



Reflection in Engineering Education: Advancing Conversations

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Abstract

This work, funded by the Engineering Education and Centered directorate, is motivated by a belief in the value of reflection for student learning in engineering, an appreciation of the range of activities that educators can leverage in order to support student reflection, and a sense of the need for resources to help educators make informed decisions in the design of reflection activities for specific situations. Against the backdrop of these ideas, our grant is operating on two levels. On a foundational level, we are establishing empirically informed conceptual frameworks and associated survey instruments that help educators and resources understand (a) what knowledge gains result when students engage in specific reflection activities and (b) what types of reactions students have when they engage in the activity. On a practical level, we are exploring ways to distribute our conceptual frameworks alongside relevant information. With our work, we aim to advance conversations about potential impact of reflection and conversations about how to leverage reflection in teaching. In the paper and poster, we will focus on both the foundational insights and practical resources that are emerging from this work.

Introduction

Education involves identifying activities for students that will lead to important forms of learning. Such activities include structured practice, having students work on projects, having students engage in new experiences, and also having students reflect. Educational scholarship is useful for advancing conversations related to specific activities and/or relationships among activities. In our work, we have been focused on advancing conversations related to the use of student reflection in engineering education.

Reflection can be understood as a form of thinking that involves stepping out, thinking about, and connecting forward. Defined in this way, reflection can be seen as distinct from other activities mentioned above and also a very broad category of possible activity. In prior work, we focused on appreciating the range of activities currently used by engineering educators to support reflection and exploring issues related to the design of reflection activities. We have sought to contribute to broader efforts to understand students' experiences with reflection, educators' efforts to design reflection activities appropriate for students, and researchers' efforts to better understand affordances of specific reflection activities.

In the current NSF project, we seek to use a **deep dive** into two dimensions of students' engagements with reflection as a way to advance conversations about reflection. In the deep dive, we have been targeting (1) students' reactions to reflection activities and (2) students' self-identified knowledge gains as important for understanding different possible reflection activities. The specific goal of our deep dive is to produce two validated survey instruments that make it possible to investigate specific reflection activities in a scholarly and comparable way.

This deep dive emphasis also provides a way for us to coordinate continued conversations with students, educators, and researchers. With students, we need to appreciate what they already know about reflection and how they talk about reflection in order to best construct our instruments. With educators, we need to appreciate what the process of designing reflection activities does and could look like in order to appreciate how to ensure information on reactions and knowledge gains is ultimately practical.

In this NSF grantees poster session paper, we highlight activities, results, and current directions associated with our deep dive into students' engagements with reflection.

Background

Reflection, as a concept, has a strong sense of familiarity for many. Readers may be familiar with Schon's concept of "reflection in action" from the widely cited *Reflective Practitioner* (Schon, 1983), or with "reflective observation" from Kolb's experiential learning cycle (Kolb, 2014). Those involved in teacher education or familiar with educational philosophy may associate reflection with Dewey's educational philosophy, usefully summarized by Rodgers (2002). Those acquainted with adult education and the work of Kember may recognize Kember's significant contributions, including the development of a scale for measuring the "level of reflective thinking" (Kember et al., 2000). Those familiar with professional development may recognize Moon's book, *Reflection in Learning and Professional Development* (Moon, 2013). Some in engineering education may be familiar with a definition recently offered by Turns and her colleagues: "Reflection can be understood as a form of thinking in which one actively and intentionally constructs meaning of past experiences in service of future action" (Turns et al., 2014). Such citations are, in fact, only a small part of the large body of scholarly literature focused on reflection. For example, the journal *Reflective Practice* is a Taylor and Francis journal that publishes six issues annually. More broadly, there are hundreds of papers addressing issues related to reflection, including topics such as teacher education and sports education.

