ABSTRACT

USE OF INTELLIGENT TUTOR DIALOGUES ON PHOTOGRAPHIC TECHNIQUES:
EXPLANATION VERSUS ARGUMENTATION

by Elizabeth Marie Cedillos

The goal of this study was to utilize an Intelligent Tutoring System (ITS), AutoTutor Lite, in comparing different methods of learning for an ill-structured domain via interaction, through self-explanation or argumentation. One-hundred twenty participants were assigned to one of four conditions: 1) didactic-explanation, 2) didactic-argument, 3) didactic-no interaction, or 4) no didactic, no interaction. All 3 didactic groups performed significantly better than the control on the multiple-choice test. The didactic-explanation group outperformed the control group, but not other didactic groups on the photography advice measure. Significant differences were found for written-type scenarios for photography advice measures, with the didactic-explanation group and the didactic-argument group outperforming the control group, but not the didactic only group, nor each other. For the photography judgment task, the didactic-no interaction group outperformed the control on the composition dimension and outperformed the didactic-explanation, which outperformed the control on the shutter speed dimension.
USE OF INTELLIGENT TUTOR DIALOGUES ON PHOTOGRAPHIC TECHNIQUES:
EXPLANATION VERSUS ARGUMENTATION

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INTRODUCTION

Many factors contribute to an enriching learning environment, but one of the most important contributions comes from an effective conveyer of information. A good instructor will provide encouragement, clarify ideas and errors, and question student’s understanding (Glaser & Bassok, 1989; Bloom, 2006). These concepts, when implemented in one-on-one tutoring, have been shown to facilitate deep understanding and better learning (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001). Not only have these concepts been implemented in human tutoring, but intelligent tutoring systems have also taken advantage of this dynamic process. Human tutors and intelligent tutoring systems provide a basis for deep learning by using techniques that encourage and facilitate deep thinking. The goal of the present study is to explore how explanation- and argument-based verbal interactions in an intelligent tutoring system (ITS) influence learning content knowledge and application of that knowledge, in the ill-structured domain of photography.

Teachers, Learners, and Tasks

The goal of teaching is to provide a foundation for learners that will enable them to become deep learners and thinkers. Glaser and Bassok (1989) identified three components that a teacher does to facilitate learning. First, one must provide a description of desired outcomes, that is, what students are to know and the skills they are to acquire (Glaser & Bassok, 1989). Next, an instructor must be able to assess a student’s competencies, knowledge, and abilities. Lastly, an instructor must make clear how learning is to take place and how the desired outcomes will be accomplished (Glaser & Bassok, 1989). With these three components in place, students should develop the skills necessary to learn and think about not only the currently presented material, but also any other content, at a much deeper level. Although teaching is a large part of how one learns, it is not solely the responsibility of a teacher; active learning must involve the student.

In order to develop the ability to deeply understand content, a learner must do a number of things, like be able to reason logically and causally and relate new concepts with old ones (Kopp, Britt, Millis, Graesser, 2010). A study by Chi, Bassok, Lewis, Reimann, and Glaser (1989) distinguishes good learners from not good learners from the way they generate ideas. Good students provide more and better explanations about a problem at hand, and are better monitors of their comprehension and what they are doing (Chi et al., 1989). Self-explanation works because the learner provides principles and concepts from their source material, while
monitoring allows good learners to identify what they do not know and do not understand (Chi et al., 1989). These abilities not only make good students, they also make good tutors as well.

**Outcomes of One-on-One Tutoring**

The benefits of one-on-one tutoring go beyond self-explanation, question asking, and monitoring. Bloom (1984) discovered what he termed “the 2-sigma problem.” In his study, Bloom (1984) divided participants into three groups: convention classroom setting, a mastery-learning group, and a one-on-one tutoring group (sometimes 2 or 3 students per tutor), where feedback and corrective procedures were given then tested. The findings from this study showed that students in the tutoring group outperformed students in a convention classroom by two standard deviations. Findings such as these are consistently found, which is why Chi and colleagues (2008) have put forth three hypotheses for why tutoring is effective. The first hypothesis states that the tutor is responsible for learning gains, the second hypothesis states that the tutee is responsible for learning gains, and the third hypothesis suggests that the simple interaction of both the tutor and student is responsible for learning gains.

Chi and colleagues (2008) compared five groups: tutored, collaborative observers, collaborating, solo observation, and a study alone group, to see which group learned better. They found that collaborative learning-type groups, tutored, collaborative observing, and collaborating, performed significantly better than either of the solo groups. Similarly, Jeong and Chi (2006) found that collaborative interaction allows for each person’s knowledge to be shared so that a common understanding of the knowledge can be found and agreed upon. The interaction allows for discussion of divergent thinking so that similar thinking is found; this is called knowledge convergence (Jeong & Chi, 2006). Findings such as these indicate that the interaction of student and tutor, or student and student, work together to guide learning and make learning gains (Chi et al., 2008). There is little doubt that the interaction between a student and a human tutor is beneficial, but the question about whether an ITS can lead to the same outcomes remains. If an ITS is going to prove beneficial, it needs to incorporate elements that are similar to a human tutor.

**Dynamics of One-on-One Tutoring**

The main goal of one-on-one tutoring is to provide clarification of information and guide learning in a more student-centered environment (Bloom, 1984). Chi and colleagues (2001) have put forth a theory for why tutoring works; they call it the interaction hypothesis (I-hypothesis).
Essentially, Chi and colleagues (2001) believe tutoring is successful because interactions between the tutor and the tutee work together to guide learning and make learning gains (Chi, Roy, Hausman, 2008). In their definition, interaction includes participating in meaningful dialogue. This dialogue can range from scaffolding, to elaboration, and to content and comprehension questions (Chi et al., 2001). Additionally, one-on-one tutoring can include monitoring, knowledge telling, correcting misinformation, and self-explanation.

