

What do our Students Strive for? Insights from a Distributed, Project-based Course in Computer Systems

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ABSTRACT

An important question for us as educators is what our students strive for in the courses we teach. If we understand what the students strive for, we can use these insights as an intellectual tool aiming to influence what they what they learn. Despite its potential for enhancing learning, this question is only little researched. In this paper, we present the results of a qualitative, empirical, phenomenographic research project into how students' experience what they strive for in a distributed, project-oriented course in computer systems. Three different motives that the students strive for have been identified in the student cohort: academic achievements; project and team working capacities; and social competence. These different motives could, in their turn, be experienced in different ways. We argue that different motives are relevant in different situations, but that some ways of experiencing certain motives are more desirable than others.

1. INTRODUCTION

What our students learn in the courses we teach is, of course, closely related to what they strive to learn. The relationship is multi-dimensional and includes many factors, such as for example how the students go about learning as well as the opportunities for learning that are offered in their environment.

It is clear from the results of this research project that learning took place during the course under investigation. The learning was multi-faceted, and frequently related to issues other than the core concepts of computer science that the course was intended to teach. It also included components such as project work, and insights concerning personal development. The words of Axel¹ can serve as a summary of his and many other students' reactions, but also of our personal reflections on these results:

¹ The names of the students are anonymized in this paper. An interviewed student, with a name starting with an "S" is from Sweden, while a student with a name starting with an "A" is from America. Also the names of students that are referred to in the quotes are replaced. Since this research is performed in a male dominated environment, only male names are used. Consequently, all students are referred to by "he".

Axel: I guess I learned a lot, but what I learned wasn't what I expected to learn.

In this paper we present what the students were striving to learn during the course. Thus the perspective is that of the students and has to be explorative to its nature. It must be data-driven, since the results grow during the research process and cannot be predicted in advance. The results are thus qualitative and interpretative.

This paper is structured in the following way: After a brief discussion about the setting from which the empirical data stems, the theoretical points of departure within phenomenography are discussed: the research approach, and the concept of an indirect object. We then describe the empirical results, followed by a discussion of what the analysis of the empirical results can reveal. Finally, we discuss the results in the context of teaching and future research.

2. THE CONTEXT OF THE STUDY

The findings discussed in this paper stem from empirical work in an open-ended project-based course in computer systems for computer science students in their third and fourth year, often referred to as the Runestone course ([1], [5]). The students worked in cross-national teams of six, with three students located in Sweden at Uppsala University and three in Michigan in USA, at Grand Valley State University. In their project teams, the students developed a software system to control a motorised toy, a Brio labyrinth, from a web-browser, see Figure 1. The task was demanding for the students; to succeed the team members had to collaborate. They interacted using different ICT-based tools, such as IRC and e-mail.



Figure 1. The Brio labyrinth, in the original version and a modified version with a camera and step-motors added

3. THEORETICAL FRAMEWORK

3.1 Phenomenography

To guide the researcher in his or her exploration of this complex situation, phenomenography [12], is selected as a research approach, since offers possibilities of gaining insights into the students' experience of their own learning and their experienced conditions for learning. The approach has proved successful for studies of how university students understand core concepts in computer science (see [1] for computer network protocols, [2], [4] and [8] for programming, [5] for information systems, [9] for the concepts of class and object, [11] for data structures, and [15] for moral conflicts in an IT project courses). It has also been used to explore issues outside the actual course content, such as for example the students' objectives in their studies (see [13] for an overview of such research).

A phenomenographic research project reveals the qualitatively different ways in which something, a phenomenon, can be experienced, understood or perceived within a student cohort. An experience, or understanding, of the phenomenon is, from the phenomenographic perspective, shaped both by the student and that which he or she experiences. This means that an experience of something would not be the same if this "something" changed. In the same way, the experiencer changes when he or she learns something. A student is thus "not the same" after reaching a new way of seeing something. This relation between the learner and that which is learnt about is illustrated by arrow 1 in Figure 2.

