E: expert
I1: interviewer 1
I2: interviewer 2

¤<40870>I1: So the problem is that ↑somehow the students are not functioning as groups. You don't think the problem is with the problem solving.

E: I am pretty sure about this.

I1: If you had given that some group of students an individual assignment -

E: Well, I think the problem is with problem solving. In the sense of the art of problem solving. That's -

I1: Right. What would have happened if you had not groups at all but had assigned as individual project in the same amount of time. Do you think that some of the students would have gotten there (.) by themselves?

¤<72403>E: I think so, yes. Like two or three. Maybe ten percent of the course.

I1: Yuh. And the rest wouldn't have.

E: But working groups - group work in general is one of the learning goals, of the class.

I1: Yuh, yuh. OK. Uh. Well let's go back to the old question. Imagine that ↑you were sitting there. A group of others yous - people like you. Uh, and you were going to solve this problem. How would you go about? What would you do?

E: (2s) How detailed would you like (2s)

¤<116670> I1: The more detailed the better.

E: (6s) Well I would start reading the problems - the problem text. Make up some concept in my mind about the problems. What is it dealing with? And then try - well maybe, I am not sure if I really would do that, but - I think I would try to connect the information that I had gotten from the lecturer about the problem - for example I asked them two days before to prepare some things, to prepare a numerical library with certain functionality - I would try to connect this information to the problem (1s) and also the context we have talked about and (3s) I would come up with some kind of plan, how to attack this problem. And then from going from this plan try to distribute it amongst group members. So ↑"you are" - they had to write up a

Sequence of individual and collaborative parts in group work

E sees the functioning of groups connected to problem solving.

E names group work as a learning goal.

E views group work as sequence of individual and collective parts:

- Individually reading the problem and connecting it to what one knows (looking up things if necessary) and the context of the class
- Individually coming up with a plan how to attack the problem
- Individual plans are brought together in group, plan is consolidated within group (“That’s something you need ag group for”), work is distributed among members

E emphasizes that group work has to start with an individual part and without focusing on synergies at this stage. Quite often he uses the phrase “modeling of the problem” when relating to this first part. This part also involves asking questions (which is something the interview will focus on later on).

Organizing the sequence of individual and group work is identified as a possible bottleneck.

poster (.) to present the results of their work - "you are going to write the poster, you are going to do part C. So prepare for part C. As soon as you have the data from part A, for example, you can do part C." That's how I would start attacking this problem (.) and look up information what I need (.) if it is not present in my mind.

¤<201940>I1: You, in your description right there you weren't a member of the group until about step three of four. It sounded like. In other words ↑you -

E: Well, the first part I think that's something that everyone in the group has to do.

I1: Individually?

E: Individually. Everyone has to make a concept of this problem, some model of this problem, what it is dealing with.

I1: Do you think that the students did that step?

E: (hhh)

I1: Like they did this (direction) everybody talking?

¤<233790>E: (5s) Some of them did this step and some of them (5s). Well, my observations showed me that some of them asked questions that are related to building a model of this problem.

I1: It seems to me that one of the things that you are doing as you are mentally reconstruct this - (to I2) you know, join in - uhm (.) is you're deciding when as a member of the group when I need to be working on something by myself or when we all are need to work on something by ourselves. When we need to come together.

E: uhuh

I1: And that's one of the things, skills that the students have to have, is to be able to distinguish which parts of [thing]

E: I agree. Yuh, yes.

Sequence of agreement about what the problem is about, individual work, pooling results and iterations of that

I1: which parts of the. (.) ↑And that may be a part of confusion for them. Because either one can be a problem. If they are trying all to do it together when it is better to do it by yourself and think it through. Uh. If you all do it separately and then try to bring it together you're going in different directions. At certain points that wrong. So, how do you know uhm when it's time to work in your own and when it is time to be in group?

¤<306888>E: Pfff. That's a tough question.

I1: That's what we're trying, right? (laughs)

¤<323009> E: (10 s) When I have a picture or a model of this problem in my head and I come up with an initial plan that something (2 s) that I need to do individually and then some kind of process starts where we in a group bring our plans together, decide which parts of the plan (2 s) are going to be done individually and where can we connect our work and bring it together?

¤<352581> I1: Does there need to be a group function at the very very beginning to lay all that out or not or can you start off with individuals?

E: (8 s) Well, you need to, you maybe need to clarify certain things about the problem. So, that's something you need a group for, in my mind. (2 s) To need to talk about certain aspects of the group.

¤<382080> I1: You may also (.) need to come together as a group briefly to be sure everybody is on the same page as to what you have to do.

E: Yes. Right. Right.

I1: A general procedure [what would]

E: Yuh, yuh

I1: This is in general how we solve problems. Let's agree on that and then (.) So your notion is, you would have something like that and then you'll go off and everybody think about it for a while. And then they will pool what they've learned.

E: That's one way I would [expect]

I1: Yeah, it sounds like an effective (.) an effective way. And the students may or may not have had anything like that in their mind when they -

¤<424232>E: (7 s) Except maybe for one group I could not observe it. I couldn't see it in class.

I1: This is something we find again and again (it this, you know, a sort of feel, is) when you look at the expert, the expert stops (.) before the question before really beginning to investigate, and says "o.k. here're some questions I need to ask".

E: mhm

I1: And the students (.) the unsuccessful students were often just immediately directioned to it =

E: Right

I1 = (grab stuff,) =

E: Right

I1: = make some solutions. So there is some kind of process that needs to happen at the very beginning when you define, see if I am right, when you define both the dynamics of what's gonna to happen in the group, make sure (everybody's agreeing with that) and you establish some kind of framework for what kinds of problem you deal with.

E: mhm

¤<477332>I1: So, then we have to know to do that first. And then, and then ideally - this is actual the ideal - then you would go into uh individual work.

E: Hmh

I1: What do people need to know about that? What do you do -

E: About the individual work?

I1: About the individual work. (2 s) What makes them successfully in individual work or -

¤<506382>E: I would say they need some (5s) idea about the concepts of the course. I mean the problems I gave them were application related. To apply the theoretical concepts we have talked about in a real problem context.

I2: When you say that they need to have the concepts of the course you mean subject matter?

E: Subject matter, yes.