An important aspect of one-on-one tutoring is scaffolding. Scaffolding is not simply confirming or denying information provided by the student as correct or incorrect; it provides the student with critical information about their performance (Chi et al., 2001). Scaffolding can provide a student with reassurance and encourage elaboration so they can add to their understanding. Comprehension questions are also important to tutoring because asking questions facilitates elaboration, inference generation, integration of new and old information, and better reasoning ability, which all lead to more learning gains (Roscoe & Chi, 2007; Roscoe & Chi, 2008). Monitoring by means of assessment and diagnosis are also important to both the student and the tutor because they allow for monitoring of student’s understanding and identifying deficits in student’s knowledge (Chi, Siler, & Jeong, 2004; Chi et al., 2004). While all these parts of tutoring are important, the element this study is most interested in is elaboration.

Tutor-based explanations are similar to tutor monitoring; tutors can provide missing, false, or incomplete information as well as correct misinformation. A tutor can also elicit more comprehensive and complete explanations from a student, allowing students to make inferences that go beyond what is presented in a textbook (Chi et al., 2004). Explanations require students to elaborate their understanding of information, thus allowing for a deeper level of understanding and a more complete answer than a student who does not utilize explanation (Chi et al., 2004).

**Intelligent Tutoring Systems**

Intelligent tutoring systems (ITS) are computer based tutoring programs that can be dynamically adapted to fit the needs that are most beneficial to any given student (Ohlsson, 1986). An intelligent tutoring program should be able to ask questions, explain answers, give examples and counter-examples, have a couple of practice problems, and provide illustrations and demonstrations that the learner would find helpful (Ohlsson, 1986). As put forth by Ohlsson (1986) an adequate ITS will contain four principles. Similar to one aspect of teaching, outlined by Glaser and Bassok (1989), the system first should have a method to diagnose the cognitive
state of the student; this means assessing what the student knows. Second, the system should be able to conduct a subject matter analysis. This is important because the system needs to be able to distinguish between actual important subject material and the not-so-important material. Third, an ITS needs to have good teaching tactics. This requires that the intelligent tutor, similar to an in-person tutor and teacher, monitors what the learner knows and responds accordingly (Ohlsson, 1986; Glaser & Bassok, 1989). The last principal an ITS should have is teaching strategies (Ohlsson, 1986). While this is ill-defined, it can be taken to mean the strategies or methods the tutor uses to engage a student during the tutoring session.

**Self-Explanation**

Self-explanation plays a big role in tutoring. We can think of self-explanation similarly to explanation whereby a student gives a non-superficial response that makes relations between texts or newly learned material and prior knowledge (Pressley, Wood, Woloshyn, Martin, King, & Menke, 1992). A main goal of self-explanation is to allow a student to check their understanding of material, check for inconsistencies in their thinking, and generate examples that can strengthen the connection of the new material to some prior knowledge (Pressley et al., 1992; Roscoe & Chi, 2008). Of course, taken together, these properties allow for students to make greater learning gains (Chi, Roy, Hausmann, 2008).

Self-explanation has been shown to increase learning gains more so than the typical classroom setting where an instructor, expert, or peer gives a simple monologue-style explanation (Chi et al., 2008; Pressley et al., 1992). Chi, De Leeuh, Chiu, and Lavancher (1994) demonstrated that students who were prompted to give self-explanations, compared to unprompted students, had a greater understanding of the material to be learned. Self-explaining students were also better at inducing information when it was not explicitly stated, had a better understanding of complex questions, and made fewer errors in their use of information presented (Chi et al., 1994). Furthermore, Jeong and Chi (2007) found that when students were paired with another student, the more they engaged in interactions, which contained some elements of self-explanation, the more common knowledge the students gained. Clearly, being able to monitor one’s understanding by giving self-explanations has its benefits, an effect that also carries over to one-on-one tutoring.

Not only can students gain more from self-explanations in the classroom, but research has also shown that self-explanation in one-on-one tutoring works as well. Roscoe and Chi (2008)
found that untrained peer-tutors engaged in reflective knowledge-building, leading to an increase in learning. Reflective knowledge-building incorporates elements of self-explanation such as monitoring understanding, elaborating on course material, integrating new and prior knowledge, and revising misunderstandings (Roscoe & Chi, 2008; Roscoe & Chi, 2007). Findings such as these indicate that explanation can be extremely beneficial in comprehension and learning. However, self-explanation is not the only form of discourse that can be effective. Argumentation is another process that has yet to be researched as an effective method of learning in tutoring, specifically in intelligent tutoring.

**Argumentation**

Argumentation, when utilized correctly, could aid in learning by helping students identify premises of information presented and making connections between premises and conclusions (Wolfe, 2011). First, it is helpful to understand what an argument is. Toulmin (1958) says an argument is a claim supported by data, these claims and data are connected by warrants, which are supported by statements that back-up and provide evidence for claims. There can also be different types of arguments. The first type of argument is definitional and attempts to describe a subject, a causal argument attempts to describe why something is the way it is, an evaluation argument describes the pros and cons of the subject, and a proposal argument attempts to address how a subject should be investigated and dealt with (Wolfe, 2011).

No matter the type of argument being made, the ultimate goal of argumentation is persuasion (Voss & Van Dyke, 2001). A person that wants to persuade another uses logic and deductive reasoning, thus if a student can make a good argument they should be good at reasoning, which would lead to learning gains. For instance, Means and Voss (1996) provided evidence that high-ability students use arguments more so than low- and middle-ability students. Additionally, Kuhn (1993) theorized that general reasoning is similar to scientific reasoning and both help develop critical thinking, which is necessary for making an argument. These are also important skills in evaluating an argument and its claims (Voss & Van Dykes, 2001). Critical thinking is a valuable skill to have when in a learning environment, which is why many standard tutoring practices make a student engage in critical thinking tasks.

