

# Lessons in Transfer: Better understanding of engineering students' metacognitive development

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**Abstract**—Metacognition plays a key role in the development of an effective, reflective engineering student who is learning to solve ill-structured problems. While we have developed an intervention to engage students in their metacognitive development within existing courses, it is equally important to consider instructors' perspectives. This work-in-progress presents the results of our analysis of 14 instructor semi-structured interview responses regarding implementation issues, instructor value for the intervention, and potential implications of adapting such an intervention. Our initial analysis indicates that instructors in our sample feel confident that they can teach students about metacognition, but that they still desire secondary supports. Ease of implementation is important so that instructors do not feel they are choosing between regular course content and students' metacognitive development. Instructors valued the ability to “diagnose” where students may have gaps in their metacognitive practice and felt that it was important to have a compelling message, perhaps from peers, to communicate the value of metacognition.

**Keywords**—*metacognition; transfer; research-to-practice; engineering*

## I. INTRODUCTION

Metacognition is an important part of successful student learning and especially solving ill-structured problems (cite U0fM Metacognition and Reflection book, Pintrich 2002, Jonassen 2011). However, students often lack metacognitive skills. We have developed an intervention to engage students explicitly in developing metacognitive self-awareness and building their metacognitive skills (cite last year's FIE paper and/or this year's ASEE paper). One aim of our work is to study students' metacognitive development in real-world settings, such as a disciplinary-focused course within a student's major. Another aim of our work, and the focus of this paper, is to understand what contributes to making this intervention transferable to other contexts and easy for instructors (faculty, graduate students, etc.) to use within their existing courses.

In the context of the Four Categories of Change Strategies model developed by Henderson, Beach, and Finkelstein [1], our approach encompasses elements of disseminating Curriculum and Pedagogy (the

intervention we have developed) and developing Reflective Teachers (encouraging and supporting instructors in adapting the context specific elements of the intervention for their courses). Both elements focus on individual instructors, but they straddle prescribed and emergent outcomes.

The intervention is made up of six modules for teaching metacognition and accessible tools for measuring metacognitive strategies among engineering students. Each module consists of a short pre-class video (~10 min) and reflection questions, an in-class activity (5-10 min), and a post-class assignment (20-30 minutes). The videos address the constructs of metacognition in a general way (though situated within engineering education), while the in-class and post-class elements are tailored to the particular class context – acknowledging that the way we engage metacognitively depends on the type of course, for example, operationalized constructs of metacognitive practice look different in problem-solving courses, lab-based courses, and project based courses. The intervention is grounded in Flavell's classic framework of metacognition [2] and more recent refinements and elaborations [3-7]. Specifically, our model of metacognition includes knowledge and regulation of our thinking processes. The constructs of metacognitive knowledge are knowing self and others, knowing cognitive demands of tasks, and strategies. The constructs of metacognitive regulation are planning, monitoring, controlling, and evaluating our thinking processes [8, 9]. The six learning modules address: knowledge of self, assessing learning experiences, planning, monitoring and control, and reflection. For more detail see [9].

After successfully piloting the intervention at one site, we are preparing to revise the intervention for additional research sites. Successfully revising the intervention for other instructors to use requires understanding faculty motivation to adopt and adapt our

intervention and knowing what supports would be needed for successful implementation. To adapt the metacognition modules to a new context, this work-in-progress seeks to answer the questions: (1) *What expectancies of success and subjective task values do instructors express about the implementation of these metacognition modules in their classroom?* and (2) *What materials or support do instructors need to aid them in the implementation of these modules?* To develop this understanding, we conducted and analyzed semi-structured interviews with 15 instructors at a transfer site. We asked what would motivate them to try the intervention and what supports they would need. We also gathered specific feedback and suggestions for the types of modifications needed for a first-year context. This work-in-progress paper reports our initial findings based on preliminary interview analysis.

## II. FRAMEWORK

Although the overall study is grounded predominantly in Flavell's [2] framework for metacognition, this portion of the study is grounded in motivation and specifically Eccles' expectancy-value theory (EVT) [10, 11]. EVT provides us with a way to examine instructor's ability beliefs and value for our proposed intervention. Literature on faculty adaptation of pedagogical changes suggests that possible barriers include lack of knowledge on how to implement the pedagogy, high costs (time and effort) associated with the implementation and a need to believe the intervention is useful to students (for a review of current literature see [12]). EVT addresses these aspects with the constructs of expectancy of success and subjective task values. Expectancy of success is a person's belief with regard to the likelihood of success when engaging in a task [10]. Subjective task values are the personal importance associated with a task and include sense of enjoyment in the task (interest value), the time or effort associated with engaging in the task (cost value), the perceived usefulness of the task (utility value) and the consistency between engaging in the task and sense of self (attainment value) [13, 14].

## III. METHODS

To answer our research questions, we leveraged EVT to explore instructor expectancies of success and values relative to implementing the metacognition modules in their classroom. The school and course context of the transfer site are very different than the pilot site offering a maximum variation case for gathering data. Interview participants were both graduate teaching assistants and faculty instructors of a first year engineering course at a large, state land-grant university.

### A. Participants

Interviews were conducted during the Spring semester of 2016. All instructors who were currently teaching or who had recently taught a specific first-year engineering course were invited, via email, to participate in an interview. We interviewed all participants who responded during the interview week. Out of 14 instructor interviews [7 of grad students, 7 of faculty instructors]. The interviews were conducted prior to transferring the intervention to the new site in order to include the feedback in intervention refinements and adaptations to the new context.

