New Orleans Jazzed about Engineering Education

Paper ID #17117

Tips & Tricks for Successful Implementation of Reflection Activities in Engineering Education

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Tips and Tricks for Reflection

Introduction

Engineering educators are introduced to an array of active learning approaches that pique their interest and spark excitement about the possible outcomes for their students. After initial exposure to new activities, contextual questions naturally arise for educators, and a clear understanding of the essential features for successfully implementing a teaching strategy becomes necessary. Reflection activities represent one approach for active learning that educators reasonably have questions about before adopting the approach.

Reflection is a topic that can have various meanings. For this project, reflection was conceptualized with the following definition: looking back on the past experience(s), to interpret and make meaning of those experiences in order to plan for the future [1]. With this open interpretation, it is still possible that reflection is messy, personal, and complicated. The body of scholarship on reflection in engineering education is emerging. Several studies discuss the challenges of incorporating reflection activities in engineering classrooms [2-10]. Although the term is not always used, reflection is a feature of engineering education and engineering practice. Examples like iteration in design processes, or when an educator allows students to re-do a test to demonstrate knowledge of the material are very common ways in which engineering as a discipline reflects.

This paper builds on the work of the Consortium to Promote Reflection in Engineering Education (CPREE) [11] in which we conjectured that educators in engineering were already doing reflection activities and we sought to document those activities. We spent the first year of CPREE talking with educators to learn what activities they use. Ultimately, we documented over 100 reflection activities facilitated by engineering educators from diverse types of institutions and shared those activities for public use in the form of a field guide. The field guide includes an overview of each activity, steps to recreate the activity, and tips and inspiration as shared by each educator who offered their specific activity for the field guide. These "tips and tricks" were very often derived from years of experience of using the activity. Collectively, these activities and their associated tips provide a set of guiding ideas for implementing reflection activities in engineering education settings. These tips became the unit of analysis for this paper.

In this paper, we present themes that were derived from over 300 individual tips in our field guide for reflection in engineering education. These activities come from many different contexts, have varying depth, time allocations, and other features that make the activities unique, yet the tips yielded similar themes for success. For this paper, we completed a qualitative analysis to identify themes across all of the tips. The themes were organized into three categories: (1) considerations for the reflection activity itself, (2) considerations for students' connection to reflection, and (3) consideration for the educator's connection to reflection. Because the themes and categories interconnected, we close the results section with a discussion of "closing the loop" to illustrate the interconnectivity.

The tips for reflection celebrate the many successes these educators have experienced with the activities, while bringing attention to some of the unintended consequences for implementing

reflection. By highlighting these successes and some of the challenges associated with reflection in engineering classrooms, we anticipate that readers will be well informed to make their own decisions as educators. Our goal in sharing these thematic findings is to call out the important considerations for implementing reflection in engineering as identified by educators. These findings will help new and experienced faculty make decisions about how to design and implement reflection activities in their own pedagogy.

Methods

This work involved thematic analysis of tips offered by engineering educators as part of a large-scale effort to document activities used by educators to support student reflection. The tips that we collected are the data for this analysis. In this section, we provide details on this data source, discuss the thematic analysis approach that was used, and identify key features of how the resulting themes presented.

Data collection

One of the primary products of the consortium's work in year one, was the production of over 100 field guide entries of reflection activities. These field guide entries captured an overview of each activity from educators who have either created or intentionally adopted reflection activities into their pedagogy, included step by step instructions, worksheets, rubrics, and resources for other educators to implement the activities on their own. Field guide entries were generated by a two step process. First, educators were interviewed about their reflection activities by local campus leadership on the CPREE project. These audio recorded interviews and supporting documents were shared with a team of researchers who then created field guide entries for each activity. The researchers created a general template to capture the outline of the activity, recipe-style instructions, and tips to successfully implement the activity. The latter section was named "Tips & Tricks" in the campus field guide entries. The content for the field guide entries and associated tips were selected from the interviews to identify and share out the most practical suggestions offered by the educators.

Often, the tips included in the field guide entries were informed by multiple iterations of the activity--both successful and less than perfect experiences with the activity. The wisdom collected from these educators was meant to inform other educators who are interested in adapting these activities in their own context. In the process of collecting and documenting reflection activities to create field guide entries, it was clear that there was a bit of overlap and transferable advice for educators who use reflection in their teaching, and thus inspired this paper. Our aim is to share practical tips with educators who will use reflection in their pedagogy.

