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CASE INTERPRETATION TOOL:
Collaboratively Coaching Students' Understanding Of Second-hand Experiences In Learning By Design Classrooms

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Abstract. This paper's focus is on the use of second-hand expert experiences in middle school earth science Learning By Design^{TM} (Kolodner, et. al, 1998, 2003) classrooms. We have identified several difficulties students have with interpreting and applying cases, as well as the role the teacher plays in guiding students as they grapple with those difficulties (Owensby & Kolodner, 2002). In trying to understand the best ways to support students as they apply expert cases to their challenge, we have developed a software tool, the Case Application Suite (Owensby & Kolodner, 2002). In this paper, we examine the feasibility of our designed tool suite and best practices for its use.

1. INTRODUCTION

This paper's focus is on the use of second-hand expert experiences in middle school earth science Learning By Design^{TM} (Kolodner, et. al, 1998, 2003) classrooms. We have identified several affordances that cases have as resources along with some of the difficulties students have with interpreting and applying them and roles the teacher can productively play in guiding students as they grapple with those difficulties (Owensby & Kolodner, 2002). Our software suite, the Case Application Suite, is designed to scaffold students as they apply expert cases to addressing a project challenge. The software suite includes three tools –- Case Interpretation, Case Application, and Solution Assessment. We've piloted it with sixth and eighth grade students as they learn geology in the context of designing a tunnel. Expert cases presented in the unit are intended to inform their inquiry, designs, and decisions. Students collaboratively discuss interpretations of each case, best ways to apply what they can learn from it, and best ways to assess the potential success of their application ideas, using prompts in the tool suite as reminders about how to do those assessments. We ask a broad question in our research study: How can we best help students as they attempt to understand an expert case, pull lessons from it, and apply those lessons to their designs; and if we can help them learn this skill, will it transfer to situations outside of LBD that require the ability to interpret and apply a second-hand experience? Our software is designed to play the role of providing scaffolding, supplementing that of the teacher, to help students not only engage in applying cases, but also learn the skills necessary to effectively engage in those processes. In this paper, we examine the feasibility of using our designed tool suite for the purposes cited and what we are learning about best practices for its use.

2. BACKGROUND

Our research group has been developing project-based inquiry science units for middle school based on the literature on how people learn (e.g., Bransford et al., 1999). Our approach, called Learning by Design (Kolodner, et al., 1998, 2003) focuses on design challenges. Students design and build a device, testing it and getting feedback on how well it works, explaining its deficiencies, and trying again. For example, to learn about motion and forces, students design and build a miniature vehicle and its propulsion system. For earth science, however, it is impossible for students to design and build a working artifact. We have had to find a different way for them to get feedback on their design decisions. One way is to compare their design solutions to solutions used by experts in real situations. Such cases can also be used as resources to help students as they are designing. The Case Application Suite is designed to help students interpret and apply cases and assess their design solutions using cases. Its design derives from two foundations – case-based reasoning (Kolodner, 1993) and cognitive apprenticeship (Collins et al., 1989). The Case Application Suite is designed to scaffold those processes. Cognitive apprenticeship suggests that skills learning can be promoted if learners have the opportunity to see the skills they are trying to learn modeled in context of use and then have opportunities to be coached through doing them themselves, within a context where those skills are needed and used repeatedly. The Case Application Suite provides examples of case-application skills to its users as well as prompts that scaffold the sequencing of the reasoning and the details of how to do each step.