The researcher stands in a similar relationship to his or her study object as the learner to that which he or she perceives, as indicated by arrow 2 in Figure 2. He or she becomes a learner in relation to his object of study: the relationship between the learners and what they learn about. The outcome of a phenomenographic research project is thus the researcher's interpretation of the students' understanding of what they experience, and is in this way shaped both by the researcher and the object of his research.

Although a phenomenon can be experienced in countless ways, phenomenographic research on learning claims that a researcher can organize these different perceptions into a limited, often rather small, set of qualitatively different categories. Each category then serves to summarize and describe a particular way in which the phenomenon under investigation is understood.

The analysis leading to the formation of the categories from the empirical data is performed by reading and re-reading statements from a student (often collected through interviews), now with the background of the original interview, then in the light of other interviews or the emerging categories. In this way the individual student comes to serve as a "carrier" of (fractions of) one or many different ways of understanding something.

The outcome describes the variety of understanding that can be found within the cohort and does not make any statement about individual students. Phenomenographic theory also argues that the categories can be organised in logical, often inclusive, structure. As the higher categories embrace the lower, they offer a wider perspective of the object, and are therefore generally more desirable.

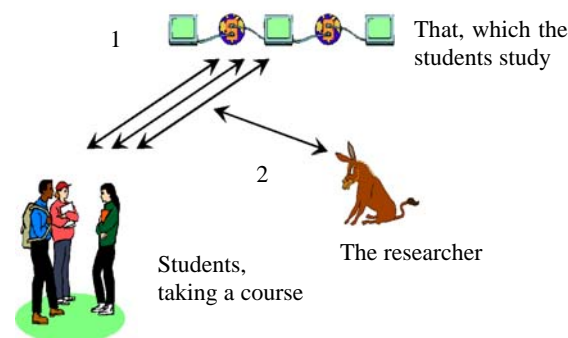


Figure 2. The perspective taken in phenomenographic research. The researcher studies the relationship between the learners and what they learn

3.2 Analysing aspects of the object of learning

In a phenomenographic research framework, a distinction is made between the *what* aspect of the learning, describing the content of the learning (for example a network protocol) and the *how* aspect, describing how the learning takes place. Moreover the phenomenographic theory of learning argues that the analyses of the *how* aspect can be further refined. Marton and Booth [12] explain the new distinction that arises in the following terms:

[T]he how aspect of learning has its own aspects of how and what, the former referring to the experience of the act of learning is carried out (we will refer to this as the act of learning), the latter referring to the type of capabilities the learner is trying to master (which we are calling the *indirect object* of learning). ([12], p. 84, our italics)

With this perspective, the *indirect object* comes to play the role of a motive, something that the students strive to obtain by studying, or a direction towards which the students' learning is directed.

Marton and Booth [12] continues by pointing out that these distinctions only serve the purpose of being a tool for the researcher and that they do not represent an actual division between the different aspects:

[T]hese distinctions are analytical, they are introduced to distinguish between different research points of view and have no actual existence as separate entities. They are different facets of an undivided whole. ([12], p. 85)

Thus, the aspects presuppose each others, are dialectically intertwined and together form a whole.

3.3 Studies concerning the indirect object

The strong contextualization is what makes studies of the indirect object stand out as different to the many psychologically inspired research projects that discusses motives as an aspect of learning (see [3] for a nice overview of the field). These studies in general discuss motivation in terms of internal and external motivation, sometimes with the addition

of new aspects, such as intrinsic or achieving motivation. They differ from the current project in their focus on the students' minds and how they react in certain situations. In contrast, the current study that has the students' relationships to their learning and their learning environment² as its object of study.

An overview of ACM conferences in computer science education, conferences within pedagogy and relevant journals indicate, that although phenomenography has been used as a framework to carry out research in computer science education, research into the students' indirect object in studying computer science is new. The on-going work of Eckerdal aims to offer insights concerning why students, who take an introductory programming course, use certain learning resources. In her work, she builds on a model developed by Kember, Wong and Leung [10], who enhance the classic dichotomy of surface and deep approaches to learning, with four more motivation indicators: intrinsic, achieving, career and surface.

One of few studies with a focus similar to the current project is that Silén [14] on nursing students in a problem-based learning environment. Her results show the different means that the students use to bring order into their study situation and their relationship to the indirect objects that the students try to achieve.