Data analysis

The data analysis was carried out by three researchers familiar with the project. An initial period of data sensitization was used in order to become familiar with the data and to explore possible approaches to coding the data. For example, initial analysis approaches explored units smaller than the tip itself, such as a phrase within the tip could be coded. The researchers also explored a coding approach that focused on the conditions that motivated the tip (e.g., personal experience

with the activity, student attitudes, educator attitudes, finite resources). From these initial analysis approaches, the need for an approach that surfaced higher level insights was necessary. Ultimately, an affinity mapping process was identified as the most appropriate method of aligning the goals of the analysis with the nature of the data source. In the mapping process, tips were treated as coherent entities and each tip was associated with a dominant theme. Attention was focused on the direct object, or to what person/entity the tip was directed to, in order to assign a category. After primary categories were identified, themes within those categories were determined. While this is not a comprehensive analysis, our aim was to capture some of the most important, transferable tips for implementing reflection in engineering education.

Presenting and interpreting results

The results below consist of the three broad categories of tips, and then generalized themes that were synthesized from the original data. As mentioned, we identified one theme for tips that was crosscutting among categories. In presenting these generalized themes, example tips are used as evidence. When specific tips are presented, they are cross-referenced with the reflection field guide entry from which they were derived. The cross reference consists of the campus name and the reflection activity number as listed on the CPREE campus field guide webpage http://cpree.uw.edu/campus-fieldguides/.

In reading the results, there are two things are important to remember. The first pertains to the interpreting what is in the original data source and the second pertains to the absence. Concerning what is present in our data source, we remind the reader that the tips represent what educators mentioned at the time of the interview. Thus, the language used in the results includes phrases such as “educators mentioned,” “educators called attention to,” and “educators highlighted.” This is in contrast to language that might over-interpret our data sources (e.g., “educators thought x was the most important” or “educators prioritized x”). While such prioritization is clearly something of interest, it is not appropriate to interpret such from our dataset.

Concerning what is absent in our data source, we remind the reader that the absence of a tip from an educator’s comments cannot be interpreted as an educator not considering such a tip to be important. In other words, if a specific tip is mentioned by only one educator, it is not appropriate to assert that other educators did not find that tip important. All that we can conservatively say is that the other educators did not mention such a tip as critical on the path to completing the specific activity successfully. Put another way, if many educators mention a similar tip, we can say that this tip was considered important, but if a tip is only mentioned by a small number of educators, it is not appropriate to infer that it is unimportant. Rather, it is simply appropriate to highlight that the tip was infrequently mentioned. We will revisit these issues in the discussion.

Results

The tips were ultimately organized into three categories: tips related primarily to the activity itself, tips related to students’ connection to reflection, and tips related to the educator him or herself. Within each category, themes were identified and each are presented with examples and

an explanation of the theme. There was one theme that was related and interconnected to the activity, students, and educator, so this theme is presented as its own category, closing the loop.

Table 1. Distinct categories across field guide entries

Category	**Themes**
1. Considering the activity itself	a. Consider whether to grade or not b. Address time and timing
2. Considering students' connection to reflection	a. Help students see the value of reflection b. Address students' possibly limited experience with reflection c. Address engineering students' hesitation about writing d. Acknowledge students' varying preparation for reflection
3. Considering the educator's connection to reflection	a. Be aware of your influence on the students b. Consider learning more about and practicing reflection c. Create an environment that respects the personalness of reflection d. Be prepared to react to what emerges e. Be prepared for the addition of reflection experiences to be an iterative process

Considering the activity itself - Category 1

1a. Consider whether to grade or not

Grading is an issue that many educators mentioned as an important factor for successful reflection activities, yet the advice depends very much on an educator's view of reflection and the kind of activity the students were being asked to complete. Many educators in the group suggested that reflection activities should be graded, as a way to motivate or help students to take the activity seriously. For example, "*Incentivize the reflection activity. To get students to take the reflection activity seriously, sometimes it can be important to grade it."* [Georgia Tech FG08]. When grades are suggested, however, there was a strong agreement that the grades should be relatively small percentage points or pass/fail grades. It was also fairly consistent among educators that grading can influence student responses. A rationale for such was expressed by one educator this way:

"Think about the grading approach. Be aware that the grading approach can significantly impact how authentic the reflections are and how involved students becoming in the reflections. Avoid awarding points to each question because technically there is no "right answer" to a reflection, rather use a more holistic credit/not credit approach to grading –did they do the reflection assignment and do their answers look like they spent time and effort reflecting." [Cal Poly-SLO FG01]

Of course, this advice is very much based on the activity itself. Grading the activity at a lower scale removes the educator from the role of arbiter of good and bad reflection. There were fewer instances in which educators suggested that grades be given and that the grade be a substantial portion of the final course grade. In these instances the experience that students were reflecting on and the depth or repetition of the reflection activity itself warranted a more substantial portion of the overall course grade.

