how have their primary focal awareness in the Envisioned, but also expectations of what the Enacted holds for learners). Consequently, when viewed from the teacher perspective the linking of Envisioned to Lived is about facilitating student learning of target skills and knowledge. High level learning outcomes can be viewed as expressions of systemic high level external values and their intent is to partially

regulate the teacher’s behaviour, but also to communicate a systemic level vision of the goals of the specific teaching and learning activities.

However, in order to achieve intellectual alignment agreement needs to be negotiated between teachers, the academic system, and learners. In this situation learning outcomes are used to both structure aspects of the different types of “players” engagement in education and the alignment of the Envisioned, Enacted and Lived from the perspectives of the different agents proposed in Figure 1. Each of the elements of intellectual alignment can be conceived of in relation to a particular player. This can, for instance, be used to capture learning an aspect of a professional competence for a student and thus provide information valuable to understand how they function in that role more completely.

Intellectual alignment between different players can also be used to study, for instance, the focus on envisioning and enactment of a teacher creating a learning opportunity and place this in contrast with the student’s experience in relation to the enacted, the lived experience of the exercise. This helps to make visible tensions in the students’ expectations and consequently allow us to reason about motivation and behaviour, in the given learning scenario.

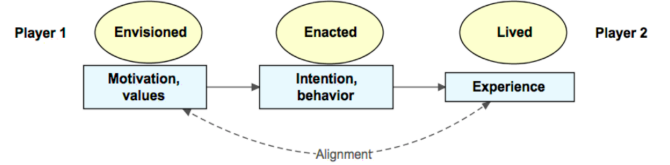


Fig. 3. Intellectual Alignment

#### V. APPLICATION CASES

We use six incidents that occurred in courses given at our own institution to explore student behaviours that we believe result from tension in the interplay between different elements of our model, the bi-directional arrows in Figure 1. We believe that even if only one student displays a behaviour or expresses a view that is in contrast to what might be considered desirable from the teacher’s perspective, this is a sign that many students may also be experiencing poor alignment, and that this should be addressed when re-designing learning environments.

It should be noted that we do not necessarily advocate changing the learning activity in response to our analysis. Rather, that the analysis can reveal systemic tensions which require us to provide learners with a more clearly articulated argument for the value of the target learning activity. We hypothesise that the majority of these situations arise due to our inability to clearly articulate the intellectual alignment and intrinsic educational value of the learning activity from a student perspective.

What all these cases have in common is that they have occurred in courses with a strong emphasis on development of professional competencies and/or where many of the learning outcomes are outside the students’ envisioned core field of

study. The incidents all occur in connection to assignments where student activity and engagement is requisite for success.

1) *Grading:* In the 2000 instance of the Uppsala University lead Runestone course students from Uppsala University in Sweden and students from Grand Valley State University in the USA collaborated on joint projects. The teachers on the American side contacted the teaching team in Uppsala about halfway into the course and expressed the view that there was a major problem and that aborting the projects might prove unavoidable.

The Uppsala team was taken by surprise, everything seemed to be proceeding more or less as it had in earlier instances of the collaboration. After discussion it emerged that the problem arose in interpretation of the rubric used to assign final grades in the course. The grading at Grand Valley State was regulated by a rubric based on the American grade scale A-F, whereas in Uppsala a student taking the course received a pass/fail grade. Since the rubric was based on performance in milestone events and was cumulative, this meant that it seemed that there would be no incentive for the Uppsala students to contribute once they had accumulated sufficient marks to pass the course.

It took some effort to convince the American teachers that the Uppsala grading system for pass in practical work required students to work both continuously and to submit complete solutions at every stage, a behaviour more well aligned with the Grand Valley State expectation of a B or A. The project continued, however to evaluate student perceptions of commitment to the project a peer evaluation exercise was included at the end of the course. Students were asked to "pay their team by allocating part of a \$100 salary to each of the team members, including themselves". They were also asked to provide a brief motivation for the manner in which they had paid each of their project team members. This outcome of this exercise was that the American students gave slightly more money/credit to the Uppsala students than to the other Americans in a team, on average. This incident is reported in detail in [27].

