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Learning in Peer Discussion

A Qualitative Study into Different Types of Discussion in Peer Instruction Sessions and their Possible Learning Outcomes

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Course: LAU395

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Examiner: Johan Lundin

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Abstract

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Key words: peer discussion, peer instruction, discussion, learning possibilities, explaining, argumentation, interaction, sensitizing concepts

Summary:
The purpose of this study is to find out what types of discussion occurs in peer discussions and what learning possibilities these types enable. The starting point is based on Eric Mazur's previous work with peer instruction. Twelve students' interactions are observed during six separate peer discussions. The students are, also, individually interviewed about their learning experience. The data show that students can exhibit three different types of discussion. These three types are: *narrow discussion*: The students state their answer and give a narrow explanation of their choice. Here, the students have the possibility to broaden and fortify their previous beliefs; *confirming discussion*: The students explain why they have picked their answer and why they have excluded the other alternatives. Here, the students have the possibility to broaden and fortify their previous beliefs to an greater extent than in narrow discussion; and *contradictory discussion*: The students get into an argumentation on why their choice is the correct one. Here, the students have the possibility to reassess previous beliefs and see the subject from a new perspective. The significant pedagogic outcome of this study is that students do not always have discussions that are good for learning. Therefore, teachers need to activate the students into having a contradictory discussion which enables better learning possibilities.

Contents

1. Introduction

A recent trend in educational research is that learning must be seen in a social context. Roger Säljö, for example, writes that humans learn by participating in practical and communicative interactions (Säljö, 2010). The question we are interested in is not whether social interaction is necessary for learning, but rather, what types of social interactions are helpful for learning. To understand this quite complicated question we are going to take a closer look into a model of peer discussion that has showed signs of supporting students learning.

Eric Mazur, professor of physics and applied physics at Harvard University, has developed a model called peer instruction (Mazur, 1990). His model is to break with traditional lecturing and instead use peer discussions as a part of the lectures. Mazur starts with a brief lecture. This is followed by giving the students a multiple-choice question which they answer individually and then discuss with a fellow student. At the end the students give him their final answer to the question. This model has received a great deal of international attention since a number of studies have shown that this model increases students' conceptual understanding of a subject. The studies are mainly physics oriented (e.g., Crouch & Mazur 2001; Lasry, Mazur & Watkins 2008; Mazur 2009; Smith, et al. 2009). What these studies do not show is what occurs in these discussions that improves the students' conceptual understanding of the subject.

This study will categorize different types of peer discussions and investigate which possible learning results are enabled in these discussions. The study is structured to first give a better insight to Mazur's model of peer discussion. Then elaborate what it means to say that someone has learned something. We will discuss our empirical data and how it was analyzed and then presents what types of discussion were found in this data. Finally this study will conclude with a discussion about what kind of learning possibilities each type holds and which implications this has on how teachers can design and use peer instruction.

2. Purpose and problem definition

There does not seem to exist a teaching method that is optimal for every student and that works in every classroom. There is no superior method that can stand as a model for what good teaching is. Thus all teachers need to have a broad variety of methods they can use depending on what, where and to whom they are going to teach. One important decision that all teachers must face is what method to use and when. The purpose of this study is to investigate what kind of learning possibilities Mazur's model of peer discussion enables, and what strengths and weaknesses this model involves. This will help teachers decide when it is fruitful to use peer discussion and what kind of support the students need. This study investigates three research questions:

1. What type of discussions do third-year engineering students engage in during a peer instruction session?
2. What learning possibilities are enabled by these types of discussions?
3. What are some implications for teaching?

3. Previous research

This chapter aims to give more insight to the structure of Mazur's model for peer instruction and present some previous research results.

3.1 Mazur's model of peer instruction

Peer instruction is a student-centered approach to teaching that was developed in the early 1990's by Eric Mazur. Research at Harvard shows that peer instruction is significantly more effective, in comparison to traditional lecturing, in improving the students' conceptual understanding of physics (Mazur & Crouch, 2001). Mazur's approach is to structure his lectures around multiple-choice questions and let his students be involved in discussions about these questions. A typical peer instruction session is started by a brief lecture in which the teacher presents the basic concepts. Then the students need to answer and discuss the following multiple-choice question (see fig 3.1). After the teacher poses the question the students have about 1-2 minutes to think and give their answer. If less than 35% of the students give the correct answer the teacher explains the subject again. If more than 70% give the correct answer the teacher will continue the lecture with the next topic. But if there are between 35%-70% students who have the correct answer, the teacher will engage the students in a peer discussion. The peer discussion usually takes place with pairs of students discussing the question with little or no guidance from the teacher. After the discussion the students will be given a chance to revise their previous thinking and answer the same question again (Mazur, 2009).

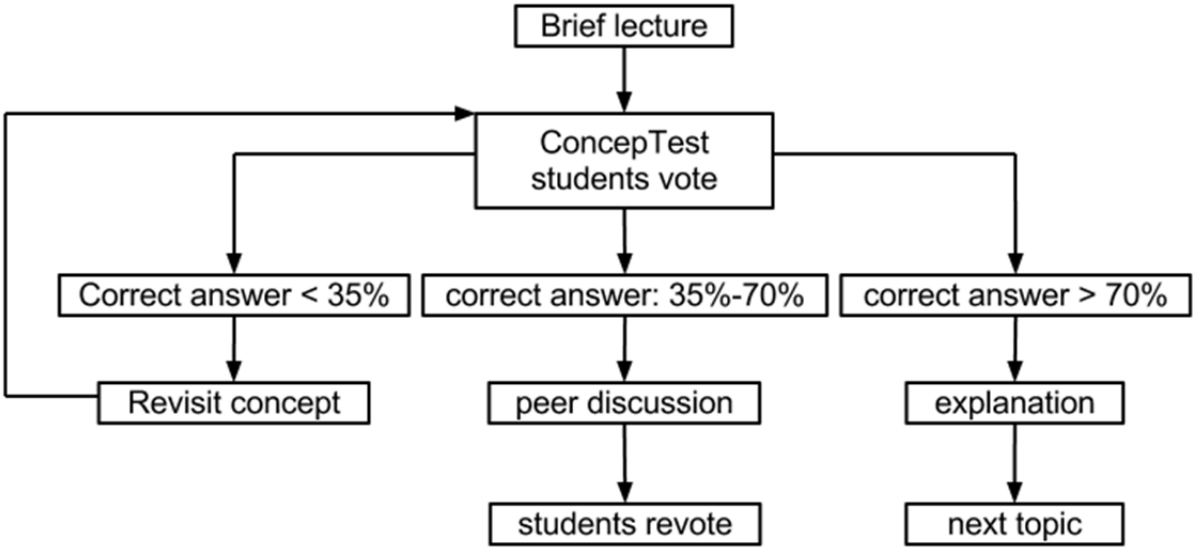

Figure 3.1 Mazur's model of a peer instruction session.

3.2 Previous research on peer instruction

There have been several studies, mainly from Harvard University, that investigate the effectiveness of peer instruction as a teaching method. These studies focus mainly on two things. The first is whether peer instruction is more effective, compared to traditional lecturing[1], in improving the students' conceptual understanding of the subject. Catherine H. Crouch and Eric Mazur concluded, based on ten years of data from introductory physics courses, that students dramatically improve their scores on conceptually-based tests when implementing peer instruction in lectures, and that the improvement is significantly larger than the improvement reported when using traditional lecturing (Crouch & Mazur 2001).

[1] A lecture during which the students are not actively involved.