Other educators who suggested that the activity be graded also included some pointers for how to grade the activities. Grading the activity was often a means to close the loop with students or to remind students to focus on the experience they were reflecting on, rather than the reflection activity itself. Others also included tips for grading such as providing a rubric, getting additional support for grading, and consider timing; themes that overlapped with other tips included in the paper.

1b. Address time and timing

The time necessary to complete an activity successfully and the timing in the academic term, or the class session were tips pointed out by some educators. The primary motivation around time as a factor for a successful reflection activity was based on the need for the educator to allow time both in class, outside of class, and of their own time to ensure that the activity could be completed successfully. Considering time alone, educators suggested other educators to allocate the time for themselves to complete the grading and give full consideration to the amount of time necessary for the reflection activity to be successful.

For some activities, it was important for the timing of the reflection activity to be closely bound to the experience that students were being asked to reflect upon. Wrapper activities, activities used to help students make sense of a class activity like a test, project, or homework assignment were a popular category of reflection activity, and timing considerations were pointed out by several educators. For example:

"Timing the assignment. The important part is to offer the chance to earn points right after the exam because they [the students] are still stinging. When they are still reeling from a difficult exam, it can provide an opportunity to talk about study habits. They also know that the final exam is comprehensive. By giving them three to four days to re-do the problems and allowing them to use any resource, the students who are truly interested in learning the material are getting a second chance with it." [Seattle Central College FG02]

Also related to time is when an activity is introduced to the class or when it takes place in the term. For activities that may require a certain level of trust between students and educators, a few educators suggested using them later in the term. At the same time, some activities yield the best

results when they are a regular part of the class that starts on the first day and continues throughout the term.

Considering students' connection to reflection - Category 2

Challenges that students experience with reflection showed up in our interviews with educators in several ways. Educators talked about students valuing reflection, their perceptions of and experience with reflection as challenges that ought to be addressed when implementing these activities. They provided several tips and suggestions to guide students' understanding of reflection. We grouped the educators' suggestions and tips into four themes: (2a) value of reflection (2b) limited experience with reflection, (2c) hesitation about writing, and (2d) preparation for reflection.

2a. Help students see the value of reflection:

Many educators expressed concerns about engineering students not seeing the value of reflection, especially in relation to their engineering courses and future career. When students do not see the value of reflection, they may not take it seriously, which in turn makes it difficult for educators to incorporate reflection activities in classrooms. Some educators related this problem to the idea that reflection may be new to many engineering students and because students have not done it before [e.g. Arizona State University FG08, Bellevue College FG07, Bellevue College FG10, Clarkson University FG01]. Educators employed different techniques to help students see the value of reflection and below we present the more salient tips:

Provide clear description. Many educators highlighted the importance of introducing reflection and providing a clear description of the reflection activity. For example, one educator said,

"*Introduce students to the idea of self-assessment and reflection. Students have probably never done anything like this, so the way you present the concept of self-assessment and reflection is important. In the beginning you want to communicate your expectations, and walk them through the process so that they can adjust successfully."* [Bellevue College FG07]

Providing a clear description of the activity would be especially helpful when the reflection activity is designed for a specific class or when the format of the activity is unique compared to other more common forms of reflection activities such as reflection essays or surveys [10]. Consider including enough information that helps students understand the relevance of the activity to the course and curriculum, requirements of the activity, and how the students would benefit from participating in the activity.

***Use alternate words for reflection*.** Educators suggested using alternative words for reflection, especially in the beginning of the term. One educator called attention to carefully naming the activities and said,

"*I decided to call them weekly status reports. I used to call them reflections, but anecdotally found that students devalued the activity. I thought that using a name used in industry may make them more valuable to students."* [Arizona State University FG10]

Other educators also used alternative names for the activity and added that disguising the reflection activity can help as an entrée into getting students to actively engage in reflection at the beginning of the course, but they emphasized the importance of discussing the reflection later in the class so the students understand what it means and how to use it in the future [Rose-Hulman Institute of Technology FG01].