### B. Data Collection

The research team designed a semi-structured [15] interview protocol to enable us to hear the instructors perspectives. First, we solicited their views of the course(s) they taught and their students' experiences. Next, we presented an overview of the intervention using examples of the videos, in-class activities, and post-class assignments. We then asked a series of questions to gauge familiarity with metacognition and ability and value beliefs with regard to teaching metacognitive skills. We asked questions including:

1. Would an intervention like this be useful to your students? Why or why not?
2. What would it take to get your students to engage in an intervention like this? Would you be willing to try an intervention like this?
3. Would you want materials ready to go? Would you want to be able to customize it? Would you want someone else to come in and lead this? Would you want training?
4. Do you think you would be comfortable talking about metacognition?

### C. Data Analysis

The semi-structured interviews were transcribed verbatim and imported into Dedoose coding software. We are currently in the process of analyzing the interviews. We are using an open-coding process to identify emerging themes related to instructor expectancy of success and values, as well as suggestions they had for implementing these modules in their classroom. To insure the quality of our findings, we are engaging in researcher triangulation practices [15] where we the research team reviews and discusses the analysis process and emergent findings.

#### IV. PRELIMINARY FINDINGS AND DISCUSSION

Consistent with our research questions, we have three categories of preliminary findings from our interviews: instructor expectancy of success, instructor value, and suggestions for implementing the modules.

##### A. Expectancies for Success

Although literature suggests that knowing how to implement a pedagogy can be a significant barrier, we found that participants were generally positive about their ability to teach metacognition. These positive beliefs are generally grounded in their own personal experiences learning about metacognition. For example, one participant speaking of their confidence teaching about metacognition said:

*Actually that's what, and sometimes I'm afraid that I talk too much about cognitive psychology research. I think it's important for us to bridge and then to talk about how people learn.*

- I104

Although they believe they could teach metacognition, we found a detractor from expectancy of success being a concern on how to fit metacognition into the course. Participants indicated that the course is full of other content that they are expected to teach. When asked if they would be comfortable implementing the modules, instructors said:

*I would be if there was any way to reduce the content in the course, frankly. That's a big portion of it, there's already a lot of existing graded assignments, already almost every minute is already accounted for in the classroom.*

- I102

##### B. Instructor Subjective Task Values

Consistent with prior research, we found utility value to be important. Specifically, instructors also mentioned how the metacognition modules would be useful in teaching about metacognition in their classroom. They mention that an attempt to teach metacognition has been made in the past and that the modules seemed like a better way to teach it.

However, unlike prior research, we found instructors expressed an interest value. Instructor values were very clearly linked to an interest in student learning. They found that the modules were interesting to them because they were interested in the potential outcomes of the modules:

*I would because I'd be interested in knowing what their misconceptions are myself to figure out how I can better assist them.*

-I100

Through our continued analysis, we will continue to examine and expand these findings with regard to utility and interest values but we will also consider cost and attainment values.

##### C. Suggestions for Implementation

In the interview, we also asked instructors about what suggestions they have for the research team in order to implement the modules in their classroom. Some common threads emerged among participants. They wanted a guidebook to help them address certain student reactions to the modules, as suggested below:

*If their responses are this, then this may indicate x, y, z, and so I can figure out possibly how to address what their responses are... How to respond to some misconceptions because it may be misconceptions with the course, but if it's maybe a misconception with prior knowledge, then it may be a little bit more difficult for me to answer that because I'm not familiar with it.*

-I100

This suggestion is consistent with supporting expectancy of success; instructors wanted a place to turn in case they needed more knowledge.

To help promote student value for the module, instructors pointed out that students respond well to the input of other students:

*Testimonies from other students would be good, that does to some extent fall into the personal anecdotes thing, but if it's other students, there's certainly going to be a stronger connection there.*

- I111

Instructors also noted that students care about something if it is graded. In implementation of the modules, some of them said they would offer the assigned work in the modules as extra credit or for a small set of points. Offering extra credit points could be considered another way to promote utility value or it could be making the cost of not doing the activities high enough that students participate.

#### V. CONCLUSIONS AND FUTURE WORK

Through our preliminary analysis we learned that EVT is a helpful lens for examining the transfer implementation of our metacognition modules. Our results show instructors generally have positive ability beliefs regarding teaching metacognition but that some secondary supports would be helpful. Our preliminary

results also suggest that we should focus on being sure the modules are easy to implement so that instructors do not feel pressure to have to choose between content and metacognition. To align with subjective task values, we should be sure the assessment tools that accompany our modules enable faculty to “diagnose” where students may have gaps and may need help. Finally, we should consider how our modules “sell” the value of learning metacognition to students through peer testimonials and/or suggestions and to how to offer points for the assignments and activities in the modules.

Future work will include continued analysis of the instructor interviews to further shape our transfer implementation plans. In the upcoming months, we will implement the metacognition modules at multiple transfer sites within and outside of engineering. In addition to testing the effectiveness of the metacognition modules, we will evaluate the effectiveness of our implementation strategies. We will also follow up with instructors after using the intervention to capture their actual experiences – either through interviews, open-ended questionnaires, or other suitable means. Although focused on a specific intervention, we believe our findings will have broader appeal as we offer suggestions for adapting interventions based on differences in course content and context.

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