I1: I then I mean, I assume, to make choices about which places subject matter are relevant or not relevant.

E: Right.

I1: Uhm. Just grabbing out -

E: Yes. And also how to, how to bring this problem into this subject context =

I1: Yuh, yes.

E: = or concepts.

¤<556970>I1: It is like the old thing of moving the theoretical thing to the word problem in elementary school or that.

E: The problems are not the typical word problems.

I1: No. But I mean it is a similar kind of move. You have to move from an abstract kind of thing to a praticular content.

E: They differ in some way that they (.), in my opinion at least, provide some kind of strategy to attack the global problem and not, and not "ok you answer this part and you answer this part." Not really related and everything is well constructed etc. etc.

Individual work in the first phase of problem solving requires connecting to course concepts.

Group work is more than distributing work among group members. The group's strategy needs to ensure that the sight of the global problem will not be lost.

¤<597934>I1: But your sense - if I understood you correctly - was that most of the students had that. They were working by themselves. They problably could have structured a strategy for - or not.

E: Not, not, no. Some of them. Maybe 10 percent of them could, could have done it.

¤<616794>I1: And the others couldn't. So, how do you do that? How do you develop a strategy for deciding what parts of the course are going to be relevant here and how do you going to do about the plan?

Deciding about what is relevant to connect to in the individual part of the group work

¤<634126>E: (6s) Well, Pólya comes to my mind. Have I solved a similar problem in the past? Do I know about a similar context where problems like this have been solved? Can I frame my problem with this context?

¤<648449>I1 Good [but]

E: (In general) how I decide -

I1 By the way, these are really hard questions you raise here.

E: I noticed, I noticed.

I1: And you are doing very well.

E: I noticed.

¤<657630>I1: Ah, they are very very hard. It's so much easier (to say you went) through other questions (than there what you do.) Well that's an interesting answer and uh they also points to where are the problems are for the students: Is it that you haven't solved this many problems? But still you solve some they deal with others. So one of the things you have to do is to go back in memory and think "O.k. what am I done before?" The work that might be relevant to this, this thing. Uh, that seems to be an important part.

¤<687402> E: Mhm

I1: Uuhm. Which is one of the positive aspects - and I assume there is a negative one too - that they have to be asking "What parts of the course are not relevant (.) here? What are the things don't I to work with." Is that a reasonable supposition?

¤<709332>E: (5s) I don't know. I am not sure if I would ask this question.

I1: OK [It may or it may not]

E: I am looking for the relevant parts, I am not looking for the part that's not relevant. And if I come up with some (.) ↑one part, and I think initially it is relevant and then it turns out not to be relevant, ok then I discard [and start again]

I1: you are constantly testing [the relevance]

E: how I would do it, yes.

¤<742248>I1: So there is two big pieces there. One is, is uhm (1s) how do you, how do you establish relevance? How to you establish this (.)m you know that week 3 class 2 problem 6 is something that I need to connect to what I am doing right now?

E: That is pretty easy in mathematics.

I1: OK, then maybe -

E: I mean, I mean (.) most concepts are (.) come with a definition. And a definition provides a context. Can I frame my problem in this context? Does it fit? Does it provide some answers I am looking for? (1s)

I1: OK

E: And if the matches I can apply it to my problem.

I1: And you don't think that's a problem. That's not a problematic thing to the students - by and large?

¤<790098>E: (4s) (hhh) I am not sure about this. I am really not sure about it.

I1: Because (1s) one -

E: Well I am sure about it. I think it is a problematic step because what I observe not only in ↑this class but also in other classes like for example last semester is, this step is (.) for the ↑students heavily assisted by things like Google and other media.

I1: Aah

E: So, they (.) When I go back in my materials and my mind and (.) try to fit it into this context and only then maybe look up further information I might require if that's necessary. (1s) What both of us observed is, they (1s) - Here is the problem. I take that literal problem and put it into Google.

I1: Oh

E: Does it come up with some kind of answer and any helpful information? Would you agree to that?

I1: Yeah. I can see that problem. So, what do you do before you go to Google?

¤<859909>E: (8s) Come up with questions I would like answered.

I1: Yeah. That is funny. How many (.) I am obsessed right now personally with questions (.) in history. I mean, it is just something we don't -

E: I am obsessed with questions too, because I think, one of our goals should be to get question into students' heads.

I1: And I find again and again, students' want answers. They don't understand you have to ask questions first -

E: Right, right, right, right. We don't have to think about answers as long as I don't have any questions in my mind.

I1: Yeah. Questions are so much more valuable, anyway.

Significance of questions and students' epistemologies

When working on a problem E tries to come up with questions he would like to have answered.

E views enabling students to ask questions as a teaching goal.

Potential bottleneck: Students do not perceive the clue of asking (self-generated) questions

Constructive alignment

How do we make students phrase their own learning goals?

¤<900316>E: I started (.) OK, I am changing context right now. Just for a minute, because it is something I am thinking about, too. You know about constructive alignment, right?

I1: Uuh, in what sense?

E: Ah, so you need to align your learning goals to your exam, and your teaching. OK. So. And I had a question in my mind about this. Who - Has anybody ever thought about aligning the learning goals of the teacher with the learning goals of the students?

I1: Yes, there is people who've talked about that and the difficulty how [we]

E: So if you have any information, I would be interested in [that]

I1: Yeah, I can't think. I cant' think [right now]

E: I couldn't find anything in the literature. We talked to Cynthia Heiner about it. She ↑liked the idea. But [she couldn't]

I1: Yuh, I've encountered that somewhere. But I can't remember where. Because, you know, we assume that its an automatic process.

E: Right!

I1: And it's not.

¤<951378>E: It's not. It's clearly not. And in this semester I've started giving out a handout with a few a questions on it: "What are your learning goals for this class?" That's the first question they had to answer upfront before class. I presented them the agenda for the class today and they had to formulate the learning goals (1s) which (3s) I have to go through all of this again. I have done this in the major part of the classes. I stopped about two weeks ago. In my opinion they were too shallow and too connected to what I presented in the agenda. So, for example, if agenda said we talk about least squares: "I would like to understand least squares". That's the pattern I saw regularly. (1s) And that's not something I (1s) would like to see there. And then after class they had to answer three other questions. One was "What can I do to approach or reach my

learning goals?" and uuh (2s) "Where do I need clarification?" and other remarks. ↓There is a third question. We can forget this third question. But the other two are important I think. And (.) it's my first attempt to come up with what are the questions in students' heads. And can I align my goals to these questions in some way?

