The Rest of the Story: Understanding Small-Group Case Interpretation Performance and Capability in Middle-School Project-Based Inquiry Classrooms

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Abstract: Learning from use of cases has been the hallmark of several approaches to education. From the perspective of learning, the ability to interpret and apply cases is a skill that is key to successful transferable learning. Our study explored the development and transfer of case use skills in middle-school project-based inquiry classrooms. Contrary to our expectations, group performance and capability did not improve uniformly over time, but fluctuated from episode to episode, leading us to examine what seemed to influence this fluctuation. We discovered that the character of group discussions and the impact of those discussions on the group's reasoning about the case were strong indicators of group performance and capability. In this paper, we describe case use and examine the character of group discussions reasoning about expert cases from episode to episode of case interpretation, exploring how these factors indicate or predict group interpretation performance and capability over time.

Introduction

Learning from use of cases has been the hallmark of several approaches to education ((Koschmann, Kelson, Feltovich, & Barrows, 1996; Williams, 1992). From the perspective of learning and education, the ability to interpret and apply cases is a skill that is a key to successful transferable learning. Interpreting and applying experiences is quite natural and useful in solving problems (Kolodner, 1993, 1997; Schank 1982, 1999), but research has shown that middle-school science students in project-based inquiry classrooms have several difficulties applying expert cases. First, they don't always understand an expert case well enough to identify lessons learned and how they might apply to their problem. Second, they don't always understand the problem they are trying to solve well enough to recognize that an expert case might be usefully applied to help them solve the problem. Third and fourth, even when students understand a situation and the case well, they can find it difficult to draw connections needed for application and predicting consequences of application.

To address these difficulties and support middle-schoolers as they develop case use skills working in small groups, we designed the Case Application Suite (CAS) to coach groups and individuals, as cognitive apprenticeship suggests, through its system of scaffolds. Each scaffold in the system supports groups in a particular way and addresses a particular difficulty that students face when using expert cases. CAS can be used help groups interpret and apply expert cases and also assess their design solutions based on that application.

We conducted a study to explore the development and transfer of case use skills in middle-schoolers in Learning By Design™ (Kolodner, et. al., 2001; Kolodner, et. al, 2003) classrooms. One of the three questions we explored was *How do small-group case use capabilities develop over time?* Contrary to our expectations, analysis of the data revealed that the development of case interpretation skills looked different for every group, and group performance improved or worsened from one episode to the next. What seemed to influence this fluctuation were a group's discussions and how fully the group was able to reason about the expert case. In this paper, we describe case use, present our study of the development of case use skills, examine the character of group discussions and its relationship to the group's reasoning about expert cases from episode to episode of case use, and explore how these two factors serve as strong indicators or predictors of group capability and performance over time.

Case Use

A case is an interpreted experience (Kolodner 1993; 1997). Cases can be divided into three major categories: personal cases, or experiences of the individual learner that he/she experiences first-hand; peer cases, or second-hand experiences of an outside learner who has a similar expertise to that of the individual learner; and expert cases, or second-hand experiences of an expert within that domain. Case use is the process of interpreting, analyzing, and applying experiences in order to address challenges or solve problems. Interpreting a case involves correlating problem-solution pairs with the criteria and constraints of the original problem, identifying the lessons that can be learned from the experts. A lesson learned is in the form of conditions that, if present, suggest a certain response (Kolodner, 1993). Applying the lessons learned to the target case is a task that involves identifying the criteria and constraints of the target case and analyzing how well they match up to the conditions articulated in the lessons learned, or design rules of thumb, from the source case. Once a potential match is discovered, applying involves determining whether the lesson can be incorporated into the solution directly, whether it needs to be adapted in order to meet the particular criteria and constraints of the new situation (Kolodner, 1993,1997; Simina, 1999), or whether the lesson cannot be applied, perhaps due to constraints that the reasoner did not take into account. Predicting the success of an application can involve either testing the implementation and analyzing its results to determine favorable and unfavorable outcomes, or in situations where the solution cannot be implemented, making predictions about both favorable and unfavorable results that might occur. Case use can be an iterative process, with a reasoner continuing to apply cases until an acceptable solution is reached that addresses all criteria, contraints, and/or unexpected results.

