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# Different stories of group work: Exploring problem solving in engineering education

## Abstract

*This article aims to further the understanding of group work in higher education, primarily in science. This is done through an empirical investigation of problem solving in small groups. Position theory is used as an analytic tool for describing the complex and dynamic processes of group work, focusing simultaneously on the physics content and the student community and how they constitute each other. We analysed four video-recorded sessions with students from two Master's programs, Engineering Physics and Bioengineering, respectively. The students addressed two introductory mechanics problems. The analysis resulted in a characterisation in terms of seven 'storylines' of two different kinds. These are argued to reflect different aspects of engineering student communities, where one kind of storylines captures ways of approaching the problems and the other kind exemplifies boundary work involved in the constitution of communities.*

## INTRODUCTION

Group discussions have been introduced in science education as a means of meeting challenges related to both equity (Lorenzo, Crouch & Mazur, 2006) and conceptual learning (Gautreau & Novembsky, 1997). An underlying assumption in such educational reforms is that exploratory talk (Barnes & Todd, 1995) will contribute to an increased understanding, which, in relation to equity, is particularly important for female students. However, when open-ended, context rich and/or conceptual problems are introduced in a university education, this is done in a context where students already have substantial experience of problem-solving and certain expectations on what

a science problem can look like, and what are appropriate ways of solving them. In this article we explore how the ways in which groups of engineering students approach qualitative mechanics problems are related to the norms and expectations within these engineering student communities.

It is well-known that students' alternative conceptions of the physical world are highly robust and difficult to change (McDermott & Redish, 1999). In particular, traditional, non-interactive teaching has been shown to have little effect on students' conceptual understanding (Hake, 1998). Instead, researchers have recommended collaborative learning in small groups, focused on core conceptual aspects, as a way to challenge these alternative conceptions. Such small group learning has also been shown to improve students' conceptual understanding of physics (Springer, Stanne & Donovan, 1999). In addition to supporting the development of sound conceptual understandings, it has been argued that working in small groups can bring several additional benefits for the students. For example, collaborative learning gives students possibilities to practice scientific language, both as a system of resources for making meanings and as a way to construct science. Collaborative learning has also been argued to help students in developing key professional skills such as working in teams. However, Scherr and Hammer (2009) have pointed out that there has been little direct investigation of what happens during instructional activities aimed at improving students' conceptual understanding in physics. Instead, the primary means of evaluation has been pre- and post-tests. A challenge for research is, thus, to try to capture the dynamic processes taking place in group work, as related to learning physics. This is important, for example, in that it may inform the set-up of such learning situations. Scherr and Hammer (2009) focused how a student's framing affects what this student notices and, thereby, what physics knowledge the student is able to access. Other examples of research exploring the interconnectedness of social and content oriented dimensions within physics learning in groups are Enghag, Gustafsson and Jonsson (2009), who analyse the students' ownership of learning using flowcharts, and Kittleston and Southerland (2004), who use discourse analysis to study concept negotiation and the engineering discourse.

In the same vein, this article explores content learning and social dimensions of learning as interconnected and mutually affecting one another, in the context of engineering students solving physics problems. Working from the premise that group work can be understood as a socially shared and culturally situated activity, we explore how these students together produce and reproduce appropriate ways of being engineering students in moment-to-moment interactions within four groups of students, from two different engineering programs.

This analysis extends an earlier case study where the theoretical and methodological framework was developed and tested on one group session. In this earlier case study, the students' conversation was analysed using positioning theory and every speech-act was analysed from both how it contributed to the problem solving and how the students positioned the physics and each other. The case study analysis resulted in five distinct storylines of two different characters: task oriented storylines that describe how the students position the physics problems and community constituting storylines that describe how individuals, not just the physics, are positioned. These storylines described the interplay between the context of the education and the context of the group session.

In this study we want to explore the framework's allowances for performing a mid-level analysis that balances student agency and possibilities for improvisation with the structural frames set by the educational context. The aim of this article is to explore how students working in small groups constitute specific engineering student communities in terms of a) the groups' ways to approach the problems and to constitute boundaries for appropriate problem solving b) the boundary work involved in the constitution of the communities and c) the interconnections between the problem solving and the community constitution.