¤<1038822>I1: Yuh, and that may not be all irrelevant to the problem we're dealing with right now. I mean there (.) a search for the immediate answer in Google may have something to do with how they imagine (.) one functions in the fields and it is about and what their goals are and what they're studying for etc.

E: Right. And especially for programming it works very well (.) because we have resources on the web that (.) provide (.)↑pretty good answers. (2s)

¤<1070114>I1: Yuh. It works until it doesn't.

E: It works it doesn't, right.

I1: And you need the problem that is not that clear. Or misinterpreted the connection. This is a non-example. Or your force your problem into what's available on the internet.

E: Right. And I think the ↑role of the person who works like this (.) changes a lot. I mean, usually you are considered the expert on some topic. And the expert's role is not to look up the answer on the web. They delegate this, this, this, this (.) yuh, part of being an expert (2s) to some unknown resource on the web (1s) and so (1s) in my opinion you need a different (.) the different uuh description of the role they, they, they, they, they -

¤<1117880>I1: Yeah, also if it's on the web they are not really need it. They think they are (playing) for is not (.) is not to be more than the just web. The web (at least) does the answer. It's the answer will (evolve) soon. But that's (beside [not intelligible])

¤<1134835> E: I am not sure about this.

I1: But uuh. OK, so, so they need to ask questions. They need to - Well, there is two things there. They need to understand their role and evolve in different way than there are. It sounds like. So there is thing about

Being an expert

Using the internet

what it means to be in the field and be operating. But then they need to know what kinds of questions, they need - Well, they didn't know that, they didn't that. Asking questions is crucial that's the (???) And then they need to know what questions, what kinds of questions. So, what questions would you be asking would you be asking at that point to decide? We are still I think on (.) on how to they know what from the course is gonna be useful for solving this problem, right? What kind of questions would you ask to help you to determine that?

¤<1184708>E: (14s) Hm, hm. What kind of questions would I ask? That's something that happens (2s) ↑implicitly somehow.

I1: Yes.

E: Well, that's about decoding the disciplines, I know. (((both laugh))) To make it explicit. (6s) I would ask questions that help me figure out the shape of the problem. And the shape and, and, and - The metaphor doesn't really fit. But something like a puzzle. What does the piece look like? And how does is fit into the remaining puzzle which I -

I1: It sounds like what you are not doing is having a list of, of like 15 categories and saying, you know, "This fits into this category". You're doing something else, it sounds like. [You are looking]

E: No, no, no, no. You mean a list of categories about subject matter, for example?

I1: Subject matter [This]

E: No, no, no, no. When I see a problem I recognize some of it fits into this (.) ↑branch of the, of the, of the -

I1: But it's something else you're doing when you are looking - When you are doing a jigsaw puzzle. You don't have in your mind uh there is, you probably (can't answer it though), there is fifteen kinds of shapes of pieces. And (what you per) number fourteen. I don't think that's what people do.

E: No.

I1: So, the students may be trying to do that. But that's not what you're doing. So, you are looking for some kind of pattern? Is that a word that's -

E: (hhh) yuh, yuh.

I1: Maybe a feeling. Make it a feeling when you look at certain things and connect (and do) something.

¤<1310802>E: (2s) It is somehow related to feelings, yuh. (2s) Whether this fits to my belief (.) that as an expert you need to (2s) develop expert intuition.

I1: Yuh. (.) Yuh in my sense is it [a psychological] -

E: And, and many, many, many, many decisions happen on this (3s) intuitive (.) level.

I1: But the students haven't developed that, yet. (2s) And they have to do it by doing it, but (.) they need some way to get there. (3s) Uuhm. If you can identify any of the things that you would (1s)- Oh, you look at a piece in a puzzle (1s) uuhm I think different people probably emphasize different things. Depending on the puzzle, we can be looking at the color, we can be looking at the shape, you can looking at the size, you can be looking at (.) the general picture of the whole puzzle and saying "how does that fit in?" (What do you think you are doing?

E: You look for clues in your problem. For example, certain keywords that appear.

I1: OK.

E: That's (.) When I said earlier I (.) ↑read the problem and then I try to come up with some kind of model of this problem. What are the entitities? And (.) how are they related in the problem? And what are the open questions? Where do I need to get to? And all these things I try to map to what I have in my mind.

I1: Yuh.

E: So, and they need to (.)- Obviously students in that sense need to identify what are the relevant topics, there. And what is expected of them. And that's something I noticed is very difficult. Presenting the results of their work. What ↑are (2s) the results that are expected of my work? Because in the posters - I looked at

the posters yesterday - and some of them just wrote down what they have typed into the computer. That's not the result! (.) That's their individual steps they have done. (2s) That's not even a strategy in some way. They just - it's on an action level. (.) They wrote down their actions.

¤<1450211>I1: So when you, when you read the question, certain things emerge for you (.) that are keys that (.) that probably affect emotions but uhm lead to a certain directions. Uhm (.) Can you think of a concrete example of something that (.) that might have been in that question that which you gave them (.) that would have, that they, would have alerted them to go towards certain parts of the course?

E: (2s) Well, one part of the problem asks for a condition of a matrix. So, condition number is a concept well defined. And here I have matrix, does it fit to my concept of condition number? Can I calculate it? And then I connect the other information I got from the teacher that two days ago that I need a numerics library that provides condition estimating. And (1s) that's pretty much (.) most of what I need to solve the problem. Here is a matrix, condition number, OK, condition estimating. I put these things together and have the condition number for a matrix.

¤<1517745>I1: Would it be reasonable to say that when you think about the material of the course uh you see it uh in some kind of schematic [whether]

E: ↑Yes and I, yes and I made the schematics as mind map of the course topics explicit to the students. We developed the mind map together (.) and I wrote that on the black board (.) and (.) two or three lectures later I added a (1s) missing piece of information to the mind map. And they really liked that (.) this mind map of the course topics.