In this case, the application of our model suggests that the situation arose due to poor alignment between the higher education structures and the teachers and students interpreting of them. The American teachers and students saw the grading rubric as an absolute measure of which grade to assign, irrespective of if the student was in the US or in Uppsala. The use of the rubric for grading students in Uppsala was only meaningful if someone actually failed to get to the Uppsala defined "pass" level. In this case passing in Uppsala also depended on contributing throughout the project. It should be noted that the Swedish Higher Education system is based on a strong sense of work ethics, which clearly played a major role in how the Uppsala students contributed to the project and interpreted the grading rubric.

2) *Self-Activation:* In 2008 student-centric educational approaches were starting to become popular, and in line with much of the research at the time we redesigned the Real-time and Distributed systems course in the IT Engineering programme. The course was structured around a series of

modules dealing with key aspects of real-time and distributed systems, tied to a case study which was used to motivate the content of each module. The case study involved coordinating autonomous rescue robots operating in real time to extract survivors from a disaster site. The case study provided a context within which to study hard and soft real-time systems problems, and the rescue robot scenario posed a range of distributed systems challenges, including atomic transactions on shared data structures, synchronisation and different forms of distributed consensus algorithms.

In each module the case was used to motivate the need for a variety of new material in the area of real-time and distributed systems. Once the scene was set students were divided into small working groups who researched different areas of the material together and prepared joint presentations. Each module concluded with several seminar sessions where all the groups presented for each other, uploaded summary reports on the material they had worked on to the LMS, and then each group worked on developing their system design in the case study using the material compiled by all the teams. When the design case had been revised the next challenge was introduced and a new module began.

The course was heavily criticised by students and reported by the degree coordinator to the board of studies as a course that was apparently of very poor quality. The students reported that they had only learned teamwork and presentation skills during the course, and that the lecturer had failed to properly structure and deliver lectures on the technical content. The examination was based on grading the case study design reports of the teams in combination with an assessment of the student's individual reflections on the learning goals of the course, together with an evaluation of the extent to which each student had worked to achieve them. The program director deemed this combination of examination methods unreliable and unprofessional.

The following exchange occurred by e-mail after the completion of the course. The Instructor comment is in response to criticism by the student that the course instructional design was inappropriate.

Instructor:

I have also an observation. Much of the success or failure of a learning situation depends on the learner and the learner's motivations. You might benefit from reflecting on your attitudes and expectations of education at University. I would argue that you had every opportunity to seek knowledge and relate it to a relevant problem in this course. You also had the opportunity to discuss your ideas and new knowledge with me during the seminar sessions. Much of the outcome here seems to imply that you expect that teachers will package knowledge and serve it to you so that you don't have to make much effort yourself to acquire and structure knowledge. Perhaps that is the role of a University in some models, but I don't think it is a particularly productive model in terms of helping people to develop lifelong learning skills.

Student:

I am well aware of that. Where I work/consulted I had to make a program that read a couple of different meters (water, heat, electricity consumptions). There were no one to turn to, and if you asked the manufacturers they handed over the wrong documentation, so you had to do a lot of guessing and research just to understand what they said. The University shouldn't do everything, but they should present the basic concepts and terminology, so when you have to implement something you don't do rudimentary errors. You should be able to hold a conversation with another student from another university, and not sound like an idiot because you have made wrong presumptions.

Now if we didn't have lectures I might still be able to do a good report, but I would miss a lot of basic concepts as that specific architecture doesn't implement it. I don't know. Maybe the student should understand that, and research some other processors too, but the likelihood of that happening is quite slim.

In this case, there is poor alignment between learning goals and the student's expectations of what is to be learnt in the course. This is in part due to the Swedish system, where learning goals are specified at several different levels, i.e. for specific courses and general for degrees.

3) *Relevance*: In an assignment designed to develop students written communication and feedback skills by asking them to give guided feedback on another student's text, one of the students objected to the assignment by submitting work that was not serious and slightly offensive, both to the teacher and to the student that had produced the text.

Question:

Is the text interesting? What is particularly interesting?

Answer:

The text is as interesting as the assignment. Not.

Question:

What can be developed?

Answer:

The report, if you turn it into a paper airplane?

In this case, there is poor alignment between the teachers motivation behind the assignment and students behaviour. The teacher sees the targeted skills as relevant for the students future profession and useful during the studies in addition to being a required learning outcome in the education. We do not have any evidence of how the student perceived the assignment, apart from what the student submitted. An educated guess, however, is that the student did not see the professional relevance and, since this was in the first course of CS studies at the university level, the student had looked forward to learning CS - not writing. Hence the assignment did not appeal to the students interests nor expectations.