## METHODOLOGY

### Analytical Approach

In the study we use positioning theory as an analytical tool. Positioning theory is a framework with its roots in social psychology and examines how participants position themselves relative one another in interactions. As explained by Harré and van Langenhove (1999), not all positionings are possible since 'not only what we do but also what we can do is restricted by the rights, duties and obligations we acquire, assume or which are imposed upon us in the concrete social context of everyday life' (p. 4). In other words, the social context – here the engineering student community of practice (cf. Lave & Wenger, 1991; Wenger, 1998) – gives the participants a sense of what they 'ought to do', but the context does not determine their actions. In positioning theory the structure of conversation is understood as tri-polar: consisting of storylines, positions and speech-acts. Examples of storylines given by van Langenhove and Harré (1999) are 'friendship', 'good-student' and 'the victim'. Positions are 'a cluster of rights and duties to perform certain actions with certain significance as acts' (Harré & Moghaddam, 2003, pp. 5–6) and a speech-act is an utterance or a constituent in the conversation (like a gesture) that has a meaning in the conversation. The focus of Davies and Harré (1999) is on positioning, whereas the concepts of 'storyline' and 'speech-acts' are not explored in depth. In this article, storyline is the main analytical tool for exploring how the participants in their conversations negotiate practice and identity. In doing so we use storyline as a way to characterise conversation into distinct, but sometimes parallel 'plots'. The concept of position is used as a way to analyse the direction of the students' moment-to-moment interactions, whereas the concept of storyline is a way of connecting the object of interaction to patterns of interaction.

### Data collection

In the study, four groups of university students, from two different engineering programmes, were asked to solve two physics problems. The instructions to the students (translated from the original Swedish) are shown in Figure 1.

The questions were chosen to promote discussions about important issues in mechanics, such as friction, force balance, and acceleration. This is also explicitly expressed on the problem sheet, where the students are encouraged to 'finish their discussion before they do any calculations'. The questions concerning an ox and a box may seem trivial to the students at first, but the questions are qualitatively phrased, and no specific values or terms are asked for, which is atypical compared to the tasks the students commonly encounter in their physics studies. A similar kind of task is analysed and used in a study by Linder, Fraser and Pang (2006). The questions are designed to include important conceptual challenges as well as, in the case of problem two, non-trivial ways of solving the problem analytically. The problem with the sled has a more traditional structure; a specific angle is to be found as a function of the variables identifiable in or given from the situation, but the formulation still points towards discussion in addition to mathematical solution. Both questions thus deviate from the typical structure of problems the students meet, but it falls within the range of themes for physics problems the students recognise and would see as meaningful within their studies.

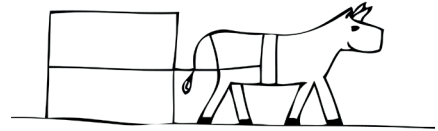
Data was collected in two rounds. In the first round, a group of four students from the Engineering Physics programme (group one) was video-recorded during 45 minutes of a voluntary group session. The tutor, who was one of their regular teachers in the course 'Mechanics', visited the group twice. An observer was also present. In the second round three groups of students from the Bioengineering programme participated. Here a similar group session focusing the physics problems (Figure 1) was integrated as a part of their ongoing course 'Mechanics with biological applications'. The students were split into three groups in three different rooms with three different observers. Two of the groups (group two and group four) were video-recorded whereas the third group (group three) was audio-recorded. The group sessions took 60 minutes each and none of

## Problems for group session in Introductory Mechanics

NB! When you solve the problems, try to finish your discussions before you start any calculations.

### 1. An ox is pulling a box with constant velocity.

\*Which forces are acting on the ox and the box and how are they related to one another?



\*Which of these forces affect the movement of the ox and the box?

\*Think about how the mass of the ox and the box matter, what happens if:  
the ox doubles its mass?  
the box doubles its mass?

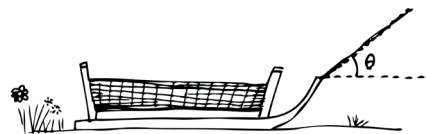
\*What do the equations of motion look like?

\*How is it possible for the ox to move forward?

### 2. A sled is pulled over snow-free ground.

\*Does it matter with what angle one pulls?

\*Is there a best choice of angle (not equal to zero)?  
Discuss arguments for and against before you solve the problem in detail.



\*How much does the pulling angle matter?