¤<1554837>I1: This is great. Because [I see so often students]

E: And I also told them that's something I would expect of ↑them to do (.) while studying the subject. (.) But I see they don't do it, so I (.) brought it into class. Because I think it's somehow necessary to construct it in your mind and also I (.) hopefully made clear that this is just one representation about the concepts and the connections of the concepts in the course. You can, you can - their dynamic in some way. It's not the only representation.

¤<1589399>I1: I think, very often the students have a very linear notion and experience of the course. I am always very very happy when a student on week seven is just stopping and mentions something on week four. Because that's we did do, but a lot of students don't. This is [where you and I]

E: That's (.) I think personally - I don't have any data on this, but that's my belief - that's the strategy that they developed in school. Because usually when you have problems or exams (.) the context is always given. (.) Context given, OK, (.) we talked about linear systems, I need linear systems' things. And then I can solve the (.) - I look for the right formula and plug in the data from the problem.

¤<1629776>I1: So, one of the first things you would to looking at the problem then is, is keep in mind your schematic, your mental map of the course and then be looking for things that I can use in certain places. This may or may not be doing. Uh there seems like a really crucial first step (.) for the problem solving. Uh and then, once they gotten the link to a particular (.) part. What I am just saying is this, you know. There're certain parts that is not problematic. I am asking about various things and you may say "This part, I have noticed that the students can do it, etc." Uhm, but supposed the got that and they have this line in their mind. Something becomes highlighted in your map and so you go over to here (.) uh is there any - do you think they have any problem at that point in accessing what was learned there and bring it over here or is that [once they get there]? =

E: Yes.

I1: = OK.

¤<1686792>E: Yes. I don't think they, the, the, the (2s) ↑concepts in this map are fully developed in the students and that that would - in my opinion - be (.) too much to ask of them. They've just started learning about the subject. So, you don't (.)- They are not a concrete as they are for me or for [name of I2] or some kind of other experts who have regular contact and lots of connections to these concepts. And (.) so, at this point they need to have a vague understanding that there is a concept and it somehow fits (.) but need to look up information (.) to make it (4s) (hhh) - to reconstruct the concept.

I1: OK. Yuh [that's]

E: You understand what [I]

¤<1735890>I1 Yuh. Because there is two pieces, I think, or three pieces. The one is - is connecting to that. The second is understanding that again and refreshing your mind. While the third is seeing how that is applicable to that particular problem. So some process of reconstructing that knowledge in your mind, bring it back to mind, reorganize it, would be a crucial part.

¤<1757467>E Yes. And what I observe in this situation is (3s) they either (5s) fall in some kind of hibernation. (2s) I see that in class. They don't do anything. They know - I don't know if they know, but they are at this point. Maybe there is a concept related to it, but they (.) don't do anything. I don't know what happens in this situation. And I regularly ask in class "Then take out your textbook - look it up." (2s) And then they start to move. And what was the second thing? Or at this point (.) they look it up on Google (((laughs))). And they - What I dislike in when they look it up on Google - I don't think Google is evil or I don't know, but they should in my opinion connect to their (.) ↑own material, to their textbook, to their notes (1s) to strengthen the connections they already have. Because when they look it up on Google and come to Wikipedia for example there are usually lots of new things and different formulations and (.) that brings in some type of uncertainty.

¤<1841630>I1 Yuh, I can see that. So they need in some ways uh relive parts of the course.

¤<1850908>E Yuh, for example if you would like to build a house - a wooden house. I would expect that you have some idea in your mind. You need some beams here and some, some, some wooden plates there. You would start and would come up with a house. It wouldn't be perfect. But you have an idea. (.) On the other hand when you (.) think about the idea of building a house and look it up on Google you suddenly start to think about certain kinds of woods, certain kinds of connections, certain kinds these things. Lots of new problems you need to solve. And that's (1s) I think not really a starting point to learn something. I think you need to build your house or whatever from your first ideas and then continuously improve on this first one.

¤<1903347>I1: That's gonna be a hard one, because I would suspect that your students are coming in with a notion of knowledge that: Google gives it to you. And it is not about you constructing anything. It is passive. They take in and then apply it. Whereas you are saying there is this process that you have to internalize it or it doesn't work (.) in some way (.) and have to be clear about it. And then Google (1s) the Google move is

Possible detriments of using Google and metaphorical description of these detriments

E describes how using Google might result in more mental work than is needed for the purpose of solving the problem. Google might give you more details than you need and it will be hard for students to discriminate between the essentials and the details.

E creates the metaphor of building a house in order to describe the problem that using the internet brings with it.

gonna be in their mind (demove). I can see that. So you got to really fight against that and make it clear that why that's not useful. But what you just've said, it could be useful to you. I mean if Google is (.) is giving you in some ways more mental work than you need (.) to have that isn't of (potential) appeal to the students. They don't know (??? yourself to people that), you know, a way Google only had that particular question (whether they don't ask it) and ask "How do I work with the eaves?" You know, they ask "How to I make house?" It strikes me as a useful metaphor for what you just said. And I like that - to think about the house.

E I just come up with it.

¤<1972522>I1 Yeah, yeah. That might be a good thing to tell the students, because they need to understand why just going to Google for the answer is harder for them - in essence. So you gonna - They have to go there. They have to take concepts that they have sort of - and sort of don't have straight in their minds -

¤<1992985>E I just come up with another idea. My son is three years old. We (.) two days ago looked at (.) flowers and bees and (.) Hummeln?

I2: Uhm, humble bees.

E: Humble bees. Bees and humble bees on it and we looked how they (.) did their work and I told him some things about it. And then we looked at the feet of the bees and the Pollen?

I1: Pollen, yuh.

E: The pollen on the leg. And it wasn't clear - what I would like to show him wasn't clearly visible. So, after that we had a question in mind and we looked it up on Google and we found a picture and then we took this picture to, to, to, to uuh (.) build on this. And I could make my point clear. But there was an open question and I, I, I, I (.) ↑I knew what I was looking for. And (.) I am afraid in some similar situation my students would look up maybe, (.) I don't know, bees and they (.) come up with some kind of biological or I don't know description of bees. Something you couldn't understand if you don't have the background =

I1: Yeah, right.

E: = in this contexts.

Exemplification of the possible detriments of using Google by storytelling

E relates the possible detriments of internet usage to a recent experience educating his son.

I1: Or even insects.

