Student Learning Through Journal Writing in a Natural Science Course for Pre-Elementary Education Majors.

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Abstract: This paper describes the use of journals in a general education chemistry course for elementary education majors. In the journals, students describe their understanding of a topic, its development, and its connection to their lives. The following types of reflections were identified in student journals: action, prior knowledge, project ideas, text resources, classroom events, and monitoring of knowledge. A multiple linear regression analysis of total course points earned versus student GPA, ACT score, number of reflections made for each reflection type, and total number of reflection made throughout all journals was used to determine the significance of the type of reflections made by students in relationship to their chemistry content understanding. The results indicate that students who reflected more on classroom events and those who monitored their knowledge correlated positively with a higher content knowledge. However, reflecting on text resources had a negative correlation to students' overall chemistry content knowledge.

Introduction & Theoretical Background

This paper reports an investigation of student journal writing as a regulator of student metacognition in a general education chemistry course. Journal writing provides an opportunity for learners to understand their own learning process, to increase their active involvement in learning, and to gain personal ownership of their learning (Moon, 1999). Writing journals encourages self-thought, which allows for the development of metacognitive practices and the promotion of new learning by evaluating prior experiences. The use of journal writing in the science classrooms allows students to reflect on their actions, prior experiences, text resources, classroom events, and current knowledge, with reflection referring to "those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations" (Boud, Keogh, & Walker, 1985). Also, reflection in writing has a strong metacognitive component that helps students monitor their learning (Bangert-Drowns, Hurley, & Wilkinson, 2004). Previous research indicates the importance of having students reflect upon their current knowledge and understanding (Brown, Bransford, Ferrara, & Campione, 1983; Puntembekar & Kolodner, 1998; Davis, 2003). Writing assignments incorporating reflection on content knowledge enables students to formulate a better understanding of unprocessed materials and events and to document how their learning occurs, increasing connections with prior knowledge. Also, using productive reflection in the classroom promotes the knowledge integration process by expanding ideas and allowing students to identify the weaknesses in their knowledge. The nature of the assignment and the prompts given to a student are import for this. Davis (2003) found that students who reflected on generic prompts had a more coherent understanding as they worked on complex projects than those students that reflected on direct prompts.

The present study examines a chemistry course for pre-elementary education majors that includes journal writing assignments in which students respond to generic prompts to present their understanding of certain key topics and to reflect upon their own experiences with the topic. Our study focuses on the types of reflection students exhibited in their journals and how these relate to student content knowledge in the course. We also studied the choices students make with generic prompts that are aimed at developing a metacognitive perspective in their writing. The theoretical framework for this study is composed of metacognition and writing-to-learn perspectives. Metacognition refers to the knowledge concerning one's own cognitive processes (Flavell, 1979). Brown (1987) related metacognition to the learners' knowledge, awareness and control of the processes by which they learn. It was determined that metacognitive learners are able to recognize, evaluate, and reconstruct existing ideas (Baker, 1991). These findings of Brown and Baker represent two views of metacognition currently known as the knowledge and regulation of cognition. Learning is said to occur when new data or information presented to a student conflicts with what he or she already knows and give the student a chance to change their mind to think differently (Cracolice, 2005).

Several different kinds of assignments have been used to promote metacognition in chemistry learning (Rickey & Stacey, 2000). This included the deliberate use of a thinking frame (Mattox, Reisner, & Rickey, 2006), student documentation of their thinking through heuristics such as concept maps (Novak & Gowin, 1984), student work in extended problem solving situations (Cooper *et al*, 2008), and working in using extended writing within laboratory work (Greenbowe & Hand, 2005; Wink & Choe, 2008). The theoretical framework of writing to learn is used in this work because it characterizes the components involved when students respond to an opportunity to write about scientific topics. The writing to learn framework has been used in work by Britton (1970) and Emig (1977). In this approach, learning is supported and assessed by students' writing about their developing ideas. One of the most common forms of writing to learn is done by informal personal journal responses related to educational experiences such as literary readings, scientific experiments, videos, or from discourse with others (McCrindle & Christensen, 1995). The process of writing journals helps with the process of understanding relationships among ideas, knowledge transformation and construction of new meaning (Wallace, 2007; Klein, 1999). A major goal of the course was for students to be able to construct ideas and generate connections between concepts to make sense of the ideas rather than simply memorizing isolated facts. Another goal was to improve students' scientific literacy by having them write about the learning of science and to consider how they process information. The writing to learn strategy will help students achieve these goals. It has been shown that students develop conceptual growth through the process of writing, including parallel metacognitive growth in the learner (Mason & Buscolo, 2000).

