Dimensions in Designing Reflection Activities

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I. Abstract

In order to support student reflection, educators use a multitude of reflection activities. Few frameworks exist to characterize choices educators have in designing reflection activities. This research explores the question: What dimensions of variation are present in reflection activities used by engineering educators? To identify dimensions of variation, we leveraged a constant comparison approach applied to documentation of reflection activities. In an exploratory phase, we identified candidate dimensions. We then chose promising dimensions and iteratively compared the activities in terms of each dimension in order to better understand the variations in the dimension. We identified four dimensions of variation: explicitness, customization, guidance, and accountability. Each dimension can range from low to high, creating a large design space. These dimensions of variation may be useful in designing reflection activities: to foreground decisions to be made, to draw attention to possible dilemmas, and to index into theory that provides deeper insight. The dimensions of variation may also be used to organize a collection of reflection activities and to inform research studies on reflection activities.

II. Introduction

Reflection can be understood as a particular form of thinking where one makes meaning of past events as preparation for future engagements [1]. There are many activities that are used by educators to promote reflection. However, there is little guidance on the space of choices and considerations that need to be taken into account when one seeks to design these reflection activities.

The purpose of this work is to ask the question: what dimensions of variation are present in reflection activities used by engineering educators? We are interested in asking and answering this question because we want to contribute to educators' "integrity of practice" [2] as related to reflection activities. We bring together existing reflection activities and a vision of educators who are making choices and able to think about their choices. In the discussion, we consider how talking about the design of reflection activities might help to scaffold 'integrity of practice'. In addition, we consider how the dimensions of variation can be used to index into theory, potentially providing deeper insight.

III. Approach

We focus our analysis on reflection activities documented as part of the Consortium to Promote Reflection in Engineering Education (CPREE) project. Between September of 2014 and June of 2015, the CPREE team collected information on more than 120 reflection activities used by educators at 12 educational institutions in the United States (i.e., the CPREE partner institutions). The CPREE team then transformed the collected information into relatively succinct descriptions for each activity—these descriptions are publicly available on the CPREE website at http://cpree.uw.edu.

Our analysis can be understood as qualitative content analysis—the content being analyzed is the written descriptions of the reflection activities. For each reflection activity, the documentation includes a title, a narrative description, a suggested set of steps for recreating the reflection activity, and hints described as "in the words of the educator: tips and tricks." The documentation for some activities also includes digital library content such as forms, handouts, or rubrics that were part of the activity. For the analysis presented in this paper, we focused on ten activities associated with one of the CPREE partner institutions in order to emphasize depth over breadth in our analysis. These ten activities are labeled in Table 1, and additional information about each of the activities can be found in the "Bellevue" field guide on the CPREE website at http://cpree.uw.edu/bellevue-college/.

Our analysis began with a data familiarization phase in order to appreciate what is (and what is not) possible with our data source. For example, our data source is clearly not an objective account of reflection activities that occurred—rather the data is a purposeful description that balanced content quality with brevity. As a result, it is important to be cautious in interpreting absence of information.

We leveraged an inductive approach and a constant comparison logic to identify candidate dimensions of variation. In other words, we iteratively compared the different reflection activities in order to identify ways in which the reflection activities were similar and different. For example, we noted that the reflection activities varied in terms of how explicitly the activity was labeled as "reflection" as well as how serious (vs. playful) the activity seemed to be. As we explored the possible dimensions of variation, we considered the potential practical and theoretical implications of potential dimensions.

This process led to the identification of the four dimensions of variation discussed in this paper.

In the next phase of analysis, we characterized each activity relative to each of four dimensions of variation and used the results of the characterization to provide a coherent explanation of the dimension of variation. This process led to the text and the table that are included in the results section.

In the final phase of the work, we explored the implications of the dimensions of variation that we had identified. In this final phase, we explored practical implications by addressing the question: How can the knowledge identified by the analysis be leveraged by educators in their efforts to use reflection activities in their teaching? In this phase, we also explored theoretical implications by addressing the question: what ideas from educational scholarship (i.e., theories, significant empirical findings) can be used to elaborate on each of the dimensions of variation and thus help deepen insight into reflection activities? For this paper, the theoretical implications discussed will be limited to the dimension of guidance.

IV. Results

We identified four dimensions of variation: explicitness, customization, guidance, and accountability. Each dimension can range from low to high. Table 1 shows the value of each dimension of variation for each of the reflection activities examined in our analysis. Below, we introduce each dimension of variation and explore how the low-high values map to the reflection activities in Table 1.