E: Yuh. It is -

¤<2075618>I1: Yuh, look. That's a great metaphor. That's the kind of thing they can understand. That's a good thing to build in. So, they have to see the class as a kind of concept map of things linked. They have to look to the problem itself and see what links there are going off. They have to follow them to a certain parts of the course. Then they have to sort of revisit that part of the course briefly. Think about what they learned. Put it together. And then for the missing pieces. Then they can go off and get filled from the missing pieces. So they have that unit. Sort that in their mind. "This is that subject. I kind of got it recently enough." Then they have to come back to the problem in some sense, plug that into the problem, connect that to the problem. How do they do that?

I1 summarizes what it means to connect.

E Or come up with information that is missing, that you need to plug in.

I1 Oh yeah.

E For example in certain problems you might come up with this information first and you can plug in. You see there is a gap. Problem leads you ↑here. And your answer is here. But you need this information.

¤<27588>I1 How do you do that? That's an interesting thing. Uhm. How do you know what you don't know?

E I have some - I think one of the problems I have given them is exactly this. (3s) Falls into this category, because (3s) - I don't know about your math background?

I1 It is pretty limited.

E Ok, so at the first part of the problem they came up with a polynomial that gives you the duration something takes in seconds.

I1 OK

E OK. And the second part of the problem asks about (2s) some expression that gives you the number of operations per time, so a different unit. And they need to convert the polynomial to the different unit. And

that's something they need to do recognize. It is not explicitly stated in the uh problem. But what is stated in the problem is to ↑connect the information from the first part to something that is found in the textbook which is taking about time complexity. Number of operations per time unit. So the idea "I need to convert this" (.) I ↑expect to be difficult for (.) most of them. And I already have one data point. One student asked me about exactly this. (.) "I did this", he wrote in an email "I did these steps. And now I am not sure what I am supposed to do." And he is exactly stuck at this point. And now he is trying to bring it back into the context of the first part of the problem. "Should I do the experiments again with this?"

¤<129156>I1 It sound like and you said this right, it sounds like what you do at that point (.) is: The details of the problems are here and some part of you is pulling up above (.) and saying "I got this there over here and there over here. And I get -" Like, going at a different level of abstraction and looking at the pieces of the problem not being locked into the individual part. So that it's a part of the process going back and forth between the whole thing and then the details. And then asking questions. Isn't that a wonderful example (how we know about it?)

¤<158887>E That's my mind. Something experts need to do. And those are master students and not some Bachelor students and that's -

I1 On the college board tests in the United States some years ago they asked a question, a simple question that involved uh - The army were trying to move so many troops and there were so many buses. And uh how many buses do they need to do that? You know that example? And something like 35% of students said "It takes 13 and a halve buses." (2s) [Because that was]

E Yeah. That's is the result of the formula.

I1 It's so - you just plug it in. But some part of your brain has to be up here looking at the problem and saying "No it's buses. It is not just number." Going back and back and forth between two different levels. And that's of course hard for the students. And they didn't know that they have to do that. So there is some part of your brain that's moving around looking at the details and again looking at the whole.

¤<224345> I1: Yeah (hhh) So you know, this is hard work, isn't it. What do you attempt to do? I mean if you can break it down, there is a lot of stuff here. Not that they can't do it. It is just that there is lot of things they

have to (.) be mastering. So they uh, so now they decided how to - they are trying to apply that problem. And what are said to be attentioned to it, but they don't know yet? They need to go back. So, in many cases they would need go back to a (.) probably to another part of the course. And then one of those lines. And then pull in another thing that allows them to move to the next step. I am assuming, but I am not sure that there is a fairly prescribed order in which you would be dealing with these things to solve the problem - or can you plunge in and move into a different directions, to do different parts?

E: (4s) (hhh)

¤<280135>I1: Is there a place [to start?]

E: No, there's, there's uh order. In the problem there is linear order. And that's something I feel I need to (.) at this point in time I need to provide them with, I cannot give them open problems. The strategy we talked about is not fully developed. So they need ↑some support. Some kind of scaffolding and that's provided by the order in the problem I think.

I1 So, there is no problem with. Maybe you do things. It's just like you are taking them through. Which is probably a very good step. To allow them to learn those other things. A lot of things we do that screws things up so much as we ask students to do too many new things at the same time and I thing they lock up and don't get anywhere. So, so providing them with - you know - later on we can give them questions where they have to figure out where to start. But that makes a lot of sense. OK, so that's not an issue in this case. Uuhm. ↓So where've we got? ↑By the way you are very very clear with this stuff.

E: I thought a lot about it.

I1: Oh you obviously have. I can tell [what people have]

E: But I still don't understand it. I still don't understand it.

I1: Yeah. But you are understanding is a hell lot than most people do about this stuff.

¤<353894>I2: Well, I guess what you are missing is is the solution, right? (2s) You said you don't understand it.

E emphasizes that he is not longing for a solution in the sense of ways of improvement. Rather he would like to understand what is going on. That is his goal. Having achieved this goal would be a solution to him.

E: I am not looking for the solution. I am looking for an explanation.

I2: OK

E: I am not looking for a solution, I am looking for an explanation. More in the sense of a theory to explain what (.) I observe. If you would call (.) I don't think you (.) Ich unterstell' Dir jetzt - sorry for the German - ich unterstell' Dir jetzt mal, dass Du mit solution eine Lösung zur Verbesserung der Lage meinst.

I2: Mmh

E: Das möchte ich nicht. Ich möchte 'ne Lösung, die mir beschreibt, was da vor sich geht. Das ist 'ne Lösung für mich. Danach such' ich.

I2: OK. Good that you said that because that hasn't been clear to me, so far. I was -

E: Und ↑dann kann ich überlagen "Was kann ich machen?", weil ich glaube es gibt nicht eine Lösung.

I2: Yuh, yuh. That's definitely - sorry.

E: OK, sondern wenn ich ein Modell hab', dann kann ich sagen "OK. Ja, das sind die relevanten Sachen, die ich kann ich beispielsweise durch die[se] Lösung einbeziehen". What I said is, I am not looking for a solution in the sense of "here is the result" and that changes the whole situation. I am looking for a solution in the sense of (.) it provides me with a theory that explains what's going on and how I can deal with these things.