### 3. Compare problem 1 and 2, what are the differences and similarities between the problems?

Figure 1: The problem sheet

these three groups finished all physics problems. All recordings were transcribed verbatim, and it is these transcriptions that were the primary basis for the analysis. A consecutive numbering of utterances are used as reference in excerpts quoted in this article. The video data was primarily used to see to whom a question was directed or whether a speech-act was perceived as a joke.

## Empirical background

The two selected engineering programmes, Engineering Physics and Bioengineering, both have high entrance requirements and the students are considered to be hard-working by their teachers, when compared to other engineering programmes at the same university. The five-year Enginee-

ring Physics programme is, like most engineering programmes, male-dominated. The introductory mechanics course is considered to be an important foundation for the following physics courses. The five-year Bioengineering programme has its focus on the interface between chemistry, biology and medicine and is one of the few programmes at the university that have more women than men. Mechanics with biological applications is an auxiliary (but compulsory) course in the Bioengineering programme. The 'friction module' in these two courses was very similar (in terms of, lecture content, teachers, textbook, and problems).

The four group sessions in our study were described as characterised by hard work and a friendly atmosphere by the observers. Two group sessions, group one (Anders, Bertil, Calle and David) and group two (Hedvig, Inga, Jan and Kristina) could be categorized as 'successful group work' from a teacher perspective: group one because the group solved both problems and group two because the students reached answers to the first problem by collaboration. In contrast, in group three (Linda, Maria and Nea) the students worked under silence by themselves writing down equations on individual papers for long sequences. In group four (Erika, Frida and Gustav) the students got stuck in their problem solving for a long time and it seemed that the strongest student, Frida, received very little support from the other two students and spoke more or less by herself during long sequences. Also in group one and group three one student appeared stronger in physics (David and Maria respectively) than the other students and the other students also positioned them as stronger.

### Analytical process

The analytical process was initiated by several viewings of the complete videos and listening to the audio-recording together with the transcripts. In addition, the authors read the transcripts of the four groups repeatedly. In the next step of the analysis the authors individually coded the transcripts of the four groups. The focus was on capturing what the students did verbally together as storylines in every speech-act. This coding was guided by the results of an earlier case study of group of physics students, as well as the analytical tools developed in this study.

While the five storylines identified in the previous case study guided our initial coding, we tried to keep close to our empirical data. Not unexpectedly, the five earlier storylines were not sufficient to code the increased data, which also had an additional engineering programme as an extended context. The coding scheme was therefore iteratively revised: the five earlier storylines were adjusted and two more storylines were added to the coding scheme. In the end all four transcripts were coded into storylines and the conversation into distinct, but sometimes parallel, 'plots'. It could be pointed out that the different storylines differ substantially both in their overall prevalence during a group work and in their extension over consecutive speech-acts. As an illustration, the storyline 'Reaching a solution to the physics problems' could be said to structure the entire group work in group one, only momentarily being replaced by other storylines, and is as such often played out over numerous consecutive speech-acts. The humouring storyline, as a comparison, also occurs throughout this group work, but only in shorter interactions, most often consisting of three to four consecutive speech-acts. However, we found some parts of the transcripts were impossible to code as a storyline, for example the sequences in group four where the students worked under silence by themselves writing down equations on individual papers. This was not surprising since we wanted to explore how practice and identity are negotiated by the participants in their conversations.

In the coding process a speech-act can be interpreted as both part in the problem solving (task oriented storyline) and at the same time a positioning of an individual (community constituting storyline). Thus, each speech-act was coded as belonging to one or several storylines. In our analysis, positioning is distinguishable as one speech-act (or several combined) that puts a person or an aspect of the students' work in relation to others through the explicit (and/or implicit) attribution of some characteristic, such as 'competent', 'simple' or 'funny'. In our application of positioning

theory we have expanded the notion of positioning to include not only the positioning of individuals but also of procedures and concepts. To be noted is that such a positioning also is two-fold, for example, a positioning of a particular task as easy also positions the speaker as knowledgeable. A storyline ranges a number of speech-acts, and its delimitation is distinguishable in speech-acts that change character, for example, in terms of the emergence of positioning with a different character or in speech-acts pointing towards a different aim for the students' attention.

## RESULTS

In this section we present our results as seven storylines, illustrated with excerpts from the four group sessions. The storylines are categorized as either task oriented or community constituting and the group sessions will be referred to as group one, group two, group three and group four, see Table 1.

