Activity Summaries as a Classroom Assessment Tool

Steven McGee, Jennifer Kirby, & Steven K. Croft
Center for Educational Technologies®
Wheeling Jesuit University

http://www.cet.edu/research

ABSTRACT

This study explored the usefulness of a classroom assessment technique called the activity summary template. It is proposed that the activity summary template enables students to process and organize information learning during an investigation. This process will in turn help students to achieve greater learning outcomes. The activity summary template is comprised of a summary of the main ideas, a statement of the importance of the activity for answering a research question, and new questions that emerge from the activity. The study took place in the context of the summative evaluation of Astronomy Village®: Investigating the Solar System™. Using a path diagram analysis, the results indicate that the activity summary template holds great promise for helping low-achieving students to accomplish greater learning outcomes. In addition, it is a useful tool for teachers to monitor how well students are processing and organizing the information they are learning.

OBJECTIVES AND SIGNIFICANCE

McGee et. al. (2001) demonstrated the overall effectiveness of the NSF-funded *Astronomy Village: Investigating the Solar System.* Students significantly increased both their understanding of complex solar system concepts as well as problem-solving abilities related to analyzing data and drawing conclusions (Dimitrov, McGee, & Howard, 2002). The results also indicate that student-learning gains on complex content were significantly greater than their gains in problem solving. Prior research indicates that an important factor in successful problem-solving performance is a well-organized knowledge base (Shin, Jonassen, & McGee, in press). This would suggest that in order to improve problem-solving performance, teachers using *Astronomy Village* should help students develop a well-organized knowledge base. In this paper we explore a classroom assessment technique, called activity summaries, that could become a useful tool for monitoring how well students are organizing new information that they process during an extended investigation.

THEORETICAL FRAMEWORK

There are three generic process skills within the activity summary template: summarizing, synthesizing, and question generation. After completing an activity or set of related activities in an extended investigation, a student completes a generic template. In this template students summarize the main ideas in the activity using three sentences, state the importance of the activity in helping to answer the research question, and generate new questions.

The activity summary template was developed as a means to track student progress during extended investigations (McGee & Howard, 1998). It has been used extensively in research related to the Center for Educational Technologies® *Astronomy Village* programs. With *Astronomy Village* students spend approximately four weeks engaging in extended investigations on cutting-edge astronomy topics. Early evaluation work on *Astronomy Village* demonstrated that students have a difficult time synthesizing the results of related activities. For the most part they can successfully complete individual activities, but they often fail to understand the connection between the individual activity and the research question. This had important implications for the extent to which students can integrate new information into a well-organized knowledge base.

The activity summary template helps teachers diagnose where students are having difficulty. The coding scheme for the main ideas measures the extent to which students identified the most relevant concepts. If students were not selecting the most relevant concepts as being important, it would be extremely difficult to synthesize those concepts with the overall investigation. The coding scheme for the statement of importance measures the extent to which the student connects a relevant main idea to the overall research question (see Appendix A for an example of one highly rated and one poorly rated activity summary). The ratings of the statement of importance have been used successfully to evaluate the efficacy of curriculum changes in the implementation of *Astronomy Village®* (McGee & Howard, 1999b). The results point to the kinds of supports that students need to synthesize learning activities with the overall research question.

In this study we were interested in two questions: (1) What factors influence the quality of the summaries and the statements of importance? (2) How do the summaries and statements of importance influence student learning outcomes? We investigated these questions in the context of the *Astronomy Village* summative evaluation.

ASTRONOMY VILLAGE*:* INVESTIGATING THE SOLAR SYSTEM

Through *Astronomy Village* students are transported to a virtual village in Hawaii where they investigate one of two core research topics: what the surface of Pluto might look like when the first NASA mission arrives in 2015, or the search for life in the solar system (McGee & Howard, 1999a). The program is designed such that a virtual mentor guides students in completing multiple investigation cycles that mirror the phases of scientific inquiry.