Be clear/explicit about the purpose of reflection. Educators highlighted the importance of discussing the reasons and rationale for doing reflection activities to help students see the value of reflection and to get them buy into the whole process of reflection. These discussions are usually specific to the type of reflection activity, and could range from discussions around how the activity could help students with the course assignments, to conversations about how it can help them with their future career and with seeing the bigger perspective [e.g. Stanford University FG07, Cal Poly-SLO FG02, Green River College FG08]. An educator emphasized,

"*I think it is important to explain the rationale for the reflection activity to students because they might value it more, rather than just doing it because they are told. The rationale I provide is that this reflection activity can help improve students' experience and help them learn how to present scientific information to other contexts."* [Georgia Tech FG09]

Express that reflection is about students. Students often think of the reflection activity as an assignment and may not see how reflection can help them as individuals. Educators offered tips such as focusing on the broader impacts of reflection activity, helping students connect their learning to the real world, and broadening the students' thinking beyond engineering [e.g. Cal Poly-SLO FG05, Clarkson University FG04, Highline College FG08, Stanford University FG05]. For example, one educator mentioned,

"*Focus on developing professionals. By connecting journaling to professional practice, sometimes you get a student who takes it very seriously–and that's really cool. Hopefully our students get to a point where they're independent professionals. How do you do that without reflecting? It's not like we're following a prescribed path throughout our careers, so practicing reflection is one way to help students prepare for the long term.*" [Highline College FG08]

2b. Address students' possibly limited experience with reflection

As mentioned earlier, reflection is new to many engineering students, so they may not know how to participate in reflection. Besides providing clear descriptions and discussing the rationale for the reflection activity, educators offered the following tips to help students engage in reflection activities:

Use examples. Providing examples is very helpful especially when the reflection activity is unique and designed for your class. Educators said that they used examples from their previous classes or shared their own reflections with the students [e.g. Arizona State University FG03, Bellevue College FG10]. However, some educators were more cautious about sharing their own reflections and opinions, especially at the beginning of a class or a group discussion, because students could converge on that opinion as being the right answer due to the educator's authority in the classroom. [Arizona State University FG08]

Repeat the activity. It is important to provide additional reflection opportunities and to have students frequently practice reflection. If students are new to reflection, they are still trying to understand the purpose and the value of participating in the activity and may need more time to learn how to reflect. By making reflection a regular exercise, students become more comfortable as they practice more and they gradually get better at focusing on the deeper meaning of reflection than mechanics of it. It is also helpful to employ various reflection activities to see what works best for your class and also have different data points to better understand students [e.g. Clarkson University FG03, University of Washington FG10]. One educator asserted,

"If I had not repeated the activity, and came back to it, I don't think they would have gotten anything out of it. Repeating it helps them to focus on coming in, doing their best in their role every day, and being prepared for every single class." [Seattle Central College FG03]

2c. Address engineering students' hesitation about writing

Even though writing is a very common tool for reflection activities [10], several educators raised concerns about using written reflections for engineering students and suggested using alternative approaches. Educators talked about issues such as engineering students dislike for writing, their pervasive belief that they are not good writers, or their choice to select engineering because they believed that the field only involved minimal writing [e.g. Cal Poly-SLO FG09, Arizona State University FG10, Rose-Hulman Institute of Technology FG01].

Recognizing different options and considering alternative methods to capture reflections does not intend to devalue writing as a powerful tool for reflection, but as one educator highlighted, speaks more to engineering students' preconceived perception of writing,

"*An important aspect of this reflection activity is to know your audience. For example, if we were a liberal arts school in the English department, students would expect to be writing. Since we are an engineering institution, most students have a preconceived perception of writing—uninteresting, not related to engineering, etc. Because of this attitude, and the fact that our students are strong visual learners, I think it is important to try to make reflection activities a little more interesting and appealing.*" [Rose-Hulman Institute of Technology FG01]

Other educators also encouraged leveraging different forms of reflection such as videos, audio, portfolios, or artwork to spark students interest in new ways. [Cal Poly-SLO FG09]. However, if writing is the best form of reflection for your class, educators suggested not to make the writing requirement too long, acknowledge that some students are resistant to writing, be prepared to receive answers that are only a few sentences written just before the reflection is due, and do not be alarmed if you see many punctuation and grammar errors. [e.g. Arizona State University FG10, Highline College FG08, Rose-Hulman Institute of Technology FG01]

2d. Acknowledge students' varying preparation for reflection

At times, students in engineering classes may not be prepared for reflection because the idea of reflection may be new to them, or they may not be expecting to reflect in this context. It is important to be mindful that where the students are coming from and how this can influence their responses to reflection because individual students react differently. It is also important to

acknowledge that not everyone is going to enjoy engaging in reflection and reflection would work for some but not for others.