4. THE STUDY

4.1 The research question revisited

In this paper, focus is on the indirect object and aims at analysing what the students are striving for in a certain course. The results of the study are contextualised, in that they have their origin in a particular situation. They are based on empirical data, and reflect the students' perspective. Furthermore, as was pointed out above, the motive that the students have for learning something is intertwined with what they are learning.

For the sake of simplicity the term *motive* is used to denote the indirect object in the rest of this paper.

4.2 The research methods

Students with different age, educational backgrounds, earlier study results within computer science, motivation (as interpreted from a background questionnaire) were selected for interviews, with the aim of maximizing the variation and richness in the whole set of interviews. The results are based on interviews at two occasions with 15 students: 8 in Sweden and 7 in the USA. The students were interviewed about computer science concepts that were important in the project, as well as issues related to their experience of studying in this particular course. A thorough presentation of the research process is available elsewhere ([1]).

The data is derived from extracts from different passages of the interviews. Much of the data stems from answers to the question "What have you learned from this?" where "from this" referred to the situation the student experienced when taking the course. The initial question was followed up by the interviewer, when clarifications were needed, or summarised the student's words in order to get a more elaborated answer. Other contributions have been collected from interview episodes where a student has talked freely and associated across different themes.

² We use the term *learning environment* in a broad sense, where it includes physical as well as social and cultural factors.

5. EMPIRICAL RESULTS

The analysis of the interviews data has revealed three different motives for taking the course:

- A. Academic achievement
- B. Project and team working capacity
- C. Social competence

The first motive describes a concern with and direction towards academic results; the second has its focus on the project itself, and that which can be learned from it; the third is turned towards the social or collaborative aspect of learning.

Our analysis shows that the three identified motives are separate entities. Consequently, there are not any logical relationships between the three, and they do not constitute a phenomenographic outcome space.

Each of the three motives is experienced in different ways by the students. As a consequence, the motives, as they are presented here are constructs, constituted by the researcher based on the categories, which in their turn are the researcher's interpretations of the students' different experience of their motives for taking this course. In other words, the motives (labelled A, B and C) only exist as theoretical entities, each of which "summarises" one set of categories (labelled 1, 2, 3 and 4).

In the following the three motives, and the ways in which they are experienced, are described. The descriptions are, for most of the categories, "fleshed out" with interview extracts, aimed at giving the reader a "feel" for the situation. For some of the categories the presentation is shorter, since we judge that the underlying interview extracts are less interesting for the reader.

Certainly the underlying analyses, from which the categories stem, are based on the full set of interviews.

5.1 Motive A. Academic achievement

This motive is directed towards, and framed by, the academic world. The categories identified illuminate what it means to learn, or to be a student, at a university. The world outside the university is only touched upon in the corresponding interview excerpts, and then as a side comment aiming to illustrate a contrast between university related issues and other aspects of the question, for example future employment. The four categories are:

- A1 To get a grade
- A2 To learn computer science for the project
- A3 To learn how to learn computer science
- A4 To learn something new

Category A1. To get a grade

Getting a grade, pass or higher, is the focus of this category. Only that which contributes to a formal recognition within the academic system, is understood as being worth doing. This perspective leads to a situation where the student is dependent on the requirements of the university system and the formal rule.

Let us listen to Alec:

Alec: Um, in all honesty I think um, some of my other group members here, um, they just want to do their job good enough to pass.

Alec's statement might be more straight forward in his judgement of others perspective on grading, compared to the other interviewees, but he is not alone.

Also for Adam, grading is important:

Interviewer: Course guidelines? With grading, for example?

Adam: I guess um, everybody has concerns about the grades. That's something that has been brought up quite a bit in the class, you know, not just in my team, but in, among everybody that, um, if things, if the code doesn't work but we've worked really hard on it and had to get through all these team issues and stuff, are we still going to fail the class because our code didn't work?

For Adam clear guidelines concerning how the grading is performed would be useful. This view does not question the grading as such, neither does it put forward any reasons for its existence or reasons why it should be abandoned. It is taken for granted and is important.