The task oriented storylines describe the groups' ways of approaching the problems. How the students address the physics problems have a structure with a distinct beginning (to make a force diagram), middle (to negotiate around the physics problems) and end (to agree that they answered the physics questions). The community constituting storylines are of a different character, describing different aspects of the social interactions in the groups: individuals, not just the physics problems, are positioned. The community constituting storylines can challenge but also run in parallel and be intertwined with the task oriented storylines. Next we will describe the seven storylines further.

### Task oriented storyline: Reaching a solution to the physics problem

In the task oriented storyline 'Reaching a solution to the physics problem', the physics problems were positioned as puzzles that needed correct answers by the students, which does not necessarily imply that the groups reach, or even are aiming for, an understanding of the physics. This storyline was the dominating storyline in all four group sessions and the abundance of the storyline led us to analyse it in terms of constituents: how the students reduce, expand and contextualise the problems. To reduce the physics problem means to make the problem smaller or less complicated.

Table 1: The storylines in our data, the dominating storyline(s) in bold type.

	Group one (Physics)	Group two (Bioengineering)	Group three (Bioengineering)	Group four (Bioengineering)
<b>Task oriented storyline</b>	<b>Reaching a solution to the physics problem</b>  Understanding the physics  Preparing for the upcoming exam	<b>Reaching a solution to the physics problem</b>  <b>Understanding the physics</b>  Preparing for the upcoming exam	<b>Reaching a solution to the physics problem</b>  Resistance to the task  Understanding the physics  Preparing for future professions	<b>Reaching a solution to the physics problem</b>
<b>Community constituting storyline</b>	Humourising  Insider	Humourising  Outsider	Humourising  Outsider	Humourising  Outsider

To expand the physics problem is to come up with new perspectives in the solution or to question earlier reductions. The third constituent is to contextualise the physics problems; the students refer to their own experiences and use this in the conversation by relating the given scenario to 'reality'. The three constituents are exemplified in this excerpt from group one, the Engineering Physics group:

44. Carl: And four normal forces here, it [the ox] stands on four legs  
 45. David: Yeah.  
 46. Carl: Four 'N2'.  
 47. Anders: Four friction forces.  
 48. David: They are not necessarily the same

In this excerpt all three constituents are represented: Calle contextualises the problem when he says 'it stands on four legs' (44) and then he reduces when he formalises the normal forces into the symbols 'N2' (46). This is followed by David who expands the problem 'they are not necessarily the same' (48), where David also introduces the dimension of 'size' to the forces in the force diagram. This storyline, and the three constituents, are present in every group session. However, there are differences in how the storyline is played out in the Engineering Physics and Bioengineering groups: the Engineering Physics students follow Lemke's (1990) stylistic norms of scientific language to a higher extent than the Bioengineering students. For example, the Engineering Physics students use the formulas and technical terms instead of naming the concepts, like 'N2' instead of normal force and 'mg' instead of gravitational force. This technical jargon could be understood as part of the shared repertoire of the local physics student community, and does as such not only contribute to an effective problem-solving but also functions to unite and define the group. Another difference between the Engineering Physics and the Bioengineering groups is that the latter refer to the situation of group work, for example, in group four when Frida says 'Now we're talking about biology again' (557). Through reasoning like this, the students reduce the complexity of the task by positioning their former reasoning as an inappropriate approach to problem-solving within the context of a physics course. At the same time, this is a form of meta-analysis of what they do, a negotiation of what is appropriate in physics and biology, respectively. This is neither present nor necessary in the Engineering Physics group. The Bioengineering students also contextualised more; here is another example from group four:

539. Frida: Eh, I thought like, if you have, three different attempts with three different cows, or perhaps two cows.  
 540. Erika: yes  
 541. Frida: One [cow] that weighs double and one with normal weight, and two different boxes, and then they race.

In this excerpt Frida tries to reach a correct solution by contextualization; by constructing a 'real' scenario she tries to get a feeling for a correct answer.

### **Task oriented storyline: Understanding the physics**

This task oriented storyline describes a different focus in how the students interact with the physics problems. Here the physics problems are positioned as means for physics understanding. The storyline is present in three groups and dominated group two. In this Bioengineering group (see Table 1) the two storylines 'Understanding the physics' and 'Reaching a solution to the physics problem' are played out simultaneously: while the students search for a correct solution they constantly ask each other questions aiming for understanding, such as 'does the ox need to weigh more than the box?' (618) and 'once it [the ox] has started, then they [the forces] should be the same?' (652). In both these examples the questions are not directly connected to a correct solution or answers to the physics problems, and, as we interpret it, the students ask these qu-



estions to gain a better understanding of the physics problems. At the same time they position the physics problem at hand as a mean for their personal understanding. However, simultaneously these kinds of questions contribute to the learning possibilities for all students in the group.

