AC 2007-773: ANALYZING STUDENT TEAM DIALOGUES TO GUIDE THE DESIGN OF ACTIVE LEARNING SESSIONS

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Abstract

Engineering faculty are increasingly using active learning methods to improve learning in their classes. Many methods and their uses are described in the literature. These methods range from impromptu techniques such as "think-pair-share" up to strategies for structuring the entire course. The strength of these methods relies on generating student interactions marked with deep cognitive reasoning. Presumably, the greater the depth of reasoning in interactions, the greater the potential for learning. We define deep interactions as conversations that show thoughtful use of schema to organize information and/or the organization of information to create schema. In contrast, shallow interactions deal primarily with exchange of information.

Active learning methods, when used properly, initiate deep student interactions. However, many teaching environments do not directly fit into the prescription of a well-researched method. Consequently, at times faculty must thoughtfully adapt these methods for their classes. However, in doing so there is no guarantee that deep interactions will ensue. Furthermore, faculty may also wish to diagnose whether their application of an active learning method is working as planned. One way to assess active learning is to assess the depth of the student interactions. These interactions may be assessed by recording, transcribing, and analyzing student dialogues. Our question is:

> What important design features for active learning sessions can be identified by the use of brief analyses of student dialogue?

This case study examines the student dialogues in four sequential active learning sessions. In each session, a student team was recorded and their conversation transcribed. The transcription was reviewed and the observations were used to improve the design of the next session. After the conclusion of the sessions, the transcripts were examined for trends that emerged across multiple sessions. Three findings emerged:

1. Briefly coding transcripts by identify major themes and then coding along those themes surfaced substantial feedback to improve the design of the active sessions. The use of coding criteria, such as the three principles of learning, was used informally to interpret the content of the coding. The iterative use of transcript coding and session improvement created sessions with dialogues showing deeper interactions.

2. The student learning appeared to be tied to context. When the case supplied the context, the students used it to create schema. When the context was not supplied, the students created their own context to use. Consequently, cases that provide a rich context appear to better support the use of schemas related to the case.

3. The students seemed to intuitively identify the challenge in each session and apply their efforts to resolving it. This included challenges that were unintentionally introduced into the

case. Including interdependencies within the case, that is information that cannot be resolved serially, appears to be one way to add challenge that leads to deeper interactions.

1. Introduction

Engineering faculty are increasingly using active learning methods in their classes.[1] Many of these methods have an established track record of facilitating improved learning.[2, 3] Furthermore, active learning methods, with their large amounts of student interactions, seem especially appropriate when teaching teamwork.

The pedagogical strength of active learning methods relies on generating student interactions marked by deeper reasoning. Presumably, deeper interactions lead to deeper and increased learning. We define deep interactions as conversations that show thoughtful use of schema to organize information and/or the organization of information to create schema. In contrast, shallow interactions deal primarily with the exchange of information.

Active learning methods, when used properly, initiate deep student interactions. However, many teaching environments do not directly fit into the prescription of a well-researched method. Consequently, at times faculty must thoughtfully adapt these methods for their classes. However, in doing so there is no guarantee that deep interactions will ensue. Furthermore, faculty may also wish to diagnose whether their application of an active learning method is working as planned.

At Gonzaga University, we use active learning sessions in a Junior-level design class. Each of these sessions combine brief mini-lectures, a problem to solve situated in a case, and a set of tasks for the student team to complete. The aim of these sessions is to teach teamwork skills such as group problem solving, team logistical planning, and giving peer feedback. During each session, the students energetically discuss the topics and work on the cases given in the session handouts. On the surface, the interactions appear to create a strong learning environment. The students are engaged, interacting, and on task.

This case study looks below the surface to assess the depth of the student interactions. The depth of interactions is assessed by recording, transcribing, and analyzing the student dialogues. The student interactions are then compared to the session handouts to infer what elements within the handouts may have contributed to deeper interactions. Our research question is:

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This case study examines the student dialogues in four sequential active learning sessions. In each session, a student team was recorded and their conversation transcribed. The transcription was reviewed and the observations were used to improve the design of the next session. After the conclusion of the sessions, the transcripts were examined for trends that emerged across multiple sessions. The data revealed that providing rich contextual information and embedded interdependencies in the active session cases contributed to the deeper interactions.