3. CASE APPLICATION SUITE

The Case Application Suite was designed primarily to play the role of a coach as individuals or small groups of students are working to interpret an expert case and apply it to their challenge, asking the kinds of questions and making the kinds of suggestions that can push the students' understanding, and questioning the decisions they make to help the students make connections and develop the ability to justify their decisions and the connections they make with evidence. Its questions generally

require a deep level of analysis and prompt students to reason as CBR suggests, e.g., to identify the different rules of thumb   that they can glean from the case, analyze their applicability to the new situation, justify their decisions, and consider alternatives. Hints and examples are provided with each prompt to give students clues about the kinds of things they can include in their answers to make them informative. Figure 1 shows the Case Interpretation Tool with the default view of the right frame and the menu used to access the examples. Its examples allow it to also play the role of "modeler," showing users how others have analyzed similar cases.
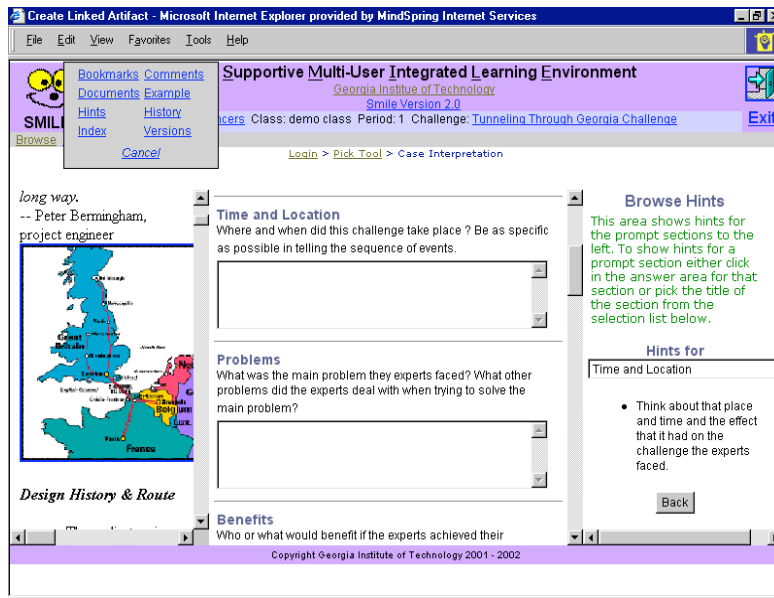

Figure 1: Case Interpretation Tool with hints in the right-hand frame and the Browse menu used to access examples

The Case Application Suite contains three tools: Case Interpretation, Case Application, and Solution Assessment (Owensby & Kolodner, 2002). Each has a left frame that displays the case or previous linked artifacts; a middle frame with prompts; and a right frame that displays hints, examples, comments, and templates depending on what is selected. The default view in the right frame displays hints. Students are scaffolded in four ways. First, the structure of the suite serves as a scaffold. Each tool corresponds to a major step in the case application process and is meant to provide a high level view of the processes they are engaging in. Second, the prompts in each tool's center frame sequence the steps involved in carrying out each high-level process. Third, hints are provided with each prompt to help students carry out each step. Finally, examples are provided as another way to help students understand what they need to be accomplishing. The Case Interpretation Tool helps students identify problems experts encountered in achieving their goals, solutions they attempted and why they chose those, what results they accomplished and explanations of those, and any rules of thumb, or lessons, that can be extracted from the experience. Figure 1 shows some of its prompts. The Case Application Tool guides students through attempting to apply the lessons of a case, prompting them to consider whether a rule of thumb is applicable and how to apply it. The Solution Assessment Tool helps students assess the potential success of their solution, analyzing the impacts they expect their solution to make. Table 1 shows prompts from the three tools.

