Proceedings of the Human Factors and Ergonomics Society Annual Meeting

http://pro.sagepub.com/

# Exploring Reflection Journals and Self-efficacy in Robotics Education

Lixiao Huang, Terri Varnado and Douglas Gillan

*Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 2014 58: 1939
DOI: 10.1177/1541931214581405

# Exploring Reflection Journals and Self-efficacy in Robotics Education

Lixiao Huang[1], Terri Varnado[2], Douglas Gillan[1]
[1]Department of Psychology
[2]Department of Science, Technology, Engineering, & Mathematics Education
North Carolina State University

Both metacognition (reflection of activities and thinking) and self-efficacy (a personal belief of being capable of doing something) influence learning outcomes. This study investigated metacognition using 17 students' reflection journals and the change of general self-efficacy and robotics self-efficacy (perceptions of capability regarding specific robotics related knowledge and skills) over a one-semester robotics education course. The reflection journals showed (1) the majority of students reported more frequently on what they did during the last eight weeks than the first eight weeks, as well as writing about planning and evaluation and (2) while writing about background knowledge, opinions, and learning had a decreasing trend. The survey results showed that students' robotics self-efficacy in the knowledge and skills significantly increased. The findings suggest that writing reflection journals can be a useful tool for robotics teachers in helping students practice metacognition and engage in a higher level of learning.

## INTRODUCTION

In order to meet the needs of advancing technology, an increasing number of primary schools, middle schools, high schools, and colleges use robotics to help students succeed in learning science, technology, engineering, and mathematics.

However, there has been a lack of empirical studies to support effective teaching in robotics education. In an exploratory study (Huang, Varnado & Gillan, 2013a), the students indicated at the end of the semester that they found that they could do many things they thought they would not be able to do at the beginning of the class. Data suggested that successfully completing the robotics education course resulted in an increase in self-efficacy.

The literature (Flavell, 1979) indicated that metacognition was an effective learning method in general, and self-efficacy also had an important impact on learning. The present study explored whether writing reflection journals might be a good teaching method to practice metacognition and whether it actually helped increase self-efficacy. Some earlier work (Huang et al., 2013a) on reflection journals in robotics education classes analyzed the data aggregately. This study included data from a new semester, and separated the data into 4 four-week stages with more specific coding.

## LITERATRATUE REVIEW

### Self-efficacy

Self-efficacy is defined as the extent to which people believe that they are capable of doing things (Bandura, 1997). High self-efficacy can aid individuals in initiating cross-cultural interactions, persisting in the face of early failures, and engaging in problem solving as a way of mastering necessary skills.

Self-efficacy is considered essential to students' success in school (Fritson, 2008). By looking into the metacognitive processes of learning a complicated, decision-making task, metacognition was found to be positively related to knowledge mastery, post-training performance, and self-efficacy (Flavell, 1979).

Essay data in a robotics education course showed that the students reported more confidence in their capabilities with technology after building their robots (Huang et al., 2013a). The students reported that they found the project especially rewarding when they finally solved their problems. Students also indicated at the end of the semester that they found they could do many things they thought they would not be able to do at the beginning of the class. The research indicated the need to test self-efficacy before and after building the robot to validate the change in self efficacy as a function of the students' experience.

The self-efficacy assessment literature showed that measuring general self-efficacy across various scenarios and specific self-efficacy focusing on subject separately would provide a more accurate result of self-efficacy (Murphy, Coover, & Owen, 1989).

### Metacognition

As a type of learning strategy, metacognition is defined as an individual's cognitive control of learning and thinking (Flavell, 1979). A study testing effects of goal orientation, metacognitive activity and practice strategies on multiple learning outcomes and transfer (Ford, Smith, Weissbein, Gully, & Salas, 1998) found that knowledge mastery orientation had a small but significant positive relation to metacognition learning strategy, and metacognition had moderate positive relations to learning outcomes, including knowledge, post-training performance, and self-efficacy. This study also found that metacognition accounted for a significant amount of variance in transfer performance. Therefore, one may assume that requiring metacognition in a robotics education course should help improve knowledge mastery, learning transfer, and self-efficacy.