2. Background Literature

This study touches on three areas of literature. First, the active learning session design in this study draws from Bean[4] and Michaelsen, Knight, and Fink.[5] Second, methods for coding qualitative data to analyze the dialogue transcripts are followed. Third, theories of learning form assessment criteria used in analyses. These areas of literature are briefly discussed in the following sections.

2.1. Active Learning Literature

Active Learning is an umbrella that encompasses methods where students interact with each other while learning course content.[1, 3] Some of these methods utilize brief interaction while others depend on lengthy interactions. For example, one method that uses brief interactions inserts "think-pair-share" activities at routine intervals in lectures.[6] At the other extreme are cooperative learning methods[7] where students interact on projects that last an entire semester.

This study investigates activities where student teams interact during the major portion of a typical class period. This length of activity was chosen because it fit the amount of content being presented. Each session presented a single collaborative engineering skill, such as group problem solving or team logistical planning.

The sessions in this study were designed to follow a model prescribed by Bean.[4] In Bean's model, groups of students work on difficult problems within class. To manage the activities he recommends creating handouts that:

1. Present open-ended tasks that allow for multiple possible solutions
2. Define specific delivered outcomes for the tasks
3. Include clear directions
4. Specify processes to fulfill the tasks

Michaelsen, Knight, and Fink[5] describe a "Team-Based Learning" method where small teams solve problems in class to learn course material. Their use of intact learning teams within the class is quite similar to Bean's approach. However, their teams are structured within the framework of the entire course which includes team grades to motivate team behavior.

Michaelsen, et al relies on the task design and accountability to foster individual contribution to teams. Their recommendations for task design are listed below. Note that these recommendations are complementary, and not contradictory, to Bean's model.

1. Use the same problem across all teams so the teams can later interact over their varied results
2. Design problems that require teams to make specific choices to complete the work
3. Simultaneously report team results to the entire class and have teams defend their choices

The sessions in this study incorporated items 1 and 2 of Michaelsen, et al's recommendations. In contrast, the sessions were concluded with a general discussion rather than a simultaneous reporting of results.

Perhaps the best-known active learning strategy is presented by Johnson, Johnson, and Smith.[7] In contrast to Bean and Michaelsen et al, they emphasize using long-term learning teams on large tasks that necessitate student learning to complete. To make long term teams function properly, the instructor must insure five elements of the learning environment.

1. Positive interdependence of teammates
2. Face-to-face promotive interactions for teammates
3. Individual accountability
4. Functioning social skills
5. An instructor insuring group processes are running

The five necessities of Johnson, Johnson, and Smith allow teams to function somewhat autonomous of the class on large projects. Without the instructor managing these five necessities, teams can lose cohesion resulting in lost learning opportunities. In contrast, Michaelsen et al. promote group cohesion by simply maintaining team task focus within the classroom. In this study, the teams were used informally to supplement the main body of the class, hence group cohesion only needed to be maintained for the short exercises in class. Consequently, Johnson et al's necessities were addressed only as needed during the sessions.

2.2. Analysis Method of Transcribed Dialogue

During each practice session, an audio and video recording was made of one of the student teams. Each recording was transcribed and subsequently coded to identify pertinent aspects of the conversation. The transcriptions were coded using standard techniques for coding qualitative data.[8, 9, 10, 11] It should be noted that transcription data is very rich in content and can be coded to inform a wide variety of investigations. Furthermore, transcriptions can be coded very deeply to surface subtle effects. Since the intent of this study was to learn from *brief coding*, the transcripts were coded to identify the most obvious features of the conversations in the categories specified by the theoretical lenses (section 2.3).

The audio and/or video recordings were also influential in the coding process. These recordings were reviewed enough times so that the coders could "enter into" the conversation. This ability to participate as a silent third party allowed the coders to see the conversation from the perspective of the participants. Such a perspective increased the ease of interpretation of utterances and responses.

2.3. Theoretical Lenses for Analysis

As transcripts were reviewed, the contents of discussions were identified. This content was then classified by applying assessment criteria. Two different theoretical lenses formed assessment criteria: Bloom's Taxonomy[12] and the three principles of learning per Donovan and Bransford.[13] These lenses were applied by choice, as appropriate to each specific transcript, rather than being applied to all transcripts.

Bloom's Taxonomy organizes knowledge into multiple levels, with each level building upon the lower levels. The lowest three levels of Bloom's Taxonomy are:

1. Knowledge (factual information or content)
2. Comprehension (assigning meaning or relational understanding to or between content)
3. Application

Students need to understand the factual information in order to understand how the information relates to itself. Students need to understand the meaning of the content in order to thoughtfully apply it.