Another study, that collects data from both Harvard University and John Abbot College, shows that peer instruction increases conceptual understanding as well as traditional problem solving skills at both university and college level in comparison to traditional lecturing. This study also shows that peer instruction is effective both for students with high and low background knowledge (Lasry, Mazur & Watkins, 2008).

The second aspect which these studies focus on is the students' learning gains during the peer discussion part of the peer instruction session. Crouch and Mazur state that "... after discussion, the number of students who give the correct answer to a ConcepTest increases substantially, as long as the initial percentage of correct answers to a ConcepTest is between 35% and 70%" (Crouch & Mazur 2001, p. 972). They also found that there are very few who change their answer from the correct one to the incorrect one (see fig 3.2).

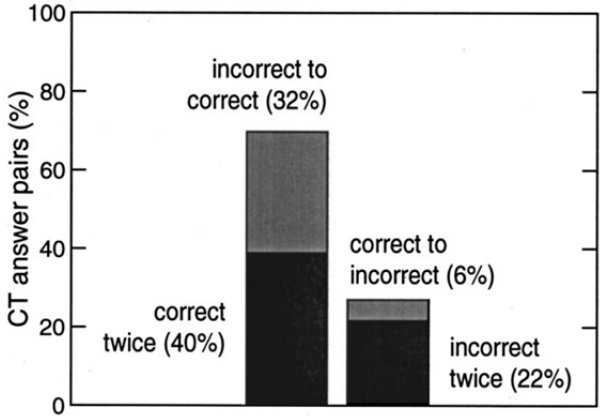

Fig 3.2 Answers given to one ConcepTests-question, before and after discussion. The answers are categorized as correct both before and after discussion -'correct twice', incorrect before and correct after discussion - 'incorrect to correct', correct before and incorrect after discussion -'correct to incorrect', or incorrect both before and after discussion -'incorrect twice' (Crouch & Mazur, 2001, p.972).

This implies that if a student with an incorrect answer is paired with a student with the correct answer, the student with the correct answer is often successful in convincing the one with the incorrect answer to change his/her answer to the correct one. This could mean that the student with the incorrect answer has learned something new based on his/her peer's arguments and therefore changed his/her answer. But it could also mean that the student with the right answer is just better at convincing the other student to change his/her answer based on other factors than strong arguments (for example, a student who is usually right or very confident in his/her answer). To distinguish between these two alternatives, Smith and his colleagues designed an experiment where they directly after the students had revoted on the first question asked them a similar, or isomorphic, question[2]. This should reveal if the students had learned something from the peer discussion or had just been convinced into an unreflected change of their answer. Not only did they find that the number of correct answers on question one increased after the discussion by an average of 20%. They also found that the number of correct answers on Q2 is 21% higher than the number of correct answers on Q1 (see fig 3.3). In addition, their study also showed that 44% of the students who answered both Q1 and Q1ad incorrectly still answered Q2 correctly (Smith, et al., 2009).

[2] The isomorphic question tests the same understanding of the subject, as the first question, but in a new context.

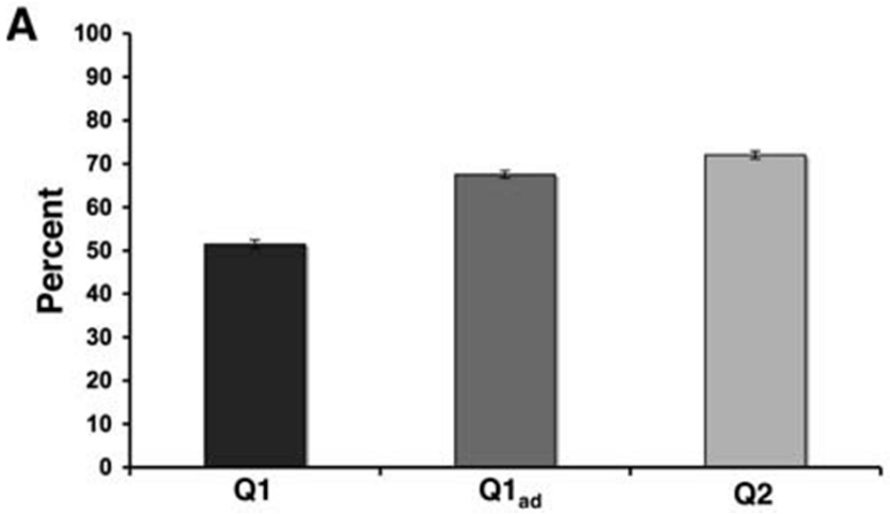

Figure 3.3 Q1 is question one before discussion, Q1ad is question one after discussion and Q2 is the isomorphic question (Smith, et al., 2009, p.123).

Smith et al. (2009) interpret their results as an indicator that the students who answered Q1 and Q1ad incorrectly still learned something during the discussion. In other words that the discussion had a great impact in making the students choose the correct answer in Q2. This is quite a bold statement since it puts a lot of pressure on the isomorphic question (Q2). What they want to show is that the supposed learning from question one can be transferred to another context and therefore shows a conceptual understanding of the subject. But this requires that Q2 is really isomorphic to Q1 and that Q1 and Q2 are on the same level of difficulty, something that can be very hard to achieve. In our study we will draw on the design employed in the study by Smith et al. (2009) and investigate what kind of learning possibilities the discussion holds that can explain these interesting results. To do this it is essential to first discuss what it means to say that someone has learned something and how one can tell if someone has learned something.

4. Theory

This chapter will elaborate on what it means to say that someone has learned something by discussing different learning theories. The focus will be on the parts of these theories that are important for investigating the different learning possibilities in different types of discussion.

Learning is a term which is used in many contexts and therefore has different meanings and implications depending on when and where it is used. The Danish scientist, and professor of lifelong learning, Knud Illeris argues that learning can be described from four different points of view. Learning can be seen as:

1. The result of a learning process; the qualitative change which has occurred for a single individual.
2. Mental processes; the processes which occur within a single individual which can lead to the wanted learning results for that individual.
3. Processes of interaction; the interactions which occurs between the individual and his/her material or social surrounding.
4. Synonymous with teaching. (Illeris, 2007, p.13)

The fourth view of learning above is, according to Illeris, incorrect while the other three definitions are adequate and meaningful. He argues that the idea of students learning by passively receiving information from a teacher is outdated and does not build on an understanding of how the learning process actually works. The three definitions of learning - as a result of a learning process, as a mental process and as an interactive process - interact with each other and thereby cannot simply be separated in practice. It is difficult to describe what an individual has learned without describing his/hers learning process.

Additional support for viewing learning as both a process and a result can be found in the work of the Israeli professor in mathematics education, Anna Sfard. She describes two different metaphors of learning: the acquisition metaphor and the participation metaphor. The acquisition metaphor can be compared to Illeris' first definition, the result of a learning process. This metaphor also corresponds with Illeris's view on learning as an internal mental process. Sfard's second metaphor, the participation metaphor, can be compared to Illeris' definitions of learning as an external process, which includes social interaction. She, also, argues that there is a risk involved in focusing exclusively on one metaphor without taking the other one into account (Sfard, 1998).