Case Interpretation Tool	Case Application Tool	Solution Assessment Tool

Time and Location Where and when did this challenge take place ? Be as specific as possible in telling the sequence of events. **Problems** What was the main problem they experts faced? What other problems did the experts deal with when trying to solve the main problem? **Benefits** Who or what would benefit if the experts achieved their challenge? Why would they benefit? **Solution(s) Chosen** What did they decide to do to meet the challenge? Give reasons why the experts chose this solution. **Alternative Solutions** Were other ways of meeting the challenge that were considered? Why were they not chosen? **How The Solution Was Carried Out** How did they put the solution into practice? What steps did they take to carry the solution out ? ...	**Our Design Goals** What are your design goals? List them separately. **Our Problems and Sub-Problems** What problems and sub-problems do you face in your challenge? **Our Criteria and Constraints** What criteria and constraints are present in your challenge? How do they affect each of your design goals? Issues and sub-issues? **Rule(s) Of Thumb** Looking back at the rule(s) of thumb that were created in the Case Interpreting Stage, which ones, if any do you think will help you solve your challenge? **Problems Addressed** What problem does this rule of thumb address in your challenge? **Criteria/Constraints** What criteria/constraints does this rule of thumb satisfy in your challenge?	**Assess Solution (Design Goals)** Which specific design goals are successfully met by your new solution? Which are not? **Potential Problems That Were Seen Along The Way** Which specific issues and sub-issues are successfully met by your new solution? Which are not? **Assess Solution (Criteria and Constraints)** Were the criteria and constrains in your challenge taken into account by your new solution? How? **Things Overlooked** Were any criteria and constraints overlooked? How? **Next Steps** If design goals, issues/sub-issues, or criteria/constraints were not met, decide if your current solution covers enough to stand alone, whether it should be meshed with another solution to make a more complete solution, or if it should be abandoned.

Table 1: A partial listing of prompts for each tool in the Case Application Suite

The tool suite is designed to complement modeling and scaffolding provided by the teacher. The teacher should model each of the stages of case use and coach students, as a class, as they attempt the interpret or apply a case or assess a solution. The software is designed to be used by individuals or small groups as they carry out those processes without the teacher. After use of the tool for each stage of case use, the intention is that groups will share their work to the class and the teacher will facilitate a discussion about what can be learned from the full range of cases and the reasoning the most successful students engaged in to do their work.

4. OUR STUDIES

We are currently piloting the Case Application Suite in the classrooms of two teachers. The software is used as a part of the LBD *Tunneling* unit. In *Tunneling,* each group serves as a team hired to help design a tunnel that runs across the state of Georgia. They need to address several issues, e.g., at what depth to dig the tunnel in a mountainous region and a sandy region, what methods to use for the digging, and support systems needed in the tunnel infrastructure. Cases are provided as a means of introducing students to different kinds of technology used to build tunnels, give them an appreciation of the difficulties and dangers they must take into account when designing their tunnels, and provide them with examples of both approaches that worked well, that they can apply to their designs, and approaches that did not work so well, that they can avoid making the same mistakes. In each classroom, there is a network of four computers, a laptop server, and a printer. The computers are next to each other, so students using them are together in one area of the classroom. LBD groups have 3 or 4 members. If a group has 3 students, they work around one computer. If it has 4, they work in groups around two adjacent computers. Two groups per period used the software in each observed class. Other groups used less-detailed paper-and-pencil design diary pages (Puntambekar & Kolodner, 1998) to scaffold their case work. The My Case Study page is a chart with four columns labeled *Case Summary*, *Problems that Arose*, *How Problems Were Managed*, and *Ideas To Apply To Our Challenge*. Both Mrs. K and Mr. J used the software in two of their three LBD classes. We are able to compare students who used the software with those who did not.

5. CASE STUDY 1: MR. J'S CLASSES

Mr. J has been teaching for 3 years and has been using LBD for all of those years. Mr. J is under pressure to complete the unit quickly, and as a result, his implementation is not as complete as intended. He uses 3 class periods to read and interpret the unit's cases. Mr. J begins by introducing the Lotschberg case – one that we provide for teachers to use to model case processing skills for the class. He reads it with the students and asks them questions about the vocabulary and about some of the causes of the problems the experts faced to make sure they understand the case, and then assigns each group one of four cases and tells them to read the case and fill out the Case Summary page. Because there are more groups than assigned cases, some cases are summarized by more than one group, and the overlap groups are chosen to use the software. The non-software students quickly read their cases and summarize them in one class period. The software students, spend the period talking with their partners and across computers about the prompts so that they can converge on an understanding of what the prompt is asking and so they can come up with an answer that they all agree on. For example, when trying to understand what happened as the experts built the tunnel, one two-member exchange went like this:

Girl: Were there any alternative solutions?
Boy: What does that mean?
Girl: Things they could've done.