The taxonomy was used as assessment criteria in the following way. When the students listed only facts or information (Bloom's level one), it was considered a shallow interaction. However, when the students organized the facts relative to each other in a meaningful way (Bloom's level two), it was considered a deep interaction.

The three principles of learning from the cognitive sciences suggest another set of assessment criteria. Many studies in this field have demonstrated that learning is a natural phenomenon that follows common patterns. Donovan and Bransford[13] summarize these patterns as three principles.

1. Learning must engage and build upon prior understandings. If prior understandings are faulty or inadequate, they must be addressed.
2. Factual knowledge must be learned within relevant schema. Conversely, relevant schemas are best understood with multiple examples of factual knowledge that fit the schema.
3. Metacognition, that is self-monitoring of learning, is fundamental to mastery.

Whereas Bloom's Taxonomy describes levels of knowledge, the three principles of learning describe *ideal conditions* for learning. Consequently, assessment criteria based on the three principles indicate whether a discussion is a solid learning environment. The three principles were applied in the following way.

1. Are the students identifying their relevant prior understandings and is there evidence that they are building upon it? This question identifies whether the discussion connects the new learning to what they already know.
2. Are the students using schema to assess or organize their information and/or are they arranging information into stated schema? This criterion is the same as differentiating a deep from a shallow discussion using the Bloom's Taxonomy.
3. The third principle of learning was not used an assessment criteria.

3. Methods: Learning from Student Dialogues to Improve Session Design

Figure 1 diagrams how good design practices for active learning sessions were identified using the student dialogues. The design of each session consisted of two elements: a case or problem to be solved and specific tasks for the students to complete. These elements were packaged in typical classroom handouts. The handouts were then used as a normal part of a regularly scheduled class. During the active session, one team of students was video/audio taped. The recording was transcribed. The case and tasks were then inserted into the transcription to make it easier to compare the session design to the conversation it initiated. The transcripts were then reviewed line-by-line in context with the given case and tasks. The video and/or audio recording were also reviewed. Characteristics of the conversations that seemed pertinent to student learning were noted. These observations were then compared to the case and tasks to create a list of plausible connections. This list of connections was then used to create a list of "best practices" to incorporate into subsequent sessions. Each subsequent session incorporated the presumed better practices and became an opportunity to observe student conversations initiated by the (hopefully) improved session design.