Furthermore, the Swedish educational psychologist Roger Säljö views learning as a socio-cultural phenomenon, where the view on learning has been altered throughout history (Säljö, 2010). He argues that mankind has not evolved much physically during our existence. On the other hand our mental and intellectual abilities have developed significantly. Säljö means this is obvious when considering what tools and instruments we use in modern society. These tools are activities and exchanges of knowledge, taking place within different instances in our society in order to maintain and promote a good level of learning and living, e.g. schools, offices and healthcare. Säljö thereby means that learning is about how people "appropriate, develop and keep societal experiences alive (...) [our translation]" (Säljö, 2010, p. 21). According to this approach to learning there is little evidence to support the theory that learning is a process taking place only inside individuals. To support the theory of sociocultural learning Säljö introduces communication as one of the fundamental cornerstones. Knowledge and skills are not solely stored in the human brain, although it is a part of the process. Instead it is what tools we use and how we use them, that is vital for the

process of learning. In interaction with other people we become aware of knowledge and skills. Säljö writes that "…it is through communication socio-cultural resources are made, but it is also through communication they are passed on. This is a fundamental idea of a sociocultural perspective" (Säljö 2010, p. 22). Hence communication is crucial for any individual to be able to learn. At the same time communication is also important for knowledge to reproduce itself and be passed on.

In addition to this, Säljö's studies point to the fact that teaching does not automatically lead to learning. A teacher cannot expect students to learn simply by attending class and listening to the teacher. It is a far more complicated process than just the theory of transfer, which simply means that one person can transfer his/her knowledge to another person with the help of visual and auditive tools, for example talking and writing. Researchers within the sociocultural field therefore find it interesting to study how physical and cognitive assets support learning for the individual as well as the group. The study of learning within the sociocultural field acknowledges three different, but at the same time concurrent, aspects.

These three aspects are:

1. development and use of intellectual (or psychological/linguistic) tools
2. development and use of physical tools (or instruments)
3. communication and the various forms of collaboration, in different collective activities, mankind has developed (Säljö, 2010, p. 22)

Similarly to Säljö, Illeris also points out that mankind have developed a great deal since our origin, and that this is mostly a cognitive development (Illeris, 2007). The kind of learning occurring today was not possible a hundred or a thousand years ago given the evolution of human society and the opportunities made possible in these different societies. Illeris describes learning as two concurrent processes: interaction and acquisition. The interactive process is focused on the communicative aspect whilst acquisition is far more focused on the cognitive and individual aspect. In short, the process of interaction can be described as an aspect of societal nature, depending on communication and the nature of the environment. The process of acquisition, on the other hand, could best be summarized as an aspect of biology with focus on evolution and the cognitive process inside the individual. Historically, educationalists have almost exclusively studied acquisition. But since the late 1980's the scientific community started to take an interest in the interactive process, and some even took it to its extremes and claimed that learning is solely based on interaction. Illeris states that learning consists of, as discussed before, the two concurrent processes of interaction and acquisition and the way in which these processes interact with each other.

Illeris' theory about interaction and acquisition culminates in the thesis on the three dimensions of learning (see figure 4.2). Here the process of interaction is visualized as the vertical arrow and the process of acquisition is visualized by the horizontal line which consists of two important factors: content and incentive. The process of interaction is about how individuals communicate and act towards one another and the aspiration for inclusion. The aspect of content focuses on how the individual understands his/her environment. Finally the incentive aspect includes feelings and motivation and is centered on the aspiration for balance between body and mind. Illeris argues that incentive is necessary for acquisition to happen (Illeris, 2007, p. 43).

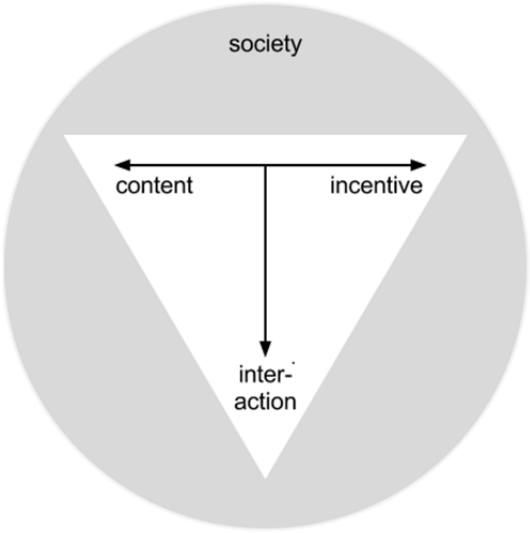

Figure 4.1 The three dimensions of learning (Illeris, 2007, p. 41).

This study will mainly be based on the theories of Illeris and Säljö, as discussed above. Their approach and interpretation of the concept of learning highlights the aspect of social interaction. This makes them useful to investigate the different learning possibilities in different types of discussion.

5. Method

In this chapter the different methods used in this study and their implications will be discussed. This will provide insight to whether the methods chosen for data collection and analysis are useful and adequate.

5.1 Design

To answer the research questions it was important to gain a deeper understanding of what happens during peer discussion. Therefore a qualitative method was chosen, in contrast to previous studies that have mainly used quantitative methods (e.g., Crouch & Mazur, 2001; Lasry, Mazur & Watkins, 2008; Smith, et al., 2009). The data was gathered during a simulated peer discussion where the students answered a set of multiple-choice questions (see Figure 5.1). The first question was designed to test their conceptual understanding of software design, henceforth Q1. This was answered individually and was followed by a discussion between the two students. After the discussion they answered the first question again and, also, got an opportunity to revise and change their answer, henceforth Q1ad. Finally the students answered a new question on the same subject, henceforth Q2. The reason for this question was to see if the results of Smith et al. (2009) can be replicated. Their results indicate that 44% of the students who give the wrong answer on Q1 and Q1ad, still answer Q2 correctly.

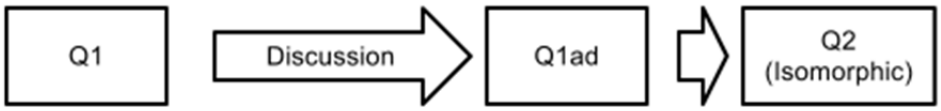

Figure 5.1 Process of peer discussion. Q1 is the question given before the discussion and which is answered individually. Q1ad is the same question but given after the discussion. It is also answered individually but may be based on the discussion between the students. Q2 is an isomorphic question in order to see if learning can be transferred.

The students in this study did not answer the same set of questions. By changing the questions and generating more varied discussions we gained a better understanding of what types of discussions can occur in real lectures. Two groups discussed question 1[3], two groups discussed question 2[4] and two groups discussed question 3[5]. The Q2 question was also alternated accordingly so it was isomorphic to the question discussed. Question 1 and question 2 are isomorphic to each other and were used as each other's Q2. The isomorphic question to question 3 was not permitted to be published in this study. This is because it is used in another study and it showed no major significance to the results.

In order to understand the learning possibilities in the discussions it is important to investigate mainly two things. Firstly, the learning process of the students. This was done by interviewing the students individually after the peer discussions. Secondly, we need to investigate the interaction between the students themselves and the interaction between the students and the environment. As mentioned before, Illeris points out that learning can be seen as three things: as the result of a learning process in an individual, the mental process of an individual or the interaction which occurs between the individual and his/her material or social surrounding (Illeris, 2007). The third view is strongly supported by the socio-cultural perspective, where learning only can take place in a social environment (Säljö, 2001). The interaction between

[3] See appendix B
[4] See appendix C
[5] See appendix D

the students and the environment was investigated by recording their discussion with an audio recorder. Their actions were analyzed by the use of sensitizing concepts (see 5.2 for more). Our collected data therefore consists of answer sheets and audio recordings; including both peer discussions in pairs and individual interviews. The recordings were transcribed in order to be analyzed and the framework to the analysis will be presented later on in this chapter.