In the course, students experienced writing-to-learn in the context of their journal work. Journals are well known in the K-12 literature, including the work of Davis (2003) that also contributes to the methodology of our work. She showed that prompts for student reflection promoted knowledge integration which occurs as learners expand their repertoire of ideas, identify weaknesses in their knowledge, and combine knowledge integration processes together. Journal writing is also used in the college science classroom, for example in a study of reflective journal writing within a first year university biology class (McCrindle & Christense, 1995). Students were randomly assigned to either write reflectively in their "Learning Journal," or produce a scientific report every week during the last five weeks of the course. The students in the journal writing group were given instructions and prompts as to the form of their journal writing. Results indicated that those students who did write reflectively on the content of their learning and the process of their leaning reported a more sophisticated conception of learning and had a direct impact on their metacognitive awareness. Similar research on lab report writing produced similar results (Keys *et al*, 1999).

Method

Participants

The participants consisted of 76 students from two offerings of the course (Fall 2007 and Spring 2009), called *The Chemical World*, who gave consent for their work to be included in a research program. Different instructors taught each course. Virtually all of these participants were enrolled in the pre-service elementary education program of the university and they took the course as part of a natural science general education requirement (Varelas *et al,* 2008), which included this course. Out of the seventy-six participants seventy-four were females and two were males, reflecting the existing gender distribution in the course. Students attend a one-hour lecture twice a week held by the instructor and a three-hour laboratory section led by a graduate student. Students are assessed by a student introductory essay, six student journals, student portfolios, unit and final exams, lab reports, assigned topical projects, and a big theme project (Wink *et al*, 2009). The present study focuses on the journal assignments, which are the major place for students to describe developments in their understandings of chemical content.

Task and Procedure

The students submitted a total of six journals, approximately biweekly, throughout the course. The journal topics that were assigned consisted of material the students covered in lecture or lab in their previous weeks of class. The approximate length of each journal was 700-900 words. The journal entries on various topics of chemistry provided an opportunity for students to reflect on their current understanding and how they came to this understanding. They were also a place where students communicated with and received feedback from the instructor. The prompts for the journals were consistent throughout the semester, with only a single assignment sheet given out at the beginning of the course. Hence, the prompts fit the category of "generic," (Davis 2003), permitting students to work in different ways within a simple scaffold. Students were instructed to include five components in their journals and were given a rubric documenting the layout and value of each component. The first three components all related to a content topic in the course and are the focus of this research. The first component prompts enabled the students to write about their current understanding of a topic. Here the students were able to express, in writing, what they know about the topic and how they know it. The second component required the students to present specific examples of chemistry and chemical substances in relation to the topic. Following this, the third journal component prompted students to make connections by writing about what the topic might mean to them in their personal history, current experience, or future plans, with frequent reference to their everyday life or career choice.

The fourth and fifth components of the journals covered other aspects of their work and are outside of the scope of this paper. Specifically, the fourth component required that students write about their ongoing work on a "big theme project," developing an idea that would become part of an individual final course project reflecting an aspect of chemistry of interest to them (Wink *et al*, 2009). Finally, students wrote a section of their journal reporting their progress in the course. In this section students expressed the concepts or skills that they find unclear or struggle with, how they were progressing, what was working for them, and what external factors were causing them trouble. They were told that a good journal would consist of approximately 700-900 words total, though many students exceeded that number.