In our own work, we have been grappling with the challenge of operationalizing reflection. Rather than focus on choosing a definition, we have been searching for commonalities among definitions. We see four threads. First, we note that reflection as commonly discussed is a type of thinking (and perhaps the term reflective thinking would be equally appropriate). Second, we note that reflection, as a type of thinking, is interesting because it produces knowledge. This insight helps us see reflection as a constructivist learning mechanism (i.e., a place where students construct their own understanding). Third, reflection (and the associated phrase "reflect on") points to the idea that reflection involves stepping outside of a situation, be that outside of prior experience or outside of one's current knowledge. Fourth, reflection has a personal element in that the situation upon which one is looking is a personal situation. In other words, one reflects on one's own experience and one reflects on one's own knowledge. When thinking produces knowledge and involves stepping outside of an idea, but is not stepping outside of one's own ideas, that is often considered critical thinking. It is this way of framing reflection that has us differentiate reflection (engagement in a particular type of thinking) and reflection activities (activities educators ask of students in order to support them in reflection).

We see reflection as a large and promising space, worthy of broad and rigorous inquiry. We see potential for a focus on reflection to bring the engineering education community closer together and foster and enrich conversations around student experiences. The National Science Foundation and others push us to look for areas of potential impact, for understudied phenomena that can make a big change, for ideas that can help us collectively organize our thinking. We believe that reflection is such a topic. Reflection links to experiential learning (a common pedagogy), to self directed learning (of significant interest), and other desirable end goals such as self awareness and mindfulness.

Scholarship related to reflection has been growing within engineering education as measured by the number of conference papers addressing the topic (Sepp et al., 2015). For example, reflection, facilitated through portfolio construction, has also been identified as a way to help students grapple with engineer identity and “feel more like an engineer” without additional courses or experiences (Eliot & Turns, 2011).

Reflection can be seen as relevant to educational issues such as diversity in engineering and bringing broader perspectives into engineering. For example, consider the issue of belongingness and its link to inclusion and retention in engineering (e.g., Foor, Walden, & Trytten, 2007). Belonging is frequently described as a feeling that emerges (i.e., not the product of intentional meaning making). While such emergence may be inevitable, it perhaps can be disrupted with reflection. In the event a student does not feel that they belong, it is also possible that they might revisit the experiences that are associated with the sense of not belonging, unpack what creates the feeling, and perhaps reconsider. For instance, if a student feels they don’t belong because all of their ideas are “shot down” by peers, they might come to a different understanding by examining these past experiences and realizing that there might be many reasons why their ideas might be getting “shot down,” including reasons that would suggest a reason to belong to engineering (e.g., the ideas are particularly creative or interdisciplinary). Further, while we certainly would not want to rely on reflection to help students overcome too many such issues, reflection can play an important role in supporting the emergence of a sense of belonging.

As scholars, we have many questions about students and reflection. Do reflection activities work? Does engaging in reflection activities lead to desired performance gains? When students engage in reflection, what is the quality of their reflection? While these are answerable questions, there is a challenge if we want more nuance. What knowledge do students perceive themselves as having acquired? How do students react to the reflection activities? Here, there is a gap—a gap in being able to characterize students’ knowledge gains and students’ reactions to reflection activities. Information on knowledge gains and reactions would be valuable for activities such as comparing reflection activities, seeking to understand why an activity is not working, and refining activities. Having survey instruments to capture such information could significantly accelerate research on reflection, as well as create more local and national conversations about the use of reflection to improve engineering education.

Activities

In the past year, we have been engaged in (1) survey development as well as (2) work to create a vehicle for distributing the surveys, (3) work with students, and (4) work with educators. We touch on each of these activities below.