As mentioned above, this study is based on answer sheets and audio recordings from twelve students in a third-year software engineering class. The students participated on a voluntary basis and were reasonably rewarded for their contribution to our study. In order to make the peer discussion sessions possible the students were divided into six pairs. There is no focus on the students or their individual background and conditions. The essential for this study is that they are on the same level of education, in this case students in a software engineering class. This will suffice for our definition of peers.

5.2 Analytical framework

According to Illeris there are three dimensions to learning: content, interaction and incentive. The data has been categorized and analyzed using only the content and the interaction dimension, hence excluding the incentive dimension. This is because it is hard to find a good way to observe and analyze students' incentives. The factors which drive us humans into action seem to be elusive and difficult to observe and categorize. The other two dimensions were easier to find ways to observe and analyze. Sensitizing concepts were used to categorize the content dimension and definitive concepts were used to categorize the interaction dimension.

To understand the content dimension in the discussions we use sensitizing concepts. The American sociologist Herbert Blumer distinguishes sensitizing concepts from definitive concepts, which are used by the majority of social researchers. He argues that definitive concepts "provide prescriptions of what to see, [whereas] sensitizing concepts merely suggest directions along which to look" (Blumer, 1969, p. 148). Glenn Bowen (2006), Ph.D. in social welfare, states that sensitizing concepts are tools with which qualitative studies are started. Researchers use sensitizing concepts in order to further understand and analyze the collected data as support of the theory. Additionally, Bowen argues that "sensitizing concepts draw attention to important features of social interaction and provide guidelines for research in specific settings" (Bowen, 2006, p. 3). The content part of the discussion will be analyzed by the sensitizing concept abstract discussion. An abstract discussion is a discussion in which the students use principles from previous experiences and discuss these in connection with the question. It is also possible for the students to use the question in another context in order to prove a statement.

To understand the interaction dimension in the discussions we will draw on the work by Jonathan Osborne, professor of science education. He has investigated the role of collaborative critical discourse when learning science. Osborne makes a distinction between explanations and arguments. "To offer an explanation of a fact is presuming it is true. An argument, in contrast, is an attempt to establish truth..." (Osborne 2010, p. 464). This distinction is based on the argumentation theory developed by the British philosopher Stephen Toulmin (1958). We did not use Toulmin's full theory due to its complex nature and Osborne's more stripped version seemed to be enough to give an understanding of what types of discussion students are involved in during peer discussion. The interaction dimension will be categorized and analyzed by exploring how the students use explanations and arguments.

5.3 Method discussion

A potential critique of the design of this study is that we collect our data using a simulated discussion and not a discussion during a real peer instruction session. The way the simulation is different from the classroom discussion is in the context in which the discussion takes place. Several aspects have, with regard to this, been taken into consideration. The students have been selected from the same class and therefore know each other. The discussions takes place in the same facilities that the students usually have classes in. The questions are picked in a way to ensure that the students have some background knowledge of the subject from their previous classes. These considerations should ensure that the character of the discussion in the simulation is not, in any major way, different from the discussion in a real peer instruction session during a lecture.

5.3.1 Answering sheets

The multiple-choice questions were handed out to the students on answering sheets. The sheets were collected and the answers compiled as indicators of possible learning results. When a student changes his/her answer one can argue that there has been some kind of change in that student's understanding of the subject. This is the method used in most of the previous research on peer instruction. If the change is from a wrong answer to a right answer it is an indication of an improvement in conceptual understanding. However, an uncertainty here is that students may change their answers for reasons other than an improved conceptual understanding. For example, students could reason that their peer usually gives the right answer and hence change their answer from Q1 to Q1ad.

During the course of collecting data the initial set of questions became subject of revision since they generated very similar discussions. We therefore made the decision to replace the initial questions with a new set of questions to see if that would lead to more varied discussions. This means that the students in this study did not answer the same set of questions. Two groups discussed question 1[6], two groups discussed question 2[7] and two groups discussed question 3[8]. However, this study is focused on investigating different types of discussions between the students, not their specific answers. The change of questions can generate more varied discussions that better represent the discussions that occur in real lectures.

5.3.2 Audio recordings

The peer discussions and the individual interviews were audio recorded in order to generate a high level of reliability. The recordings have been transcribed to ensure that the students' statements are not altered. Because of our recordings, we can revisit the interviews and discussions at any point and investigate further. Moreover, another person may also listen to the recordings and make another analysis. Thereby we have raised this study's reliability. Conducting interviews and writing down observations and results simultaneously would have decreased the validity and reliability as one cannot maintain focus on both the interview and the writing. Furthermore, it is difficult to describe an interview retrospectively. One may also conduct this research with video recording. But in view of our purpose, we did not find it necessary to do so. We believe this even could have obstructed the students from discussing without restrictions. Finally, we do not have the intention to analyze the physical interactions and body language between the students. This study focuses on students' verbal interactions in the discussions and how this is connected to learning.

[6] See appendix B
[7] See appendix C
[8] See appendix D

5.3.3 Interviews

This study does not claim to make wider assumptions in other contexts than in the specific discussions that we observe. Furthermore, since we are doing a qualitative study of the students' views and beliefs we cannot analyze their answers as true or false (Esaiasson, Gilljam, Oscarsson & Wängnerud, 2007, p. 291). Therefore we made the decision that questions starting with "Why...?" were needless. We also wanted to avoid these types of questions as they can generate a feeling of guilt and pressure making the students reluctant to give a proper answer (Esaiasson et al., 2007, p. 298). Instead we used follow-up questions starting with "Can you explain your thinking in...?" or "Can you elaborate on ...?". The interview focused on two aspects. Firstly, we have the aspect of the subject: How do the students come to their conclusions? Secondly, we take the aspect of interaction and motivation into account: What are the students' thoughts and how do they perceive their possibilities to learn? (see Appendix A)

There are several aspects to keep in mind when deciding between conducting individual interviews and group interviews. The advantage of a group interview is that we can observe the interaction in the interview between students. The disadvantages are that it is difficult to distinguish the students when transcribing and to make sure all students answer all the questions. The benefits with an individual interview are that we can easily transcribe the dialogue and make sure that all students answer all the necessary questions. The disadvantage is that the process of interviewing the students one at a time is prolonged compared with a group interview. For our study, the most reliable method is individual interviews. The individual interviews show us how each student thinks and enable us to draw conclusions in comparison to the observed discussions and results from the answer sheets.

6. Results

This chapter will present the different types of discussion that were identified in the data. The next chapter will discuss how each type of discussion is connected to a certain learning possibility. The different types of discussions are characterized in terms of different discursive actions and supported with illustrative quotes from the peer discussions and the interviews.