Category A2. To learn computer science for the project

In this category, learning of computer science is in focus. The project serves both as a tool (by offering examples) and a catalyst (by giving motivation and direction) for the learning. The motive is to learn computer science, but the decisions about what to learn are dependent on the requirements of the project. The educational framework dominates the situation since it sets the limits for what it is possible to do.

Stig points out during the first interview that the project offers possibilities to learn computer science:

Interviewer: If you look at the knowledge of the subject in the whole group [...], do you together know enough computer science?

Stig: Umm, I think so. If not, we can learn that, I believe that.

Alec also comments on learning computer science during the following episode of the second interview:

Interviewer: If I may go back to another question you talked quite a lot about and what you learned from this. You mentioned RMI, you mentioned Java coding. What else, some technical skills?

Alec: Client server applications, this was my first. I learned just basic set up. How to manage it and things of that nature. Learned a lot about how to comment and manage your code. Even though I was the only one working on it we did have it set up that you could track where last updates were done at so you would know where problems were. Little bit about running applications and learning some language. Most of our projects up until now had just been programs here. You make programs, you hit output on your screen. We never have interface with motors, cameras.

Interviewer: Did you learn anything from that?

Alec: Uh, a little bit. Most of the time when you do stuff like that it makes it more feasible. It is within grasp now, you can actually do this, ya know, you don't just think about it and go "wow I wonder how they do that". So a lot about that. The main point of it was reading somebody else's code and making sense of it. That's where most of my time went.

Alec offers both a list of what he has learnt (Java coding, RMI, client-server applications etc.), and tells that he has learnt to analyse code. He discusses his learning in terms of the project, and clarifies what he has learnt. From his last statement, it can be seen that the learning is not a side effect, but something he has been striving for, by using words as "wow, I wonder how they did that".

Category A3. To learn how to learn computer science

In contrast to category A2, where learning of computer science for the purpose of the project has been discussed, we now meet a perspective on the learning in this project, which is more focused on the process than on the result: Learning here means to learn to find out something about computer science. The project serves as a tool that enables the learner to learn how to learn and to discern that which is relevant to know.

Samuel spontaneously discusses learning how to learn computer science:

Samuel: I'd like to say something, perhaps not directly related to all this, but I would like to say that this whole concept of doing courses is an excellent learning opportunity.

Interviewer: Yeah

Samuel: [...] You get, in some way, challenged to find knowledge in unconventional ways and this is really important this experience. [...] We teach ourselves stuff by participating in the course to discover new things [and to be] creative in locating information. [...] I look for information much more often now, 'cause I feel I need to do that in order to complete some tasks, some sub-tasks.

In the following lines of the interview, Samuel further stresses that it is important to learn to find information, and continues the discussion by comparing this project course to other courses he has taken.

Category A4. To learn something new

The perspective is widening from category A3 to category A4. The important issue is that what is learnt is new. To learn something new, the learner has to take his own responsibility for his learning, independent of the formal setting. As in the previous category, the direction in which a student strives is directed towards the subject matter of computer science.

An example can be found in the statement of Abraham:

Interviewer: [...] Would you say it is good or bad?

Abraham: That's right. Yeh, it's still good, I still enjoy it because I'm doing something I never did before, and meeting international students. Um, working in, just the IRC chat is very interesting, I think.

5.2 Motive B. Project and team working capacity

In this motive, attention is turned towards the team and its project. As for Motive A, four categories are discerned, each describing a certain way of experiencing the motive of learning to work in projects and teams:

- B1 To pass the project
- B2 To gain familiarity with working in projects
- B3 To learn how a project functions
- B4 To become a better professional

Already at this stage similarities between these categories and those of the A motive (Academic achievement). The nature of these similarities, and the reasons for them, are discussed later in this paper.

Category B1. To pass the project

The idea of “getting through”, “doing the bare minimum” or “just getting rid of” the project is mentioned in some occasions during the interviews. None of these utterances were explicitly expressed as opinions of the interviewee himself, his team mates, or other named students. Instead, the context in this discussions concerned possible problems in “the other sub-team” or “other teams” have occurred. It is hard, if not impossible, for us as researchers to determine to what extent such statements contain “hidden” messages about the interviewee or his own teams.