We focus on the use of expert cases because they are typically very descriptive explanations of an experience (Carroll and Rosson, 2005), pointing out both positive and negative outcomes and the sequence of events that led to those outcomes. Since experts within a domain have a very rich and connected understanding of that domain, their experiences can help students learn about the complex processes carried out in that domain, reinforce strategies that yield positive results within that domain, and keep students from making mistakes the experts have made (Carroll and Rosson, 2005). They can also make good models of how to interpret one's own experiences. In this work, expert cases are good as descriptive explanations of an experience because a first-hand experience in the domain of geology and tunneling is not possible for students. They cannot experience first-hand designing a tunnel or taking a core sample as it happens in the real world. Therefore, expert cases provide a way for students to understand an experience that they do not have first-hand access to.

Learning by Design (LBD)

Learning By Design (Kolodner, 1997; Kolodner et. al, 1998; Kolodner, et. al, 2003) is an approach to learning in which middle school students learn science skills, practices, and content by engaging in design projects. Based on the suggestions made by cognitive apprenticeship (Collins, Newman & Brown, 1989) and case-based reasoning (Kolodner 1993; Kolodner 1997), LBD's activities are designed so that students experience the concepts and practices they are learning, and its sequencing aims to help students make connections between their experiences (inside and outside of the classroom) and the science they are studying and learning (Kolodner et. al, 1998; Kolodner, et. al, 2003.

LBD has two Earth Science Units – *Digging In* and *Tunneling Through Georgia*. *Tunneling Through Georgia* teaches students about geology and earth science concepts by having them design plans for a set of tunnels that will run across the state of Georgia. They must investigate the geology of their tunnel site and how that geology can impact their design plans. *Digging In* is a unit that introduces students to the skills and practices they will need in order to engage in the *Tunneling Through Georgia* unit. Students investigate agents of erosion and erosion management methods through designing a basketball court at the bottom of a hill and it's surrounding areas in such a way that the hill does not erode onto the basketball court.

During both units, the teacher provides modeling and coaching as cognitive apprenticeship suggests, modeling for students the kinds of questions they should be asking themselves and each other as she facilitates whole class discussions, prompting students to help them focus on important aspects of their design, experiment, expert case, etc., and coaching small groups as they discuss their ideas, design and carry out experiments, build and test models, and plan for presentations. Students also use, design diary pages (Puntembekar & Kolodner, 1998), paper-and-pencil scaffolds that help students organize their thoughts and make their ideas more complete and coherent as well as the Case Application Suite to help them interpret and apply expert cases.

Expert Cases In LBD

In LBD, expert cases are in the form of narrative stories, describing the experiences of experts as they try to achieve goals and address problems that come up along the way. They are written to include all of the descriptiveness needed for students to understand the connections within the expert case, making the lessons students should be learning from the expert cases clear. Expert cases in LBD focus students' attention on problems that they may encounter, and help them connect their experiences to the challenge they are trying to achieve. Expert cases help students focus on things they need to be mindful about, consider, and address as they design their final plans. LBD provides affordances for students to see the importance of using the experiences of others as they solve the challenge.

During *Tunneling Through Georgia*, students use up to twelve expert cases as resources, interpreting and applying them to address potential problems that may arise in their section of the tunnel. The expert cases are taken from tunnels that were built in various parts of the world at different times in history, helping students understand the complexity of tunnel design, the different kinds of problems that can arise during tunnel design and building, the different solutions that have been employed to design and build tunnels, and the different kinds of technologies available that have been used to build tunnels. These cases are written and presented in such a way that lessons that can be learned from them are visible. Even though the expert cases in the *Tunneling Through Georgia* Unit are written to make the lessons student can learn from them visible, students still need help interpreting the expert cases and applying the lessons to their designs.

Case Application Suite (CAS)

We designed the Case Application Suite (CAS), to scaffold students as they engage in case use through its system of scaffolds. This system of scaffolds has 5 parts: the structuring of tools suggests a high-level process that students are engaging in; within each tool, structured questioning, or prompts makes the task sequence clear by focusing students' attention as they are carrying out or reflecting on a task; for each prompt in the sequence, hints, or task-specific/domain-specific questions or statements, are provided to refine a task; for each prompt in the sequence, sample nice answers (examples) are provided that can be used to model a process or a specific step; and for some tasks in the sequencing, a template or chart to help with lining up ones reasoning is provided. CAS's tools are linked in sequence to make the process sequence of interpreting and applying expert cases visible to student groups. First, groups interpret an expert case using the Case Interpretation Tool, identifying the goal(s) of the experts, the criteria and constraints present in the expert case and how they informed the problems the experts faced and the solutions they employed to address those problems, the tools and technology needed to implement the solutions, and any design rules of thumb the expert case suggests.