¤<438496> I1 Yuh, that makes sense. Ok. It sounds to me like you are getting a lot of insights into what's happening and not happening with the students. And there is a ↑lot of pieces here.

E [Well, I learned a lot.]

I1 And any one of these missed could be a black. You know. Students (that didn't) get any further. They go into some kind of meaningless work to fill out the time because they don't know what to do. And it's an iterative process which is also familiar. You go out there and you come back and go out there and you come back. You go (.) ↑this level and you go back to that level. And back and forth. So it seems that you have

several levels. There is this - It's not a simple linear thing. You go here and you go "oh, I did this back over here and now over here". And so there is lot of places where students can get lost in this.

¤<488304>E That's something that has regularly - in my mind, in my opinion at least - regularly been part of the course.

I2 What has been part of the course regularly? Sorry, I missed the point.

E This -

I1 This getting lost, you mean.

E We don't have a linear way through the material. We connect things from a different angles with each other. And we go back a little bit and now we talk (4s) I have some pictures in my mind. I cannot describe them.

¤<523956>I1 Well, there are two questions to ask about that. Is that an inherent (.) quality to the work? To which when you are doing this work is it inevitably involve that? ↑Or would it be possible to give students at least (1s) well. Put it back. I am saying - In some situations you can actually produce something like a flow chart for students and saying "do this, do that, do that, do that!" Uh, the danger of that is that they will apply that to every situation. But nevertheless it can be useful as a step in which they can get to see the sequence of things than you can complicate it. Sometimes that's got, sometimes it's not. But (.) this may not be a situation in which -

E: Are you taking about (2s) giving them some kind of flow chart or having them develop their own flow chart.

¤<582920>I1: No, either one.

E: That's something different

I1: Yuh, but it's very different. But in both cases you're imagining -

E: because the second one requires the ability (1s) to develop some kind of flow chart.

I1: That's right.

E: And that's something that's (1s) maybe one of my, well I am pretty sure, one of the learning goals =

¤<601149>I1: Oh yuh. I understand [that]

E: = and should be across courses.

I1: Sure. But what I'm asking is

E: Because this flow chart in my mind at least is something dynamical and you need to develop it again and again for new problems.

¤<614206>I1: Yeah, but there's. I am trying to get something a little different. It may not be a meaningful question, but let me press a little more. In some fields you can probably produce (.) a flow chart which will allow someone to perform the activity straightforward. That you decide you always do A, then you always to B, then you always do C. In other situations you can't do that because (.) =

E: Yeah, OK

I1: = sometimes - let's say - sometimes you go up here etc. Is there something about this - the type of problem you are dealing with - that means that a flow chart is always misleading because you don't do that or (.) is it (.) you know - in any particular case there may be flow chart which gets you to the right place.

¤<659908>E: Well, I tried to integrate ↑some aspects of a flow chart to the mind map I earlier talked about.

I1: OK

E: That's part of the connections between the things that appear in the mind map. So "I have this and this splits up into these three things and the condition to go this way and this way is that", for example. That's I think some notion of a flow chart in there.

I1: Yuh, OK.

E: A flow chart how you can navigate this mind map.

¤<694318>I1: And this, I am sorry, I am going off for my own intellectual (.) thing here, which may not be relevant. But, I am just curious about that. Are there fields in which the flow chart is a ↑lie? In other words that when you really operating in it (1s) ten people would do this in ten different ways. Uhm, and that's the appropriate thing. In other circumstances - you know - Are these fields like that? But it sounds like in this one you could imagine (.) giving students a pathway through a problem (.) which was at least one of the best ones.

¤<732054> E: (2s) That's something I want to do today (1s) because I want (4s) - I thought about what to do right now because I haven't finished working on the problems. And I think it is important to do this work instead of starting with a new topic. We have two more classes (.) until the lectures end. And (1s) my plan for those two classes was to start with a new topic (1s) or to bring in a new topic they already read about. And now I decided to (2s) today spend the time on working on the problems. And I talk to the groups that were working on problem 1 and working two problem 2 and come up with some strategic help. To make sure they understand the way through the problem and then have them follow this way.

I1: Yeah. This seem to me the essential crucial thing (that you're dealing with it) like this. If they don't get this kind of process I wonder if they going to be successful in the field at all in the long run. I mean, really understanding what you're talking about this kind of thing.

E: This is something I am wandering about, too.

I1: Yuh.

¤<808808>E: Right now, the situation is that (.) anyone gets a job. From friends in industry I - they need any kind with a computer - any kind of person with a computer science background. And they hire everyone.

I1: That's a disadvantage for the teachers, but -

E: It is.

I1: It's a disadvantage for the students too in the long run, I bet. You know, the first time there is a down turn or something like that (.) people would really (know how to do it to gonna staying there). But's that another matter. That's hard.↑ So uuhm

¤<845357>E: Well it depends on your, on your (1s) beliefs about work, I mean (2s) - If employers hire everyone they usually don't get to do the things you are maybe interested in doing. You get to do some easy things. Copy and playing. One of my friends told me about he spends his whole day copy and pasting things. And you don't need someone with a computer science background. That's not challenging, that's not -

I1: But it seems like, like it would be really useful for you to spend some time (.) going through your process like what you just talked about here really showing how you do it maybe interactively, saying you know "Here is - What you think the next step is?" and then "Well, but I (you know there's problem here), that's good and think about this". Because I can see why somebody would be confused uhm with this process which is actually a pretty elegant one you're describing.

¤<907564> E: But I am afraid from what I have observed in the past we had similar situations in this semester. And (1s) on a metalevel they don't learn from it. I cannot see any effect.

I1: One thing you might [think -]

E: Maybe it's because of me. I cannot see any effect or it really didn't have any effect or takes some time. I don't know but (4s)

¤<935810> I2: What effects are you here referring to or hoping for? Could you make that explicit at that point. When you say that you don't see any effects. What would you like to observe?

E: (2s) A situation that is very present in my mind is uuh the textbook talked about certain operations on matrices. Uuhm and one aspect of these - of the definition of these operation was for me at least immediately clear. That those definitions are a specifications for someone who is able to program. You can immediately write a program fulfilling the specification. (.) And that I noticed was new to them. [The connection]

I2: This idea?