- (1) Survey development. In the past year, we have been focusing on developing the survey focused on students' reactions to reflection (we chose to focus on the more complicated survey first in order to ensure key issues were raised). We developed over 15 candidate questions for each of our ten "reaction bases" (I.e., the basis for which a student articulates a particular reaction, such as reacting negatively because of a feeling of being **forced** or reacting positively because of a feeling of enjoying the **challenge** of a particular activity). Exploration of the research for each basis, and subsequent development and discussion of the candidate questions, took around 3 months. In addition, we conducted an initial data collection and data analysis cycle in order to surface challenges associated with formatting the survey and confirming the statistical analysis (in collaboration with a statistical consulting unit on our university campus).
- (2) Creating the vehicle for distributing the survey (i.e., the reflection activity toolkit). In addition to developing the survey, we have been developing a reflection activity toolkit as a vehicle for distributing the survey alongside other relevant reflection activity resources. The survey and other existing reflection activity resources are parts of the toolkit, but we are also working on developing the overall toolkit structure so that the toolkit and its resources will be practical. We participated in a university innovation program to advance our effort to create an integrated toolkit. In addition, we wrote and presented a conference paper in which we shared insights emerging from our work to design the toolkit (Turns and Roldan 2019).
- (3) Work with students. During this period, we completed an analysis of data we had collected during the first year (data about students engagements with reflection) and presented the resulting paper at ASEE. Relative to our prior work (in which we had heard a small amount of information from many students), we focused in this paper on gaining more information from a smaller number of students but looking to hear students' stories about the range of activities they use, and the reactions and knowledge gains associated with different activities. Using a qualitative interview data collection approach and a cross-case analysis strategy, we identified meanings in motion, varied practices, felt engagements and school life divide as themes that appeared in how the student respondents talked about their experiences with reflection.
- (4) Work with educators. We conducted two projects exploring how educators experience the design and enactment of reflection activities with students. In one project, three educators each designed and enacted a "micro-reflection activity" (i.e., a 3-5 minute activity) with their students on a weekly basis. In the second project, the focus was on a single

educator's effort to design and enact a much larger reflection activity as part of a capstone design course sequence.

Results

In this section, we highlight some of the results emerging from the work. The results presented below are connected to the four threads of activity.

(1) Survey development. Our survey development efforts have been successful at illuminating the complexities of this survey development process. For example, we are gaining evidence about the potential combination of reactions that are possible (e.g., students can carry seemingly conflicting views such as being concurrently positive and negative about seemingly the same, such as reacting both negatively and positively to the challenge of an activity). In addition, we are gaining evidence about how the act of answering questions about reactions can influence how students react to the activity (in other words, collecting data on the phenomenon of reactions can influence the phenomenon). Of note, students have commented that describing their reactions through the survey has helped them “warm” to the survey. These aspects of our survey are important for users of the survey to know.

(2) Creating the vehicle for distributing the surveys. In our paper, “A translational, research through design effort in engineering education,” (Turns and Roldan, 2019) we explore the question: “What insights concerning translational design efforts have arisen from a research-through-design effort in the domain of supporting student reflection?” Specifically, we leveraged a research-through-design orientation to explore the types of work involved in creating a toolkit, and this resulted in the identification of three important types of work: Choosing a just-enough definition, building a practice-facing framework, and creating practitioner-relevant offerings.

- Just-enough definition: “A just-enough definition is one that provides enough information for the practitioner audience to appreciate the work contained in the research and to be interested. A just-enough definition creates a foundational alignment and a bridge.” In the paper, we discuss our movement to “reflection as a form of thinking that involves stepping out, thinking about, and connecting forward” as a just-enough definition.
- Practice-facing Framework: In the paper, we characterize a practice-facing framework as one that “(a) frames educational practice in terms of ultimate particulars and situated action, (b) emphasizes learners and educators as part of practice, and (c) positions research as inspiration.” In the paper, we discuss our framework which “follows the design process where educators can work on a reflection activity through efforts to identify their input (e.g. how many students), think through various dimensions of the activity they are designing, think about the kind of engagement they want to design for students and consider the potential outcomes of the engagement.”
- Practitioner-relevant offerings: In the paper, we introduce the notion of sufficiently-emic offerings as those that help “educators with what they need help with, on their terms, and attending to an etic perspective that reminds us to attend to learning.” In the paper, we discuss the effort to ensure that what is in the toolkit (such as the surveys we are developing) can be situated as sufficiently emic.

(3) Working with students. In our paper, “Students’ Engagements with Reflection: Insights from Undergraduates,” (Roldan et. al, 2019) we report four themes related to undergraduate engineering students’ experiences with reflection: Meaning in Motion, Varied Practices, Felt engagements, and School Life Divide. These interviews with students helped us grasp the importance of asking questions about both the positive and negative contributions of each reflection activity in our questionnaire. This adds complexity to the survey development, but our work with students shows the importance of capturing the nuanced student reactions to reflection activities. Our concluding statement in the paper captures this main takeaway for our survey development: “This research attempts to humanize students’ experiences with reflection and offers a cautionary note about making assumptions around students and reflection. Moving forward, we suggest capturing and responding to student reactions to reflection activities, framing and scaffolding reflection activities, and designing reflection activities that allow students to build on what they bring.”