An important finding from Wiley and Voss (1999) found that when students make arguments they increase their understanding of information; they called this knowledge-transforming. Knowledge-transforming, much like explanation during tutoring, is when a student
makes connections beyond the presented information; an important skill to learn in order to get the most out of a learning experience. Additionally, Butler and Britt (2011) have found evidence that argument-type tutorials can improve student essays by helping them make higher-level qualitative changes to content rather than simple wording changes that did not increase the qualitative content. If students are able to increase the qualitative content of an essay, this means that their critical thinking about the subject matter is improving.

**Effectiveness and Shortcomings of Intelligent Tutoring Systems**

Evidence that self-explanation can be implemented by an ITS has been examined with outcomes demonstrating their effectiveness of eliciting self-explanations. One such system is iSTART and iSTART 2, which stands for Interactive Strategy Training for Active Reading and Thinking (McNamara, Levinstein, & Boonthum, 2004; Levinstein, Boonthum, Pillarisetti, Bell, & McNamara, 2007). This system has been found to improve self-explanation reading training (SERT) at levels similar to an in-person tutor by having students explain, elaborate, make inferences, paraphrase, and monitor their comprehension (McNamara et al., 2004; Graesser, McNamara, & VanLehn, 2005). While there is some research that has examined the outcomes of self-explanation in an ITS, little research has been conducted that examines the use of argument-based learning using an ITS.

A logical next step for the ITS world is to employ an argument-based teaching strategy; this would be especially useful for an ill-structured domain such as photography. Few have examined the effectiveness of an ITS’s use of argumentation as a teaching method. However, Wolfe, Britt, Petrovic, Albrecht, and Kopp (2009) found that a web-based ITS was effective at teaching students how to make counterarguments. While this does not necessarily indicate that using argument-based teaching can lead to learning gains, it does demonstrate that students, while using an ITS, can make arguments and improve their knowledge about argumentation (Wolfe, et al., 2009).

Another aspect of ITS’s that is necessary for effective learning is the use of natural language dialogues. Natural language dialogue simply means spoken dialogue similar to what would occur with a human tutor (D’Mello, Graesser, & King, 2010). Research has demonstrated that natural language dialogue produces better outcomes than typed conversations (D’Mello et al., 2010). Natural language dialogues are now a central part of ITS’s, and much research has gone into creating an appropriate natural language dialogue. Why2-Atlas is one such ITS that
uses natural language to teach qualitative physics (VanLehn, Jordan, Rose, Bhembe, Bottner, Gaydos, Makatchev, Pappuswamy, Ringenberg, Roque, Siler, & Srivastava, 2002).

One of the most successful ITS’s is AutoTutor. AutoTutor uses natural language during dialogue sessions with students. Similar to one-on-one tutoring, AutoTutor engages in a conversation with the student that allows them to answer, then improve upon their response to questions by drawing out the learner’s knowledge (Graesser, Lu, Jackson, Mitchell, Ventura, Olney, & Louwerse, 2004). AutoTutor uses latent semantic analysis (LSA) to determine if the learner’s response is conceptually similar to the desired response; this has been shown to be as reliable as human judgments (Graesser et al., 2004). The use of LSA allows AutoTutor to monitor what the student knows, similar to a human tutor. Also similar to a human tutor, AutoTutor can answer questions, correct incorrect ideas, and provide missing information (Graesser et al., 2004). AutoTutor has consistently been shown to improve learning gains, deep levels of comprehension, and the use of metacognitive strategies (Graesser et al., 2004; D’Mello et al., 2010; Graesser et al., 2005).

AutoTutor Lite is a moderated version of AutoTutor. AutoTutor Lite is an ITS that can be run on-line and not as a software program. Additionally, the conversational aspect of AutoTutor Lite is not as good as AutoTutor; it cannot answer questions and feedback provided is predetermined based on amount of expectation text that the tutee meets. In response to a participant’s reflection, AutoTutor Lite provides probing feedback that the programmer can input prior to the tutoring session. AutoTutor Lite cannot differentiate content of responses and can only identify if responses are relevant to entire expectation texts. However, AutoTutor Lite does use LSA and allows the creator to upload any content they want into the program instead of information that is pre-determined by a third party. This means that we can create our own tutorial on any subject matter. The present study’s tutorial topic will be photography, because, as an ill-structured and artistic domain, it lends itself towards proper formal techniques and opinions that can be argued for or against.

Goals & Hypothesis

The goal of the present research is to determine if argument-based student-tutor verbal interactions are better than explanation-based interactions for teaching in some ill-structured knowledge domains. That is, can one learn concepts of photography better when they have to make an argument for or against using certain parameters in photography? I hypothesize that for
declarative knowledge items, participants who receive the didactic-explanation interaction tutorial will perform better than participants in the didactic-argument interaction tutorial because they will be providing a technical response during their interaction. This type of response will allow them to learn the varying aspects of photography better, whereas the didactic-argument will be forced to “pick a side” and will not be as inclusive in their interactions. Additionally, I hypothesize that participants who receive the didactic-argument interaction tutorial will perform better on making judgments about photographs and on knowledge application tasks, because these require causal reasoning which takes place during argumentation.

**METHOD**

In order to compare the effectiveness of the two types of interactions four conditions were used in this study. The didactic-explanation condition, had an explanatory-type of interaction integrated in the tutorial. Participants were prompted with a good (“Can you give an explanation for why the photograph you just saw was well composed and correctly exposed?”) and a bad (“Can you give an explanation for why the photograph you just saw was poorly composed and incorrectly exposed?”) interaction. The didactic-argument condition were essentially asked the same question except were asked to make an argument for both a good (“Can you make an argument for why the photograph you just saw was well composed and correctly exposed?”) and bad (“Can you make an argument for why the photograph you just saw was poorly composed and incorrectly exposed?”) photograph. The didactic-no interaction condition did not have any interaction and instead only received the didactic tutorial on photography that the other two conditions had. To control for time on task, an irrelevant tutorial with no interaction was used as the fourth condition.