"*Acknowledge different students' reaction to reflection.The other tip is that it is a good idea to acknowledge that not everyone is going to enjoy engaging in reflection, but as educators we are also aware that not everybody enjoys solving differential equations.[...] I make sure to highlight that reflection is an opportunity to stretch yourself and do something that you are not comfortable with [...]*" [Cal Poly-SLO FG02]

While there is a commonly held idea that engineering students are disinterested in reflection activities, some educators had a different experience and talked about when students take reflection very seriously. [Cal Poly-SLO FG02, Rose-Hulman Institute of Technology FG09]. One educator mentioned,

"*I was surprised by how seriously students took this informal task. Some of them wrote quite astutely and deeply on the brief question I asked. That surprised me because I wasn't sure if they would take it seriously and expend effort on it. I thought they might think, "Oh well, I'm just trying to fill up words" but they really did pose interesting responses*" [Rose-Hulman Institute of Technology FG09]

Overall, educators highlighted the importance of being mindful of the audience and factor it into your expectations for reactions to reflection.

Considering the educator's connection to reflection - Category 3

As an educator it is important to acknowledge that engaging students in reflection may require a balance in acting as a facilitator and demonstrating some level of transparency. Depending on context and situation, inviting students to reflect creates a space of options and methods that more rigid assignments and requests of students do not always allow. Reflection may invite vulnerabilities on the part of the student and the educator that do not fit the norm for engineering education. Because of this, a deeper, and possibly more personal knowledge of reflection may be necessary for successful implementation. Within this category, we explain the themes to consider that impact the way educators approach and engage in the use of reflection in engineering education including: (3a) awareness of influence, (3b) knowledge and practice of reflection, (3c) respect for the personal nature of reflection, (3d) ability to react to emergent qualities of reflection, and (3e) iteration.

<u>3a. Be aware of your influence on the students</u>

Tips suggested that educators be aware of their influence on the students. "In doing these types of reflection activities, sometimes students mark high confidence responses because they think that is what the educator wants to see. To help mitigate such false-high confidence responses, when starting the activity, be transparent about the purpose of the reflections and encourage students to authentically respond [Arizona State University FG06]. "*However, you may choose not to share your own opinion, especially at the beginning of a discussion, because students*

could converge on that opinion as being the "right answer" due to your authority in the classroom." [Arizona State University FG08]

3b. Consider learning more about and practicing reflection

As reflection may be new to some engineering educators and is a quite messy topic, a few tips pertained to ways that instructors can help gain more knowledge about reflection to leverage when implementing new reflection activities in the classroom. These included tips such as engage in reflection yourself or read about reflection first. For example, a tip from [Georgia Tech FG09] mentioned using a mentor when first implementing a new reflection activity, "*The first time someone implements this reflection activity, it can be helpful to do it in conjunction with someone who has used this activity before."*

In addition to understanding reflection, several tips expressed a need for realizing the value of reflection. One tip suggests that *"it can be challenging to understand the value of a reflection activity when it may seem unrelated to the academic requirements of the course."* [Cal Poly-SLO FG02]. Other tips reinforced that despite initial skepticism, reflection activities can be powerful in the engineering classroom and this is worth consideration. For example, one educator pointed out,

"*The first time I used this reflection activity in the art and engineering class I realized that it helped the students' learning significantly. Initially, I was concerned that it was taking time out of class, but was then amazed while facilitating two focus groups and reading their write-ups at how much this helped students and their learning.*" [Arizona State University FG07]

Finally, tips advocated for being strategic about the purpose of the reflection activity and what you expect the students to get out of it.

"Be intentional in adding a reflection component to the course. I think you should be intentional in why you're adding a reflection activity to the course, and in doing so, it is important to have a plan. Not, 'Oh I think I'll try reflection today' but I want to do a reflection activity with my students because it serves this outcome or this objective or I'm trying to get this out of students." [Rose-Hulman Institute of Technology FG09]

And another educator highlighted,

"Think about and understand the objective of the reflection activity. In asking students to reflect, make sure you are clear on the objective of the reflection activity—what do you want students to get out of engaging in the reflection activity? Understanding the objective of the reflection activity can result in genuine care about how the answers to the reflection can inform and improve the class experience for students." [Cal Poly-SLO FG01]

3c. Create an environment that respects the personalness of reflection

An idea expressed in a broad range of tips was that a key factor in supporting reflection was not just the reflection activity but also the *"dynamic in the classroom environment that the teacher initiates"*. [Cal Poly-SLO FG10]. These tips comment on creating a certain relationship between

the student's and the educator as well as helping students understand that reflection is personal and about them.

Because reflection is an inherently personal experience, educators expressed different strategies for creating an environment that supports and encourages reflection. Tips express the importance of creating a partnership between the students and the educator.