(4) Working with educators. In our paper, “Designing and enacting weekly micro-reflections as a means of professional development of early-career educators: Voices from the field,” (Turns et. al, 2019) we focused on educator design and enactment of reflection activities of 3-5 minutes (micro-reflection activities). As articulated in the paper, “we asked: under what circumstances and in what ways can engagement in micro-reflection activities during one’s teaching contribute to advancing one’s teaching?” In the project, three educators with different levels of teaching expertise engaged in adding micro-reflection activities to weekly 2-hour classroom sessions. This effort gave us an opportunity to appreciate potential motivations that educators may have for engaging in work on reflection activities and also to appreciate the context into which our insights on student reactions and student knowledge gains might go.

In the paper, we note: “a total of 30 micro-reflection activities were used. These activities included: turning questions into snowballs, comparing before-and-after understandings on index cards, performing skits of memorable moments, and crowd-sourcing visualizations of students’ level of understanding. ...These activities varied by materials used, by social engagements, and by purposes (e.g. assessing student learning, supporting student learning, or simply having fun). In addition, some activities created information that was processed after the activity (such as some activities that involved students sharing information on notecards) while other activities were primarily in the moment (such as embodied activities).”

The paper includes narratives from the educators concerning their rationale for the activities and their observations about how the activities turned out. Comments related to student reactions and student knowledge gains are woven into these narratives. For example, “I saw a handful of delighted/amused responses from the students when I revealed the prompt,” “I was paying attention to how to phrase the request because I recognized that saying *what is a purpose* as opposed to *what is the purpose* alleviates pressure from student thinking there is one right answer,” and “I began to wonder if I had done a disservice to my students by not having them reflect on their knowledge/understanding of the material.”

A second paper related to educators, “It’s not just one thing: Exploring a personalized interdisciplinary design playbook assignment,” (Adams and Turns, 2019) was motivated by the

challenge of innovation in engineering education. It focused on the question, “What perspectives are useful for bringing to the surface insights that come out of a specific case of innovating, and with these perspectives, what insights do we see?” The innovation at the center of this case, the Interdisciplinary Design Playbook (IDP) was designed to support student reflection. Through this paper, we concretized that the reflection structure allowed educators to make sense of their innovation experience.

Five perspectives were identified: “demanding problem definition, a discursive approach to translation, sustained coordinated action, lurking provocation, and predictable emotional labor to name specific insights associated with this case.” We summarize the paper by noting that, “the findings showcase issues around the timing and timescales of the work, who is doing the work, the contours of the work, and the psychosocial demands of the work. We see the work of the educator that is involved in order to get students to the point of doing their work (and subsequently learning). We see the work of explaining through materials, the work of sustaining, and the work of managing emotions, particularly in the face of novelty and risk. This broad picture of work raises questions about how to support those engaged in innovating, how to acknowledge the work of innovating, and how to support the risk-taking that is inherent in innovating. Foundationally, we can acknowledge the critical nature of acknowledging the work as invisible work has many consequences.”

Closing thoughts

Looking broadly, takeaways from our first two years include the following: (1) undergraduates talk easily about reflection and there are multiple viable ways to do this talking, (2) reactions and takeaways, while theoretically distinct, can merge in student talk, such as illustrated by the example “I enjoyed how we got to hear the problems of others,” (3) finding time to explore reactions and takeaways can be hard. In the context of designing reflection activities, it can be difficult to think about and debug student reactions against a backdrop of trying to plan and enact the reflection activity, (4) our initial models can be imposing to audiences, and (5) the work on a conceptual framework and survey can be treated not only from a scholarly perspective but also a designerly perspective.

As we move forward, we are grappling with three tensions: (1) how to broadly capture student reactions without having a survey that is too long, (2) how to address the observation that a survey capturing reactions to a reflection activity is, in a way, a reflection itself, and (3) how to ethically and efficiently make sense of the data that results from the surveys we are creating. Addressing these tensions will be part of our effort to finish the survey development, demonstrate the use of the surveys through an example study, and ultimately catalyze research on reflection in engineering education.

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