¤<984896>E: This idea. And also what was new to them is that they can use programming as a way to understand the mathematics (.) the operational character - what does it do? (.) And I noticed that and I immediately took it into the classroom and had them (.) implement the specifications and then build on it and we build a bigger program and bigger program and bigger program around that. And then at one point a few classes later (2s) I spent a few minutes on reflection. "What did we do here?" Because my goal was that - to provide them with a way to (2s) understand the material (5s) with a new way to understand the material (3s) with a new way to understand the material by for example programming (.) the mathematics behind. To connect programming. Something they are familiar with. Something they can experience more clearly than just reading mathematical textbook. (1s) Something they can play around with and (2s) I think I made it clear (.) that (.) this is a strategy to deal with literature for a computer scientist. (1s) But (.) the effect I am missing is that they apply this strategy to new contexts.(.) I don't see that happening.

I1: Yeah, that's also one of the big (.) challenges. (.) Transferability is just a (.) is a challenge in every field. (.) Uuh and it takes time sometimes.

¤<1089134> E: Maybe.

I1: And sometimes, you know, one course isn't enough. Or sometimes they [even]

E: No, I agree isn't enough and it should be (.) a part of any course. I think we should (.) here at our university we should connect mathematics with programming, for example. (.) And I talked about it (laughs) at lunch to our dean and he wasn't so sure about this.

I1: I guess the frustrating thing about what we do is that (1s) there is reasons to suspect that some of these students five years down the road will be faced with some problem. And some piece of what you did will come back and leave them to [reconstruct some of the steps] =

E: Hopefully [hopefully]

I1: = but we don't get to see that =

E: Yes

I1: = and so we don't know what the real impact of what we're doing is. Something else you might consider (.) is uuhm (1s) we give students assignments ↓like you did this time - you might consider giving the assignments not on a whole task but on the pieces of it. [In other words -]

E: What do you mean?

I1: Uuhm, what's a (2s). Take some part of the problem (.) solving that we've been talking about. Uuh like, uuh (2s) relate this problem to the concept map.

¤<1162552> E: Oh, so make that, make this problem solving part of the assignment?

I1: That's the assignment.

E: OK

I1: You know, this time we do that and we need [to =]

E: I need to watch the video. So, I remember what I said about problem solving.

I1: = in insolation or the part you do with the very nice [piece]

E: Oh, that's similar to what Cynthia said when we talked to her. And that's something I really would like to do, but(.) I don't have time. But it was the first time I had this lecture so that took a huge amount of time, but in the future we should this in some way.

¤<1202074>I1: (Or that's easy than - Nice piece here.) You are very good on this path (you are pretty good.) I am learning a lot of this. But uhm the nice piece you had about how you have to sort of reestablish your knowledge of a particular area of the course before you use it - which is something we don't know to teach to use, we act as if the student learn it just marching through. And they don't even realize that they have to go back and go through a process to be -

E: In my opinion that's so wrong [in teaching]

I1: And so [sometimes]

E: Because suddenly the teacher has some superhuman abilities. And I don't think someone who is new to a subject has everything just from listening. You cannot expect that. Maybe some people are like this but the majority of humans are not.

¤<1257833> I1: Some of my colleagues said to me (???) that "It's always the next to last math class that you take that you understand." It's (different) the last math class you take.

E: We try to (2s) address this by having them read the text upfront (.) in Just in Time Teaching. So, they're familiar with the material, they had initial contact with the material. They don't come unprepared. Well, actually they do come unprepared because if the time between reading and the lecture that's covering the material is too long - and I had this several times because I found out other issues to address first before going into the -. Like for example right now. They had to finish their reading about their new subject last week. And we still haven't talked about it (.) because I found new things to talk about first.

¤<1317045> I1: Uhm the other issue of course is you are saying is time. Uhm often though you can work in uhm (1s) what you having them do in terms of modeling just the processes with a particular subject matter. In other words you want your reiterate your reflection on this and then say "OK now imagine you are doing a problem which you're to use this" but you are also modeling that piece of the process. Uh, but you you've just described is a very (.) very complicated long process and I would really urge you to think about slicing it up to pieces and only at the end of the game to integrate it. The notion of integrating is an important thing. They can learn all the pieces and not know to put it together. But really they have to get all the pieces to the very natural before they can really integrate them into this seamless process that you do.

E: I agree, I agree. Yuh. That's something I immediately see a benefit in. Yuh.

I1: What you've done here and what's on that tape I think is extremely valuable. Well, I don't know you feel it at all.

I2: So do I. ¤<1386786>[...not transcribed...]

¤<1441738> I1: Here this is beautiful. I mean you are so much easier to work with than a lot of people (???) we interview (???) Where you got to drag it out because they are not (???) But you came out just with a very

clear vision. Now of course reality always is more ambiguous than we want it to be but if you really go ↑teach this you may find there is other pieces that you have in, you know, there and other things that they need to do.

¤<1468255> E: Well blame him. He put some question in my mind. Well, some of them are my own but some of them are coming from him -

I1: Well something else I am really [in the last year] =

E: But the starting point are again the questions we have in our mind,

I1: = In the last year or those two before two things very particularly affected me. One is spending more time with Just in Time Teaching. We are asking how valuable the connection is between Decoding and Just in Time Teaching. We are going to do another session in October with Gregor Novak and with a woman he works with at the Airforce Academy at the National Society of Scholarship of Teaching and Learning. And we are going to do another on in Los Angeles in the campus next year. ¤<1515691>

And the other thing was a group at Mount Royal University in Canada. They've been working on Decoding. And they (.) they're coming up with a new volume in the New Directions of Teaching and Learning series of what they are doing. They will (???) all sorts (???) choosing using phenomenology and (???) stuff like that. In connection of ways that I have not even thought about. But the piece I got of them which's so powerful was community. Was a hell - what happened right here is so essential that they created a group, they interviewed each other, they did transcripts, everybody wrote a comment to on their own transcript and then they kept interacting. And I think that - it's very hard to this by yourself, but you got colleagues that can talk and share - I mean, it's a - I am always felt that but I feel even stronger now watching what they've done which is really quite interesting there. So uhm, I think what you're doing here is, is (.) certainly worth not only the exploration but also of, of publicizing. Either through papers or conference papers or articles or whatever. Down the road I think it may something you want, it may not fit in your group but I think it would certainly be a good thing to do if it fitting with your group lens.