A slightly different version of the storyline 'Understanding the physics' is unfolding in group three when Nea notices that she arrived to the same solution as Maria and wonders if the third student, Linda, is following them:

774. Nea: I got the same [equation] as you, mm, are you?

775. Linda: No, I didn't quite follow.

776. Maria: Eh, 'cause if you have in x-direction and y-direction, it is the same that I have done, I have replaced the 'N' with the 'N' you get in y-direction

When Linda admits that she does not follow (775) Maria explains how she has done (776), and our interpretation is that this is not in order to convince Linda that she has the right answer but to help Linda to understand how she reached the answer. Here Nea and Maria focus on another student's (Linda's) understanding in their conversation, and at the same time they position the physics problems and the group work as means for understanding. The examples above are in contrast to group one, where the storyline of 'Understanding the physics' became more of a disruption than an integral part of the conversation:

44. Calle: Yeah, but had the ox been able to pull the box if the box was heavier than the ox?

45. Anders: Yes

46. David: Yes, suppose so ....

47. Calle: Show that, why

Here is again an example where the question of one student (44) can be interpreted as asked because he wants to understand the physics, since it has little connection to reaching a correct solution of the problem. However, in group one Calle's question is followed by a short silence and a moment of perplexity, which indicates a problem in the storyline. When no other student helps Calle in his attempt to gain a better understanding, he stresses again that he wants to understand: 'show that, why' (47). The question is similar to questions frequently posed in group two, but here the storyline of 'Understanding the physics' challenges the dominating storyline 'Reaching a solution to the physics problem' which results in an awkward moment in the conversation.

### **Task oriented storyline: Resistance to the task**

In the storyline 'Resistance to the task' the physics problems are positioned as boring and irrelevant to their student community. This task oriented storyline is present only in group three. Here it challenges the storyline 'Reaching a solution to the physics problem' since the main objective of this storyline is to stop solving the physics problems in the situation. An example of this storyline is when a student, Nea, asks the other two students if they should do something 'more' with the questions about the ox and Maria answers: 'No, I can't think of it right now. Maybe later, can't think of it right now'. In the way she says this she positions the physics problem as something that could be postponed and perhaps not needs to be solved at all. However, at the same time she indicates that she might be able to answer it if she would give it a try. Later, when the students discuss the sled, Maria says with a joking jargon: 'Maybe it is all for the best to stop here and skip it' (556). At that time only half an hour has passed and the other two perceives Maria's positioning of the physics problems as unimportant as a joke. This storyline is present on several occasions in the beginning of the group session and becomes stronger and stronger as the session progresses. In the end of the session Maria asks the observer if he thinks they should do the derivation the tutor previously advised them to do. The observer answers 'Maybe you should finish your reasoning [and finish



off the problem with the sled]’ an utterance that positions the students’ discussion as unfinished. Nevertheless Maria meets this answer with resistance:

1229. Maria: No, I don’t know.

1230. Nea: No, I don’t think we will get any further.

1231. Linda: I think it feels like we have finished.

At this moment the storyline of ‘Resistance to the task’ has taken over the conversation, both Nea (1230) and Linda (1231) agree that they should end the group session without solving the last question. The group session ends half a minute later.

### **Task oriented storyline: Preparing for the upcoming exam**

In this task oriented storyline the students focus on preparing for the upcoming exam and the physics problems are positioned as means of preparing for the exam. This storyline is present only occasionally in group one and two. In group one the tutor was in the room and the conversation had a joking jargon when Anders exclaims that none of the jokes would be well received on the upcoming examination: ‘Michael [the examiner] would have a heart-attack if you wrote that on an exam!’ Anders continues the storyline with yet another joke: ‘He [the examiner] would die instantly!’ With these two utterances Anders positions the group’s previous jokes as inappropriate in the context of an exam. Later Anders positions the group session and says that the problems they are currently working on are much easier than the one they can expect on the exam. He thereby also characterises the group session in relation to the expectations within the local physics student community, where problems of this kind are not the norm and where their difficulty seems to be measured largely in relation to how mathematically demanding a problem is. In the second group Inga estimates their solution as reasonable because (664) ‘It is not an exam’, which is backed up by Kristina. Inga and Kristina thereby position the requirements on what is said in the group session and written in their solution as different from the requirements in their future exam. Through comparing the physics problems in these ways and their solutions to what is expected on an exam, the students can be interpreted as negotiating what is appropriate problem-solving behaviour within their student community.