The data was mainly categorized by two discursive actions seen used by the students. The first discursive action used to categorize between different types is based Osborne's concepts of explanation and argumentation. Remember here, the difference between an explanation and an argument is that an explanation assumes that the fact is true while an argument is an attempt to establish the truth (Osborne, 2010, p. 464). The discussions were categorized in different types depending on whether the students were focusing on giving explanations or focusing on giving arguments. The other discursive action is based on the sensitizing concept abstract discussion. Remember here, an abstract discussion is a discussion in which the students use principles from previous experiences and discuss these in connection with the question. The discussions were categorized in different types depending on how rich the discussions were in content of abstract discussion. From this analysis, three different types of discussion were identified:

- *Narrow discussion*: The students state their answer and give a narrow explanation of their choice.
- *Confirming discussion*: The students explain why they have picked their answer and why they have excluded the other alternatives.
- *Contradictory discussion*: The students get into an argumentation on why their choice is the correct one.

	range	resource	reasoning	Descriptive level of discussion
Type 1 narrow discussion	one/few alternatives being discussed	None/litte abstract discussion	State/agree	state
Type 2 confirming discussion	Most alternatives being discussed	More prior experience/knowledge	Compare/motivate	Explain
Type 3 contradictory discussion	Most alternatives being discussed	Even more experience/knowledge	Counter arguments/question and challenge	Argue

Figure 6.1 Table of the three observed types of discussion. As shown above, markers in the definition are range: to what extent the students have discussed the alternative answers; resource: what prior knowledge the students express and relate to the discussion; reasoning: what strategies and approaches the students use in the discussion. The final column shows on what general level the discussion is.

6.1 Type 1 - Narrow discussion

The first type of discussion is characterized by a low number of alternatives being discussed as well as a low extent of abstract discussion. The students more or less simply state their answer with their peer agreeing. The discussion is over when the students have reached a consensus on what they believe to be the correct answer and they do not show any desire of discussing the question further. This type of discussion therefore tends to be much shorter than the other types: 1-2 minutes long in comparison to 4-6 minutes for Type 2 and Type 3.

Half of the groups, three out of six, engaged in this type of discussion, and these students picked the same alternative. Two groups picked an incorrect alternative and one group picked the correct alternative. The students did not know if they had picked the correct alternative or not, but they knew that they had picked the same alternative.

Participants	Q1	Q1ad	Q2
A1 + A2	W + W question 1	W + W question 1	R + R question 2
A3 + A4	W + W question 1	W + W question 1	R + R question 2
B1 + B2	R + R question 2	R + R question 2	W + W question 1

Figure 6.2 Table of the three pairs of participants in type 1 discussions. For question 1 and question 2, see Appendix. Correct or incorrect answer on the question is indicated by wrong (W) and right (R).

The following excerpt is an example of how the interaction between the students works in this type of discussion:

A1 The tricky part as I see it is the word “Reuse”.
A2 Yes.
A1 What is meant by that really? If you should use class B in itself...
A2 Or if you should subclass it.
A1 Yes, exactly. Or change it...
A2 Or use it somewhere else.
A1 Mm, that’s the most unclear [part of the question] since it’s not a word we normally use. But as I interpret it, we want to use class B as it is. And since class B is defined as an inheritance of A then the answer, for me anyway, is that it must inherit from A.
A2 Mm, I had the same reasoning.

Here, the content of the discussion in this group, which we will call A1A2, is confined to comparison and support as one student explains his/her choice of alternative and the other student supports this statement. In the discussion the students clearly support each other’s theories and explanations. There are no alternative interpretations of the answer. When both students are done comparing and confirming each other’s answers, the discussion is treated as completed.

The excerpts below are from two different interviews with students from two different Type 1 discussions. The answers are characteristic for students in Type 1 discussions and show that

the students themselves used the discussion only to confirm their own theory. The question was: Did you find the discussion stimulating?

> A2 It was good for making me more certain, I interpreted the arrow in the right way. So it's nice to have a discussion to... Maybe the discussion would have given more if it was a question where we had different answers in the beginning and we could discuss why one alternative would be better than the other. But still, one becomes more certain having a discussion and agreeing.

Student A3 answered the same question in the following way:

> A3 It was quite brief, we had both picked the same answer so it was not exactly an discussion. More of agreeing of our choice. So we did not actually have any arguments. It was quite brief. I think that perhaps with such an easy question you don't really need a big discussion about it.

These excerpts support the classification of Type 1 discussions as narrow and limited to one or few alternatives being discussed. The students themselves even exhibit uncertainty as to whether their discussions are discussions at all, as they know they have the same answer and there is no opponent to contradict their theory. This shows that the students are satisfied with confirming their answer with each other and neglect to discuss alternative answers or principles. The first excerpt also shows that the students express a confidence boost, from Q1 to Q1ad, by talking to their peer about the question and their answers.

There are occasions in all Type 1 discussions where one of the students tries to introduce more abstract explanations or arguments in the discussion. Here is one example:

> B3 But I'm unsure of the second alternative, I want to use that one to kind of, but I don't know if it means the same thing, I don't know.
> B4 Uh... [pause] But the... no.
> B3 [Quick response, interrupting B4] But no, you don't need to. It's just that B is the same as A but something else as well.
> B4 Mm.
> B3 That's right. [Pause] Well, then I agree with you.
> B4 Well, alright then.

This excerpt shows how the students try to broaden the discussion. But once they begin to, the discussion comes to a halt and the question is not being taken any further, leading the discussion to an end. This example shows how Type 1 discussions are characterized by short discussions where alternative answers or principles do not seem necessary to discuss. Rather it seems that the main objective is to find the right answer and to reach an agreement on that answer.

6.2 Type 2 - Confirming discussion

The second type of discussion is far more extensive in time and content than Type 1. During this type of discussion most of the alternatives are taken into account. The students also engage in a discussion which allows them to bring in a variety of resources, such as previous knowledge and experiences, which provide the discussion with more abstract substance. They compare and explain why their choice is right and why the other alternatives are wrong before

coming to a consensus and ending the discussion. However, the students also tend to agree with each other on the majority of the statements being made. The explanations are either new explanations or additions to the explanations by their peers. There are very few counter arguments that could provide an alternative perspective on the subject. One group in our data was engaged in a Type 2 discussion and both students in this group picked the same incorrect alternative.

Participants	Q1	Q1ad	Q2
C1 + C2	W + W question 3	W + W question 3	R + R question 4

Figure 6.3 Table of the pair of participants in Type 2 discussions. For question 1, see Appendix. Due to the fact that the questions are being used in other research activities, we cannot display questions 4. Correct or incorrect answer on the question is indicated by wrong (W) and right (R).

The following excerpt illustrates the difference between Type 1 and Type 2 discussions, where the students continue to discuss after the initial stating and agreeing:

C2 So, we believe design B...
C1 Yes.
C2 What did you think?
C1 Uhm, well I went a bit on intuition. I dismissed [alternative] C direct generally.
C2 Mm, yes.
C1 Because it doesn't make sense to have one responsibility per class, a responsibility that tight.
C2 No, then it becomes too many classes.
C1 Yes, exactly. It would be... absurd, especially when some things, thinking of a responsibility as send and receive, are very related. Then I think it would become too much.

Here, there is an initial consensus but rather than just simply stating the explanation to the answer, like in Type 1, the students continue the discussion. C2 is asking for a motivation to the answer and thus the discussion is lead on to a level of explanation and argumentation.

As another example of a Type 2 discussion, consider the following excerpt where the students are discussing question 3:

C2 And A is a bit... well everything in the same class, we have learned that you shouldn't have that.
C1 Yes, exactly. Well... I pondered a bit about it that... it wouldn't be that terribly anyway.
C2 No, it's a pretty small system actually.
C1 Yes, exactly. Because if one were to consider it [alternative A] to be a part of a bigger system if you would expand with more functions then I think B is much better than A in that case. Because A would be infinitely long almost.
C2 Well yes, you have to make some leveling there. You don't want too many distributions, not too few either.

C1 Yes, exactly.

This is an example of how the students take different alternatives into account. They also widen the discussion with hypothetical comparisons and bring in outside experience to the discussion. The two excerpts above are typical for Type 2 discussions in the sense that the students express the same opinion and view. There are no counter arguments in the discussion making it a discussion without new perspectives to the students.