Boy: They could've built over or around the mountain.
Girl: {shaking her head} No, they can't go over...
Boy: {interrupting} Yes, they can...
Girl: {interrupting} It's too high--it goes straight up {she raises her hand in an upward direction}.
Boy: But, see, if you put train tracks over a bridge, you know, how it goes over the water...
Girl: That costs a lot, and I don't think they had all that back then...
Boy: {interrupting} But it would be better than tunneling in {as in inside the mountain}...
Girl: {Interrupting} But they didn't know how to do that quick and easy.
Boy: Oh yeah. Well, say they could've gone around then.

They continue in this fashion, questioning each other's statements, showing sections of the passages that uphold or refute those statements, and agreeing upon an answer. The software groups ask the first author questions when they don't understand something. In particular, they ask what "carrying the solution out" means and what a rule of thumb is. With respect to carrying the solution out, this prompt asks them to describe how the experts implemented their solution. When she explains to them that this question is asking about the steps that the experts used to actually take the solution from just an idea on paper to a real structure, one of the students says, "Oh, it's like the process they used." With respect to the rule of thumb question, this prompt assumes an understanding of what rules of thumb are, and there is a template provided to help the students create rules of thumb. But students do not know what a rule of thumb is. She explains that a rule of thumb is a lesson they learned from this case—something that they could use in their challenge or something that someone reading their interpretation could learn from them. All of the groups seem to understand and continue working. These students get about halfway through the prompts in the Case Interpretation Tool in one class period. The following day, Mr. J has groups who are finished begin presenting their cases to the class. The software groups continue working at the computer. After each group finishes their presentation, they write down on the class whiteboard one fact, one idea, and one question they have gleaned from their case. As the groups give their presentations, Mr. J asks them questions to help them clarify the points they are making, and he pointedly asks them what they learned from their case. After the software groups finish their interpretations, it is their turn.

We observed all of the students as they gave their presentations, and we collected their final Case Interpretation Tool printouts or their Case Summary pages. Across the board, the software groups identified more problem-solution pairs (e.g., workers inhaling large amounts of soot was a problem, so ventilation shafts were built to circulate the air). The software groups also seemed to have a better understanding of the process the experts used to implement their solution – they mentioned these processes in their presentations, while the non-software groups did not. Interestingly, despite having had little experience creating rules of thumb, the software students were able to use the rule of thumb template as a guide to help them create relatively cogent rules of thumb.

ü"Take core samples before you ever start digging--never start digging on two sides of a mountain and try to meet in the center together because of problems like the tunnels might meet and be inches, even feet apart"
ü"Never mess with nitroglycerine because it is a dangerous substance and always plan out projects because you don't want to get unorganized."
ü"You shouldn't start from two ends of the tunnel because you could end up somewhere else instead of the same point...Make sure that your workers can withstand the temperatures"