### **Task oriented storyline: Preparing for a future profession**

In this storyline the physics problems are positioned by the students as means for becoming better in their future profession. This task oriented storyline challenged the storyline of ‘Resistance to the task’ in group three. Here is an excerpt from group three in the beginning of the group session:

268. Maria: No, (giggle), I only want an excuse so I will be able to understand why I need to study mechanics

269. Nea: Yeah

270. Linda: But it will be good when you manufacture prostheses in the future (laughter) if you not already do

271. Nea: But you will surely have [use] for

272. Maria: Prostheses for the hip-bone, I mean hip-joint or

273. Linda: The hip ball.

The excerpt starts with Maria who is resisting the task (268) but then Linda objects that it is useful with mechanics in her future profession (270). Thereafter the storyline of ‘Preparing for a future profession’ takes over the conversation (271-273) and both Nea and Maria contribute to this storyline. This storyline occurs several times during the third group session and sometimes with little connection to the physics problem. For instance Linda says: ‘it is important to do these things and to do product development’ which has no relationship with anything said before. This storyline also sheds new light on the storyline ‘Resistance to the task’, as it indicates that this re-

sistance can be understood in relation to perceiving these physics problems as peripheral within a Bioengineering student community. With other kinds of physics problem with more connection to engineering as a profession this storyline could perhaps have been more dominating in the conversation. A shared characteristic with the storyline 'Preparing for the upcoming exam' are that both are directed towards larger contexts than the problem-solving as such, but whereas the previous storyline points inwards, towards expectations within a student community, the latter links this student community to a potential professional community, on an outbound trajectory.

### **Community constituting storyline: Humourising like an engineering student**

In this community constituting storyline the students position themselves and each other as humorous through joking. However the laughing matter is also positioned since jokes also mediate attitudes and opinions (Ohlsson, 2003). The physics problems are the main laughing matter in this context and are often intertwined with the problem solving. Here is an example from the second group where the students discuss the difference between starting to move compared to moving with constant velocity for the ox:

654. Kristina: It [the ox] needs extra [force] in the beginning to be able to...

655. Hedvig: Does it lose weight then, or?

656. Inga: (laughter)

657. Jan: It is the farmer who pushes a little in the beginning so it gets started.

658. Inga: Oh dear

Here Hedvig's absurd suggestion that the ox loses weight (655) positions her as humorous but it also positions Kristina's physics argumentation as illogical in relation to the group's former conversation. Hedvig's joke is therefore also a contribution to the problem solving. Jan's joke (657) is more of a repetition through which he agrees that the group's reasoning is lacking, but it is also in this context an absurd contextualisation. This is characteristic for most jokes in all groups; they are strongly connected to the problem solving and position the physics within it, for instance, elaborating on cows that move with the speed of light. Especially in the Engineering Physics group, the jokes are often based on absurd suggestions about how to solve the physics problem, and the way it is done also positions the teller of the joke as knowledgeable. An example of this is David's statement: 'Yeah, the flower gives us a friction coefficient close to one.' (295). Apart from positioning students as humorous or knowledgeable the jokes have other functions in the group sessions as well: to make an absurd joke is a possibility to say something potentially incorrect about the physics solution without losing prestige, and thereby contributing to further learning possibilities. Furthermore, like in Hedvig's case (655) in the beginning, jokes can be a non-threatening way to point at weak points in the group's argumentation. Thus, this storyline is tightly intertwined with the task oriented storylines, simultaneously contributing to the problem-solving and the community constitution, as humour is a social phenomenon based on a shared practice within a community (Ohlsson, 2003).