The following excerpt from the interview with a student from a Type 2 discussion will aid as additional classification and understanding of that type. The question is: Did you find it [the discussion] stimulating?

> C1 Yeah, yeah I think so. Discussing these type of programing patterns is very helpful to develop your understanding and often times discussions have helped me from believing one practice is the best to believe another practice is the best and I think that's pretty general thing if you can come with enough arguments you can basically convert anyone to your way of thinking. So I think such discussions are very helpful, especially when it comes to programming where there's no one specific solution that is correct, just one that is neater, I guess. 'Cause it's not so much about facts, it's more about... It's subjective really.

Students who engaged in Type 2 discussions viewed the discussion as an opportunity to explain different alternatives in order to reach a correct answer, and therefore also discussed most of the other alternatives to exclude them.

6.3 Type 3 - Contradictory discussion

Here, the students take the discussion to a more abstract level. The students also use counter arguments as they try to reinforce their answers and prove their peer wrong. They use previous knowledge and external experiences to support their arguments and show that the principles are applicable outside of the context of the question and situation.

Two groups engaged in a Type 3 discussion and both pairs had different answers on Q1 before the discussion. But in one group, B3B4, a student changed his/her alternative from Q1 to Q1ad and in the other group, C3C4, neither of the students changed their answer from Q1 to Q1ad. In the individual interview it is clear that, even if none of the students in C3C4 changed their answer, one of the students, C3, reconsiders which alternatives might be true. The discussions of this type begin with argumentation to why they have chosen their respective answers.

Participants	Q1	Q1ad	Q2
B3 + B4	R + W question 2	W + W question 2	W + W question 1
C3 + C4	W + R question 3	W + R question 3	R + R question 4

Figure 6.3 Table of the two pairs of participants in Type 1 discussions. For question 1, question 2 and question 3, see Appendix. Due to the fact that the questions are being used in other research activities, we cannot display questions 4. Correct or incorrect answer on the question is indicated by wrong (W) and right (R).

As an example of how the argumentation plays out in a Type 3 discussion, consider the following excerpt where the students in group B3B4 are discussing question 2:

> B3 But I don't think you need to inherit from A. If you change something in class B then why would you need to inherit something from A, you already inherit from A, I think.
> B4 Yes, well I don't need to inherit something new. But if I subclass something I must inherit what's in there. It depends on what it [pointing to arrow?] refers to, if it...
> B3 Yes, exactly...
> B4 If it refers to the fact that I must have that exact behavior or... because class B inherits automatically.
> B3 But it's not the arrow we investigate. That means that... if you draw an arrow from B to A, then it means that we inherit it.
> B4 Mm.
> B3 But the question is if we change class B...
> B4 Yes, that's right.
> B3 So then it's clearly answer 3.
> B4 Yes, ok. Precisely, it's that structured.

Here the students use arguments and not explanations since they try to convince each other how the arrow works and then choose an alternative instead of the other way around. This can clearly be seen by the fact that it is at the end they first mention which alternative they should choose. Note how B4 starts this segment of the discussion with a counter argument to what B3 believes regarding how the inheritance works. Here, B4 presents a new view on how inheritance works that conflicts with what B3 said in his/her argument. This excerpt also provides a glimpse of how the discussion is more abstract than the Type 1 discussion, when the students bring in the more abstract term subclass to explain how the arrow and inheritance work.

As an example on how counter arguments affect the individual learning process, consider the following excerpt from the interview with B4. The question is: What made you change your answer?

> B4: The discussion we had really made me realize that... why B was a subtype of A is kind of logical when you see B to A. So you know that B knows about A and that's the logical way to program it. That convinced me that [alternative 3] was the right answer.

Here, B4 does admit to succumbing to B3's answer, as it made him see the question in a logical way. This shows that students can influence their peers to see the subject from another point of view by using counter arguments.

As an illustration of how both counter argumentation works and how they use abstract arguments in Type 3 discussions, consider the following excerpt from the discussion between C3 and C4 where they are discussing question 3:

> C3 It's for the most general case I believe that [model] one is better.
> C4 Yes, if we want to expand...

C3 Yes, but maybe it's unnecessary to do that by some... Yes well, if one were to see it again... then it feels like a better...
C4 But how are they linked there? Because later on we must somehow, depend on "connection" I guess?
C3 Hmm, well yes [pause]. But then A should still be lying in there somehow. That the modem in control determines how it is transmitted and then...
C4 But it's more, you can't really come to that there... or can you? Because it's more a have relationship? [pointing to the class diagram] An arrow like that?
C3 Hmm, that's right.
C4 The modem doesn't have any public...
C3 Well maybe it is...
C4 It doesn't have any public methods whatsoever.
[pause]
C4 If you were to code this it would be interesting, because then you would have needed, then you need some kind of interface towards the others.
C3 Mm, I believe I thought more of heritage so then you could access... It could just be that it's only have [relationship], just a separation of the code then.

Here, the students in C3C4 present different principles and try to draw on outside experiences to support their arguments. They use examples from other contexts than the question itself, which hints that the dialogue is being driven by an inquiry to understand each other's point of view. The students in this group seem to understand each other's point of view but do not share it due to a lack of convincing arguments. The following excerpt shows an example of how the students perceive the discussion. It's from the interview with C3 who is answering the question: What are your general thoughts about the discussion?

C3: It was good to have I guess, you get a new perspective on the question and though it did not change my final answer my choices were changed between the questions so I had a different mindset but in the end I chose the same.

Here, the student claims that even though he/she did not change answer from Q1 to $Q1_{ad}$ he/she gained a new perspective through the discussion.

C4, on the other hand, did not perceive the discussion with C3 as stimulating, but instead brings up an important aspect of the questions in the interview. Consider the following excerpt were C4 answers the question: Have you had any good experience when it [questions to discuss in classroom] has led to good discussions?

C4: It probably depends on the subject. If it's an interesting subject then it's a good idea, but for the teachers it's hard to know how the students think about the subject, are they interested or are they just there for...

This student points out that some questions are just not interesting enough in themselves to create good discussions, and some students do not have any interest in learning the subject for that particular lecture.

7. Discussion

We have identified and described three different types of discussions that students engage in during a peer instruction session. In this chapter we will discuss what kind of learning possibilities that each type of discussion holds and implications for how teachers can design and use peer instruction.

7.1 Possible learning results

As mentioned earlier, Illeris argues that learning can be seen as three things; as the result of a learning process in an individual, the mental process in an individual or the interaction, which occurs between the individual and his/her material or social surrounding. These three views of learning interact and affect each other and thus cannot simply be separated in practice. It is difficult to describe what a student has learned without describing the learning process and in which context the student has learned it (Illeris, 2007). Possible learning results should in this context be seen as learning results that can become possible because of the process the student has gone through and how the student has interacted with the social and material environment. In general, a student who has gone through a good learning process and has been engaged in a good interaction with his/her social and material environment has the possibility to gain better learning results. With good interaction we mean an interaction that contains a discussion with a broad variety of content and that content should be contradictory in order to distinguish and discover the right answer. Thus a good learning possibility is when students in the discussion are aspiring to find the truth, not simply to be satisfied with what they believe to be true.