"I believe that in supporting reflection it is important to treat education as a partnership. In doing so, as an educator it is important to create a safe environment. [Cal Poly-SLO FG04]

These tips emphasize trust, commitment, and transparency. A tip from [Clarkson University FG06] for example states that "*forming relationships with students is 100% necessary.*" Another tip states,

"A*cknowledge your long term commitment to students. You also have to commit. When you see that student on campus it matters that you connect and remember so you can ask about a placement test or how an English class is going.*"[Highline College FG01]

"*Be fully transparent with students about the reflection activity and any associated agendas. This transparency may contribute to students' buy-in of the reflection activity."* [Cal Poly-SLO FG03]

Educator tips also cited that students would sometimes miss the point of reflection and be instead focused on course content or critique of the educator. Tips offered suggestions such as "*Focus on what they [the students] feel. One of the key points is that it [the reflection activity] needs to be about what it means to them.*" [Seattle Central College FG01]. A few educators provided tips to not collect student's reflections as a means of helping students understand that reflection is for and about the students. [Seattle Central College FG06, Arizona State University FG10]

3d. Be prepared to react to what emerges

When implementing reflection, it is important to be aware of the dynamic nature of these reflection experiences in the classroom. Reflection opens up the possibility for reactions to be different in each class, for things to not work every time, and for the motives or usefulness of reflection to be questioned. A variety of tips from educators across the campuses address issues related to the dynamic issue of reflection.

Reflection experiences that allow students to express their thoughts about the class can open the door for criticism. Tips from several campuses tell educators implementing reflection to "*be prepared to deal with criticism*" [Georgia Tech FG10], "*try not to take things personally*" [Cal Poly-SLO FG02] and "*be open to what they [the students] say*" [Cal Poly-SLO FG01]. For example, one educator mentioned,

"The first time you implement an activity like this, in which students giving you feedback, it can be intimidating—what if you don't like the feedback? Over time the way I've dealt with this issue is not to take things personal and to have a rationale for my teaching practice and to share that rationale with students." [Georgia Tech FG01]

3e. Be prepared for the addition of reflection experiences to be an iterative process

Tips expressed the importance of knowing that adding reflection will be an iterative process. Do not expect that you will succeed the first time. Like implementing any new thing, it takes time to figure out what works. In contrast to the tip to be improvisational, this is more about big picture structure of the course rather than being dynamic in an everyday sense.

"Expect revision, but remain encouraged. If you put together something like this expect revision after revision. There are things that I would like to work better the next time." [Bellevue College FG07]

"Don't do this if you aren't planning to make a change. There's always stuff that can be changed and the best people to critique me are the students who are there every day. They know what is working for them and what isn't." [Cal Poly-SLO FG03]

Also,

"You can expect to fail on a semi regular basis and not quite get the response quality you want." [Stanford University FG01]

These tips can initially be read as condescending or judgemental of educators who wish to use reflection in their classes, yet these tips also highlight the unique vulnerabilities that reflection may introduce to educators. As educators, our students are aiming to provide us with correct responses, expect that we are experts in domains beyond our disciplinary knowledge, and that we are responsible to answer or respond to what comes up when we introduce reflection. We raise these themes not as a criticism or qualification to be successful at reflection, but in order to call out the consequences that many educators face when implementing reflection in their engineering classrooms.

Closing the Loop - Crossing Categories

One recurring idea expressed by educators was the idea that reflection can act as a channel for communication between students and educators. Many educators felt that "closing the loop", by leveraging student reflections to inform their teaching, was important and tied to benefits for successful activities, for the benefit of students, and for the benefit of educators. Educator's offered advice such as "*close the loop with the reflection*" [Arizona State University FG03], "*debrief the reflection assignment*" [Arizona State University FG04], or "*respond to and address students' feedback***"** [Georgia Tech FG06]. This theme was a general expression that student reflection experiences can provide feedback to educators and thus serves as an opportunity for educators to improve their teaching by "closing the loop".

While one tip advocates for "*keep[ing] the activity private*" to "e*mphasize that this [reflection] is a private activity*" [Seattle Central College FG06], many educators expressed that they saw reflection activities as an opportunity to gain insight from the students about their experience.