Adam makes one of the more explicit statements as a part of a long discussion during the second interview, and makes it clear that he refers to the project:

Adam: [...] And whether that was intentional or not, I think it's possible to get through this without learning a new language or learning new concepts or stretching yourself as far as the straight education aspect goes.

Category B2. To gain familiarity with working in projects

The second category of this motive describes the experience of gaining familiarity with working in complex projects. Many examples, similar to those presented for Category A2 can be found in the data.

Category B3. To learn how a project functions

In contrast to the second category, the motive for the learning about project work is here generalized, or abstracted, from a particular situation.

An interview extract with Adam can serve as an illustration to this category:

Interviewer: If I understood you correctly, you think the group dynamics and project management area you have learned quite a lot. Is that correct?

Adam: I think I have, yea, I think my eyes have been opened to what team projects are like and real business situations and how it should be handled, how it probably isn't always handled, how people react to it, things like that. More psychology than anything else.

Adam states that he has learnt “what projects are like”. In these words, and in the continuation of the quote, he states that he has learnt about projects as such.

Category B4. To become a better professional

In the fourth category, the usefulness of working in teams is discussed in the context of a future professional life.

Before the interview extract below, Abraham and the interviewer had discussed if the project in the course was well-specified or ill-specified. The discussion continues:

Interviewer: It is not a well-specified problem, I do agree on this description.

Abraham: Right, right. Yeh, I think, yeh, I see what you are saying. I think in the real world this will probably help. Because I can imagine going to projects or jobs where, um, the people are not really going to help me very much, or they're not going to have very protected work for me. They are going to have parts missing, they are going, you know, I'm sure I'm going to get a lot of that. Or it is going to be: 'I need you to learn this in 2 days'. I'm sure there will be a lot of that, so, yeh, I suppose that I can see, yeh, now I know how frustrating it will be. (laughter).

Abraham describes possible situations in his future work, where tasks may not be related to his particular competence. Here, he argues, the experience gained from this project will be valuable. Abraham's perspective extends from his current situation and also refers to his future career.

5.3 Motive C. Social competence

A third motive has been identified in the data that focuses on achieving social skills from the studies in the collective nature of the learning in the international project environment. Three categories of this motive have been discerned:

- C1 To learn particular social skills
- C2 To learn together
- C3 To take responsibility for the team

Category C1. To learn particular social skills

Two particular topics, both with a strong social inclination, stand out as desirable among the students: (a) to get to know others, and (b) to get to know another culture. These topics, and the interview extracts that they are based on, are straightforward and are for this reason omitted from the discussion in the paper.

Category C2. To learn together

To get a chance to develop something together, as well as the joy of learning together often shine through in this project. The wish for joint learning that is constituted in the collaborative situation characterizes the second category.

A straight forward example can be found in the dialogue with Anthony:

Interviewer: Which problems and good experiences have you had during the collaboration?

Anthony: I really enjoyed working on the project. It's the first time I ever got to design something, and it's the first time I ever got to work on something this size. And I had a lot of fun because I was able to learn from my classmates. That project was fun. [...]

Anthony indicates that he finds the learning together with his friends rewarding in itself, saying that it is “kind of exciting”, or “I had a lot of fun because I was able to learn from my classmates”.

Category C3. To take responsibility for the team.

In this category, a sense of responsibility as a wish to stand up for the team and its joint decisions serves as a motive in the project course. The obligations a student has to his team as a team member here overshadow the importance of the grading.

A cut-clear example of an expression of a strong sense of responsibility can be found in an excerpt from the first interview with Albert:

Interviewer: But this different grading, do you think it would be um, is a factor that might be a problem for the project?

Albert: Um, I don't think so. [...] But, you know, I feel that, you know, if you are a group you should work hard to the best of your ability whether you are being graded on it or not, or which style of grading.

6. ANALYTICAL INVESTIGATIONS

In the previous section, the categories of the phenomenographic outcome space are defined. Now, these categories can be further analysed, according to the phenomenographic theory, and a logical structures between the categories can be discerned. The aim of such an analysis is to reveal the underlying factors that unite, or distinguish, the categories and to gain further insights of the whole situation.