One-hundred twenty participants were recruited from the psychology subject pool at Miami University and were given 1 credit for their participation in the study. After collecting informed consent, participants were randomly assigned to one of four conditions: 1) didactic-explanation interaction (n = 31), 2) didactic-argument verbal interaction (n = 29), 3) didactic-no interaction (n = 31), and 4) an irrelevant tutorial and no verbal interaction (control) (n =29). Using AutoTutor Lite, a didactic tutorial was presented to participants on a computer monitor. Participants wore headphones to hear the didactic information and to not disturb other participants in the room. All tutorials, except the control, contained the same content on photography; the only difference was the type of interaction. In the didactic-explanation
interaction, participants were asked by ATL to explain concepts related to the photography tutorial they just received; likewise, for the didactic-argument interaction, participants were asked to make a couple of arguments for or against using certain elements of photography.

Upon completion of the tutorial, participants were directed to Qualtrics to complete the three dependent measures. The dependent measures included: 1) a multiple choice test of declarative knowledge items (Appendix A), 2) a knowledge application test where participants received a novel photographic situation and responded in writing on ways improve the photograph (Appendix B) and 3) a judgment of photographs that were composed with, and in violation of, the learned principles from the tutorial (Appendix C), and. When participants had completed the study, they were given debriefing forms.

RESULTS

I conducted an ANOVA on multiple-choice items to test for difference between conditions. There were significant differences in scores $F(3, 116) = 18.273, p < .001$. Tukey’s HSD post-hoc test indicates all didactic tutorial conditions performed better than the control, however, there were no significant differences in scores between the didactic-argument, didactic-explanation, and the didactic only conditions (see Table 1 for means and standard deviations for multiple-choice items).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didactic &amp; Explanation</td>
<td>20.39</td>
<td>3.84</td>
</tr>
<tr>
<td>Didactic &amp; Argument</td>
<td>19.69</td>
<td>3.41</td>
</tr>
<tr>
<td>Didactic Only</td>
<td>19.16</td>
<td>4.58</td>
</tr>
<tr>
<td>Control</td>
<td>13.19*</td>
<td>4.38</td>
</tr>
</tbody>
</table>

* Control groups < didactic groups, $p < .05$

For the application task, two raters made independent judgments on 4 different scenarios that participants were told to give advice to the photographer on. The rater’s were trained on the first 30 participants so their data is left out of the analysis, leaving 90 participant’s data to analyze. Additionally, several participants did not respond to some of the questions so their responses were given scores of zero but were still included in the analysis.
For the scenarios, participants were given 2 scores. The first score was content and knowledge based. For each scenario there were multiple dimensions participants had to include in their answer to receive points; participants could receive up to 3 points per dimension. One point was earned for mentioning the dimension, 1 point for making a correct suggestion as to what to do with the dimension (e.g. increase aperture), and 1 point for providing a reason as to why to change the dimension. Participants could also get extra points for a dimension not defined in the scoring rubric, though scores never went above the maximum score as defined by the rater’s rubric. Maximum score based on the pre-defined rubric for scenario 1 was 9, 15 for scenario 2, 9 for scenario 3, and 12 for scenario 4 (see Appendix D for photography advice rubric). The second score served as a measure of argument-making ability. For this score the number of reasons given was counted, in other words, the more reasons the higher the score. Inter-rater reliability was calculating by taking the difference of the total number of missed judgments (raters did not agree) and the total judgments made then dividing by the total judgments made. An inter-rater reliability score was calculated for each scenario. For scenario 1 inter-rater reliability was 92%, for scenario 2 it was 91%, for scenario 3 it was 83%, for scenario 4 it was 89%.

An ANOVA for the total score of all 4 scenarios combined, shows a significant difference in knowledge score, $F(3, 86) = 3.83, p < .05$. Post-hoc analysis revealed that the didactic-explanation group significantly outperformed the control group but not the didactic-argument or the didactic only group. When each scenario was broken down separately, an ANOVA reveals no significant differences in knowledge scores for scenario 1 (Starry Night), $F(3, 86) = 1.88, p = .138$, for scenario 3 (Waterfall), $F(3, 86) = 1.96, p = .126$, or for scenario 4 (Dog), $F(3,86) = 1.61, p = .193$. However, there was a significant difference among groups for the knowledge scores in scenario 2 (Sunset) $F(3, 86) = 4.203, p < .01$. For scenario 2, Tukey’s post-hoc test indicates the didactic-explanation group significantly outperformed the control group but not the didactic-argument or the didactic only group (see Table 2 for means and standard deviations for total scores for all scenarios combined and each scenario).
Table 2

*Mean Total Score on Knowledge Application by Condition (standard deviations in parenthesis)*

<table>
<thead>
<tr>
<th>Condition</th>
<th>All Scenarios Combined</th>
<th>Scenario 1: Starry Night</th>
<th>Scenario 2: Sunset Ship</th>
<th>Scenario 3: Waterfall</th>
<th>Scenario 4: Dog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didactic &amp; Explanation</td>
<td>*17.92 (5.53)</td>
<td>4.29 (1.52)</td>
<td>*6.2 (2.15)</td>
<td>3.71 (2.01)</td>
<td>3.71 (2.07)</td>
</tr>
<tr>
<td>Didactic &amp; Argumentation</td>
<td>16.19 (5.38)</td>
<td>4.00 (1.79)</td>
<td>5.76 (2.91)</td>
<td>3.76 (1.70)</td>
<td>2.67 (1.53)</td>
</tr>
<tr>
<td>Didactic Only</td>
<td>14.26 (8.00)</td>
<td>3.57 (2.10)</td>
<td>4.74 (3.72)</td>
<td>3.13 (2.38)</td>
<td>2.83 (1.72)</td>
</tr>
<tr>
<td>Control</td>
<td>11.59 (7.10)</td>
<td>3.10 (1.85)</td>
<td>3.32 (2.90)</td>
<td>2.50 (1.74)</td>
<td>2.68 (2.15)</td>
</tr>
</tbody>
</table>