In the first investigation cycle students are introduced to the core research question concerning either the surface of Pluto or the core requirements for life. During the exploration phase of the investigation, students see the types of data they will use in the investigation to prepare them for future analyses. In the background research phase students read library articles and listen to lectures to help them understand key background concepts. During the data collection and analysis phases students use the results of their analysis to draw conclusions about the research question. Students complete the investigation by hosting a virtual press conference. A virtual press corps asks them questions about the investigation the students just completed. This core investigation cycle lasts about one week.

Students then follow the same sequence of phases as they did in the core investigation when they undertake a focused investigation on a narrower topic. For example, students may investigate whether icy volcanoes could exist on Pluto by examining the surfaces of icy moons in the solar system. Or students may examine temperature-pressure relationships on a variety of planets and moons to determine where the conditions are right to support liquid water.

Teachers using *Astronomy Village* have adopted one of two basic approaches. In the first students complete the core research project and then complete each of the focused investigations related to the core research project. In the case of Search for Life, there are four focused investigations. In the second approach students complete the core research project and then complete just one focused investigation. The teacher ensures that each of the focused investigations has at least one project team working on it. The students then host a press conference for their peers so that all of the students can learn the content in each module.

ASSESSMENT INSTRUMENT

Three principles guided the design of the assessment instrument. First, the assessment instrument should reflect important thinking and problem-solving skills from the discipline of planetary science (Hickey, Wolfe, & Kindfield, 1999; Sheppard, 2000). In *Astronomy Village*® students investigated authentic questions, such as whether liquid water exists in the solar system. These require important thinking and problem solving skills from the discipline of planetary science. Therefore, we achieved this principle by designing assessment tasks that reflect the thinking and problem solving that *Astronomy Villag*e targets.

The second guiding principle was measuring the extent to which students transfer their thinking and problem-solving skills into new contexts (Bransford, Brown, & Cocking, 1999). This principle reflects the philosophy that a critical aspect of education is whether learning transfers (Sheppard, 2000). When there is no specific transfer situation, the assessment becomes the transfer situation (Hickey, Wolfe, & Kindfield, 1999). *Astronomy Village* supported transfer by having students investigate critical processes and features on a variety of planets and moons. For the assessment instrument students had to transfer their understanding to hypothetical planets and moons.

The third guiding principle was ease of administration and scoring for the target population. In prior research at the high school level, we have had success measuring complex problem-solving and argumentation abilities using an extended response format (Shin, Jonassen, & McGee, in press; Hong, McGee & Howard, 2001). However, at the middle school level there was concern that the extended response format would better reflect students' writing abilities than their problem-solving abilities. In addition, the extended response format was too labor intensive to score within the budget limitations of the project. We therefore chose to use a machine-readable multiple-choice format. Taking into account the three guiding principles collectively, we felt confident in developing an assessment instrument that would measure important learning outcomes in a cost-effective manner.

We identified the key complex content ideas that were presented in each of the nine investigations within *Astronomy Village* along with the key problem-solving skills related to drawing conclusions from data and inferring planetary processes from analyzing images of surface features. We contracted with item writers to develop the assessment items related to the underlying concepts within the investigations. The resulting instrument has four subscales: Search for Life complex content, Search for Life problem solving, Mission to Pluto complex content, and Mission to Pluto problem solving. This study focused on the Search for Life complex content and problem-solving subscales.

INVENTORY OF METACOGNITIVE SELF-REGULATION

Students also completed the Inventory of Metacognitive Self-Regulation (IMSR), which measures five factors related to awareness of learning processes and control of learning strategies (Howard, McGee, Shia, & Hong, 2001). The IMSR includes 32 items that use a five-point Likert scale. For each of the 32 items, students are instructed to circle the answer that best described the way they solve problems in math or science class (1=never, 2=seldom/rarely, 3=sometimes, 4=often/frequently, 5=always). The validation of the IMSR is discussed elsewhere (Howard & McGee, 2000). The five factors are:

- <u>Knowledge of cognition.</u> How much do learners understand about their unique cognitive abilities and the ways they learn best. Includes an awareness of one's own learning and memory processes as well as learning strengths and weaknesses.
- <u>Objectivity</u>. Do learners stand outside themselves and think about their learning as it proceeds. Includes an awareness of their learning goals and alternative choices in accomplishing a learning goal.