4) *Time consuming*: Inspired by a very successful similar course in human-computer interaction (HCI) at another uni-

versity, our HCI course was redesigned with an element of gamification and a final event which involved presentations in front of a jury of invited industry experts. Faculty of the course had good contacts in the health care area, so health care applications were the focus of the project based course. The teachers planned the course based on the rationales presented above with the intent to create a student centric and motivating learning environment with a direct connection to industry.

To their surprise many students seemed not to be motivated to engage in the setting, and the gamification component and the jury in particular did not have the expected positive impact on student motivation. In fact, for quite a large number of the students taking the course the impact on motivation was quite the opposite to that expected. An example of this is the observation made to the teaching team by the following student.

"Completely unnecessary to put energy on it, you do not seem to understand how a student works.

A contest where the prize is to make an additional presentation? ..."

In this case, there is poor alignment between the teachers ambition to create an inspiring educational setting and the students ambitions to focus on passing the course with minimal workload. The tension here lies both in the component of enaction with implications for legitimation. The student experience of engaging with the structures established in the course (enaction) was not aligned with the values and motives that the teachers ascribed to a prospective student population during the design process. This poor alignment resulted in the students questioning the legitimacy of the teaching team, questioning the validity of the exercise, and observing that they did not embrace the values ascribed to them. This illustrates a need for change in the educational setting in general. The student focus on doing as little as possible is not in the best interest of either the student, or society. However, it reveals a student focus which places value on the degree as a symbol of employability rather than the degree as an opportunity for personal growth and learning.

5) *Formalia*: The final case teachers who had developed assignments intended to broaden the students' perception of the course contents.

In the first case the teacher had developed an exercise that focused on students developing awareness of the application of key conceptual material by reading about the concepts involved and presenting potential practical applications. However, due to an administrative error the teacher failed to clearly announce the due date for the assessment at the start of the course. As a result of this, the students applied pressure through the director of studies to compel the teacher to cancel the assignment, even though they saw the assignment as both educational and interesting.

"We think it is a good assignment, it is interesting and we would learn a lot. We would really like to do it, but since it was not announced properly we shouldn't have to."

The second example concerns the introduction of new formative assessment measures into a course. The intervention was the result of low attendance rates at lectures in previous offerings of the course. To address this situation the teachers decided to introduce short quizzes during the lectures. Successful participation gave bonus points towards the final exam. Students used a number of course management technicalities to persuade the teachers to rescind this practice. Finally the teachers agreed to cancel the quizzes for fear of breaking regulations, although in fact on later investigation they would not actually have contravened any formal regulations.

In both cases, there is poor alignment between the teachers' ambitions to create an inspiring learning environment and detailed formalia imposed by the Higher Education System in particular the processes surrounding course specifications and course management. It can also be argued that there is poor alignment between the formalia and a focus on student learning. In particular there is poor alignment between the formalia associated with quality assurance systems for courses and the teachers, as well as between these formalia and the students. Both the teachers and the students had assumed that there were regulations that had been violated. That assumptions and myths about rules and regulations in higher education structures can influence behaviour, as in these cases, clearly illustrates that there is room for improvement.

## VI. CONCLUSION

In this paper we have presented and illustrated the use of a framework for analysing the interplay, and alignment of perspectives, between key agents in Higher Education. The model draws on previous work in our research group, e.g. a longitudinal study of student identity development [1] and the PhD thesis of Wiggberg [2] which contrasts students' experiences with teachers' expectations. The above examples show how the framework supports analysis of learning situations and permits a more sophisticated understanding of negative events, especially by identifying where the issue originated. For instance that a learning situation is experienced in a negative manner from the teaching point of view since from that perspective the examples above represent missed learning opportunities.

The framework can also be used to analyse positive events and thus provide insights into why something had a desirable outcome from the teaching point of view. Whether the situation studied is positive or negative is irrelevant for lessons learned. The understanding gained can be used to improve the educational system in general, and teaching staff can use the framework as an integral part of a scholarly approach to education.

We argue that the issue of positive or negative in the cases presented above actually has a "right answer". Take for instance the idea of students actually using all the time allotted to a course, or degree program, to learn. Intuitively this sounds like a positive situation, but for a student it is perhaps more important to be able to pass a course, or degree program, in as short time as possible. This said, from a societal point

of view, it is negative that students spend time and energy on avoiding learning activities. This behaviour could however be indicative of degree programs (particularly in engineering) being overstuffing with content.

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