*Indicates significant difference in knowledge for scenario, p < .05; didactic-explanation > control, p < .05

Scenarios were further broken into either written-type scenarios, whereby the total knowledge and content score for scenario 1 and 2 are added together, or picture-type scenarios, whereby the total knowledge and content score for scenario 3 and 4 are added together (see Table 3 for means and standard deviations of total score for each condition and scenario-type). There was a significant difference between conditions for the written-type scenarios, $F(3, 86) = 4.29, p = .007$. Post hoc analysis indicates the didactic-explanation group and the didactic-argument group outperformed the control group, but not the didactic only group, nor each other. Unfortunately, there were no significant differences between conditions for any of the argument-making ability, or “reasons,” scores (see Table 4 for means and standard deviations for total reasons for each condition and scenario).
Table 3

Mean Total Score on Knowledge Application by Scenario Type and Condition (standard deviations in parenthesis)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Written (Scenarios 1 &amp; 2) Combined</th>
<th>Photograph (Scenarios 3 &amp; 4) Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didactic &amp; Explanation</td>
<td>*10.50 (3.07)</td>
<td>7.42 (3.53)</td>
</tr>
<tr>
<td>Didactic &amp; Argumentation</td>
<td>*9.76 (3.49)</td>
<td>6.43 (2.94)</td>
</tr>
<tr>
<td>Didactic Only</td>
<td>8.34 (5.30)</td>
<td>5.96 (3.55)</td>
</tr>
<tr>
<td>Control</td>
<td>6.41 (4.33)</td>
<td>5.18 (3.29)</td>
</tr>
</tbody>
</table>

*Indicates significant difference in knowledge for scenario-type (written or photograph), \( p < .05 \); didactic-explanation > control, \( p < .05 \); didactic-argument > control, \( p < .05 \)

Table 4

Mean Total Reasons on Knowledge Application by Condition (standard deviations in parenthesis)

<table>
<thead>
<tr>
<th>Condition</th>
<th>All Scenarios Combined</th>
<th>Scenario 1: Starry Night</th>
<th>Scenario 2: Sunset Ship</th>
<th>Scenario 3: Waterfall</th>
<th>Scenario 4: Dog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didactic &amp; Explanation</td>
<td>3.92 (2.50)</td>
<td>.88 (1.08)</td>
<td>.92 (.93)</td>
<td>.96 (.86)</td>
<td>1.17 (1.00)</td>
</tr>
<tr>
<td>Didactic &amp; Argumentation</td>
<td>3.76 (2.34)</td>
<td>1.00 (.84)</td>
<td>.90 (1.04)</td>
<td>1.19 (.98)</td>
<td>.67 (.73)</td>
</tr>
<tr>
<td>Didactic Only</td>
<td>3.74 (3.35)</td>
<td>.91 (.95)</td>
<td>1.09 (1.65)</td>
<td>.91 (.90)</td>
<td>.83 (.72)</td>
</tr>
<tr>
<td>Control</td>
<td>2.86 (2.38)</td>
<td>.55 (.74)</td>
<td>.68 (.84)</td>
<td>.77 (.69)</td>
<td>.86 (.83)</td>
</tr>
</tbody>
</table>

Photography judgment scores were totaled based on the investigator’s own judgment on how well a photograph demonstrated the six dimensions of photography. Participants who are in the didactic conditions should be familiar with all six dimensions they were asked to make a judgment about. Each of the 15 photographs was judged as to whether or not they displayed a dimension well; the photograph was either classified as displaying the dimension or not. If a photograph displayed multiple dimensions well, then they were counted for all dimensions they displayed, therefore a photograph could be classified on more than one dimension. All
photographs that displayed a dimension were considered to represent that dimension. Thus, participant’s judgment scores on each photograph that represented the same dimension were added together to get a score for the dimension. For example, photograph 2, 5, 8, 12, and 14 were considered to be a good representation of the “rule of thirds” dimension, so participant’s scores on those photographs were added together to represent that dimension and analyses were conducted based on the photography dimension (see Appendix E for which photographs were in each dimension). Therefore, the photography judgment scores and analyses were based on how well participants were able to identify a good use of each dimension.

In the photography judgment task, an ANOVA revealed no significant differences on four of the six dimensions of photography. These include: 1) aperture, $F(3, 113) = 1.28, p > .05$, 2) rule of thirds, $F(3, 114) = .096, p > .05$, 3) exposure, $F(3, 112) = .5, p > .05$, and 4) ISO, $F(3, 113) = 1.28, p > .05$. There were significant differences in 2 of the 6 different dimensions of photography, composition, $F(3, 115) = 2.91, p < .05$ and shutter speed, $F(3, 114) = 4.81, p < .01$. Post-hoc tests indicate that for the dimension of composition, the didactic only condition performed significantly better than the control. Additionally, post-hoc tests indicate that for the dimension of shutter speed, the didactic only and didactic-explanation conditions significantly outperformed control condition (see Table 5 for mean performance and standard deviations on photography judgments).