¤<1601507> E: Well right now it doesn't because I need to finish my theses. [...not transcribed...]

¤<1630768> I1: Just think about the possibility of sharing this some time in some form. Uh, think about what material you could collect that would be evidence of change. And just tick those what you're doing. And then when it becomes appropriate if you want that it becomes appropriate then you're in position to do that. I think this would be valuable to a lot of people. I am gonna certainly -

E: I need to write down notes.

I1: There's a group on our campus that are using decoding in computer science and I think they would, I mean, what you just did would be terribly valuable to them and sure to a lot of other people because you've clarified a (- Though the problem with) what you've done -

¤<1670120> E: I think we've, we can pretty much clarify the problem pretty well. Now we need a (.) strategy to attack the problem.

I1: Yes, but, but understanding what the problem is as you said a few minutes ago is having a concept of its (???) and important for you.

E: That's a major part of understanding the problem.

I1: There's so much of stuff that happens with (.) teaching and learning. It's just (1s) blindly grabbing some kind of method and throwing it at the problem.

E: Right, yes.

¤<1699216>I1: And you divide the problem which is (.) in the method and you can find a lot of methods out there and do it (but you you really need to find it. Well though) the problem with what you've done I think is that it is very sophisticated. You already thought about whole lot of this stuff. And I could imagine somebody else reading it (.) cold (.) having difficulty grasping some of the concepts that you came up with so immediately. You have to, you know, there are people out there who there who (gobble) this up and saying "this is great." Other (might say) "What do you mean all this?" You know this thing about the concept map and moving over here and that kind of stuff. Uhm, so you have to explain it. (By that) I think down the road when you wanna to this I think this is, this will be a great project.

¤<1742483> E: Well, that's difficult for me because (1s) it feels natural to me. I have problems (.) looking at this from the angle of those people that have problems with it.

I1: Well, as you said (yourself a lot of) these people do (.) automatically, you know, it is just instinctively because they soaked it up. And if they haven't stopped to think about it the things you're taking about they are gonna "What? What do mean?" I mean if they spend time on it I think they'll probably see it. "Oh yuh, I am doing some of these things." But uhm. Anyway that's great, great work!

¤<1782438>E: Well, thank you. But. (.) Yuh, well, I feel I am one step closer to my desired solution.

I2: But the positive thing is, uh (.) what you have talked about is a generic problem. It's not related to numerics at all. I mean, that has been clear to us upfront, I agree. But, but =

E: It's not, it's not related.

I2: = that, that means =

E: I am using numerics as a vehicle [to approach the problem.]

I2: yeah, yeah, but that means at least from my perspective, I have plenty of opportunities, it's not - to work on that because it's related to, to, to any of my classes. And, yuh, the bottom line is, I am just - which became clear to me right from the beginning "OK, we are assuming that students are capable of uh attacking problems in groups and individually and that intertwined. And uh that needs more support, more scaffolding." And this interview has at least shown at a few points how that might look like.

¤<1848648> I1: Although that's whole area that we didn't explore fully. Which is the dynamics of (.) "how does someone take advantage of the dynamics of the group?" Which is a whole different dimensions [here]

E: That's a whole different dimension, yes.

I1: But if they can't do this stuff the group dynamics is not gonna help much, unless they have some sense of what you're talking about right here about this kind of skill because (.) having an effective group that don't know what it's doing - I mean effectively in terms of the (.) interactions.

E: But there is one question: Can maybe (1s) addressing group dynamics - I am thinking about Team Based Learning, for example - if you frame your classes in Team Bases Learning scenarios, can this help with the problems we observed in my class, for example?

I1: I think it can be -

E: For example, one - immediately - Last time I had Tobias Reinhardt with me in during this exercise in class and we talked about it afterwards and one (2s) - Maybe you can explain it to us. And one keyword that fell afterwards in the discussion was accountability.

¤<1921520> I2: Hm. That's a got question: What is the meaning of accountability?

E: In our group we talked about accountability. What is the proper German translation? What is the meaning behind it or the intended meaning behind it? We couldn't really figure, but we could recognize it that accountability was lacking last time and the group work. Because people unprepared, people don't bring their notebooks, people bring their notebooks but don't have their software on it. They cannot program, they have not spend time on (.) the numerical libraries I explicitly asked them to prepare for this class and things like that. And I personally believe that's something that goes into the category of accountability.

I1: Oh that's a big piece of this, for sure.

E: But we lack a clear definition of what accountability or - not really a definition but a meaning. (.) Maybe you could help us with understanding accountability? There's no proper German translation.

¤<1986881>I1: Yeah, wow. What is accountability? (I mean this is one of these words) we use.

E: How would you differentiate between accountability and liability, for example? Or accountability and responsibility?(4s) In this context?

I1: Well, (1s) those're - ↑That is a brilliant question and you turned it on to me. So, liability, responsibility, accountability. Those were the three you mentioned? Well, liability is uhm - it's a matter of felling, of course, a lot, but it's closer to legal issues. It's - is not necessarily a moral dimension. Uh. You can be a terrible person and uh

Accountability

I2: and yet liable, because you're sticking to the rules.

¤<2044765>I1: Yuh, right. And you avoid the liability. Somebody else can be doing the right thing. They can go (probably change the laws of evidence) the time you could have gone in someone's - hitting the car accident, you're trying to help them, stay alive and then you're sued for that. In the (real) life that would be liability. You would, you would probably use the word accountability but it will be, ¤<2067604> you would be accountable, you would be acting positive in terms of accountability, but you have a negative liability in that situation. Although - that's not - accountability is not the word you would use there but still you could. So, that's one distinction uh between them. Responsibility and accountability are closer to each other. Uhm. But (.) responsibility, I think, it seems to me is more of an individual term. "I am responsible for things in the world." Accountability is being - involves uh

I2: Another - to which you are accountable to.

¤<2107372>I1: Yes, that's right. You can be responsible to God, you can be responsible to your consciousness, you can be responsibly to a lot of different - to an abstract principle. You wouldn't be accountable to an abstract principle. There has to be a social dimension, I think, to accountability. Well, I think, I did that (((laughs))).