Table 1 The four dimensions of variation along with the specific values for each of ten activities analyzed for this paper.

Dimension - Reflection Activity	Dimension-Value				
	Low	Low /Medium	Medium	Medium/ High	High
Explicitness					
Biology Meets Computer Science: DNA Project					
Exam Analysis					
Metals 1.0: Art & Engineering					
Professional Lab Notebooks: An Introductory Research Lab Course					
Reading Reflections in Physics					
Scheduling Your Student Life					
Seeing the Forest: Linear Algebra Application Project					
Team Member Evaluations: Diving into Engineering Teams					
White Papers in Math					
Earn Points Back – Test Assessment					
Customization					
Biology Meets Computer Science: DNA Project					
Exam Analysis					
Metals 1.0: Art & Engineering					
Professional Lab Notebooks: An Introductory Research Lab Course					
Reading Reflections in Physics					
Scheduling Your Student Life					
Seeing the Forest: Linear Algebra Application Project					
Team Member Evaluations: Diving into Engineering Teams					
White Papers in Math					
Earn Points Back – Test Assessment					
Guidance					
Biology Meets Computer Science: DNA Project					
Exam Analysis					
Metals 1.0: Art & Engineering					
Professional Lab Notebooks: An Introductory Research Lab Course					
Reading Reflections in Physics					
Scheduling Your Student Life					
Seeing the Forest: Linear Algebra Application Project					
Team Member Evaluations: Diving into Engineering Teams					
White Papers in Math					
Earn Points Back – Test Assessment					
Accountability					
Biology Meets Computer Science: DNA Project					
Exam Analysis					
Metals 1.0: Art & Engineering					
Professional Lab Notebooks: An Introductory Research Lab Course					
Reading Reflections in Physics					
Scheduling Your Student Life					
Seeing the Forest: Linear Algebra Application Project					
Team Member Evaluations: Diving into Engineering Teams					
White Papers in Math					
Earn Points Back – Test Assessment					

A. Explictness

The dimension of explicitness has to do with the extent to which the reflection activity is explicitly represented to the learners as an instance of reflection. A reflection activity that features high explicitness is one that is clearly labeled as reflection. A reflection activity that features low explicitness is one that is not called out to students as reflection. High explicitness can help a student see continuity among reflection activities and perhaps, over time, help students develop their own reflective practice. Low explicitness can be useful in instances where students have awkward associations with the notion of reflection or where the additional effort to name an activity as reflection gets in the way of the work of the activity.

In our analysis, two activities were identified as "medium-high" in explicitness. In both cases, the activity was called out as reflection on a form that was given to students (the forms were from the digital content of the CPREE website). At the other end of the spectrum, six activities were identified as low in explicitness. In the documentation of these activities, there was no indication that the activities were explicitly called out as reflection. Finally, two activities were identified as "medium" in explicitness. In these activities, the documentation suggests the concept of reflection was explicitly leveraged in the activity (such as embedded in the "Lab Notebook" activity explanation), but this explicitness was less salient that then two "medium-high" activities.

B. Customization

The dimension of customization has to do with the extent to which an activity is adapted to the specific context of use. A reflection activity that features high customization is one that is specific to the context, i.e., bespoke. For example, an activity may be carefully arranged to provoke reflection by creating a specific circumstance (e.g. de-familiarization or surprise). A reflection activity that features low customization is one that is generic. Low customization results in an activity that can be ported easily from one context to the next without a need to revise the activity because the activity features nothing specific to the context of use. Such activities are much more repeatable and reusable in a variety of contexts. These "low" customization activities seem to be less about creating a specific circumstance that provokes reflection and more about creating recurring opportunities to reflect.

In our analysis, four activities were identified as "high" in customization. In each case, the orchestration of the reflection activity was tightly tied to the class context in which the activity was carried out. For example, in the case of "Lab Notebooks," students were given a specific set of instructions for the lab notebook and the instructions for the reflection component of the notebook was embedded in the overall instructions. In the "Exam Analysis" activity, the educator created a form specific to the exam that students had just taken. At the other end of the spectrum, one activity was identified as low in customization. This activity, "Test Assessment" represented a very generic version of an activity—students were told that they could reclaim some points on a recent exam by redoing problems that were marked wrong and providing an explanation of the mistake. Finally, five activities were identified as "low-medium" in customization. These activities all leverage some form of customized questioning of the students (such as questions on a form or questions verbally given to students). The choice of the questions seemed to suggest a level of customization, but the questions themselves seemed relatively generic.