- Problem representation. Are learners aware of strategies they use to understand the problem fully before proceeding.
- Subtask monitoring. Do learners break the problem down into subtasks and monitor the completion of each subtask.
- Evaluation. To what extent are learners aware of checking their work throughout the entire problem-solving process to evaluate if it is being done correctly.

METHOD

While completing the modules in *Astronomy Village*®, students completed summaries of many of the articles and activities in the module. Each student completed from 3-5 activity summaries. Two independent raters judged the quality of the summaries and statements of importance. Any disagreements in rating were reconciled through discussion. Interrater reliabilities using Cronbach's alpha were greater than 0.70 for both the summaries and the statements of importance. For all of the subsequent analyses, each student was given one score for their summaries and one score for their statements of importance based on the average of each factor across all of the summaries they completed.

RESULTS

To answer the question of what factors affect the quality of the student activity summaries, we used regression analysis to test the following pretest factors: content understanding, problem solving, and metacognitive self-regulation (See Table 1.) For the quality of the summaries there were only two metacognitive self-regulatory factors that were statistically significant—knowledge of cognition (ß = .34, $P < .001$) and objectivity (ß = -0.36, $P < .001$). These two factors accounted for 20.1 percent of the variance. Neither content understanding nor problem solving were statistically significant predictors.

The results for the quality of the statements of importance were similar, except instead of knowledge of cognition, problem representation (ß = .27, $P < .001$) and objectivity (ß = -0.35, $P < .001$) were significant predictors, accounting for 11.9 percent of the variance. Once again, neither content understanding nor problem solving were statistically significant predictors.

It is interesting to note that achievement-related variables were not significant predictors of activity summary performance. The fact that different metacognitive self-regulation components predict the quality of the summaries and statements of importance indicates that these are distinct process skills. This conjecture is confirmed by looking at the correlation between the main ideas and statements of importance ($r = 0.12$).

Table 1: Standardized Beta Coefficients for Statistically Significant Predictors of Activity Summary Quality

	Main Ideas	**Significance**
R^2	20.1%	11.9%
Content	•	•
Problem solving	•	•
Knowledge of cognition	0.34	•
Objectivity	-0.36	-0.35
Problem representation	•	0.27
Subtask monitoring	•	•
Evaluation	•	•

In order to investigate how the quality of the activity summaries influences student learning outcomes, we used regression analysis, controlling for the influence of pretest performance. The results indicate that the activity summaries are significant predictors of both content as well as problem-solving learning outcomes (see Table 2). After controlling for pretest performance on content understanding, the quality of the summaries (ß = 0.31, P < .001) and the statement of importance (ß = 0.13, P < .05) were significant predictors of content understanding posttest performance. In addition, knowledge of cognition (ß = 0.18, P < .01) was a significant predictor. These four factors accounted for 63.9 percent of the variance.

After controlling for pretest performance on problem solving, the quality of the summaries (ß = .13, P < .05) and the statement of importance (ß = .16, P < .01) were significant predictors of problem-solving posttest performance. In addition, problem representation (ß = 0.14, P < .05) was a significant predictor. These four factors accounted for 76.2 percent of the variance.

Table 2: Standardized Beta Coefficients for Statistically Significant Predictors of Posttest Performance

	Content Understanding Posttest	**Problem-Solving Posttest**
R^2	63.9%	76.2%
Pretest	0.40	0.62
Main ideas	0.31	0.13
Significance	0.13	0.16
Knowledge of cognition	0.18	•
Objectivity	•	•
Problem representation	•	0.14
Subtask monitoring	•	•
Evaluation	•	•

Figure 1 shows a path diagram summarizing the results of the combined regression analyses related to content understanding.