Reflection referred to a cognitive process of learning (Daudelin, 1996), and it was through reflection that experience could turn into learning outcomes, and then improve performance through learning transfer. The process of reflection was described as having four stages: identifying the problem, analyzing the problem, formulating and testing a tentative theory to explain the problem, and taking actions or making a decision. Writing a journal is one form of reflection (Daudelin). In a robotics education course, reflecting on the activities, knowledge, ideas, and feelings has the potential to provide opportunities for the learners to practice metacognition.

### Journaling

Journaling, including E-journals or incidental writing, has many benefits in learning mathematics and engineering (Banker, 2004; Hawkins, Coney, & Bystrom, 1996).

Students who did journaling with or without explicit cognitive behavioral therapy instruction significantly increased their grades at the middle of the semester compared to that at the beginning of the semester (Fritson, 2008). Davis and Hult (1997) compared the post-test performances among three groups: taking notes only, taking notes and writing summaries, and a control group without taking notes and writing summaries. They found no significant difference in performance among these three groups right after the lecture, but significantly better performance in the note-taking plus summary writing group than other two groups in a test after 12 days from the lecture. Davis and Hult argued that writing summaries made students aware of main ideas of the lecture, and students would memorize relevant points in a logical way. Writing reflection journals is similar to writing summaries. Therefore, it is reasonable to predict that writing reflection journals would help with retaining the lecture content in a robotics education course.

Our initial study (Huang et al., 2013a) analyzed all journal entries to show the frequency of a certain topic as a whole. In order to see whether students' emotions changed over the semester, this present study analyzed the data at different stages along the semester.

### Research Questions

The research questions of the present study were:

1) Did students improve their self-efficacy through the class?
2) What do students actually reflect on in their reflection journals?
3) Did students change the reflection contents over the semester?
4) What is the relationship between the reflection journal writing and self-efficacy?

## METHOD

### Participants

The study used 17 college students (2 female, and 15 male) who were enrolled in the robotics education course during the spring 2013. The age range was 19-36 years old (*mean* = 23).

### Measures

**General self-efficacy.** The 8-item general self-efficacy questionnaire was developed by Chen, Gully, and Eden (2005). It had moderate test-retest reliability ($r$ =.62), and high content validity, with 98% of contents rated as general self-efficacy items (Chen et al.). The general self-efficacy survey was administered at the beginning and the end of the final robot project, that is, at the beginning of stage 3 and the end of stage 4.

**Robotics self-efficacy.** The robotics self-efficacy survey was developed for the robotics education course, using the approach of developing a computer self-efficacy survey (Murphy, Coover, & Owen, 1989). The goal of the survey was to measure the students' confidence level in the knowledge and skills involved in the robotics course (from 1= very little, to 5=quite a lot). One example of the knowledge and skills is knowing the types of robots.

**Reflection journal.** All students were required to write a reflective journal at the end of each class session on tumblr.com, the form of which could be text, videos, and/or photos. The guiding questions for the reflective journal included: 1) What did I do today? 2) How did I do it? 3) What did I like/dislike? 4) What did I learn? This study only included the text data. The students were asked to respond to the guiding questions in a narrative format, without bulleted lists, at length of one to two paragraphs.

### Procedure

In a 16-week robotics education course, the students first spent 8 weeks learning robot fundamentals and the technological problem solving process, and then used their knowledge and skills during the last 8 weeks to design, construct, and program a fully functional semi-autonomous robot that solves a real world problem or issue. The general self-efficacy survey and robotics self-efficacy survey were administered at mid-semester before the students started building their final robot and again after the robot exhibition at the end of the semester. The reflection journals were generated at each class throughout the 16 weeks.