Table 5

<p>| Mean Performance on Photography Judgment (standard deviations in parenthesis) |
|----------------------------------|------------------|------------------|------------------|------------------|</p>
<table>
<thead>
<tr>
<th>Photography Dimensions</th>
<th>Didactic &amp; Explanation</th>
<th>Didactic &amp; Argumentation</th>
<th>Didactic Only</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture</td>
<td>65.69 (10.59)</td>
<td>65.31 (15.98)</td>
<td>71.29 (14.30)</td>
<td>69.46 (15.29)</td>
</tr>
<tr>
<td>Composition</td>
<td>45.42 (8.36)</td>
<td>42.79 (8.85)</td>
<td>*48.26 (10.57)</td>
<td>41.54 (10.19)</td>
</tr>
<tr>
<td>Shutter Speed</td>
<td>*66.67 (8.86)</td>
<td>60.66 (16.18)</td>
<td>*69.32 (13.85)</td>
<td>56.71 (16.51)</td>
</tr>
<tr>
<td>Rule of Thirds</td>
<td>31.29 (7.96)</td>
<td>31.54 (8.54)</td>
<td>32.00 (8.37)</td>
<td>30.86 (8.66)</td>
</tr>
<tr>
<td>Exposure</td>
<td>65.40 (11.76)</td>
<td>64.52 (15.35)</td>
<td>68.16 (14.31)</td>
<td>67.92 (13.87)</td>
</tr>
<tr>
<td>ISO</td>
<td>74.43 (12.63)</td>
<td>69.34 (16.15)</td>
<td>76.13 (14.24)</td>
<td>70.43 (18.42)</td>
</tr>
</tbody>
</table>
*Indicates significant difference in judgment of photographic dimensions, \( p < .05 \); composition: didactic-only > control, \( p < .05 \); shutter-speed: didactic-only > didactic-explanation > control, \( p < .05 \).

**DISCUSSION**

The findings from this study suggest that an interaction between an ITS and a student can lead to differences in learning. This supports Chi and colleagues’ (2008) third hypothesis regarding tutoring. Generally speaking, the significant findings from this study show that groups that received the tutor, even with no verbal-interaction between the ITS and the student, performed better. Unsurprisingly, for knowledge items, all groups that received the tutorial outperformed the control group. However, in regards to the specific hypothesis whereby the didactic-explanation group would outperform all groups, there were no indications that they gained more knowledge. This is surprising because one would expect a group that had verbal-interaction with the ITS to gain more knowledge than simply receiving information. This does not support the hypothesis that the use of explanation in tutoring leading to learning gains (Chi et al., 2008). These findings may be due to the short duration of the tutorial and students being able to easily recall information at the time of testing. However, there were no ceiling or floor effects of scores found for any conditions. This suggests that learning did occur and the multiple-choice items were somewhat challenging even with receiving a tutorial.

In regards to the interaction element of the ITS, a visual examination of the interaction data suggest that while not all participants completed the interaction, many received good coverage scores. This suggests that participants did have an interaction with the ITS, but because not all of them continued with the interaction the benefits of the interaction with the tutorial was probably lost. As outlined by Pressley and colleagues (1992), the use of explanation allows for the student to check their understanding of material and inconsistencies in their thinking so that a connection to new material and prior knowledge is made. If the participants are not engaging in a complete interaction, they are not getting all the feedback from the ITS to help build that connection. Though participants in the interaction group may not have completed the interaction with the ITS, there were still a few significant findings.

Many findings showed that the didactic-explanation groups significantly outperformed the control group on the photography advice measures. Additionally, the didactic-explanation group had higher scores, though not significantly, than the didactic-argument and didactic-no interaction group. The didactic-argument group also performed better, though not significantly,
than the didactic-no interaction group. Even though findings such as these were not significant, there is a trend that suggests that interaction between the ITS and the student, and not just knowledge from the tutorial, leads to differences in learning. If more participants fully engaged in the interaction, this may have led to significant findings.

It is interesting to note that when participants were presented with a written description of a photographic scenario the didactic-explanation and argument groups performed better. However, when given an actual photograph only the explanation group performed better than the control group but did not perform significantly better than either the didactic-argument or the no interaction group. In line with previous research (McNamara et al., 2004; Graesser, et al., 2004), these findings indicate that the interactive element between the ITS and the student leads to learning gains. What remains to be determined is why the interactive groups performed better on written photographic scenarios.

The didactic-argument group did not give more reasons than any other conditions. These findings are somewhat contrary to previous research that has found that making arguments increase understanding of information (Wiley & Voss, 1999). This suggests that reasoning ability may not be as easily improved as simply framing a study session in an argumentative format. However, there is a non-significant trend in the averages indicating that making argument-type responses have the potential to lead to learning gains that are significantly better than a didactic-only tutorial. In the current study the differences in the instructions between the explanation and argument groups was simply giving instructions that could have been too subtle for participants to pick up on; they might not have even known they needed to make an argument.

For the judgment task, participants performed well on two of the six dimensions of photography in that they were able to identify whether a photograph had good or bad composition or used an appropriate shutter speed. For the composition dimension the didactic-no interaction condition performed significantly better than the control, which is expected. However, one would expect that all didactic conditions would outperform the control and if nothing else then the interaction conditions would perform better than the no interaction condition. For the shutter speed dimension, the didactic-no interaction again outperformed the control and the didactic-explanation condition. Both of these findings were unexpected and little explanation can be offered as to why this occurred.
One possible explanation is that the interaction with the tutor forced participants in the argument and explanation conditions to focus on elements that were not composition and shutter speed. This would mean that participants in the interaction condition focused on other elements and did not fully understand composition and shutter speed. Apparently, no other psychological studies have had participants make standardized judgments on different dimensions of photographs, such as composition and shutter speed, in the manner that this study used them. Therefore, I created these materials and used my own judgment for the making photography judgment dependent measure, which may or may not be an accurate judgment of the photograph. Because judgments were based on the researcher’s judgment of the photograph, the photograph may fail to fully capture the dimensions of photography I aspired to assess. Therefore, participants may have made more accurate judgments on a different dimension that were not accounted for.

Additionally, the subject of the study, photography, is considered an ill-structured domain. Being an ill-structured domain in and of itself means that even though elements of photography are well established, they can still be scrutinized subjectively. This means that participants’ opinion about how well a photograph captured different dimensions of photography was subjectively different than the parameters the experimenter set for each dimension of the photographs. This could also be true for the knowledge application task because participants gave advice based on what they subjectively thought may be a better photograph. This is of course allowable due to the nature of the photography as an ill-structured domain.