6.1 Relationships between categories

We will first describe the relation between the categories, and after that turn our attention to possible correspondence between the motives.

Categories of motive A. Academic achievement

The focus on the university world dominates this motive. It describes what, in the form of academic achievement, a student can strive for in the course. The four categories differ in their foci; in the relationships between the dependencies: on university requirements and own responsibility for the achievements; and if the educational framework or the content of the learning dominate the category. These aspects are summarised in the different columns of Table 1.

As can be seen from the second column ("What is in focus?"), the learning of computer science differs between the categories. The subject area is not present in the first category A1 (where only the grade is in focus), but appears as a set of isolated concepts, determined by the project and its needs in the second. In the third, learning about how to learn computer science is in focus. Learning, as an effort to learn something new (category A4), does not limit itself to the subject area, but also considers learning of computer science in a larger context. Certainly, the higher categories are more desirable than the lower from the perspective of a teacher in computer science.

An important qualitative difference divides the first and second

category on the one hand, and the third and fourth on the other. The first two describe situations where the learner is dominated by his experience of the formal requirements, while he has autonomy and controls his own achievements in relation to the learning content in the last two categories. Thus, two broader categories "dependence on formal requirements" versus "own responsibility for achievements" can be identified. The higher categories are more desirable.

Categories of motive B. Project and team working capacities

The categories of the two motives A and B show many similarities. Both motives are described in four categories and demonstrate structural similarities. For this reasons, we will omit the detailed description of the structure of motive B.

Instead, the content-related similarities between the two motives are analysed. Identifying the similarities between the first categories is straightforward: Both A1 and B1 describe categories of a motive, where the fulfilment of the perceived formal requirements is that which is striven for. The unifying idea for the two second categories is the motive for a specific feature of the project, computer science (in A2) or project works (in B2) respectively. The third categories describe motives to learn about something that can be generalised: how to learn computer science (A3), and how to learn how projects function in general (B3). Finally, both the fourth categories point to an aim to reach new achievements outside the current situation.

Categories of motive C. Social competence

The third motive, Social competence, describes an interest for, and a willingness to develop and learn from the social dimension of the project. Learning and working with others in an environment, that in important ways is socially constituted, are core aspects of this motive.

As can be seen from Table 2, a logical, inclusive structure between the categories can be discerned. The first category (C1) focuses on one person, the second on a smaller set of individuals and the third (C3) on a larger formal setting. The focus is thus broader in the higher categories, and includes the lower. Also is the sense of responsibility evolving over the categories: In the first (C1), only the personal learning and development is considered, and is seen in isolation. In the second, still the personal learning is present, but the interaction and the joint learning with others are stressed. The sense of responsibility is here extended to those with whom a student has personal links. Finally, in the third category a situation is described where the motive is enlarged and now includes a sense of responsibility for the team, its work and its members.

Table 1. Analysing Motive A. Academic achievement as a motive

	Category	What is in focus?	Dependency on requirements vs. own responsibility	Dominating aspect
A1	To get a grade	The grade	Dependence on university requirements	The educational framework
A2	To learn computer science for the project	Computer science concepts	Dependency on university requirements	
A3	To learn how to learn computer science	Learning to learn computer science	Personal learning dominates over formal requirements	The content of the learning
A4	To learn something new	Learning something new	Independent learner	

Table 2. Analyzing Motive C. Social competence

	Category	What is in focus?	Responsibility for?
C1	To learn particular aspects from the social setting	Focus is on self	Own learning
C2	To learn together	Focus is on personal friends	Meaningful interactions with others
C3	To take responsibility for the team	Focus is on the formal group	Responsibility for others

6.2 Analysing the logical relationship between the motives

Although it is not possible to describe a formal logical structure between the three motives, they certainly are related, since they stem from the same students and their experiences of the same environment.

The similarities between the two motives, A and B, have been established. Yet they are different, as they represent different motives that the students strive for. For both, the higher categories are more desirable than the lower, since former take a wider perspective on that which is to be learnt within computer science and project work, respectively.