### Coding

The discourse data were examined and decomposed into approximately 2500 minimal meaning units. The four guiding questions were used to create the basic coding dimensions. However, journaling about what they did and how they did were often difficult to separate, so they were combined into one dimension as "doing". Some units in the reflection journals could not be covered by any of the three coding dimensions; therefore, a few new coding dimensions were created: planning, evaluation, background knowledge, and irrelevant information. Written captions above or under the videos and images were not included in this initial analysis. The final data set consisted of 1990 units. Detailed definition of the coding dimensions were as below.

- **Doing**: is about what they did in a class. All activities they conducted; normally contains verbs indicating their actions. For example, "Today we finished 2 worksheets on gears and speeds".
- **Learning**: is about what they learned if they indicated that they learned something. Normally the sentence contains the words "learn" or "figure out". For example, "We have learned a great deal about pneumatics and how they work as well as unique and practical operations they have in everyday tools and items".
- **Planning**: is about things to carry out in the near future, and it is more about objective progress, however, if the sentence includes future tense, it will likely be planning. For example, "I do believe that I know where to begin my troubleshooting next class, and should be able to finish the program".
- **Opinion**: is about what they think and how they feel about the project. For example, "Gears are important to learn, but difficult (in a way) to learn".
- **Evaluation**: is about the progress of their project, not specific things they finish. It also includes description of the current status; problems they encountered. For example, "The NXT program needs upgrading and added content because all of the information and help is not available".
- **Background knowledge**: is about describing certain principles, background knowledge that supports what they did and why they did it. For example, "The way the machine is going to work is that there is going to be a bump sensor next to the golfer".
- **Irrelevant information**: is about things that are totally unrelated to the learning process. For example, "Happy Pi day!"

The first two authors both coded 200 items and then calculated the inter-rater reliability. They adjusted the coding definitions and then coded another 200 items. When the reliability reached a satisfying level with the simple reliability at 85%, and kappa value of .92, the first author finished coding the whole data set.

## RESULTS

### General Self-efficacy

The comparison in general self-efficacy before building the final robot (*mean* = 4.52, *SD* = .55) did not show significant difference from that after (*mean* = 4.38, *SD* = .50).

### Robotics Self-efficacy

The robotics self-efficacy survey results showed a significant increase, with paired sample test, $t(17) = 2.66$, $p < .05$. Post hoc analysis showed that the confidence in the following five items were significantly improved: 1) Knowing the types of robots, operating Gear Training; 2) Understanding Gear Ratios and Force; 3) Building Simple Machine; 4) Electro-optic Proximity Detector; 5)Vernier.

### Reflection Journal

The data analysis used the counts of units on each coding dimension and the results showed different trend (see Figure 1 and 2).

*Coding: Doing.* During all four four-week stages, students reported most frequently what they did (see Figure 1), and the percentage at stage 1 (40.7%) was close to that at stage 2 (42.4%), and stage 3 (48.7%) close to stage 4 (50.1%). Overall, students reported much more about what they did during the final robot project than learning the fundamentals of robotics (see Figure 2).

*Coding: Opinions.* The next highest frequency of coding dimensions was opinions. 437 units were coded as opinions. It started with 24.4% at the stage 1, then increased to 28.2% at stage 2, and then decreased to 18% at stage 3 and even less at stage 4 (see Figures 2). The students' reported positive feelings when they successfully solved a problem, learned interesting knowledge, and enjoyed watching the robots carry out cool tasks, etc. The students reported negative feelings when they had concerns about their capability of completing the project, frustration due to the robot's malfunction or missing necessary parts, etc.