7.1.1 Type 1 discussion

In Type 1 discussions the students acknowledge the other student's reasoning, agree with each other and quickly come to an agreement. In these discussions there is no real argumentation, only a short series of explanations to why they have chosen the "correct" alternative and the discussion is over very fast. The resources in this discussion that the students can learn from are their own explanation on why their alternative is correct and their partner's explanation to why the alternative is correct. To explain why the alternative is right, the students need to formulate their explanations in their own words. So even if they have the same explanation they may have two different formulations of it. According to the sociocultural perspective, communicating is the essence in creating and sharing knowledge. To expose yourself and others to ideas you are automatically involved in a process of learning (Säljö, 2010, p.22). In the process of turning thoughts into words, the students need to structure their thoughts and they might see their own explanation in a new perspective. In general, when a student turns his/her thoughts into words it seems to make the thought clearer. It also seems to make the thought more open for self-critique. This phenomenon can be observed in every classroom where the teacher only needs to ask the students to explain their thinking to make the students see and correct their own mistake. But we have in our study no data of any students in the Type 1 discussion changing a wrong answer to the correct one. This would have been an indicator of a student correcting a mistake in their explanation. The results show that students tend to stick to their alternative and are more comfortable with their choice after the discussion. This is an indicator that Type 1 discussions are incapable of challenging previous beliefs in order to get closer to a more correct understanding of the subject. However, the learning possibilities the students have in this type of discussion are a broadening and strengthening of previous beliefs. This happens regardless if the answer is correct or not, and can therefore strengthen misconceptions.

7.1.2 Type 2 discussion

Our results show that Type 2 discussions start the same way as Type 1 discussions, with acknowledging the other student's reasoning and agreeing with each other. But then the students continue to discuss the other alternatives, give explanations to why they are wrong and some of the discussions contain references to more general principles. To try to explain why the other alternatives are wrong is good since there is as much value in knowing what is wrong and why, as there is in knowing what is right and why (Osborne, 2010). By widening the discussion to include more explanations and general principles the discussion offers better possibilities for learning. Firstly, the students have a greater chance to get familiar with arguments that they did not know before and to hear more arguments explained in different ways. This process of broadening and strengthening previous beliefs is the same as in Type 1 discussions. But since there are now more explanations in this type of discussion the students have more material to draw on to broaden previous beliefs. Secondly, having both more explanations and general principles makes it easier to construct their own principles, which help them transfer their learning to other contexts. In other words, by taking what is common in the explanations and make sure they do not contradict each other they can broaden their previous beliefs about the subject. This will make the subject easier to use outside the context of the question (Illeris, 2007, p.68).

In the interviews, all students from Type 1 and Type 2 discussions said that they kept their initial answers since their ideas were confirmed by their partner. This shows that the reason the students from these types of discussion kept their answer, and even gained more confidence in their answer, is that their choice was confirmed by another person. There is therefore a high possibility that social experience and interaction played a vital part in the discussion and the decision-making in Q1ad. The desired reason to keep or change the answer should rather depend on the quality of the argument. The students exclude the other alternatives when they answer it individually but not in the discussion. There lies a danger in these discussions. When the students acquire new explanations to their false beliefs they also gain more confidence that it is a correct belief and therefore have less motivation to question it and correct their mistake. These discussions do not seem to aspire for a quest to find the true answer, but rather a quest to pick the 'correct' answer and give an explanation to why it is correct. And the correct answer in this case seems to be based on something different than the strength of the argument: the "correct" answer is found when the students come to a consensus.

7.1.3 Type 3 discussion

The third and final type of discussion offers an opportunity for the students to see the question from another point of view and hence offers a possibility for conceptual change. What mainly distinguishes Type 3 discussions from Type 2 discussions is the use of counter arguments. There is a shift in focus here from explaining their answer to arguing which alternative is right (see Figure 5.1). This shift is important for what learning possibilities the discussion holds. Jonathan Osborne, for example, points out that argumentation plays an important role in science education since it seems to be a core process in learning, thinking and creating new understanding. He also writes that arguments containing counter-arguments and rebuttals have the greatest value, "as they require the ability to compare, contrast and distinguish different lines of reasoning" (Osborne, 2010, p.464). This means that the possibilities for learning are much better in Type 3 discussions. This type of discussion has the same richness in terms of content as Type 2 discussions and thus the same potential to broaden and strengthen previous beliefs, but the use of counter arguments also opens up for the possibility for the students to

reassess previous beliefs and see the subject from a new perspective. With this follows the possibility to spot and correct misconceptions.

7.2 Implications for teaching

Our results show that students do not always discuss the question in a way that helps them to learn. Teachers need to encourage students to discuss the questions in a way that includes argumentation and different perspectives on the problem. More specifically how this could be done is an area for further study, but we can offer some thoughts on what might work. One strategy, also used by Eric Mazur, is to encourage students to discuss with a partner who has picked a different alternative. Another strategy is to encourage students to discuss all of the alternatives and try to defend them, instead of just choosing the one they think is right and coming up with an explanation to why it is right. This requires that the teacher explains the difference between an argument and an explanation.

We have seen that the discussion can actually strengthen the students' misconceptions. The teacher needs to address this after the discussion. One way to do this is to not only explain why the correct answer is correct, but also why the other alternatives are wrong. Another way is to do a different kind of assessment in order to identify and correct student misconceptions.

The discussion part of this study analyzed the content and interaction part of Illeris's three dimensions of learning. But Illeris also emphasizes that having incentives to learn is equally as important. The interviews show that the students have had experiences of discussions where they did not discuss at all. If the discussions are going to be of good use for learning, there must at least be one student in the discussion who is there with an incentive to use the discussion to learn. This can be triggered when the students have chosen different alternatives. But the problem with using multiple-choice questions is that the teacher cannot force the students to answer the way he/she wants to, and even if they do the discussion might not reach its full potential. In some cases it might be better to use more open questions where there are a greater number of answers, and maybe more than one correct one, to increase the learning potential of the discussion. What the teacher loses is the opportunity to choose which alternative answers the students should discuss, usually common misconceptions, and the opportunity to collect quantitative data. The teacher must, as always, balance the gains and losses against each other and choose the most effective strategy in that particular situation.

7.3 Further research

This study has shown that students have different types of discussion when engaged in a peer discussion. What the results do not show is what enables these discussions and what teachers need to do for students to engage in Type 3 discussions. The previous section presented reasoning thoughts on what teachers may have to do. But this study's qualitative data, which is based on few participants, limits which conclusions can be drawn. There is a need for another study to explore when students engage in the different types of discussion, especially Type 3 discussions which have the best learning possibilities. A study that answers which circumstances enables students to engage in Type 3 discussions and what teachers can do to create these circumstances.

8. Conclusions

What types of discussion do third-year engineering students have when engaged in peer discussion?

We have seen three different types of discussion; narrow discussion, confirming discussion and contradictory discussion. The narrow discussion is characterized by a stating content where the students give a narrow explanation of their choice. The confirming discussion is wider than previous level due to that more alternatives are discussed. The students explain why they have picked their answer and give a reason to why they have excluded the other alternatives. The final level, contradictory discussion, contains another aspect of dialogue than the confirming discussion. Here, the students get into an argumentation on which alternative is the correct one.

What learning possibilities are enabled by these types of discussion?

The learning possibilities vary in our three different types of discussion. In the first type of discussion, the students are given the possibility to broaden and fortify their previous beliefs. This is achieved by the students presenting each other to new perspective on the same answer. Their explanations are getting confirmed by their peer.

The second level of discussion also contains the similar learning possibilities as in Type 1. Here, the students broaden and fortify their previous beliefs to an even greater extent. In addition, the learning possibilities are increased by the inclusion of principles and contextual references.