Student journals were first coded for the types of reflection on understanding of the six journal topics. The coding scheme for journals is shown in Table 1. This was created from a coding scheme for student reflection in journals that was derived from Davis' study of student reflections on generic and direct prompts (Davis, 2003). This enabled us to code for the *types* of reflections found within the student journals. Each reflection written by the student was coded with the non-hierarchical indices 1-6 to note the type of reflection. Two coders independently coded students' journals for reflections. There was a 92% interrater-reliability between the two coders.

Table 1: Coding for Student Reflection in Journal Responses

1. Reflection on actions: involves thinking about what ways of behaving are most appropriate, as well as contemplating very general goals.
2. Reflection on prior knowledge: involves thinking specifically about prior experiences in which knowledge was gained.
3. Reflection on project ideas: involves thinking about the conceptual ideas presented in the project itself (Mineral, Nutrition, and Big Theme)
4. Reflection on text resources: involves thinking specifically about information presented in the textbook, lab instructions, or handouts.
5. Reflection on classroom events: includes thinking rendered from individual experiences from lectures, labs, and discussions from peers, teaching assistants, and the instructor.
6. Reflection on knowledge: indicates a focus on monitoring or improving one's understanding

Lastly, during the second course offering, students completed the Metacognitive Activities Inventory (MCA-I) developed by Cooper, Sandi-Urena and Stevens (2008) at the end of the semester. This survey represents a way to see if students are metacognitive during problem solving tasks in chemistry. The results of this survey and the reflection made by the students will be compared to see if those students who are actively metacognitive during problem solving are also metacognitive during writing.

Data Analysis and Findings

Journals

Throughout the semester students wrote a total of six journals. Six different reflections were apparent in the journals after reading through them, listed in Table 1. All journals were coded for these reflection types. Examples of student reflection responses for the six coded categories are shown in Table 2.

Table 2: Examples of student reflection code

Reflection Type	Example from Student Work
Action	I find if I take the extra time to figure out how to do each problem and read the chapters, I could be well off and prepared. The only problem is managing enough time to set aside for chemistry.
Prior Knowledge	Over the last weeks we have learned unit conversions in the metric system in class. I grew up in Germany and used the metric system all my life and am used to the system. It is easier to use and convert in the metric system because it is all powers of ten. I am confident in my understanding of the common prefixes used.
Project Ideas	I think that in order to do my individual project it is necessary to know how to work with unit conversions because this will help me understand better how much of each chemical is put in food to make it grow faster and better.
Text Resources	I came to understand the properties about polarity and functional groups of organic compounds through reading chapter 9 in Chemistry for Changing Times. Reading the book gave me a basic idea about what functional groups are and what it means to have polarity.
Classroom Events	The labs have helped me understand better how scientists work because I have to follow the same procedures/steps they use in order to complete the labs. In order to do the labs I have to think like a scientist and this is very interesting and fun.
Knowledge	I feel very confident about my progress in class so far because I am been able to understand how the cycles work and their importance to our survival. I am able to analyze the cycles and point out where each of the four spheres takes place and why.

Regression Analysis

To understand how the journals might impact learning, we did a multiple linear regression analysis of the sum of all points earned in the course as the dependent variable against student: GPA prior to course enrollment, ACT composite score, the number of reflections made for each of the six codes in the six journal entries, and the total number of reflections made in each of the six journal entries as the independent variables. This analysis sought to determine which variables correlate significantly with student content knowledge of chemistry. The analysis was done for each of the two classes and an aggregate of both classes. Before the two class sets of data were combined and analyzed, a comparison was done between them to see if there were any significant differences between the students in the two courses. An independent t-test was conducted on prior GPA, ACT composite score, and course grades given to the students. There was no significant different between the two classes in prior GPAs ($t(74) = 0.140$, $p > 0.05$), ACT ($t(74) = -1.210$, $p > 0.05$) and course grades ($t(74) = -0.743$, $p > 0.05$). Each class was given the same set of assignments and covered the same chemistry material. Student course grades derived from the total number of points the student earned during the semester. Both of the two classes had a total of 1075 points that a student could earn. The students' GPA that was used for this analysis was their GPA prior to the semester in which they took the course.