Next, they apply the design rules of thumb gleaned from their interpretation using the Case Application Tool to examine their challenge's goal(s) and criteria and constraints, and to analyze the design rules of thumb based on the criteria they match and the suggestions they make for a possible solution. Then, as the last piece in applying the design rules of thumb, groups determine whether the design rule of thumb makes sense for their challenge; if it does not, the design rule of thumb is abandoned, but if it does make sense, groups determine whether the design rule of thumb can be applied directly or whether it should be modified in any way to address the particular criteria and constraints of the group's challenge.

Finally, the application of the design rules of thumb to the group's challenge is assessed using the Solution Assessment Tool. In particular, groups engage in an assessment of their solutions by making predictions about which criteria and constraints they think are addressed by applying each design rule of thumb to the challenge solution, making predictions about which criteria and constraints are not addressed by applying the design rule of thumb to the challenge solution, and deciding if the challenge solution is complete as is, requires the application of other design rules of thumb to become more complete, or requires further investigation to become more complete.

Our Study

To explore our research questions, we integrated CAS into the 7th grade classrooms of a private suburban school in Atlanta, Georgia, where the teacher enacted both Learning By Design Earth Science Units. Students worked in small groups of three or four for both units, switching groups between units. This paper focuses on their use of the Case Application Suite to help with case use during the *Tunneling Through Georgia* Unit. To understand how small group case use capabilities developed over time, we observed students as they used CAS, videotaping their discussions as they answered the prompts in the Case Application Suite. This allowed us to understand how well students could interpret and apply cases using the Case Application Suite's system of scaffolds, and it helped us to describe the effects of the software on the small group's development of case use skills. Video observations also provide context for the changes we saw in the group Case Interpretation Tool artifacts we collected. In particular, we transcribed group discussions to understand how changes in group discussion related to changes in group capabilities and changes in group performance through Case Application Suite artifacts.

We also collected group artifacts created from the Case Application Suite's tools, which allowed us to describe the development of case use skills as a result of additional coaching provided by our system of scaffolds. Each group had three (3) Case Interpretation Tool artifacts and one (1) Case Application Tool artifact. There were no Solution Assessment Tool artifacts. We focused on three target groups during our analysis of data: the Blue Ridge, Ridge and Valley, and Coastal Plains groups.

We developed a coding scheme, comprised of fifteen Likert-scale dimensions as well as characterization elements to analyze each group's CAS artifacts based on a variation of grounded theory (Strauss & Corbin, 1998; Law & Wong, 2003). We wanted to be able to line up group CAS artifacts, for example, Case Interpretation Tool artifacts for a group, compare the quality of answers from expert case interpretation to expert case interpretation, and both quantitatively and qualitatively describe changes that occurred in the group's ability to interpret those expert cases. Using this approach provided a consistent way for us to talk about changes, if any, that occurred over time as groups developed interpretation, application, and assessment skills, and it also made our findings more consistent and connected since we used the same set of dimensions and ranges across all artifacts. Group CAS artifacts were coded in the same way by two raters. Both raters independently coded 1/3 of the target data set to establish reliability, and then one rater coded the entire set of target data. Discrepancies in ratings given during the reliability phase were resolved by negotiation. We then created detailed case studies for each target group, including a description of the enactment of each episode of case use, coding results for all student and group artifacts, and descriptions of group discussions along with excerpts of transcribed video observations of those discussions.

Results

Because each group interpreted expert cases more than once, we were able to address small group case interpretation capability and performance. Table 1 shows two sets of results. First, it provides a summary of coding results/ratings for performance of group interpretation skills over time using the Case Interpretation Tool (columns 5 and 7). Coding results revealed that there was variation across case interpretation performance over time for groups. Our data revealed that during Case Interpretation Tool use, the Blue Ridge group's interpretation performance decreased and then increased over group case interpretation activities. The Ridge and Valley group's interpretation performance were best in the first episode and decreased from there. The Coastal Plain group's interpretation performance increased from the first to the second episode and then remained the same.

This wasn't what we expected. Instead, we expected performance to improve uniformly over time. This led us to turn to the video observations of small groups using the Case Interpretation Tool to understand more about the kinds of discussion each group was having as they used the tool. Video observations revealed that as groups responded to the prompts while interpreting an expert case using the Case Interpretation Tool, many would discuss their ideas before entering a final response into the software. Looking at group work in concert with those transcribed group discussions helped us understand how those discussions changed over time and how changes in discussion affected group interpretation capability and group work.