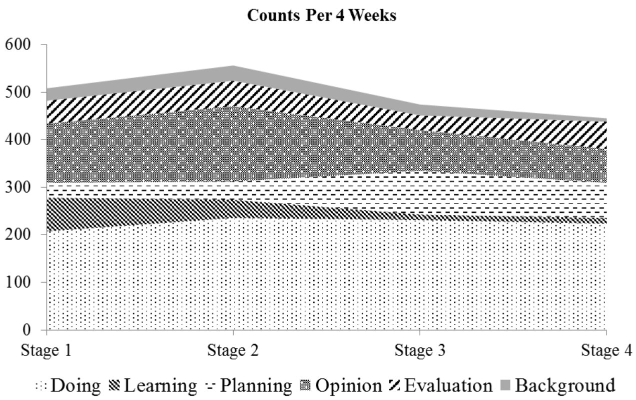


*Figure 1.* Counts of Meaning Units per 4 Weeks

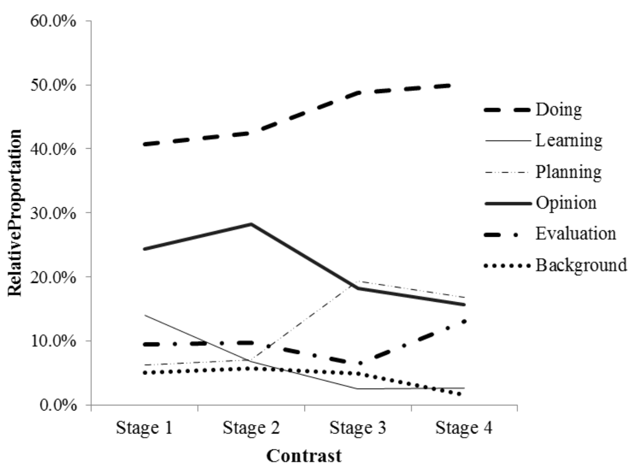


*Figure 2.* Frequency of Reflection Journal Contents across the Stages

*Coding: Learning.* Learning started with a moderately high proportion of 14% at stage 1, but consistently decreased to 2.7% at stage 4.

*Coding: Planning.* Similar to the coding dimension of doing, reflection on planning at stages 1 and 2 had similar scores, as did stages 3 and 4. Much like reflections on doing, the students reported more about planning as the course progressed, with a large change in the proportion of reflections about planning when the course shifted into the final robot project part between weeks 8 and 9.

*Coding: Evaluation.* Interestingly, the students reported the most about evaluation at stage 4 when they were finishing up the final robot.

*Coding: Background knowledge.* The counts of background knowledge decreased over the semester, from 5.1% at stage 1 to 1.6% at stage 4.

## DISCUSSION

The reflection journals were analyzed in 4 four-week stages, yet the course could be actually divided into two parts: the first eight weeks of training the basics of robotics, and the last eight weeks of working in a team of three to four to design and construct a robot to solve a real-world problem. Data across the stages confirmed that the change may have to do with the class setting about teaching the basics and later building their own final robot.

### Did students improve their self-efficacy through the class?

*General self-efficacy.* Results of the general self-efficacy survey were not significant. This may be due to ceiling effect. The average of the beginning general self-efficacy was already 4.51, and the ending general self-efficacy was 4.37. It would be very difficult to reach the full score of 5. Therefore, the change was not significant. This result is confirmed by similar research (Fritson, 2008), which indicated that students did not have significant change in self-efficacy between mid-term and the end of the term.

*Robotics self-efficacy.* The difference in some items of robotics self-efficacy survey before and after building the final robot during eight weeks was statistically significant. If the survey were implemented at the beginning of the semester, more items might also show significance.

### What do students actually reflect on in their reflection journals?

The contents of students' reflection journals fell under seven coding dimensions, including: what they did that day (doing), what they learned (learning), what they want to do next (planning), how they feel (opinions), and why they design the robot that way (background knowledge), how the project is going (evaluation), and random comments (irrelevant information).

Interestingly, many journal entries described the problems students encountered during that class time, either solved or unsolved, and then reflected on planning to how to solve the problems in the next class. This might indicate that encountering problems increases planning activities in order to solve the problems.

**Did students change the reflection contents over the semester?**

As seen in Figures 1 and 2, the reflection on doing occupied the major portion of the reflection journals and kept on increasing throughout the semester. The reflection on planning increased over the last 8 weeks, and the reflection on evaluation increased during the last 4 weeks. Yet the reflection on learning decreased throughout the semester.