C. Guidance

The dimension of guidance has to do with the extent to which the reflection activity provides support for a learner to be successful. A reflection activity that features high guidance is one that provides extensive support for the learner so that he/she is succeeds in their engagement with reflection. A reflection activity that features low guidance provides little specific support for the learner in order to support successful engagement with reflection. Such activities rely on the learner's prior understanding of and ability to engage in reflection.

In our analysis, two activities were identified as "high" in guidance. For example, in the "Exam Analysis" activity, the highly-customized form mentioned above also serves to provide students with extensive guidance for how to think through their exam performance. At the other end of the spectrum, four activities were identified as low in guidance. The documentation for these activities suggests students were simply assigned to do the activity without additional guidance to help them with the steps of the activity. Finally, four activities were identified as between "high" and "low" in guidance. In all of these cases, students are given a collection of questions that collectively function as guidance. The "Lab Notebook" activity was identified as "medium/high" in guidance because of the extensive number of prompt questions included in the instructions given to students (instructions available in the digital content portion of the documentation). While the prompts are all relatively generic, they seem to sequence students through a process of reflective thinking.

D. Accountability

The dimension of accountability has to do with the extent to which to the reflection performance is "counted." A reflection activity that features low accountability is one for which students are not required to provide any evidence of the nature of the reflection. A reflection activity that features high accountability is one for which students are required to provide evidence of their engagement in the activity, and also receive a grade to account for their engagement.

In our analysis, one activity was identified as "high" in accountability. In this activity, the "Lab Notebooks" activity, students are provided with rubrics for each portion of the notebook including the portions devoted to reflection. The presence of the rubric indicates that students are being held accountable for their reflective work. At the other end of the spectrum, five activities were identified as low in accountability. In each case, there is no evidence that the activity was graded or that students were held accountable in any other way. Finally, four activities were identified as having "medium" accountability. In these cases, there is mention of grading but the extent of the grading seems modest. For example, in the case of the "Reading Reflections" activity, there is mention that each reading reflection is worth two points which represents a very modest amount of the total

number of points for the class. In the case of the "Test Assessment," students get credit if they do the activity (i.e., a form of accountability) but the activity itself is optional.

V. Discussion

This analysis identified four dimensions of variation in the design of reflection activities: explicitness, customization, guidance, and accountability. These identified dimensions were salient for the activities analyzed and we make the inference that the dimensions will be salient for other activities. As we discuss below, the dimensions are interesting because they have practical and theoretical value. Given the inductive nature of our analysis and the limited number of reflection activities used to guide the analysis, we note that other dimensions certainly exist.

The values associated with each dimension of variation are based on what we observed in our selected data. In particular, we benchmarked "low" and "high" based on what we observed in our data. It is anticipated that what counts as "low" and "high" might shift if additional reflection activities were added to the analysis. What would not shift is the relative positioning of the reflection activities in terms of the dimension of variation. As such, the variations we noted will not become unimportant but may underrepresent the space of variation.

In this analysis, the characterization of each activity in terms of each dimension of variation was based on the written, public documentation. Since such documentation only provides a small window into the activity as enacted, it is possible that the documentation may not exactly align with what would have been captured had the reflection activity been observed. For example, the educators might have been more explicit when talking with students or might have provided more guidance than what is captured in the documentation. While interesting to note, this does not alter the plausibility of the dimensions and variations noted in this analysis.

VI. Practical Implications

The value of the dimensions from a practical perspective lies in how they support educators in achieving integrity of practice in relation to the use of reflection activities. The dimensions provide a language that educators can use to think through their choices for working with students, and subsequently articulate the rationale for their work with students.

This language provides a foundation for rationale choice among activities. For example, an educator could set targets for each of the dimensions (such as high accountability and low explicitness) and then either look for activities or design activities that feature these values for the dimensions. An educator might also use these dimensions of variation and the variations described in this paper to imagine how an existing activity might be modified. Consider Figure 1 in which two reflection activities have been characterized along all four dimensions of variation. It would be possible to imagine what the "Test Assessment" activity might look like with higher values for each dimension. Similarly, an educator could imagine how the "Lab Notebooks" activity might be configured if it had lower values across the dimensions.