"Be aware that the reflections give you important insight into student learning. What I like the best about it, is that each week, I can really see what the students are learning. It is also an

opportunity to correct any misconceptions or catch students who are going down the wrong track." [Rose-Hulman Institute of Technology FG06]

Methods of Closing the Loop. From the tips, three methods of "closing the loop" were mentioned by the educators. The first method for closing the loop is ***using reflection responses to change the structure or content of the course*** based on new insight. The comments emphasized that feedback could inform structure or content changes in your course. Arizona State University FG01, for example, advocates for a "*just in time*" teaching methodology where feedback is quickly provided to the students. This allows for a "*teaching approach can be flexible and dynamic to students' current needs."* [Arizona State University FG01. Bellevue College FG04 cites that feedback from the students helps so that you as the educator can *"adjusting the content and schedule throughout the term."* The second and third methods relate to giving students feedback based on their reflection responses.

The second method suggested for closing the loop is to give individual feedback to each student on his or her reflection. One educator expressed, *"I think it is important to read and respond to every student's reflection."* [Arizona State University FG03]. Another mentioned, *"Daily, I checked the students' answers to bootcamp problems and where needed provided personal feedback."* [Stanford University FG03]

The final method of closing the loop is to debrief the whole class based on the reflection responses. One educator mentions *"After reading the reflection assignments and assigning credit, take a few minutes in class to thank the students for sharing and debrief what you saw in the reflections."* [Cal Poly SLO FG09] and another educator adds, *"Debrief students on the assignment."* [Rose-Hulman Institute of Technology FG08]. When handing the written assignment back to students, take a few minutes to debrief what you saw in the reflections.

Reasons for Closing the Loop. The educator tips and tricks reveal a variety of motivations for educators to use reflection as an opportunity to "close the loop". One major reason for closing the loop by providing students with feedback was to help the students feel as though their voices are being heard and to help motivate students to continue to provide feedback and reflect. One educator said, *"Help your students feel heard. ...It is very important that the responses are shared with the students in the next day or two as it reaffirms the teacher's commitment to keeping a dialogue going in regards to teaching and learning."* [Green River FG05]. Another educator stated, *"Acknowledge the reflections. Make sure to act on, acknowledge, respond to, or address the reflections in some way, so that students feel like their reflections are being heard."* [Cal Poly-SLO FG02]. Educators felt that if students knew their feedback was going to be seen and how it would be used, they would be more motivated to reflect. One educator mentioned, *"Make sure that students know that their responses are being read. Students need to know how feedback to their reflection responses is given back to them and that their responses are important for the success of the class."* [Bellevue College FG09]. Another educator expressed *"I think it is important to read and respond to every student's reflection… I think it helps the quality of the reflections if the students know that you are actually spending the time reading their writing, they tend to make more of an effort and do a better job."* [Arizona State University FG03]

Another key benefit of closing the loop was the opportunity to address misconceptions that students might have or to generally change the course to better fit students needs. Several educators mentioned that closing the loop was an important to help correct student misconceptions. One educator mentions, *"It is also an opportunity to correct any misconceptions or catch students who are going down the wrong track."* [Rose-Hulman Institute of Technology FG06]. Another educator highlighted,*"Debrief the reflection assignment. When handing the written assignment back to students, take a few minutes to debrief what you saw in the reflections. This approach allows a dedicated time and space to discuss in a follow-up class such things as the big misconceptions that emerge from the reflections."* [Arizona State University FG04]

Educators also discuss how closing the loop presents an opportunity to change class content or structure. "*There's always stuff that can be changed and the best people to critique me are the students who are there every day. They know what is working for them and what isn't"* [Bellevue College FG05]. Another educator explained *"Be flexible in the formatting.... This [new] approach works because it is important to find approaches that resonate with the students, and that way, any student can be sure that their values are represented in that list"* [Stanford University FG01].

Other benefits to closing the loop include acting as a role model for reflection "*show them that you are reflecting on the feedback they are giving you by debriefing students on theme from the" reflection activity"* [Georgia Tech FG11]. Another benefit was that you can help *"relate what we're doing in class to their field of interest"* [Seattle Central College FG07].

While educators advocated for closing the loop, they also shared some challenges or things to be aware of. Many educators felt that time matters when giving students feedback. One educator stated *"I realized that students need quick feedback on their reading responses… This reflection activity requires you, as an educator, to respond to the students' feedback immediately."* [Arizona State University FG01. *"It is very important that the responses are shared with the students in the next day or two"* [Green River FG05]. *"Give students feedback before the next exam"* [Rose-Hulman Institute of Technology FG06] as a means to help them prepare for the next iteration.

