



## On an Upward Trend: Reflection in Engineering Education

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## Abstract

In this paper, we are interested in exploring the question: how much explicit, named attention has reflection received in engineering education scholarship and how do we interpret these results? We conducted a systematic literature review of the ASEE (American Society of Engineering Education) conference publications to better understand the role of reflection in engineering education scholarship through assessing the number of papers that involve reflection in some way.

In our search, we categorized the publications by scope of reflection: the extent to which reflection is mentioned, and type of reflection: how reflection is being operationalized. As a result of our findings, it is evident that there has been a significant and recognizable upward trend in the explicit attention to reflection across the body of the ASEE conference publications. Understanding the trends of reflection across literature can help us further analyze its prevalence and importance in the engineering education community.

## Introduction

In engineering education, there has been an increase in pedagogical approaches that position students at the center of the teaching practice, like problem-based learning, project-based courses, and capstone design courses.<sup>1,2,3</sup> Such pedagogical approaches often engender reflection by engaging students in reflection activities to promote learning.<sup>3</sup> Reflection, which can be facilitated by reflective activities, can be defined as the process by which students recall certain experiences and evaluate them using a variety of lenses to assign significance or meaning to that experience.<sup>4</sup>

Reflection is a rich field of study that is gaining attention through named attention in engineering education. This increased attention can be seen through examples such as the funding of the Consortium to Promote Reflection in Engineering Education (CPREE) ([www.cpreed.uw.edu](http://www.cpreed.uw.edu)). Our study aims at exploring and clarifying reflection's growing trend in engineering education as a way to provide a frame of reference for other educators and scholars. We are interested in exploring the question: *how much explicit, named attention has reflection received in engineering education scholarship and how do we interpret these results?* To answer this question, we conducted a systematic literature review of all conference publications from the American Society of Engineering Education (ASEE). Our exploration sought to answer this question by assessing the number of papers that explicitly mention reflection.

## Background

Reflection can be described as, "...an intentional and dialectical thinking process where an individual revisits features of an experience with which he/she is aware and uses one or more lenses in order to assign meaning(s) to the experience that can guide future action (and thus future experience)."<sup>4</sup> This intentional process can be used as an educative technique to aid students in assigning meaning to experiences. Educators have the unique opportunity to take an active role in helping to facilitate reflection through many activities. Activities that support reflection are diverse in nature and purpose in the classroom, but can be achieved by using assorted methods including portfolios, reflective essays, journals, and other activities.<sup>5</sup>

Many fields have investigated reflection as an integral part of their approaches to both their work and educative practices such as health sciences and human-computer interaction (HCI).<sup>6,7</sup> More recently in engineering education, contributors have embarked on broadening the discussion on reflection's importance to teaching and learning, in addition to including reflective techniques to stimulate student learning.<sup>4,5,6,8,9</sup>

Reflection can be facilitated in many different ways in education. For example, Hicks, Bumbaco, and Douglas<sup>5</sup> make an interesting contribution to the discussion by proposing the division of certain activities into experiential reflection and retrospective analytical reflection activities. Experiential reflection includes activities such as games, simulations, service learning, or internships. They suggest that retrospective reflection, which seeks to connect previously learned information or experiences to present circumstances, can be facilitated through activities such as mapping or self-evaluations.<sup>5</sup> Similarly, Walther et al.<sup>9</sup> investigate the use of emotional triggers in facilitating reflection discussions among engineering students.

While engineering education has not traditionally incorporated reflection as a part of the curriculum, there is a call for more purposeful integration of reflection into engineering education, "Students learn by doing, but only when they have time to reflect – the two go hand in hand. Why, then, don't engineering curricula provide constant structured opportunities and time to ensure that continual reflection takes place?"<sup>8</sup> Similarly, the need to investigate reflection in engineering education is vocalized by Turns, et al.<sup>4</sup> "While care must be taken in drawing inferences about the role of reflection in engineering education based on the number of research publications, the limited number does suggest opportunities for more investigation of the issue."

The analysis presented in this paper seeks to explore the extent to which engineering education scholarship has highlighted reflection by seeking to answer the question: *how much explicit, named attention has reflection received in engineering education scholarship and how do we interpret these results?* Our systematic literature review seeks to answer that question by (1) identifying the number of papers in the ASEE conference proceedings that mention reflection in engineering, and (2) determining the extent to which reflection is mentioned (the scope of reflection) and operationalized in the paper content or discussions (the type of reflection). As a result of our review, we hope to provide a landscape for the growing attention of reflection as related to engineering education. In the next section, we will discuss the method we used in conducting our systematic literature review.