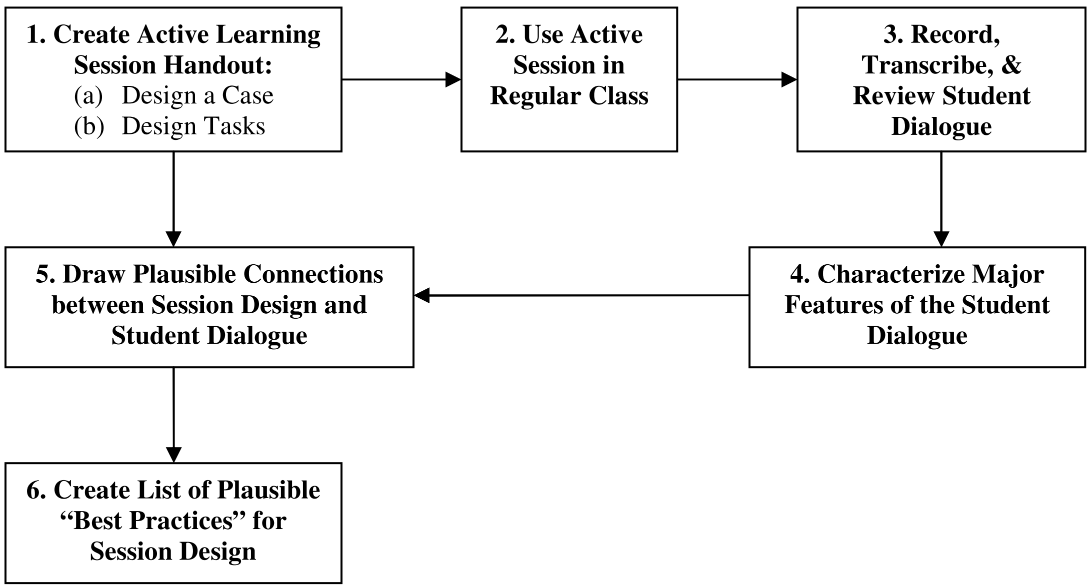

Figure 1. Steps to Surface "Best Practices" for Active Session Design

3.1. Basic Structure of Sessions

The class was divided into four-person teams for the active sessions. At the beginning of each session, the four-person teams were divided into pairs and given a short exercise. The purpose of the paired exercises was to get the students thinking about their prior experience relative to the topic. It was hoped that such discussion could surface their pre-existing knowledge and set them up to build upon it. Following the opening exercise, a mini-lecture (10-15 minutes) presented the topic and its application. Following the lecture, the teams of four worked to complete the tasks related to the case. At the end of the session a general discussion was used to summarize the case.

4. Results: Observations and Inferences as the Sessions Progressed

Though the analysis of each session was brief, typically less than 7 hours, many characteristics of student conversations were observed and logged. These observations led to many improvement ideas for subsequent sessions. The following sections report and briefly discuss the two most pertinent observations from each session.

4.1. <u>Session 1</u>

The goal of session 1 was to present an open-ended problem solving method and have the students apply it. Students were presented with this six-step method:

1. Define the problem situation
2. Define the goal of the solution
3. Generate alternative solution strategies
4. Plan a solution strategy incorporating the best alternative ideas
5. Implement the solutions strategy
6. Evaluate whether the solution strategy worked

Students were given this case:

> *You work in a factory that employs 1,000 laborers. Your boss calls you and says, "Steve (or Stephanie) the bearing manufacturing line is shut down. The workers are sitting on their thumbs until it is up and running again. You know how much money this is costing us—we might not get our monthly bonuses! Get down there and fix the problem."*

4.1.1. <u>Observation 1</u>

The student teams were given this task:

> *Apply steps 1-4 of the open-ended problem solving process to the case. Record your thoughts.*

The intent of this task was to give the students practice using the process. However, the ensuing dialogue seemed to be marked more by "simple doing" than by "thoughtful doing." Coding the student statements based on the three principles of learning showed the students primarily engaged in simply listing information (factual knowledge) without using any stated criteria to check if the information was sound (evidence of applying a schema). Note that many statements in the multi-turn discussion below present unchallenged ideas accepted by tacit agreement. (Each new paragraph signifies a change of speakers.)

> *¶1: So, the first one—*
> *¶2: Preoccupy workers—*
> *¶3: Find equipment dude.*
> *¶4: —while fixing equipment,*
> *¶5: —machine—*
> *¶6: You could some of these more knowledgeable workers, particularly, maybe—*
> *¶7: Yeah, uh—*
> *¶8: Ask veterans for help—*
> *¶9: Ask veterans for help—*
> *¶10: Offer lunch breaks, heh, heh, heh,*

In completing this task, questioning between group members only occurred once when there was a disagreement at the factual level. A reference to an overarching schema was mentioned only once to check if the list of ideas assembled into a reasonable plan.

Notably, the student-generated solution adequately fulfilled the task. This result implies that deeper interactions were not required because the case was too easy. An obvious inference is that the case must represent significant challenge to generate deeper discussions.

4.1.2. Observation 2

Later in the session the students were given the task:

> *Which step would you be prone to skip if you were in a hurry? Why would you skip the step you identified?"*

The intent of the first question was to explicitly surface the students' propensities to short-cut the process. The propensities represent the students' preexisting *practical* knowledge of "how to do the process quickly." The second question was intended to generate student discussion challenging them to modify their preexisting propensities. This would represent building on preexisting knowledge in a practical way.

In doing this task, the students listed when they would skip each step and what might happen if they skipped it. However, the student team opted not to discuss the second question, "Why would you skip the step you identified?" As a result, relevant, faulty, preexisting knowledge was surfaced, but never challenged.