A few educators point out strategies for how to give feedback because reflection can involve emotion [Rose-Hulman Institute of Technology FG06]. One educator makes an effort to *"write something encouraging"* on each reflection to *"help motivate all students"*. Another educator *"be prepared to give students constructive criticism"* and feels it is *"important to start with something positive"* and then *"be prepared to help students move forward"* by providing constructive criticism. [Arizona State University, FG02]

Discussion

In the previous sections, we presented tips for incorporating reflection activities into engineering education contexts. These tips, organized around activity design, student concerns, and educator behaviors, are significant because they have bubbled out from over 300 individual tips shared by 100+ educators representing diverse educational contexts. Our fourth theme, closing the loop,

was cross cutting as far as it related to features of a successful activity, a method to address student concerns, and practical for educators. The focus on tips is interesting because of its practicality and thus serves as a complement to more theoretical work on reflection. The tips can help educators improve existing reflection activities, imagine or design new activities, debug activities that are not necessarily working well, and have conversations with students.

The analysis of tips presented in this paper paves the way for next steps. For example, the tips create a sense of a space, and surveys could be created to elicit from educators their perceptions of the significance of the tips in each part of the space (e.g., the significance of tips related to the activity relative to tips related to addressing student concerns). As another example, in doing the analysis for this paper, there was a perception that some tips seemed campus or context specific. For example, is it possible that an observation that "students are likely to be unfamiliar with reflection" is more likely to be true on some campuses than others? Are there patterns to what types of tips are associated with different campuses or different institution types? Are there patterns relating tips with educators' prior experiences in bringing reflection into their teaching and/or the depth with which educators have been involved in thinking about and exploring reflection? While answering such questions was outside of the scope of the current analysis, it would be interesting for future research. Finally, the current exploration of the tips invites deeper exploration concerning when, under what conditions, and how certain tips might work. For example, it would be interesting to further explore the tip that educators consider using terms other than reflection when introducing reflection activities. When might this help, and when and under what conditions might this not help?

A reason to more deeply explore some of the tips is because of the occasional ambiguity that shows up. For example, in the section on grading, we report that many tips around grading showed up but synthesizing those tips into simple, higher level tips proved elusive. Further, the emphasis on grading seems to stem from an assumption that students will not take reflection seriously unless grading is attached to it. Yet, one of the tips explicitly suggests that educators "be prepared for students to take reflection seriously." As another example of ambiguity, the observation that students may have never been asked to reflect does not align with a concern about "reflection fatigue" reported in other papers on student reflection [10]. What explains these ambiguities? Certainly there are many possible explanations. Future work could (a) turn to relevant theory, (b) explore existing empirical evidence, or even (c) gather new evidence to delve into the ambiguities.

An additional reason to more deeply explore some of the tips is because of potentially problematic nature of some of them. For example, a generalized statement that "engineering students do not like writing" is just that, a generalized statement. In this example, the generalized statement is problematic because it masks the idea that engineering students actually have a range of attitudes toward writing and that specific groups of engineering students may have different profiles in their attitudes toward writing. To address such a problem, an educator could gather data from students specifically around their writing attitudes and use the data (rather than the generalization) on which to base the reflection activity. While the problem of generalization may stem from the format of the "tip" (i.e., short, simple, assertive), critical reading of the tips around the generalizations made about students is still warranted.

When reading with a critical eye, we might also encounter tips that seem to assign a problem to students when the problem may be much larger than them. Consider the tips stemming from a concern that students will not value reflection. Such a premise suggests that we just need to address "student valuing of reflection" in order to move ahead. What if, however, the students are getting their values from the larger system. If so, a less blameful tip might be written in a more inclusive way to suggest that "students may reflect the values of engineering and thus not initially value reflection." And, as a different emphasis, if student attitudes are learned from us, then the student attitudes can be read as telling us about our own attitudes. These issues suggest the importance of critically examining the tips in order to surface assumptions.

Conclusion

The work in this paper complements efforts to offer reflection activities to engineering educators. The tips and tricks for reflection celebrate the many successes these educators have experienced with the activities, while bringing attention to some of the unintended consequences for implementing reflection. By highlighting these successes and some of the tensions associated with reflection, we anticipate that readers will be well informed to make their own decisions as educators. Our goal in sharing these thematic findings is to call out the important considerations for implementing reflection in engineering as identified by over 100 educators. These "tricks of the trade" will help new and experienced faculty make decisions about how to design and implement reflection activities in their own pedagogy.

Acknowledgements

This material is based on work supported by The Leona M. and Harry B. Helmsley Charitable Trust through funding of the Consortium to Promote Reflection in Engineering Education (CPREE), a collaboration of twelve educational institutions including: University of Washington, Arizona State University - POlytechnic Campus, Bellevue College, Cal Poly San Luis Obispo, Clarkson University, Georgia Institute of Technology, Green River College, Highline College, Rose-Hulman Institute of Technology, Seattle Central College, Seattle University, and Stanford University.

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