### **Community constituting storyline: Establishing insiders and outsiders**

In this community constituting storyline the students position themselves and each others as insiders, that is, knowledgeable engineering students, and outsiders, that is, incompetent problem-solvers in physics, in the engineering student community. In doing so they constitute boundaries in several dimensions, both between student and professional communities and between different disciplinary communities. Here is an example of how the Engineering Physics group position themselves and each other as insiders:

137. Calle: What do the equations of motion look like? [reads the text out loud]

138. David:  $s=v*t$

139. Anders: An old classic.

With the word 'classic' Anders positions the equation ' $s=v*t$ ' as trivial and as shared knowledge in the group. In doing so, he positions both himself and the group as knowledgeable and as insiders in physics. Such subtle positioning is frequently intertwined with the problem solving and the jokes in the Engineering Physics group; David is repeatedly positioned by the other students and by himself as a knowledgeable physics student. However, there is also a sequence when David insinuates that Calle's suggestion on how to find the right answer is stupid. He thereby contributes to the problem solving and simultaneously positions Calle as an incapable problem-solver, that is, an outsider. In the three Bioengineering groups on the other hand, positioning other students as capable problem-solvers are extremely sparse. The Bioengineering students position themselves almost entirely as outsiders in relation to physics. In these three groups the most frequent positioning is a positioning of either themselves or the entire group as outsiders, for example in group four:

515. Frida: How good we are at this (laughter)

516. Erika: Mm, but forces have never been my thing

In the example above Frida first positions the entire group as non-capable with her irony (515) and then Erika reinforces this statement with positioning herself as non-capable (516). Another example from group two is when Hedvig asks 'Are you sure that we don't need a muscle force' (555) and Inga answers 'We are not sure of anything, Hedvig' (556) and thereby positions the entire group as non-capable.

The structure of how the Engineering Physics students position themselves as insiders and the Bioengineering students position themselves as outsiders is also reflected in that the Engineering Physics students found expertise within the group while the Bioengineering students generally positioned the teacher as the 'physics expert', drawing a boundary between their student community and a professional physicist community, represented by the teacher.

In the Engineering Physics group, David is frequently positioned by the other students and by himself as a capable problem-solver. The other students in the Engineering Physics group do also occasionally position themselves as capable, for example, Anders in the example above (139). Such positionings of someone in the group as a capable problem-solver is almost completely absent in the Bioengineering groups. Instead, in these groups the teacher is positioned as the capable problem-solver, the 'physics expert'. For example, group two does this explicitly the second time the tutor enters the room, when Inga exclaims 'Now you were very timely' and immediately asks a question about the second problem, stressing that the group does not remember how to solve this type of problems. Inga thus positions the group as incapable problem-solvers and the tutor as capable. This may not be so surprising, since Inga here constructs a traditional teacher-student storyline; however, the same teacher-student storyline does not exist in the Engineering Physics group, where no sharp boundary is constituted between student and professional physicist communities. In contrast, the Bioengineering students position the subject biochemistry as inappropriate in the context of problem solving in mechanics 'Now we talk biology again' (557). Since biochemistry is their main subject, these utterances reinforce them as outsiders in physics, but also as insiders in biology, constituting a boundary between the two disciplinary communities. Furthermore, the establishing of insiders and outsiders is also interlinked with what is seen as appropriate problem-solving approaches within a certain community, as discussed in the context of the storyline 'Reaching a solution to the physics problem'.

## DISCUSSION

In this article we have used the concept of storylines to analyse university students' interactions with each other in group sessions in physics. This has resulted in the identification of seven different storylines, which collectively can be said to reflect different aspects of the four different group

sessions. However, more important is that the storylines illustrate different facets of engineering student communities, where the task oriented storylines capture the groups' ways of approaching the problems and the community constituting storylines exemplify boundary work involved in the constitution of the communities. This is not to say that the storylines are exclusive to engineering student communities, in particular some versions of the community constituting storylines are likely to be found also in other disciplinary contexts.