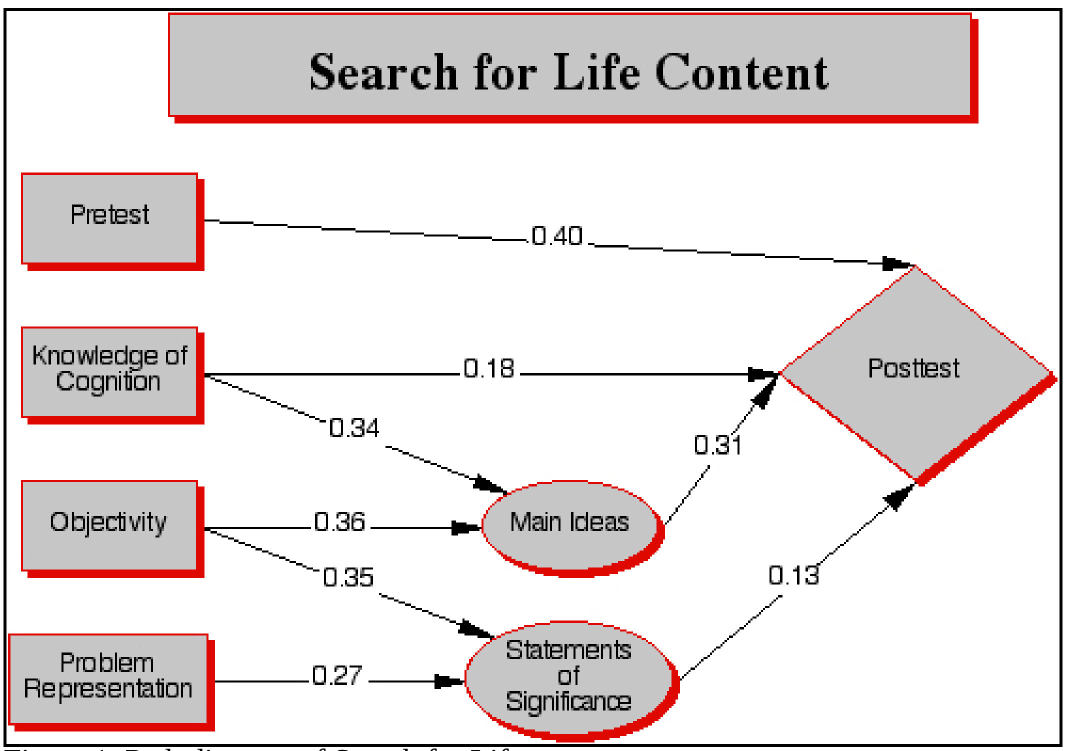

Figure 1: Path diagram of Search for Life content.

Figure 2 shows a path diagram summarizing the results of the combined regression analyses related to problem solving.