The third and final type offers an opportunity for the students to see the question from another point of view and hence offers the possibility for new knowledge to be learned. The use of counter arguments opens up for the possibility for the students to reassess previous beliefs and see the subject from a new perspective. With this follows the possibility to spot and correct misconceptions.

Implications for teaching?

Teachers need to encourage students to discuss the questions in a way that includes argumentation and different perspectives on the problem. One strategy is to encourage students to discuss with a partner who has picked a different alternative. In some cases it might be better to use more open questions where there are a greater number of answers, and maybe more than one correct one, to increase the learning potential of the discussion.

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Appendix

Appendix A: Interview guide

Interview guide

Purpose of the interview: *Getting an insight on how the students perceive the discussion and their learning process in the discussion?*

Structure

1. Information to the students. (Either both groups at the same time or one group at the time) **(1-3 min)**
2. Distribute questionnaires 1 to the first group. answered individually. **(1-2 min)**
3. Diskussion **(6-8 min)**
4. Distribute a new questionnaires 1 to the first group. answered individually. **(1-2 min)**
5. collect all questionnaires 1 och and distribute questionnaires 2. answered individually. **(1-2 min)**
6. Interview person 1. **(10 min)**
7. Interview person 2 **(10 min)**
8. Done. **(MAX 40 min in total)**
9. continue to next group.

Information

- This study is made as a support to the course evaluation and aims towards improving the learning and the teaching for students and teachers.
- You will be split into groups of 2.
- The whole procedure will take about 30 min per group.
- You will answer two multiple-choice questions. The first question will be followed by a discussion and then you will get to answer the same question again. And then you will get a second question for which there will be no discussion.
- All your answers will be individual. Your individual answers will not be shown to the teacher or anyone else but the interviewers.
- When you have answered the questions, we will interview each of you individually for 10min each.
- We will record the discussion and the interview, then transcribe and anonymize. When the study is done the recordings will be deleted.
- As a reward for participating in this study, you will each receive a cinema ticket.

Interview

introduction

Say hello and tell them about how long the interview will last. Ask the students if its okay to use their answers/discussions in publications and emphasize that their individual answers will not be shown to the teacher or anyone else but the interviewers. Try to create an environment that is relaxed and permissive and convey respect for the interviewee.

Initial question

- What did you think of the questions? Were they easy/difficult?

Questions about the subject

- Can you explain your thinking when you answered Q11? How did you think when you answered Q12? Q2?
    - Which answers did you choose between in Q11? Q12?
        - Why?
        - (Why did you change your alternatives?)
    - (Which answers did you choose between in Q2?)
    - Can you tell me what made you change/keep your answer from Q11 to Q12?
        - Did your fellow student affect your answer in Q12?
        - What arguments affected your decision to change/keep your answer?
            - Which argument would you say was the most convincing?
    - Did the discussion help you in answering Q2?

Questions about interaction and motivation

- What are your general thoughts about the discussion?
    - Did you find the discussion stimulating?
        - In what way was this discussion stimulating?
    - What did you learn from the discussion?

- Do you think that the discussion would have been different if the where more people in the group?
- Do you think that the discussion would have looked different if I had told you the correct answer before the discussion?

Concluding questions

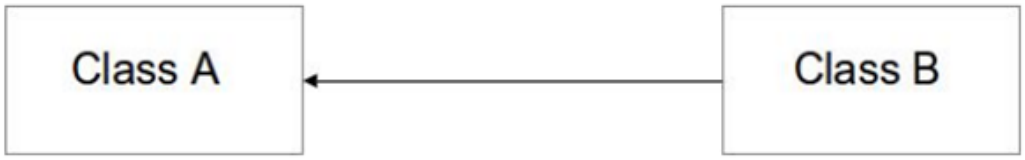
- Do you think this would be a good activity to use in a lecture? When? For what?
- Was the language a problem during the discussion?

End the interview

Thank them for the interview and give them their movie tickets.

Appendix B: Question 1

Consider the design below:



If we want to reuse Class B, we: *
*(Check **one** box)*

- ☐ 1. have to change class A
- ☐ 2. also need to use Class A
- ☐ 3. do not need to use Class A
- ☐ 4. need to inherit from A

How confident do you feel about your answer?
(Where 1 is not confident at all and 10 is very confident. Circle your answer)

1 2 3 4 5 6 7 8 9 10

Appendix C: Question 2

Consider the design below:

If we change Class B, we: *
*(Check **one** box)*

- ☐ 1. need to change Class A
- ☐ 2. need to inherit from A
- ☐ 3. do not need to change Class A
- ☐ 4. can not do that, because B uses A

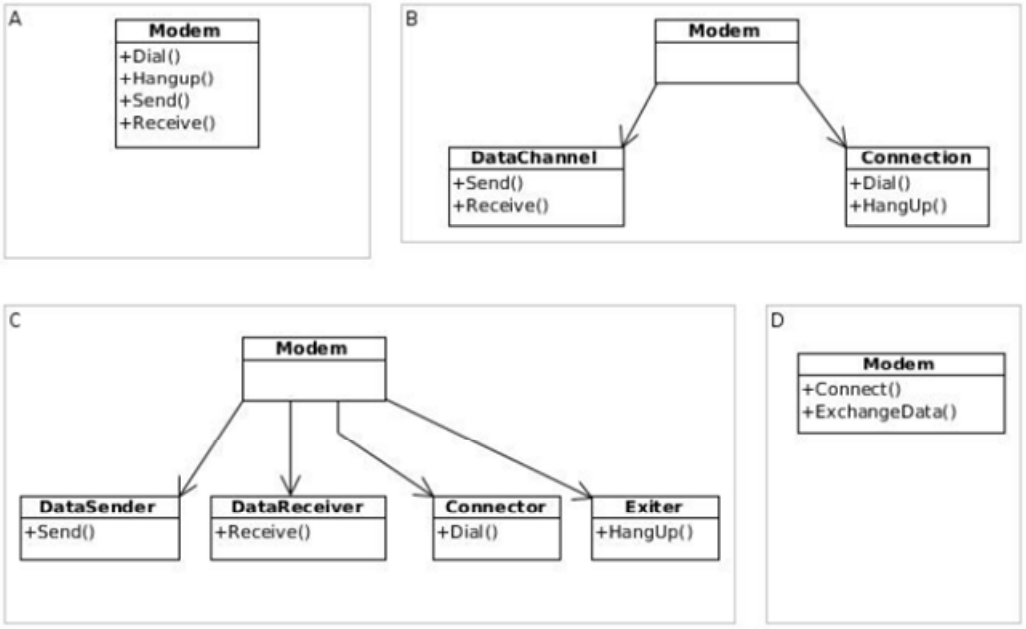
How confident do you feel about your answer?
(Where 1 is not confident at all and 10 is very confident. Circle your answer)

1 2 3 4 5 6 7 8 9 10

Appendix D: Question 3

Question 1.__ Student:___

Consider the designs of the same system below:



Which one is a better design, considering assignment of responsibility?
*

Please choose **only one** of the following:

- ○ Design A, because the system is too small to split up in different classes with different responsibilities.
- ○ Design B, because operations that are part of the same task are combined to a responsibility.
- ○ Design C, because every operation is a responsibility.
- ○ Design D, because it is necessary to reduce the amount of operations in a class, not the responsibility.

How confident do you feel about your answer?
(Where 1 is not confident at all and 10 is very confident. Circle your answer)

1 2 3 4 5 6 7 8 9 10