The linear regression model for all three data sets (Fall 2007, Spring 2009, and Aggregated Data) shows a relation between student course grade and four predictor variables, shown in Tables 3-5. This signifies that between 58% and 63% of the variance in student course grade is explained by student prior GPA and three types of reflections made by students in journal writing. The first predictor variable is the students' prior GPA. A high prior GPA is a good prediction of doing well in the class. Student reflection on classroom events (Code 5) and on their knowledge (Code 6) correlated positively and significantly with higher performance in the course. Student reflection on textbook, handouts, and worksheets (Code 4) correlated negatively and significantly with higher course performance.

Table 3: Fall 2007 regression analysis for prediction of course grade based on student GPA, ACT, reflection type, and total number of reflections during Fall 2007

Significant Predictor Variables	β
Prior GPA	.731
Code 4	-.144
Code 5	.052
Code 6	.086

Note: Regression equation: Grade = .409 + .731(GPA) - .144(Code 4) + .053(Code 5) + .086(Code 6), ($R = 0.794$, $R^2 = 0.630$)

Table 4: Spring 2009 regression analysis for prediction of course grade based on student GPA, ACT, reflection type, and total number of reflections during Spring 2009

Significant Predictor Variables	β
Prior GPA	.551
Code 4	-.020
Code 5	.038
Code 6	.034

Note: Regression equation: Grade = .593 + .551(GPA) - .020(Code 4) + .038(Code 5) + .034(Code 6) ($R = 0.764$, $R^2 = 0.584$)

Table 5: Aggregated data regression analysis for prediction of course grade based on student GPA, ACT, reflection type, and total number of reflections

Significant Predictor Variables	β
Prior GPA	.590
Code 4	-.031
Code 5	.033
Code 6	.075

Note: Regression equation: Grade = .315 + .590(GPA) - .031(Code 4) + .033(Code 5) + .075(Code 6) ($R = 0.783$, $R^2 = 0.613$)

MCA-I Survey

The Spring 2009 class of the *Chemical World* was given the Metacognitive Activities Inventory (MCA-I) survey to see if students who were metacognitive during problem solving were also metacognitive in their writing. This 27 item self-report instrument assesses students' metacognitive skillfulness when solving chemistry problems and may be used as a diagnostic tool in deciding to implement interventions by the instructor (Cooper, Sandi-Urena and Stevens, 2008). Students select their agreement with the items from a 5-point Likert scale (1, strongly disagree to 5, strongly agree). The score was reported as a percentage of the maximum number of points attainable. The higher the percentage a student received relates to a higher metacognitive awareness the student has during problem solving activities. The percentage of the maximum number points for each student was correlated against each of the six reflection types, and the total number of points the student received in the class. The results of these correlations are shown in Table 6.

Table 6: Correlations of MCA-I Survey

Variables	MCA-I Score
Code 1	-0.041
Code 2	-0.034
Code 3	0.061
Code 4	-0.436**
Code 5	0.512**
Code 6	0.574**
Total Course Points	0.564**

Note: N = 45, *$p < .05$, **$p < .01$

The results of the correlations analysis reveal that students who reflected more on textbooks, homework, and worksheets tend to be less metacognitive during problem solving activities (r = -0.436, p = 0.03). However, students who reflected more on classroom activities (r = 0.512, p = 0.00) and reflected on their own knowledge (r = 0.574, p = .000) tend to be more metacognitive during problem solving activities. Lastly, students who did well in the course and who are assumed to have a high chemistry content knowledge (r = 0.564, p = 0.00), tend to also be more metacognitive during problem solving activities. Therefore, students who are highly metacognitive in their writing by reflecting on interactions within the classroom (Code 5) and on their current knowledge (Code 6) of the chemistry content tend to be more metacognitive when they are engaged in problem solving of chemistry problems.