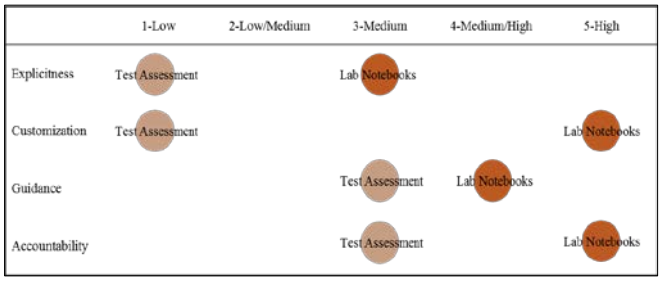

Figure 1 This illustrates how the dimensions of variation can be used collectively to create an activity profile. The lightly colored circles show the level of accountability, customization, explicitness and guidance for the reflection activity "Test Assessment" while the darker circles show the level of accountability, customization, explicitness and guidance for the reflection activity "Lab Notebooks."

Complementing the rationale choice perspective, another way to view these dimensions of variation is as naming a set of dilemmas associated with the design of reflection activities, since the choices for each dimension of variation have potential negative consequences. Designing practices that support reflection can involve making choices that have no optimum solutions. Consider the accountability dimension and the potential problems for both high *and* low accountability. Low accountability may make it possible for learners to avoid reflection, and thus not benefit from reflection. High accountability may entice learners to only focus on what is asked, to depend on educators to tell them what to do, and to resist reflection. As this analysis suggests, there are benefits *and* problems associated with any decisions related to accountability, and thus it is possible to see the decision about accountability as a dilemma that an educator needs to navigate in the design of reflection activities. A similar analysis is possible for each of the dimensions.

VII. Theoretical Implications

While each of the dimensions suggests a practical interpretation, it is also possible to associate each dimension with a deeper, more theoretical frame. With a view of learning as a process of becoming through transformation via participation in cultural communities of practice [3]; [4]; [5], we draw from socio-cultural historical theories of learning [5], that foreground the intertwining of cultural practice, identity and the development of skills, knowledge, and expressive capacities [6]; [7]. These theories broaden the scope of what has traditionally been considered as learning to go beyond knowledge or expertise and to include the ways that students conceptualize themselves in relation to content and their future goals. For engineering educators, translating these theories of learning into practice raises questions about "integrity of practice" [2], where educators justify their decisions about teaching and learning activities to themselves, to students, and beyond. Young and Irving [2] highlight common challenges educators are faced with, namely: a language with which to think or talk about teaching, the ability to describe underlying approaches that inform teaching and learning choices, and using the knowledge on learning and teaching within a discipline. Using reflection for facilitating an integrity of practice enables educators to make sense of their situation; to transform the purposes of education and attitudes of educators;

and to establish a professional discourse through a sharing of practice among educators across disciplines and contexts where higher education policy is the focus.

Consider the dimension of guidance. Classrooms can be conceived as highly complex structures where they support "multiple, overlapping zones of proximal development that foster growth through mutual appropriation and negotiated meaning" [8]. Given appropriate supports, students are able to reflect upon their thinking and revise their work [9]. Revision of ideas is important in promoting students' metacognitive learning and helping students develop a reflective "habit of mind" [10]. Metacognitive processes such as this, however, require specialized support in the classroom [11].

Contrary to the view that guided reflection activities 'constrain" and "systematize" the process of reflection, one study using a typology of reflective practice for teacher education [12], showed how it can successfully act as a scaffold for developing a reflective habit of mind. The 'guides' in the study were in the form of a typology with three dimensions of reflective thought: descriptive, comparative, and critical. The typology is used to accomplish various goals by providing preservice teachers parameters for: initiating and mediating discussion, action, and making sense of one's actions, thoughts, and feelings in reflective and portfolio sessions. For research and practice purposes, the typology helps organize students' and educators' understanding of reflection and how it can be organized. In addition, guided questions in the typology are used to establish a "common language" when thinking about reflection and the expectations of the Teacher Education Program. Through oral and written feedback, the educator as mentor used the typology of reflection as a tool to ask preservice teachers probing questions about why particular recounted events were important to the students.