6. CASE STUDY 2: MRS. K'S CLASSES

Mrs. K has been teaching for 10 years and has been using LBD for 4 years. Mrs. K's implementation is closer to the one suggested by LBD materials; she models cognitive skills as we suggest, and her implementation of case interpretation lasts 6 class periods. Mrs. K has created a template similar to the Case Study design diary page that has columns labeled *Facts, Problems, Solutions, Constraints, Ideas/Rules of Thumb, and Questions*, which she has transferred to a large piece of yellow paper that is hanging up at the front of the classroom. She reads the Lotschberg Case with the students, and as they identify facts, problems, and solutions, she writes them on the yellow paper under their respective headings. After they have read the case, Mrs. K helps them think about and state rules of thumb that she writes on the yellow paper under Ideas/Rules of Thumb, and from those rules of thumb, she pushes the students to formulate questions that she writes under the Questions heading. At the end of this exercise, she informs them that they will do the same thing with the cases that they will be assigned, and she assigns a case to each group. In one of her classes, software groups are chosen as in Mr. J's classes. In the other class, which is smaller, Mrs. K chooses the software groups to be those that have the same case(s) as the software groups in her other period. Students read their assigned cases as they are in the library or using the tool. The next day, non-software groups go to the library to search for additional information while the software groups begin using the Case Interpretation Tool. Mrs. K's software groups tend to talk across computers more than they talk with their immediate partner, and they always converge on a group answer before entering an answer into the computer. Questions that arise are about criteria and constraints, as well as rules of thumb. They know what constraints are, but they need an explanation of critera. The first author gives them a definition by example to explain the distinction, and the groups seem to understand and continue working.

When the software groups finish their interpretations, they too go to the library to seek more information on their cases. The next day, as the groups transfer what they've learned onto Case Summary templates, Mrs. K walks around to each of the groups, asking them clarification questions and helping them formulate rules of thumb and questions from those rules of thumb. Later, as each group presents their case to the class, Mrs. K and the students ask questions about each case. The quality of the presentations in Mrs. K's class was very high among both the software and non-software groups. But examining their artifacts and videotapes of the presentations shows three differences. First, the software groups make connections between being unable to satisfy criteria and

constraints and the outcomes that result. Second, they have more sophisticated causality to their rules of thumb. The non-software groups rules of thumb are in the form of simple imperative statements (e.g., "Control water problem", "Take core samples"), while the software groups' rules of thumb explain why (e.g., "Take core samples--they can save your life because if you hit the wrong kind of rock, you can get hurt" , "You should always have an oxygen pass so the toxic fumes can get out"). Third, the software groups tend to include the process the experts used to implement the solution. For example, one software group noted that because the experts couldn't drill through the mountain like they wanted to, they had to build the mountain in an S shape. Their non-software counterpart made no mention of this, even though the fact that an S shape was chosen over other alternatives was an important facet of the solution.

7. DISCUSSION

These observations suggest that the tools will be effective, and they provide important hints with respect to the role the teacher plays in making their use effective. In both teachers' classrooms, students using the Case Interpretation Tool seemed to have a better understanding of their cases than those students who did not use the tool.

ü *While software can prompt the right kinds of analysis among students, students engage better in targeted skills when the software complements teacher modeling and coaching of those same skills.* Even in the absence of active modeling by the teacher, as in Mr. J's classes, the students were still able to pull out important facts and solutions, identify positive and negative outcomes, and understand the role that technology played in the design and building of the expert's tunnels. But when the teacher modeled the process of understanding the case, and coaches students as they attempted to do it for themselves, they not only identified more problems, but they were also able to articulate why the problems arose and formulate ways that they could prevent making the same mistakes.

ü *It is important for the teacher and the tool used in class to use the same vocabulary and value the same reasoning.* Mr. J did not familiarize the students enough with LBD's concept of rules of thumb that they were able to take full advantage of the tool.

ü *It's worth it to take the time for students to use resources well, even if it cuts into other activities.* Mrs. K not only modeled the processes she wanted students to engage in, but she gave them time to both pull out the problems and solutions experts experienced and to explain the causes of results experts experienced. As a result, students were able to extract lessons that they could apply later. If Mr. J had given students as much time as Mrs. K had to read and interpret the cases, they might have progressed farther.

We are still collecting and analyzing data about use of the entire suite of tools and about students' ability to transfer what they learned using the tools to other case interpretation and application situations. We will use what we find to revise the prompts and hints in the tools to make them more effective and to develop teacher materials explaining how to integrate tool use into their classroom practices. During the coming school year, we will be running a more in-depth analysis addressing the big questions of our research study.

8. ACKNOWLEDGEMENTS

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