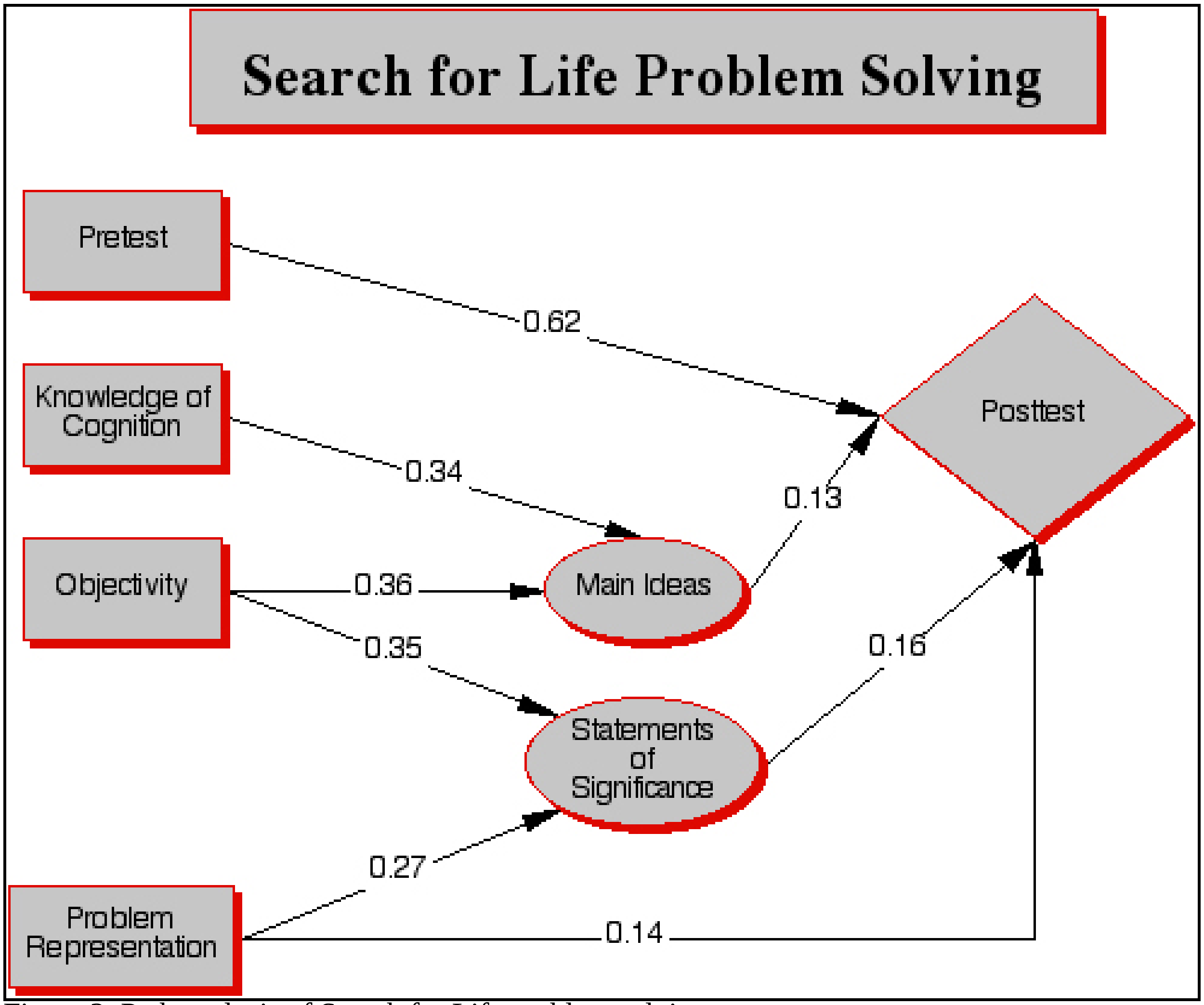

Figure 2: Path analysis of Search for Life problem solving.

CONCLUSION

The results of both path diagrams demonstrate the importance of the activity summary template for helping students develop both content understanding and problem solving. For content understanding, the influence of the activity summary template was equivalent to the influence of the pretest performance. For problem-solving performance the influence of the activity summary template was significantly less than the influence of the pretest performance. The results for problem solving are consistent with prior research on *Astronomy Village*® (Dimitrov, McGee, & Howard, 2002). Students achieved a significantly greater learning outcome on the content understanding subscale than on problem solving. In other words, *Astronomy Village* had a greater influence on Search for Life content understanding than on problem solving. Therefore, the influence of the activity summary template on problem solving performance was limited.

It is interesting to note that prior knowledge of the discipline, as measured by the pretest scores, was not a significant predictor of activity summary quality. The most significant predictors were knowledge of cognition and problem representation. These results highlight the promise of this formative assessment approach for enabling low-achieving students to perform well in inquiry-based learning environments. Prior research has demonstrated that low-achieving students with high metacognitive self-regulation can perform equivalent to or better than high-achieving students who are low on metacognitive self-regulation (Howard, McGee, Shia, & Hong, 2001). This research helps to clarify the mechanisms by which metacognitive self-regulation can enable low-achieving students to perform well in inquiry-based learning environments.

The results of the study point to the importance of helping students to process the information that they learn from the activities they engage in. The activity summary template seems to hold great promise as a classroom assessment tool to monitor how well students are developing a well-organized knowledge base that will assist them in problem solving.