The dilemma lies in providing supportive scaffolding for learning the process of reflecting without making it prescriptive [13]. Research on learning and cognition has shown that prompts used in reflection activities, with a focus on planning and monitoring, improves student understanding (e.g., [14]; [15]). When prompts are designed for orienting students to perform specific actions and contextualized within a learning activity, students' metacognitive skills and capacity for sense-making becomes sophisticated over time (e.g., [16]; [17]). However, carefully designed prompts also have the potential to disrupt student learning by creating confusion or students may perceive prompts as irrelevant [18] when directing them to features that fall beyond their zone of proximal development [19]. Davis [20] highlights that the mode of delivery and the level of customization also creates drawbacks. Prompts delivered by a computer that have a generic design versus in-person with a customized design have calibration implications. In coaching sessions, calibrating to students' needs is essential and challenging when delivering scaffolds via technology. While it is essential that reflection activities are carefully designed with scaffolds, there is also a potential value in designing reflection activities with less specific scaffolds in particular learning situations [21].

Developing a metacognitive habit of mind and facilitating reflection provides students with the capacity to develop their sense-making skills. In turn, generic prompts provide educators evidence of the kinds of reflection students engage with when they are accountable for directing their reflection [21]; [22]. In Davis' [20] study, students provided with generic prompts for reflection developed significantly more sophisticated understandings of the subject matter as opposed to the students who received guiding prompts. In a student-centered learning environment, affording students greater autonomy by providing them with opportunities to take control of their own reflection facilitates more concrete experiences. Students responding to a generic prompt aligns more to their own thinking at that time. Consequently, this implies that scaffolds partially defined by students [20] affects how educators might design scaffolds for reflection with low guidance. Generic prompts for reflection align with individual students' zone of proximal development [19] while also accomplishing a predetermined instructional goal. Moreover, with positive effects on student learning, White and Frederiksen's [11]; [23] work demonstrates that when students routinely answered the reflective assessment prompts, they developed greater understanding of both the subject matter and the inquiry process. However, students may not be able to reflect when generic prompts are provided and may need more guidance.

Guiding prompts provide students with scaffolds that help guide their thinking. For example, in the "Cover Letter" reflection activity, students are asked to (a) demonstrate understanding of a future opportunity, (b) make an argument that they are prepared to contribute in the realm of this future opportunity, and (c) share where they see their own growth. Davis [20] explains that these guiding prompts are designed to elicit student planning and monitoring as well as orient students' focus in a particular direction while still allowing them to make different interpretations [24]. Yet, guiding prompts may be constraining and encourage a different type of reflection. Davis, Linn, and Clancy [25] show that when students are given guiding prompts, they struggle to make interpretations about the specificity of the prompt, which leads to confusion or ignoring all prompts. For reflection activities, the framing of the prompts may have negative effects, thus reframing them in a positive light may help students in identifying their shortcomings which students often perceive as negative.

Davis [20] explains that prompts used in a complex learning environment can be effective in promoting understanding and conceptual change while also providing scaffolds for sense-making. This view is further supported in research that shows how metacognitive prompts encourage students to reflect on their problem-solving processes, inquiry methods, lab work, and explanations (e.g., [21]; [22]; [11]; [23]). From Davis' [20] study, generic prompts for reflection provided students with opportunities to reflect more broadly and meaningfully; whereas in Jay and Johnson's [13] study, guided prompts helped structure students' reflective thinking and establish a common language for reflection and course expectations. Designing reflection activities with low or high guidance has implications for developing a reflective habit mind While research highlights both the affordances and

constraints, Welch [26] points out that students need support when connecting their experiences to course material, for challenging their beliefs and assumptions, and for deepening their learning. Thus, the purposeful and strategic design of reflection activities encourages the development of a rigorous, adaptable learner-centered approach that both challenges and supports students in learning through reflection [27].

VIII. Conclusion

Explicitness, customization, guidance, and accountability are four reflection activity dimensions of variation that are worthy of interest by engineering education practitioners and engineering education scholars. These dimensions of variation are "of the world" in that they are present in activities shared by engineering educators. These dimensions of variation are of practical significance because they can be used as part of a thinking exercise to refine reflection activities for specific contexts. The dimension of guidance, including the dimensions of explicitness, customization, and accountability are dimensions of variation of theoretical interest because each can be connected to a body of theory that speaks to larger significance.

The space of reflection activities is broad, as evidenced by the CPREE corpus, and the set of activities themselves underscores creativity and insight of practicing educators. We are identifying the issue of helping educators navigate the dilemmas as worthy of future research. We see our work as helping to specify a design space that will scaffold educators' integrity of practice by giving them tools to "explain and justify" their decisions about reflection activities.

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