Second, Table 1 describes the character of the kinds of discussions each group engaged in (columns 3, 4 & 6). Our analysis of the data revealed and helped us identify and name five pairs of characterizations for group discussions: more-informed vs. less-informed, chaotic vs. classification-focused vs. content-focused, engaged vs. disengaged, between-group (inter-group) centered vs. within-group (intra-group) centered, and system-scaffolded vs. single scaffolded. In an informed discussion, group members refer to the case itself and its facts, looking at the text of the case itself as they are collaborating, while in less-informed discussion, group members rely on their memories of the case. Chaotic discussion has no particular focus and lacks direction; classification-focused discussion focuses on giving an idea a particular label based on the definitions of the labels in question; and content-focused discussion uses the content surrounding an idea to understand how an idea should be articulated. Engaged discussion is characterized by the active participation of more than half of the group in discussions and more than half the group focusing on the task at hand, while disengaged discussion is characterized by a lack of participation and focus by half or more than half of the group. Intra-group centered discussion focuses on what the group understands about the case and its lessons, while inter-group centered discussion focuses on how an audience outside of the group might interpret the group's interpretation. Finally, single-scaffolded discussions are those that employ only one of the software's system of scaffolds, while system-scaffolded discussions employ two or more of the software's system of scaffolds.

Table 1: Character Of Group Discussion During Case Interpretation Use and Group Performance Over Time.

Name of Group	**Expert Cases Interpreted (in order of interpreta-tion)**	**Character of Discussion During 1st use of Case Interpretation Tool**	**Character of Discussion During 2nd use of Case Interpretation Tool**	**Changes in Performance For Case Interpretation Across 1st and 2nd Uses of Case Interpretation Tool**	**Character of Discussion During 3rd use of Case Interpretation Tool**	**Changes in Performance For Case Interpretation Across 2nd and 3rd Uses of Case Interpretation Tool**
Blue Ridge	St. Gotthard, Tecolote, and Chunnel	Informed, classification-focused, engaged, intra-group, System-scaffolded	Less-informed, classification-focused, disengaged, intra-group, System-scaffolded	Decrease	Informed, Content-focused, disengaged, inter-group, Single-scaffolded	Increase
Ridge And Valley	Queens Midtown. Mono Craters, and Simplon	Informed, classification-focused, engaged, intra-group,	Less-informed, classification-focused, disengaged, inter-group,	Decrease	No video	Decrease

		System-scaffolded	System-scaffolded			
Coastal Plain	Frejus, Tecolote, and Hudson	Less-informed, chaotic, disengaged, intra-group, Single-scaffolded	Informed, classification-focused, engaged, intra-group, Single-scaffolded	Increase	No video	No Change

Across the three episodes of interpretation for the Blue Ridge group, we saw two major changes in the group's discussions over time. First, the Blue Ridge group went from using the definitions of criterion and constraint to classify ideas as such or to support or refute the classification of an idea to using the content of the expert case to provide context for how the idea should be articulated. Second, this group began considering that an audience other than themselves might read or use their interpretation in the future, and they began to focus some of their discussion on what that audience might not understand and how their responses should be articulated to help that audience understand. As an example of the first change, very short excerpts of the Blue Ridge group's discussion about criteria and constraints are shown side-by-side in Table 2. The first column characterizes the group's discussion around criteria and constraints in both the first and second uses of the Case Interpretation Tool, where a group member would pose an idea and the group would spend time classifying whether it was a criterion or constraint based on the definitions of criterion (something the experts wanted to address) and constraint (something the experts had to address). The second column characterizes the group's discussion around criteria and constraints during their third use of the Case Interpretation Tool, focusing more on the context surrounding the rise of a criterion or constraint and using the expert case to support how the criterion or constraint should be described.

Table 2: Excerpts of Blue Ridge Group Discussions of Criteria And Constraints Over Time.

Using definitions of criteria and constraints	Using context around criteria and constraints
David: Here's a criteria! I have a criteria! **Theresa:** Yes… **David:** The building of two towns to house the workmen. **Billy:** Right. **Margaret:** That's a constraint. **David:** It's not a constraint—they didn't have to do it, but it was something he did. **Margaret:** Yeah, but if you didn't do it, then the workers would die…	**Theresa**: Um…Criteria. Lining in concrete. Is that a criteria? **David**: Yeah, be- **Billy**: Well, except for where it was permeable, and then they were gonna line it in steel. Iron. **Theresa**: No, it wasn't permeable. Like, that's- **Billy**: No, the chalk. Near France- Theresa: The chalk was a mixture of chalk and clay.