REFERENCES

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Research Council.

Dimitrov, D. M., McGee, S., & Howard, B. C. (2002). Changes in students' science ability produced by multimedia learning environments: Application of the linear logistic model for change. *School Science and Mathematics Journal, 102*(1), 15-22.

Hickey, D. T., Wolfe, E. W., & Kindfield, A. C. H. (1999). Assessing learning in a technology-supported genetics environment: Evidential and systemic validity issues. *Educational Assessment, 6(3),* 155-196.

Hong, N. S., McGee, S., & Howard, B. C. (2001, April). *Essential components for solving various problems in multimedia learning environments*. Paper presented at the meeting of the American Educational Research Association, Seattle, WA. [Online] http://www.cet.edu/research/papers.html

Howard, B. C. & McGee, S. (2000, April). Metacognitive self-regulation and problem solving: Expanding the theory base through factor analysis. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA. [Online] http://www.cet.edu/research/papers.html

Howard, B. C., McGee, S., Shia, R., & Hong, N. S. (2001, April). The influence of metacognitive self-regulation, aptitude, and achievement on problem solving. Presented at the annual meeting of the American Educational Research Association, Seattle, WA. [Online] http://www.cet.edu/research/papers.html

McGee, S., & Howard, B. C. (1998). Evaluating multimedia in the context of use. *Journal of Universal Computer Science, 4*(3), 273-291.

McGee, S., & Howard, B. C. (1999a, April). Generalizing activity structures from high school to middle school science. Symposium presented at the meeting of the American Educational Research Association, Montreal, Canada. [Online] http://www.cet.edu/research/papers.html

McGee, S., & Howard, B. C. (1999b, June). Using design experiments as a means of guiding software development. Paper presented at ED-MEDIA: International Conference on Educational Multimedia, Seattle, WA. [Online] http://www.cet.edu/research/papers.html

McGee, S., Howard, B. C., Dimitrov, D. M., Hong, N. S., & Shia, R. (2001, April). Addressing the complexities of evaluating interdisciplinary multimedia learning environments. Presented at the annual meeting of the American Educational Research Association, Seattle, WA. [Online] http://www.cet.edu/research/papers.html

Sheppard, L. (2000). The role of assessment in a learning culture. *Educational Researcher, 29*(7), 4-14.

Shin, N., Jonassen, H. D., & McGee, S. (in press). Predictors of well-structured and ill-structured problem solving in an astronomy simulation. *Journal of Research in Science Teaching*.

APPENDIX A

Name____Brad Witers___________________________ Date____Oct 23, 1999______________

Name of Activity_**Looking for Life in all the Right Place**s______________________________

Activity Summary – Good Example

1. **Main Idea**: Please write 3 sentences about the main ideas for this activity. Try to concentrate on the ideas that are most important to the question of finding life in the solar system.

One of the main ideas in this packet is can life exist in an environment where it is cold, hot, salty or acid like conditions. Also if organisms can live on harsh conditions on earth could there have been or is there life on other planets.

2. **Importance**: Please write 2 sentences about how this activity helps in your investigation.

The connection between this, looking for life packet activity, and the Search for life core research question is how different life forms or organisms or anything living can live in or not live in harsh or perfect conditions. Also another connection is to use the information that scientists have to find out whether or not there is life on other planets.

Name___Kirby_Kenwood_______________________ Date________Oct 22, 1999___________

Name of Activity_**Looking for Life in all the Right Place**s____________________________

Activity Summary – Poor Example

1. **Main Idea**: Please write 3 sentences about the main ideas for this activity. Try to concentrate on the ideas that are most important to the question of finding life in the solar system.

One thing we learned about was hyperthermophiles. We also learned where hyperthermophiles live and that they live in very hot temperatures. One last thing is we learned about phycrophiles and that they love cold.

2. **Importance**: Please write 2 sentences about how this activity helps in your investigation.

The connection is that we know that things can live in temperatures of 211 degrees Fahrenheit and so cold as 0 degrees Celsius and they can be even microscopic. So they might even live in places we never thought of.