4.2. Session 2

The goal of Session 2 was to have students define a complete action item for a teammate, that is, define clear expectations for a teammate's assigned task. Action items were described as having these characteristics:

1. Specify a single owner
2. Specify a completion date that fits the team's schedule
3. Define clear expectations on the quality level of what is to be completed

They were given this case (shown in part):

> *Your project team needs to turn in a large three-section report in one week. Three members of the team will each write one section….*

4.2.1. Observation 1

The first task was:

> *Write one action item for teammate "Victor" who will write the analysis section [of the report]. Make sure that "Victor" has very clear directions and expectations.*

The intent of this task was to have the students wrestle with clearly defining expectations for Victor that mesh with other requirements in the case. Clearly defining an acceptable level of writing quality is difficult for students. The student dialogue was coded by writing summaries to describe portions of dialogue separated by natural breaks. These summaries revealed that the team struggled to develop an action item for an *analysis section* because they did not understand what an analysis section entailed. At several turns the discussion returned to answering, "What is an analysis section?" rather than, "What are our expectations for Victor's work?" The following portion of dialogue typifies the students' difficulties.

¶1: So what does an analysis typically cover?
¶2: Isn't analysis, isn't it like a comparing kind of thing or is it the evaluation section we do at the end?
¶3: I think isn't it a (mumble)?
¶4: Like how?
¶5: I think the analysis has more to do with the ending of the—.
¶6: So is this then before we've already designed any of it where we like have three and are choosing from the three and the analysis—or is the analysis like we're defining the problem— or discussing—?

Ultimately, the students failed to develop a complete action item. However, they did define due dates to accommodate review and editing time, which was a portion of the overall task.

The obvious lesson is that when students encounter something they don't know, their knowledge gap may derail the desired learning task. This problem may be particularly difficult for faculty to address since it requires that faculty intimately understand what students know and do not know. This suggests that the case should be rich in information to avoid unintended sidetracks. It also suggests that requesting clarification should be a standing rule in the class. Interestingly, in this session the students did not ask for clarification.

4.2.2. Observation 2

At the beginning of session 2 the student pairs were given a case in which their team would need to deliver a large amount of work in a short amount of time. The case concluded with:

You do not know your teammates, but must rely on them to finish the project.

The pairs were given this task:

Make a list of 5 things that could go very wrong with your teammates' contribution.... Discuss ways to prevent it and write down your 3 best ideas.

The goal of this beginning exercise was to surface pre-existing knowledge about how teammates can fail so that the students would couple the necessity of action items to their experience. The recorded student pair did complete this portion of the exercise. However, the opening case was completely separate from the case presented after the mini-lecture. Some students did not make the transition from *part a* to *part b*. When the team of four encountered difficulty defining *analysis section,* they went back to the first case looking for clues. Unfortunately, the first case was not related to the second, which further confused some students.

This student difficulty suggests that a session design with a single case with several facets would be more reliable than using two disjoint cases. It also seems reasonable that discussions would be deeper if students spent more time on a richer case than splitting their time between two cases

4.3. Session 3

The goal of session 3 was to have the students learn how to create and use an agenda to structure and run a project meeting. Agenda items were described as having the following elements:

1. Item title that specifies the topic of discussion item
2. Item goal that states the completion criteria of the discussion item
3. Item facilitator that identifies who on the team will lead and monitor the specific discussion
4. Item time limit to focus participants on completing the discussion and decisions

The case incorporated three improvement ideas. First, a single case was created for both the opening pair tasks and the later team tasks. Second, the case included sufficient information to fill student knowledge gaps. Third, an interdependency was built into the case to deepen the complexity. The case was:

> *You are assigned to a four person team in your Junior design class. The team is very busy completing a complicated design project. In fact everyone is busy. George has been researching available sizes of stepper motors. Marlene and Tim need the specifications for the motor to continue their 3D CAD modeling. However, George can't choose the motor without size constraint information from the CAD models. You are the team facilitator and have some cost information that is important to keep the design choices within budget. You will run the weekly meeting to keep the team progressing.*

The interdependency in this case concerns choosing the motor size. Marlene and Tim's CAD work depend on George's information search and vice versa. The work cannot be completed serially. The case also includes the two complicating factors of the team's busyness and the cost information. Unlike the interdependency, the complicating factors could be resolved serially.