For the Ridge and Valley group, video observations revealed that they also began to consider that an audience other than themselves might read or use their interpretation in the future, and they began to focus some of their discussion on what that audience might not understand and how their responses should be articulated to help that audience understand. For example, as one group member identified an expert solution, another group member began typing in the identified solution into the software. Noticing that the group's typer typed "Due to high pressure in the tunnel," as opposed to high pressure *on* the tunnel, the first group member told the typer about the error and referred to the expert case to highlight the error, but the typer did not seem to hear him. Remaining persistent, the first group member used his persistence to get the group typer to change the wording to "Due to high pressure *on* the tunnel," stating that others reading their interpretation in the future might think that the high pressure was *in* the tunnel as opposed to *on* the tunnel if the wording was left as it was. However, their group discussions also changed in some negative ways. Over time, they did not seem to use the written expert case to generate, support, and/or refute ideas during Case Interpretation Tool use, and their discussions were less informed than they were during their first use of the Case Interpretation Tool where they used the expert case a great deal. Group members also seemed to disengage from group discussions over time.

The Coastal Plain group's discussion became more informed over time and they used the written expert cases more to generate, support, and/or refute ideas. Their discussions moved from being unfocused and full of chaos to using the definitions of criterion and constraint to classify ideas as such or to support or refute the classification of an idea. The group was also more engaged in group discussions over time. For example, during the group's first use of the Case Interpretation Tool, they did not seem to work well together. An atmosphere of confusion resulted as one group member continuously begged the other group members to focus on the task at hand. They struggled to talk about the expert case and respond to the prompts in the tool. However, in later episodes of Case Interpretation Tool use, the Coastal Plain group was able to work much better together, listening to each other and being more involved in the group's discussion.

From our analysis of the data, we identified and named five pairs of characterizations for group discussions: more-informed vs. less-informed, chaotic vs. classification-focused vs. content-focused, engaged vs. disengaged, between-group (inter-group) centered vs. within-group (intra-group) centered, and system-scaffolded vs. single scaffolded. We found that analyzing the character of discussions not only seemed to show more than group artifacts alone, but it also ultimately affected what was typed. We also discovered that a group might be far more capable than their performance showed at a surface level; performance and capability were not synonymous.

Discussion

We studied middle-schoolers in LBD classrooms interpreting expert cases in their small groups supported by CAS. We found that group performance varied from episode to episode of case interpretation, and the character of a group's discussions seemed to impact how well they were able to interpret the expert case. Due to the variations across group performance, it is difficult to make provide concrete answers to our earlier research question, *How do small-group case use capabilities develop over time?* However, when we examined and analyzed group discussions via video observations more carefully, several trends emerged that seem to serve as indicators or predictors of group case interpretation performance and capability.

- *The more informed the discussion, the better the interpretation of a case*
  In an informed discussion, group members referred to the expert case itself and its facts, looking at the text of the case itself as they were collaborating, and as shown in Table 1, this seemed to correlate to better interpretation performance. As an example alluded to in the results, when the Ridge and Valley group used the expert case to inform their discussions as they did during their first use of the Case Interpretation Tool, their ability to interpret the expert case was very sophisticated, and they were able to identify a design rule of thumb that included correct causality or justification (e.g., *If water somehow seeped through the permeable rock, you could use compressed air to pump it out of the tunnel and put a thick blanket of clay on the river bottom, because it would counter the air pressure and prevent the river from letting in.*). However, when they relied on their memories of the expert case, their ability to interpret the expert case suffered and the design rules of thumb they created were much more general with incorrect justification (e.g., *When water is a problem use holes drilled in the tunnel to extract water because water will flow out because of the law of gravity*.)
- *As groups develop their ability to interpret cases, they seem to move from chaotic discussion to more classification-focused discussion and then to more content-focused discussion.*
  As student groups developed interpretation capability, they seemed to move from a lack of focus to having discussions that focused on classifying ideas, and finally moving to discussions that use the content of the expert case to understand the context of an idea and inform how that idea should be expressed. Of our three target groups, the Blue Ridge group showed the most definitive movement from classification-focused to content-focused discussion. During the first and second episodes of Case Interpretation Tool use, the Blue Ridge group, used the definitions of criterion and constraint to classify an idea as a criterion or constraint or to support or refute a classification. They used phrases like "they didn't *have* to do it" and "what limitations did they *have* to face" to do those things. In their third episode of Case Interpretation Tool use, their discussions did not focus on whether an idea generated should be a criterion or a constraint, but focused rather on the context that caused the criterion or constraint to arise or how the criterion or constraint should be articulated.
- *The more engaged group members are in the discussion, the better the interpretation performance of the group.*
  Engaged discussions involve the input of more than half of the group who are sharing multiple perspectives and experiences. The Coastal Plain group showed much better interpretation performance for their second use of the Case Interpretation Tool than for their first use. This was due, in part, to more members of the group focusing on the task of interpreting the expert case and engaging in the group discussion. As such, the Ridge and Valley group showed that discussion where group members are disengaged resulted in poorer case interpretation performance, as they lost more and more interest in interpreting the expert cases over the course of the activity which resulted in a decrease in group case interpretation performance.
- *Inter-group centered discussions seem to result in more specific and detailed discussions than intra-group centered discussions and are reflected in ideas the detail of descriptions in group artifacts*
  Typically, all of our target groups focused solely on what the group itself did or did not understand. However, the Blue Ridge and Coastal Plain groups did have moments of inter-group centered discussion during Case Interpretation Tool use, as was described earlier when one member of the Ridge