Not only is photography an ill-structured domain, it is also a visual domain. This could mean that a different type of learning is taking place and may require a different type of teaching method. The learning gains that are typically found with ITS may not be as great if a visual domain, such as photography, is used. Additionally, the use of argumentation or explanation may not transfer well to a visual domain during both teaching and learning of the subject.

**Limitations**

In the photography judgment task, the researcher used their own judgment on photographs. This is far from a standardized method to evaluate judgments. Future research should explore more standardized measures to assess participants’ qualitative judgments on photographs. In order to do this, advice and judgments from advanced and expert photographers
should be obtained. Additionally, photographs could reflect use of only one dimension of
photography, instead of multiple dimensions that the photographs in this study portrayed.

Other than measurement issues, the feedback the ITS gave participants during the
incorrectly exposed and poorly composed interaction may not have been adequate. This
judgment is based on an examination of coverage scores, which were lower for the incorrectly
exposed and poorly composed interaction than compared to the correctly exposed and well
composed interaction. On each turn in AutoTutor Lite, if a user meets a threshold, or falls below
it, during an interaction it will provide appropriate pre-programmed feedback. Because the pre-
programmed feedback was based on the parameters set by the researcher, they may not have
been adequate. Therefore, feedback may not have been appropriate and participants would not
get a lot out of the interaction.

**Future Research**

The manipulation of type of interaction was subtle and participants may not have known
they were to make an argument; instead, they may have simply been regurgitating what the tutor
had said. In order to strengthen the manipulation of interaction type, future research should
provide a brief tutorial about parts of an argument and advice on how to make an argument. This
will make the interaction-type more salient and participants can attempt to make more
argumentative-type statements. Additionally, the goal of argumentation is to persuade another
(Voss & Van Dyke, 2001), which was a lacking element in the present study when asking
participants to make an argument. Along with teaching participants how to make an argument,
future research should provide them with an incentive so that they have a higher desire to make a
persuasive argument. This will ensure they approaching the information with the goal of making
an argument.

It would also be interesting to see how long the effects of the tutor last. The tutorial itself
was short, which means that participants could easily have remembered the information that they
had just seen. A follow-up study should include a condition that would assess knowledge gained
and applicability of that knowledge one week after receiving the tutorial. Results from a study of
this type could demonstrate if explanation or argumentation has longer-lasting effects on
knowledge gains, or if these interactions create longer-lasting effects when compared to no
interaction.
The present research aimed to examine the effectiveness of explanation and argumentation used by an intelligent tutoring system. Though hypotheses were not fully supported, the significant results indicate that interaction, either through explanation or argumentation, with an ITS can be beneficial. Having students think through and elaborate on their answers provides a foundation that is necessary for students to learn. The present research demonstrates that different methods of teaching and learning can be utilized by an intelligent tutoring system. Furthering the types of teaching methods that an intelligent tutoring system can use is a step towards using these systems in different learning environments.
REFERENCES


APPENDIX A
Multiple Choice Questions

1) If taking a portrait of someone, where would you align their eye?
   A. At the intersection of a “rule of thirds” vertical and horizontal line”
   B. Along a “rule of thirds” vertical line
   C. It doesn’t matter as long as their whole face is in the photograph
   D. The very center of the photograph

2) If considering the rule of thirds, where would you place the horizon of a photograph of a landscape?
   A. You should angle the camera so the horizon is slanted
   B. The very bottom so you can get the sky in the picture
   C. Along one of the horizontal lines
   D. The very center of the photograph

3) Exposure is
   A. The amount of light the sensor is exposed to
   B. How fast the picture is taken
   C. A way to center a photograph
   D. None of the above

4) A wider aperture (small f-stop number) means?
   A. The object in the foreground is in focus while the background is blurred
   B. The depth of field is larger
   C. There will be less light on the lens
   D. All of the above

5) How should the imaginary lines be arranged using the rule of thirds?
   A. One in the top right corner to the bottom left corner and one in the top left corner to the bottom right corner so they intersect in the middle of the photograph
   B. One horizontal and one vertical so that they intersect in the middle of the photograph
   C. Two vertical lines that are equal distances apart and two horizontal lines that are equal distances apart
   D. Three vertical lines that are equal distances apart and three horizontal lines that are equal distances apart

6) A side effect of increasing ISO is that
   A. The picture is very clear and detailed
   B. There is less light
   C. There is less “noise”
   D. There is more “noise”
7) What does it mean when a photograph has too much light?
   A. There is too much light on the sensor
   B. The sensor was not exposed to enough light
   C. The picture was underexposed
   D. The aperture was small

8) Why would you want to underexpose your subject?
   A. To create a silhouette
   B. So that it does not distract from the background
   C. To increase the amount of light
   D. To get rid of motion blur

9) What is the easiest way to change the depth of field?
   A. Change the f-stop/aperture
   B. Use the rule of thirds
   C. Getting closer to the subject
   D. Using the zoom

10) To maintain a sharp and pure photograph, exposure should be controlled first and foremost by
    A. Aperture
    B. Shutter Speed
    C. ISO
    D. All of the above

11) A larger f-stop number means
    A. The aperture is smaller
    B. The aperture is larger
    C. The depth of field is shorter
    D. There is more light on the lens

12) If you have a longer shutter speed what type of effect might this create?
    A. The image will be dark and highlight reds
    B. The image will have motion blur
    C. All the colors will be vivid and highlighted
    D. You can’t change shutter speed

13) When using the rule of thirds, how many horizontal lines should be used?
    A. 1
    B. 2
    C. 3
    D. 4
14) What is it called when the background of a photograph is blurry or out of focus?
   A. Bokeh
   B. Broken
   C. Static
   D. Grainy

15) How would you make a river or waterfall appear to be moving in a photograph?
   A. Move the camera in the direction the water is flowing as you take the picture
   B. Have a longer shutter speed
   C. Increase the f-stop
   D. Decrease the ISO