4.3.1. Observation 1

The first task given to the team was:

> *You are the meeting facilitator. Write two solid agenda items for the meeting. Carefully discuss if the goal you have chosen will do the right job.*

The intent of this task was to have the students' develop useful agenda items for a common teamwork situation, that is, untangling work interdependencies. The ensuing student dialogue quickly developed into a disagreement about how to resolve the interdependency. The dialogue was coded to identify what evidence each student was citing to support his case. Two turns from the discussion are shown below:

> *¶1: Well, we're going to say maybe give half an hour for all brainstorming—uh—goal would be to create estimates for general ideas about both points.*

¶2: Uh, I think that's trying to accomplish too much and like it's too vague. I think if you follow up—included in this ten minutes—George is leading the discussion that's what the meeting was talking about—

The disagreement led the team into a far deeper discussion of the task than discussions in sessions one and two. Note the speaker in ¶2 offers his rationale for why the suggestions by the speaker in ¶1 were inadequate. Explicit references to rationale for positions ran throughout the discussion from both sides. This disagreement was never fully resolved and was concluded by the team agreeing to disagree:

¶1: Does this make sense (to you)?
¶2: No, it makes sense, I disa—I don't agree.
¶3: Ha-ha-ha—that makes sense!

The deep discussion was initiated, in part, by the interdependency embedded in the case. Without the interdependency, there would have been little for the students to wrestle with in their discussion. The lesson learned from this result is that one way to add useful complexity to a case is embedding interdependencies.

4.3.2. <u>Observation 2</u>

The next task given in this session was:

Which part of the meeting protocol and agenda struck you as truly useful? …One-by-one tell the group what you felt would be useful and why.

Each student cited a different aspect of running a meeting as important, typically followed by a few turn conversation to clarify and agree. What is noteworthy about this discussion was its depth. One student connected his learning with a future project. Another connected the topic to a previous experience that day. There was evidence in the statements that the new knowledge about how to run meetings had been connected to the students' previous experience (knowledge) and relevant schema. For example:

¶1: I thought the biggest one [helpful agenda item or technique] was—just because I had a meeting like two weeks ago where I thought this was really helpful—where it says, "process check" cause it is the easiest thing in the world just to get off topic.
¶2: Just to make sure you know where everybody's at?
¶3: And—I mean that it's hard to say that's —that's the most important thing because these other things are kind of the foundation for what you build a good meeting. But assuming you kind of had rudimentary standing agenda items and these other things, it wouldn't really matter at all unless you had this good process check. I think that's king of the key. You can have a meeting without one, but you can't have a good meeting without it.

In this reflective task it appeared that the students were easily drawing well-formed ideas from their previous discussion. One implication of this apparent ease is that the learning in the previous discussion was deep. In other words, the observable depth of discussion in the previous task was a strong indicator that the students were learning.

4.4. Session 4

In session 4, the overall task was to create specific, measurable product specifications before a product has been designed. Product specifications were described as a formal goal statement in the open-ended problem of creating a product. Students were presented with the following structure for writing a product specification:

1. Choose and label a few broad categories of product requirements such as "safety" or "usability."
2. Identify and label specific product requirements such as "product weight" or "product cost" to fully define the general category.
3. Define a measurable product performance for each specific product requirement.

Student pairs were given this case:

> *We have trouble with small pesky mammals (SPMs) that chew through the walls. Fifty percent of the homeowners have the same problem. Design an inexpensive product that will solve the problem. There are two other factors to consider: SPMs are on the endangered wildlife list and people in the area believe that SPMs carry a bacteria that infects people upon contact.*

4.4.1. Observation 1

The student teams were given this task:

> *Imagine that you…bought a box marked "The ANSWER to Small Pesky Mammal Problems." Discuss how you would verify that the product actually meets the requirements of cost, disease, and endangered wildlife. Jot down a list of what you would verify, how you would verify it, and how your verification method could be used before you had a completed prototype design.*

This task was intended to stimulate thinking about predicting product performance during a design phase. Since the instructions eliminated the simply answer, "We'll test performance," we anticipated the students would identify an analysis method or yes/no criteria with each specific product specification. The student dialogue was coded to identify the content relevant to this case and task.

The students created a step-by-step use scenario for the product by garnering information from the case. Using this scenario they identified nine product features to verify. This list of nine covered all the requirements within the case. The excerpt below shows the development of a use scenario (¶1, ¶7, ¶8) to identify product requirements.

> *¶1: So we're gonna verify that um the product can like trap an SPM—*
> *¶2: —and keep it—and not kill it?*
> *¶3: —and contain it. Yah, without harming it.*
> *¶4: (copying) —SPM without harming it.*
> *¶5: Um, and if you wanna not—to not touch it with your skin*
> *¶6: Right. So it would contain it in a manner that—like self-contained.*

¶7: Oh right! So you could take it, it would trap it—and it's got food in their—you just pick it up and take it out—
¶8: —SPM disposal facility?
¶9: —the SPM range or um reserve.