The community constituting and the task oriented storylines interact and distinct practices are constituted in the different groups at different times. The same task oriented storyline may therefore have considerable differences in character depending on the boundary work done in the intertwined community constituting storylines. For example, the kind of discourse established in the dominating storyline 'Reaching a solution to the physics problem' depends on whether the storyline 'Establishing insiders and outsiders', establishes the group as insider or outsider in the situation. Similarly, the interpretation of other aspects of the situation such as the division of labour and the rules as constituted in the group work (cf. how these terms are used in activity theory, e.g. Roth & Lee, 2004), are associated with the insider-outsider establishment of the group. When constituting the group as insiders, this is associated with that a scientific discourse is taken for granted, and a formal language as the norm for communication. The students follow the 'rules' and accept them more as their own, and the division of labour points towards the students and the teachers as individual scientists, each one working on (part of) a solution, and possibly communicating about it. The students thus constitute themselves as part of the same community as the teacher. This contrasts the groups that constitute themselves as outsiders. In these cases the rules for solving problems are not incorporated into the group's own repertoire, instead they are treated as given by experts, the teachers, belonging to a community of non-students. For example, in working with the first problem, Kristina explicitly refers to how the teacher has given 'rules' for problem-solving: 'It feels like, he [the teacher] always says that you should look at it as two separate systems...'. The division of labour here may be individual or collaborative, but the teachers is set apart as expert, and is not a part of the same community. The goal of the storyline 'Reaching a solution to the physics problem' in these two cases may differ in their tone, even though the immediate goal of reaching the solution is the same. In the insider case, reaching the solution is the endpoint, and you can move on to the next problem. In the outsider case, the verification by the teacher becomes important, and the relevance of reaching the solution may also be reflected on in different respects.

It is of course not possible to make general claims based on a small qualitative study such as this, but it is still interesting to reflect on the differences between the engineering programmes distinguishable within the storylines. For example, in the storyline 'Reaching a solution to the physics problem' we found that the Physics Engineering students used a scientific language to a higher extent than the Bioengineering students, whereas the Bioengineering students contextualised more. The purpose of shared scientific language is that it makes it possible for the students to communicate easily with each other and to reduce the problem quickly and routinely. The Engineering Physics group's behaviour shares many similarities with Kittleson and Southerland's (2004) case study on engineering discourse; rather than discussing concepts of science the engineering students only exchanged numbers or graphs with each other. Kittleson and Southerland explain this with that the students viewed themselves as being homogeneous with respect to academic ability, which had implications for how they communicated with each other, the students believed that they shared an understanding for engineering, and therefore could let data speak for itself, like the Engineering Physics students in our case study let the physics equations dominate the communication. Also in the storyline of establishing insiders and outsiders the Engineering Physics students behave similarly to the students in Kittleson and Southerland's case study: the students describe themselves as 'a lot of smart people' and the Engineering Physics students in our study often position themselves and each others as knowledgeable engineering students. Since our male group and the male students in Kittleson and Southerland's case study share so many similarities

it is tempting to draw conclusions on gender issues in engineering education. For example Bianchini (1997) and Danielsson (2009) have shown how status and gender relations play a significant role in learning physics. However, the differences could, in principle, just as well depend on, for example, which engineering programme the students belong to, or pure coincidence for that matter, since every session is by its nature unique. Further research on a larger set of data is therefore desirable, including an analysis of the power relations in the group, looking closer on positioning, how the students position and are positioned by themselves and by the teacher. It would also be motivated to include group sessions where the students work with problems from thermodynamics, optics or some other branch of physics.

In these ways, storylines was functional in characterising the group work as a learning situation, both in terms of community and task. However, we found the concept of storyline less useful when we analysed the sequences where the students did not interact with each other. In our case study groups one and two communicated with each other all the time, but in group three the students worked under silence by themselves writing for long sequences and in group four one student got very little support from the other two students and spoke more or less by herself during long sequences. Silence with no body language and monologues with no response became difficult to code since storylines are something the students constitute together. All in all, the storylines show that the process of students' learning of science in group sessions is multi-faceted and complex.

Our results have demonstrated the importance of what storylines the students constitute in their interaction for the character of their community, and what aspects of the task at hand that are raised in the discussion, and thus potentially what their learning outcomes may be. What kind of community that is constituted and reconstituted among the students that leads to successful study results is not straight forward. Andersson and Linder (2010), in a study of retention from a similar programme of Engineering Physics at another Swedish university, do an analysis of the discourses of how the students talk about their studies, and find that students adopting the student community discourse fully have the best achievements during the first year, while students with a focus on understanding or an idealised idea about what it means to be a scientist may be less successful. This macro-perspective on the situations that we investigate from a moment-to-moment perspective, may provide some clues to important aspects for teachers to learn from our results: An awareness of what such discourses and adherent communities look like as they manifest in meetings with the students in teaching may open possibilities to support some community crossing – inviting the students to being experts –and challenging some restricting storylines – such as a single-minded focus on only reaching solutions to the physics problems – may support the students in their studies overall.

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