16) What is the easiest way to create a silhouette?
   A. Overexpose the photograph
   B. Increase the ISO
   C. Underexpose the photograph
   D. Decrease the f-stop

17) You are far away from any city lights and you want to take a picture of the night sky because there are so many stars, but when you look at your photograph it is dark and no stars are visible. What happened?
   A. You did not follow the rule of thirds
   B. The shutter was left open too long
   C. The photograph was underexposed
   D. The photograph was overexposed

18) What would best suit a situation where there is low light?
   A. Low ISO setting
   B. Faster shutter speed
   C. Smaller f-stop
   D. Larger f-stop

19) If you were taking photographs of your friends but there were a lot of cars zooming by in the background what method might you use to take away from the distracting background and focus on your friends?
   A. Zoom in on their face
   B. Decrease ISO, smaller f-stop number (larger aperture), longer shutter speed
   C. Decrease ISO, larger f-stop number (smaller aperture), longer shutter speed
   D. Increase ISO, smaller f-stop number (larger aperture), shorter shutter speed

20) How does a photograph become overexposed?
   A. Too much light hits the sensor of the camera
   B. Not enough light hits the sensor of the camera
   C. The photograph was taken with a fast shutter speed
   D. A wide aperture was used
21) The smaller the f-stop number,
   A. The smaller the aperture
   B. The larger the aperture
   C. The less light the lens can pick up
   D. None of the above

22) You took a picture of your friend in front of the Eiffel Tower, both your friend and the tower are in focus. What is the depth of field?
   A. The distance between your friend and the Eiffel Tower
   B. The distance between you and your friend
   C. The distance between you and the Eiffel Tower
   D. The distance from the camera lens to your friend

23) If you have a large aperture setting, then you will have
   A. More light
   B. A smaller depth of field
   C. An out of focus background
   D. All of the above

24) You are the school’s sports photographer and you want to capture the hockey team’s winning goal, you might want to
   A. Set your shutter speed to be faster
   B. Set your shutter speed to be slower
   C. Make sure the f-stop number is larger
   D. Underexpose the photograph

25) What is shutter speed?
   A. The amount of time the shutter is closed
   B. How the photograph is arranged
   C. The amount of time the shutter is open and the camera’s sensor is exposed to light
   D. The distance between the nearest object of focus and the furthest object in focus

26) A decrease in ISO means that there is
   A. Less light is allowed onto the lens
   B. More light is allowed onto the lens
   C. No light is allowed onto the lens
   D. ISO cannot be decreased

27) How can you get “noise,” or a grainy and impure photograph?
   A. Lower ISO setting
   B. Faster shutter speed
   C. Higher ISO setting
   D. Lower f-stop number, which will increase the depth of field
28) How the photograph is arranged and the elements that make it more compelling is called the
A. Composition
B. Rule of thirds
C. Bokeh
D. Depth of field

29) If you are properly using the rule of thirds, how many sections will your photograph have?
A. 6
B. 3
C. 12
D. 9
APPENDIX B
Photography Advice Instructions and Task
On the next few items you will be presented with either a situation that a photographer might find themselves in or a photograph. Please write a paragraph or two with advice and/or suggestions that you would give the photographer in the given situation.

1) A photographer wants to take a picture of a starry night sky. He is not concerned with noise because he figures he can change that with some post-processing in Photoshop. However, he wants the stars in the photograph to leave light trails. How would this photographer achieve this effect? What should his settings (i.e. aperture, shutter speed, etc.) be set at (generally speaking, not actual numbers)?

2) Imagine you are the beach and you want to take a picture of the setting sun over the ocean. However, you also want to include a ship that is off in the distance. How would you set up the photograph so the composition complies with the Rule of Thirds? Also, think about how the light from the setting sun will affect the way the ship comes out. What will you do to address the effect created by the setting sun on the ship with regards to aperture, ISO, and shutter speed)?

Please write a paragraph or two with advice and/or suggestions that you would give to the photographer regarding improvements to this photograph.

Please write a paragraph of two with advice and/or suggestions that you would give to the photographer regarding improvements to this photograph.
APPENDIX C

Photography Judgment Instructions and Task

Next you will be shown several photographs and will be asked to make judgments about how well each photograph carries out the different components of photography.

*Below each photograph, the following instructions and scale were displayed to participants:

On a scale from 0 to 10, with 0 being the worst and 10 being the best, please give your judgments about each characteristic of the photograph.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
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<th>4</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tbody>
<tr>
<td>Use of rule of thirds</td>
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<td>Depth of field/Aperture/f-stop</td>
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</tbody>
</table>

1:

![Image of a bridge with birds in the sky.]

2:

![Image of a close-up of red berries.]


### APPENDIX D
Photography Advice Inter-rater Scoring Rubric

Scenario 1: Starry Night

<table>
<thead>
<tr>
<th>Dimension Identified</th>
<th>Correctly States How to Modify Dimension</th>
<th>Gives a Reason for Modifying Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO</td>
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<td>Shutter Speed</td>
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<td>Aperture</td>
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<tr>
<td>Other</td>
<td>0</td>
<td>1</td>
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</tbody>
</table>

Scenario 2: Sunset

<table>
<thead>
<tr>
<th>Dimension Identified</th>
<th>Correctly States How to Modify Dimension</th>
<th>Gives a Reason for Modifying Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule of Thirds</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Shutter Speed</td>
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<td>Exposure</td>
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<td>Other</td>
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Scenario 3: Waterfall

<table>
<thead>
<tr>
<th>Dimension Identified</th>
<th>Correctly States How to Modify Dimension</th>
<th>Gives a Reason for Modifying Dimension</th>
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<td>Rule of Thirds</td>
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<td>Other</td>
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Scenario 4: Dog

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APPENDIX E
Photography Judgments Dimensions Categories

An “X” means the photograph represented the dimension.

<table>
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<tr>
<th>Photograph</th>
<th>Rule of Thirds</th>
<th>Depth of Field/Aperture/F-Stop</th>
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