The student-created use scenario can be considered a schema to organize the product requirements. To test for fit and completeness of the requirements, the students simply stepped through the product use. At each step another product requirement was identified. The learning advantage is that the students were handling the factual information within the relevant schema (second principle of learning).

The students were able to create the use scenario because the case was rich in information. The information provided a whole context for the product need. The inference for session design is that the cases need to provide rich, rather than sparse, information that sets the entire context for the problem being solved. Rich information allows the students to jointly enter the problem context in their solution.

4.4.2. Observation 2

Though the student pair created and used a schema to identify product requirements in the task above, they also glossed over an important part of the task. The latter end of the same task stated:

> *Jot down a list of what you would verify, how you would verify it, and how your verification method could be used before you had a completed prototype design.*

The students failed to create a product verification method for any of the product requirements. Initially the students realized that both "what to verify" and "how to verify" were required.

> *¶1: OK, so we need—what to verify. So I'll say that's first—is there a coupled list, right? What you verify, how you verify it, how it could be used.*

When the students addressed the "how to verify" task they settled for a broad solution of a "thought experiment" but did not attempt to apply it to any of the requirements.

¶1: How could the verification method be used before you had a completed prototype?
¶2: Before you—uh?
¶3: It says Einstein called it a thought experiment. You should be able to follow the function of one of these [requirements] in your head pretty easily.
¶4: Yah. —(Long Pause)—Brainstorming?
¶5: Yah, that's good enough for me. Um, I think, I think that's that.

The low performance on the second portion of the task (settling for a broad solution) is a sharp contrast to the high performance on the first portion (creating and using a schema). This implies that when reviewing depth of thinking in a transcript that high performance at one point does not necessarily predict high performance across the board, which is an easy mistake to make.

5. Discussion: Comparing Observations across Sessions

The following subsections trace three themes across the sessions: what can be learned about the methods, the contextualized nature of the student discussions, and how complexity affected the discussions.

5.1. Transcript Review Methodology

The reviewing and coding of the transcripts changed over the four sessions. Since the intent was to learn from "brief" reviews, the coding approach was modified to serve that purpose. The first session was coded to identify elements of the three principles of learning within the dialogue. This approach did identify these elements, but it was also clear that many relevant phenomena in the dialogue did not fit these criteria. In session two, the coding was shifted to follow the content where the three principles of learning were used informally to assess the content. The student disagreement was the predominant feature in session three and so the disagreement was coded to identify the points and counter-points in the disagreement. The reflective task at the end of session three contained many references to pre-existing knowledge and so was coded to identify elements of the principles of learning. The fourth session was coded to identify task completion and in doing so the creation of the use-scenario schema became obvious.

By session four the coding approach evolved into a simple pattern:

1. The session transcript was read a time or two to identify dominant themes or characteristics.
2. The transcript was quickly coded to identify elements within the theme.
3. Criteria such as the three principles of learning were informally applied.

This evolved approach, though not rigorous in characterizing any one facet of the dialogue, was very effective in identifying improvement opportunities for the active learning sessions. Each review identified features of cases and/or tasks that did not initiate deeper dialogues. Collectively, the series of reviews and subsequent improvements did show a trend toward increased frequency in deeper interactions.

The review and coding of transcripts also highlighted the sharp difference between the surface appearance and the actual dialogue of the active learning sessions. On the surface, the student teams were engaged and on task. The conversations were energetic with a large majority of the students contributing. By these indicators, the active learning sessions could be deemed "good learning environments." However, below these surface indicators it was obvious that many conversations could be potentially much deeper. The transcripts also showed that the potential for deeper conversations was sometimes achieved.

5.2. Apparent Level of Cognitive Effort and Contextualized Learning

The cognitive effort expended by speakers was evident in many places in the transcripts. For example, on certain tasks the speech patterns would become halting with repeated phrases, repeated ideas, and longer pauses. The speakers would also more carefully phrase and fine tune ideas. These markers in speech pattern were interpreted as the speaker thinking more deeply to work on a task. In general, these episodes also included the use of schema to organize or explain ideas. Interestingly, conversational references of case context frequently accompanied the use of schema. Three tasks exhibited this trait clearly.

In session two, the students could not define what a report analysis section was. Through repeated attempts, someone would offer a potential definition for the group to accept or not accept. In these attempts, the students would include a reference to a context. The students suggested contexts of the report topic, the prior case, reports in a prior class, and examples in a textbook in a prerequisite class. It appeared that the students were hunting for the right context to explain the definition.