The students were supposed to learn things all through the semester, so why did the reflection on learning decreased? Two explanations seem plausible. First, the students were provided with fundamental training of building materials, sensors, and mechanism though working on simple robots during the first half of the semester, while their task was changed to designing and building their own robot during the second half of the semester. The information at the first half semester involved more explicit terms that they could write about, while the building process was more about the ideas and problem solving skills that they might have less awareness of describing what they just learned.

Second, there were actually different levels of learning. According to Blooms' revised taxonomy of educational objectives (Krathwohl, 2002), remembering, listing, and understanding information are the lowest level of learning, while application, analysis, synthesis, and evaluation are higher levels of learning. Finding that the students report less on reflection about learning but more on planning and evaluation may be a good indicator that they were increasingly engaged in higher level learning as the semester progressed.

**What is the relationship between the reflection journal writing and self-efficacy?**

Results indicated that the robotics self-efficacy increased over the eight weeks. Students' reflections about activities, evaluation, and planning also increased, indicating advanced levels of learning. In other words, we may conclude that when the students engaged in higher levels of learning activities, they became more confident about their capabilities of building robots. The reflection journals served as an approach to observe what the students were doing at each stage. They also helped students become aware of their learning process, especially specific robotics knowledge.

This analysis showed the different aspects students reflected about in their class journals, as well as the difference in the amount of each aspect over the stages, indicating their learning curve. The results would appeal to robotics education practitioners. Since the teachers use Lego robots in STEM education, the results might shed some light on a possible effective way of teaching robotics.

**Limitation and Future Direction**

As part of the course requirement, students also kept a team journal when they were constructing their team robot. The data included in this paper were only individual reflection journal data. It would be interesting to explore whether the team journal show any different results from the individual journals.

In the course, the students also used a 2-page problem solving log template to document the problems they encountered and the processes they used to solve them (see an initial analysis in Huang, Varnado, & Gillan, 2013b). Analyzing the problem solving logs at different stages is another way to study metacognition.

Lastly, students posted many pictures and videos when they were working on the projects, which could be complementary to the verbal data.

**Acknowledgement:** Thank Dr. Jason Swarts at NC State for his guide on the verbal data analysis method.

## REFERENCES


Banker, T. G. (2004). E-Journals: Reflections and communication improve learning outcomes. *Journal of Scholarship of Teaching and Learning*, *4*(1), 35-40.

Chen, G., Gully, S. M., & Eden, D. (2001). Validation of a new general self-efficacy scale. *Organizational Research Methods*, *4*(1), 62-83.

Davis, M., & Hult, R. E. (1997). Effects of writing summaries as a generative learning activity during note taking. *Teaching of Psychology*, *24*(1), 47-50.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, *34*(10), 906-911.

Ford, J. K., Smith, E. M., Weissbein, D. A., Gully, S. M., & Salas, E. (1998). Relationships of goal orientation, metacognitive activity, and practice strategies with learning outcomes and transfer. *Journal of applied psychology*, *83*(2), 218.

Fritson, K. K. (2008). Impact of journaling on students' self-efficacy and locus of control. *InSight: A Journal of Scholarly Teaching*, *3*, 75-83.

Hawkins, S., Coney, M. B., & Bystrom, K. E. (1996). Incidental writing in the engineering classroom. *Journal of Engineering Education*, *85*(1), 27-33.

Huang, L., Varnado, T., & Gillan, D. (2013a). An exploration of robot builders' attachment to their LEGO robots. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *57*(1), 1825-1829. SAGE.

Huang, L., Varnado, T., & Gillan, D. (2013b). Practices of Teaching Problem Solving Skills in Robotics Education. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *57*(1), 1830-1834. SAGE.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, *41*(4), 212-218.

Murphy, C. A., Coover, D., & Owen, S. V. (1989). Development and validation of the computer self-efficacy scale. *Educational and Psychological measurement*, *49*(4), 893-899.