Conclusion

The objective of this study was to determine the effect of journal writing in a natural science course for pre-service elementary education majors. It is not common in science classes for students to be able to write down their learning process of a certain science topic and integrate this to formulate a final understanding. Reaching this point of reflection in their journal helps students self-regulate their learning. The use of journals in the classroom provided students an opportunity to become self-regulators of their learning. These entries made by the students helped facilitate discussion with the instructor that might not have happened in the classroom or laboratory. Having the instructor aware of student thinking can help guide students in the right direction to correctly monitor their understanding. This reflection process is important for the instructor to reflect back on. Cooper *et al* (2008) noted that it is essential for not only the student to be aware of metacognition but also for the instructor to be aware of how students are learning. Students were able to express what they know and what they are struggling with. Some students even wrote about how they would try and better their understanding if they were finding it hard to grasp the central ideas of the topic. In their writing they also talked about where they developed this understanding from for certain topics such as from prior experiences, the lecture, text resources, laboratory, discourse with peers, the teaching assistant, or the instructor.

Our use of specific codes to categorize different types of reflection revealed that the positive relationship of reflective writing and content understanding depends also on the type of reflection. As noted earlier, students with strong content were very likely to write about their current understanding as developed from their own thinking (code 6) or from classroom activities (code 5). Students who reflected on text resources tend to have a lower content understanding of the chemistry topics in the course. Reflecting on learning from the classroom events provides a better opportunity for students to experience new learning situations by engaging in activities with others. When students reflect solely on text resources they are more likely to be engaged in the activity alone or to take a simple reading of the text and use it as the basis of understanding, and this does not, we believe, provide the student with new experiences to help facilitate change in understanding. A possible threat to the validity of this research is that we did not know anything about the writing of the students coming into the course. Knowing the students' prior writing skills would help us determine how well students are at expressing ideas. If students struggle at this task they may struggle with reflecting on their learning and being able to formulate well structured reflections.

Implications for Research and Instruction

The journal produced by the student is an artifact that can be used at the end of the semester as a planning resource for exams. The student is aware of the understanding they had by referencing the journal and are able to evaluate their current understanding to see if understanding has changed at the end of the term. At this point the student can monitor what they need to review in order to succeed on exams. This whole process is a good source of self-regulation for students to take part in, and gives them time to sit down and think about their understanding of science topics. Also, it is a substantial and consistent tool for students to learn about themselves as learners.

This research confirmed a relationship between content knowledge and journal writing, supporting the idea that this writing-to-learn activity is valuable as a means of supporting students in the exploration and understanding of their learning processes. It has been noted that the reflection process offers an opening for students to understand their learning process and increase their active involvement in learning (Moon, 1999). It also helps students gain a personal ownership of their learning.

These findings add to the research literature on the analysis of writing-to-learn and reflection in instructional learning of science. The findings show that not all types of reflection correlate with improved learning, which implies that it is essential for researcher to examine the content of specific reflective students, not just overall reflection. Second, the link of metacognition to learning in this work is strengthened by the additional use of the MCA-1 survey as an independent measure of metacognition in problem solving.

There are three implications on writing-to-learn as a result of this research study. First, students may benefit from directed reflections (Davis, 2003). This benefit requires activities, and this is an active classroom (Varales et al, 2008). A major component of direct reflection is knowledge growth within the learner (Davis, 2003). Second, caution about what may be rote recapitulation of textbook material. Lastly, if students know there is a potential direct relation between journal topics and assessment, they may perform better on both.

The second major implication relates to the particular benefit of reflection in both writing and in problem solving. McCrindle and Christensen (1995) also found that journal writing tasks in a science class not only promote metacognitive thought but also helped learners gain more developed cognitive strategies and attain better learning outcomes.

Third, having students write reflective journals is a very good way to detect how they express metacognitive awareness, complementing other strategies (Mattox, Reisner, & Rickey, 2006; Greenbowe & Hand, 2005; Cooper, Sandi-Urena, Stevens, 2008; Keys et al, 1999). But the findings of specific benefits from reflection on knowledge (an explicit metacognitive act) and on activities, but not on the textbook, also suggest that providing an activity-rich environment for students to use as the basis of their reflection is important. These results seem to provide additional support for the effectiveness of learning in a mode where the student actively creates knowledge, often in conjunction with other peers (Cooper, 2005).

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