The disagreement in session three revolved around whether certain agenda items would properly facilitate a planned meeting. As the students presented their agenda ideas, they would refer to how the agenda item would influence the future meeting. They used the context of the future meeting, albeit their projection of the meeting, to defend their ideas. Further, when responding to another's idea, the respondent would also refer to the future meeting.

In the two previous examples, the students created the elements of the context because one was not provided. In session four, the situation described in the case provided the context. The students then constructed the use-scenario based on the given context.

In each of these examples, context was used to explain or organize the ideas. This suggests that the student learning, at least initially, is anchored to the specific context. It seems reasonable that the students were not applying "free floating" schema, but rather schema anchored in specific context.

5.3. Challenges that Facilitated Learning and Challenges that Failed

Each session presented different challenges to the students. In the first session, the students easily generated an adequate solution without much deliberation. This ease can be traced to two characteristics of the session design. First, the tasks could all be completed by simply compiling factual information and arranging it in a few lists. Elements that fit within the lists were obvious and the order of the information was unimportant. Second, the information in the case could be dealt with serially. The facts could be separated from each other with no necessary consideration of how one choice affected another.

The second session introduced a term the students could not interpret, "analysis section in a report." Since the term was not understood, the task dependent on the term was impossible. This challenge was unintended. Throughout the task, the students continued attempting to resolve this challenge. In other words, the students focused their efforts on overcoming the challenge that confronted them. Unfortunately, the challenge did not lead to the desired learning.

The case in the third session contained an intentional interdependency and two complicating factors. The students primarily discussed how to resolve the interdependency. Two different solutions were presented by different students and several minutes were spent defending their solutions. During the defense of the solutions, many pertinent rationales were stated. In contrast, the student did not discuss the complicating factors.

In terms of challenge, the interdependency in case three was a much higher challenge than the complicating factors. The complicating factors could be dealt with in a serial fashion independent of the other tasks. It appears that the students intuitively recognized the interdependency as the greater challenge and devoted their efforts to it.

The fourth case contained the challenge of creating a complete list of product specifications without omitting one. The students accomplished this task by using the rich information in the case to create a product use scenario.

One particular type of task, that of providing a self-reflection of learning, brought mixed responses. In session one the students ignored the task of, “Why would you skip the step you identified?” In contrast, in session three the students gave very clear answers to a similar task of, “Which part of the meeting protocol and agenda struck you as truly useful?” Significantly, the discussion in session three was much deeper than the discussion in session one and was likely the contributing factor. This suggests that when reflective exercises are used to solidify learning, they need to follow exercises that already create strong learning. In other words, reflective exercises may not be expected to shore-up learning from exercises that did not produce deeper learning.

6. Conclusions

Three diverse conclusions emerged from the data: one methodological, one related to how contextual student learning appears, and one related to the design of active learning sessions.

Conclusion 1: Briefly coding transcripts by identify major themes and then coding along those themes surfaced substantial feedback to improve the design of the active sessions. The use of coding criteria, such as the three principles of learning, was used informally to interpret the content of the coding. The iterative use of transcript coding and session improvement created sessions with dialogues showing deeper thought.

Conclusion 2: The student learning appeared to be tied to context. When the case supplied the context, the students used it to create schema. When the context was not supplied, the students created their own context to use. Consequently, cases that provide a rich context appear to support student dialogues that use schemas related to the case.

Conclusion 3: The students seemed to intuitively identify the challenge in each session and apply their effort to resolving it. This included challenges that were unintentionally introduced into the case. Including interdependencies within the case, that is, information that cannot be resolved serially, appears to be one way to add challenge that leads to deeper discussions.

7. Future Investigations

Many elements in this study were encouraging. Recording, transcribing, and coding student conversations provided an excellent window to see how active learning sessions actually functioned. This perspective quickly suggested simple changes to improve learning in the active sessions. Subsequent sessions “worked” better than the earlier sessions.

The study also suggested further investigations. First, analyzing a larger set of sessions would increase both the variety of observable events and the certainty of events observed multiple times. Second, analyzing each session more carefully would refine the understanding of how session design affects the learning environment. Since analyzing more session and analyzing them more carefully both increase the analysis time, a more efficient analysis method is needed. Analysis based on multiple reviews of the video recording may provide just such an analysis method.

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