and Valley group pressed another to type that there was high pressure on the tunnel instead of in the tunnel to provide clarification for someone else reading the group's interpretation of the expert case "cause they might think it was in the tunnel". Consideration of an audience outside of the group did not occur until the second or third time groups used the Case Interpretation Tool to interpret an expert case, suggesting that moving from a focus on what the group understands to considering an audience outside of the group takes time and repeated episodes of case interpretation to develop.

- *The more complete the reasoning of a group, the more likely a group will display more capable case interpretation and better interpretation performance.*
  For case interpretation in particular and case use in general, reasoning involves not only interpreting or applying an expert case, but it also involves the discussion that informs that interpretation or application. This is because, as we've seen, much of the group's reasoning happens during their discussions. We've described examples that support the idea that when the group worked well together, focused on the task, and engaged in in-depth discussion about the expert case, they were able to reason about the case in more detail and with more specificity than when they did not.

Our analysis revealed that two factors seemed to impact group performance most: the character of group discussions and the completeness of the group's reasoning. As Table 1 summarized, when group discussions were informed, non-chaotic, and engaged, group performance increased; otherwise it decreased. Therefore, these three characteristics seem to affect group performance more than the others. This is evidenced, for example, by the fact that the Blue Ridge group's performance increased from their second use of the software to their third use and the Coastal Plain group's performance increased from the group's first use to their second use of the software even though these groups only used one scaffold (i.e., prompts). This is not to suggest that the system of scaffolds does not really make a difference; instead, we suggest that use of the system of scaffolds alone does not increase group performance, but the character of group discussion around those scaffolds does. Our analysis also suggests that an increase in interpretation performance was also the result of groups reasoning about the expert case more fully. The impact that group discussion had on group interpretation performance and the Case Application Suite's role in supporting and guiding that discussion suggests that the more informed, engaged and non-chaotic the discussion when guided by the Case Application Suite's system of scaffolds, the more complete the reasoning will be that the group engages in.

Future Work

While the trends discussed in the previous section do begin to shed light on factors that impact the ability of small groups to interpret and apply expert cases over time, this study is really a first step in understanding both the development of case use skills over time in small groups as well as the specific role CAS played in that development. Our data suggests that the prompts and templates helped small groups organize their ideas and prompted them to have the kinds of discussions that could be characterized as more-informed vs. less-informed, chaotic vs. classification-focused vs. content-focused, engaged vs. disengaged, between-group (inter-group) centered vs. within-group (intra-group) centered, and system-scaffolded vs. single scaffolded. These characterizations and the trends that emerged provide insight into small group reasoning and serve as a first step in really understanding the trajectory of case use skills learning in small groups supported by CAS.

From a cognitive capability perspective, future work might include developing a study that would allow us to look more closely at the particular skills that are being developed, how they are being developed, and the order in which they are being developed. This may uncover not only additional factors that resulted in the variability across group interpretation capability and performance, but also uncover how to better integrate CAS into classroom activities, help small groups take advantage of the full affordances of CAS' system of scaffolds, and suggest changes or additions to CAS' design.

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