These motives are both directed towards a world of formal studies, emphasising two different aspects of such a world. The collective environment, constituted in the collaboration between the students, serves as a vehicle that enables these motives to develop. Without the collaborative environment, it would not, for example, be possible for an individual to learn about team-work.

For the third motive, C, the roles of the collaboration and the project are “switched” compared to the two that have previously been discussed. The collective, or social, experience is here in focus, with the project being the vehicle that makes this learning possible. In other words, the experience of the collaboration itself (interpreted in a broad sense) here forms the core aim towards which the students strive, while the project serves to enable this learning.

Thus, the three motives are related to each others. Motive A and B share the same structure, while motive C is related to the other to in the different roles of the collaboration.

7. CONCLUSIONS AND IMPLICATIONS

A complex picture has been drawn on how students, who take an internationally distributed project course, strive towards different motives with their studies. These different motives are, in their turn experienced in different ways. The categories are valid on a collective level, and do not describe individuals. An individual student, however, shifts both between motives and between the different categories of a motive. It has also been established that some ways of experiencing the motives are more desirable than others, in that they express broader perspectives on the subject area, the project work and the social aspects of the course.

Now, this summary can be used as a starting point for a discussion about the applicability and the implications of the work, for teaching and learning as well as for future research.

In general, different situations suggest various motives as desirable. For example, a teacher, teaching a beginners’ programming course, might find it desirable to stress learning of the core concepts within computer science, while the collaborative aspects might be regarded as the most important for a teacher on an advanced project course.

The project has demonstrated that the students themselves set which motives they strive for in a course. Their motives might, or might not, be the same as those that are expected by a teacher. Still, the students’ experienced motives and the teachers intended aims are not independent. The students do not experience their learning of the subject area as isolated from the learning environment. Instead, their experience of the learning encompasses many aspects of the subject area and the learning environment [1]. A teacher can use several of these aspects of the learning environment to introduce changes in a course that are intended to influence what the students strive for.

Exactly how to encourage certain motives is for the individual teacher to decide, knowing his or her own course aims, the students and the situation. As the results of this research project are abstract in their nature and situationally bound, specific claims about which specific actions a teacher should take cannot be made. The paper aims to make a teacher aware of the complexity of the situations and serves as a platform for his or her own reflection.

However, we can conclude from the research projects that the more advanced categories are more desirable: Here learning of something important, computer science or team working capacities (A and B, respectively) and a sense of responsibility for the whole (C) is in focus. In other words, it is important that teaching encourages students to strive for the advanced motives.

Literature frequently discusses a distinction between *deep* and *surface* approaches to learning. While the former focuses on the content of the learning (or the signed), the latter is directed towards the text (or the sign). Certainly, a deep approach to learning is more desirable than a surface approach, for reasons similar to what was argued about the more advanced categories presented in this study. Different ways to encourage students to experience a phenomenon in advanced ways, corresponding to the higher categories, have been proposed. For example, Ramsden [13] argues that clear goals, appropriate workload and appropriate assessment are among the factors in the teaching that encourage students to search for meaning-related (as opposed to superficial) constituents of their learning. To what extent these suggestions are relevant for a teacher who wants to encourage his or her students to experience their motives in different ways, needs to be determined. Ramsden’s suggestions, that are based on a meta-analyses of several research projects, seem however to be a good starting point for such a research project.

As a researcher, one could only speculate in the different ways as the results can be brought back to a teaching situation. The teacher, knowing his or her students and the course that he she teaches is certainly more competent to invent mechanisms to implement the ideas in his or her particular course. However, the three different motives that have been identified in the student cohort taking are valuable on their own right. Thus, although only the learning aims within computer science are

clearly stated in the official course description, the other motives should not be neglected. The results also show, that for each motive, the more advanced categories are the most desirable. This project also contributes to research in computer science education in two other important ways. It presents results concerning the students' learning that could constitute a starting point for future projects, both such that aim to improve education, and such that further explore the students' motives for their studies. It also shows that data-driven, explorative, qualitative research, when performed according to theory-based guidelines, can serve to build an understanding for our students' learning of computer science. New results that could not have been found through the use of quantitative approaches become available for other researchers to build on. In this way it constitutes an important contribution.

8. References

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