## Methods

Our inspiration for using the systematic literature review approach to determine reflection trends in engineering education stemmed from a similar study performed in medical education. Mann, et al.<sup>7</sup> examined "existing evidence about reflection and reflective practice and their utility in health professional education."<sup>7</sup> Their systematic literature review consisted of researching and reviewing papers related to the inclusion of reflective practices in medical education.

Systematic literature reviews are also suggested as a methodology in engineering education research.<sup>10</sup> Our systematic literature review process is an effort to trace the historical development of reflection in engineering education in service of highlighting its growing

popularity in scholarship. By using a methodology drawing from both Borrego, et al.<sup>10</sup> and Mann et al.<sup>7</sup>, a broad landscape of the body of literature relating to reflection in engineering education can be established.

To determine the degree to which reflection has been discussed in the ASEE annual conference papers over the past 18 years, our review incorporated three phases: (1) searching for relevant papers using the ASEE website, (2) determining the degree to which reflection is discussed (i.e. the scope of reflection), and (3) determining the ways in which reflection is operationalized (i.e. the type of reflection).

### ***Pilot Study***

As an initial step, we performed a search for papers in the ASEE conference proceedings that included the term, “reflection” in the body or title of the paper. Our rationale for the search was that papers that included the word “reflection” would be indicative of their relation to the theme of reflection.

We used the ASEE search engine for conference proceedings (<http://www.asee.org/search/proceedings>) and followed the ASEE recommendations for using the search engine. For example, the entry, “Reflection AND year:2010” returns a list of papers inclusive of the word “reflection” published in the year 2010. We repeated this procedure for each year (1996-2014) and recorded the number of papers for each year, then the results were compared. Ultimately, we discovered that there was a positive, increasing trend line over time of papers mentioning reflection. These preliminary results prompted us to dig further.

### ***This Study***

First, in the same manner as the pilot study, we used the search engine to look at each year more carefully. We searched each year of the conference (1996 – 2014) for papers explicitly using the terms “reflection” and “reflexivity.” We deleted all duplicate papers across the two to give each year a total number of papers. The early years of the conference consistently returned numbers under 100 papers, while the most recent year (2014) returned a number of over 350 papers. Second, we collected each paper’s title, author(s), and web link from each year and placed them into a spreadsheet. As an initial step, we discarded obviously irrelevant papers such as papers focused on optical engineering. For example, papers which operationalized reflection as, “ultrasonic wave reflections,” were discarded from our analysis.<sup>11</sup>

Also, emerging from the pilot study were four categories of the type of reflection, which highlight the ways in which reflection was being operationalized throughout the articles. Main categories that emerged were separated between reflection activities and not reflection activities. The categories that emerged were: an activity using portfolios, an activity using reflective essays, another type of activity that supports reflection, and not an activity. Papers that were included in the “activity – other” category covered a wide range of activities including surveys and discussions, among other things. No other activities were as prominent from our pilot study as portfolios and essays, so those activities became separate categories. In addition, three categories defining the scope of a paper also emerged. The scopes of reflection are: main focus, serious thread, and casual mention.

### *Determining the Scope of Reflection*

After our initial data collection, each paper was individually analyzed to determine the scope of reflection. Using the search function in a standard PDF document reader, each paper was searched for words that included the word fragment, “refle-.” This word fragment was used as it captures all uses of the words relating to reflection—reflection, reflect, reflexivity, and reflexive. Depending on how each term did or did not explicitly reference reflection, we determined the paper’s scope of reflection and coded it using one of the four scopes of reflection: main focus, serious thread, casual mention, or N/A. Papers categorized as “N/A”, are those in which reflection was not employed appropriately in reference to the scope of the project. For instance, some papers used the term “reflection” in reference to optics such as, “ultrasonic wave reflections,” and were discarded from our analysis.<sup>11</sup>

Papers such as “An Experience Using Reflection in Software Engineering” exemplified a strong central reflection theme and multiple accompanying reflection discussions.<sup>12</sup> These papers were categorized as having a “main focus” on reflection. The next category included papers that highlighted reflection as an aspect of the paper, but were not explicitly focused on reflection as the main theme. Papers such as “Construct Costa Rica: International Service Learning”<sup>13</sup> exemplify this second category in which reflection is a “serious thread.” Finally, many papers were evaluated which briefly mentioned reflection such as “A Classroom Discussion of Applied Ethics.”<sup>14</sup> Papers in this category were referred to as having a “casual mention” of reflection. From our review, it was obvious that some papers were not relevant to our study and discarded. These papers generally operationalized the theme of reflection in reference to authors’ personal experience, such as “Faculty Reflections on a STEAM-inspired Interdisciplinary Studio Class.”<sup>15</sup>

### *Determining the Type of Reflection*

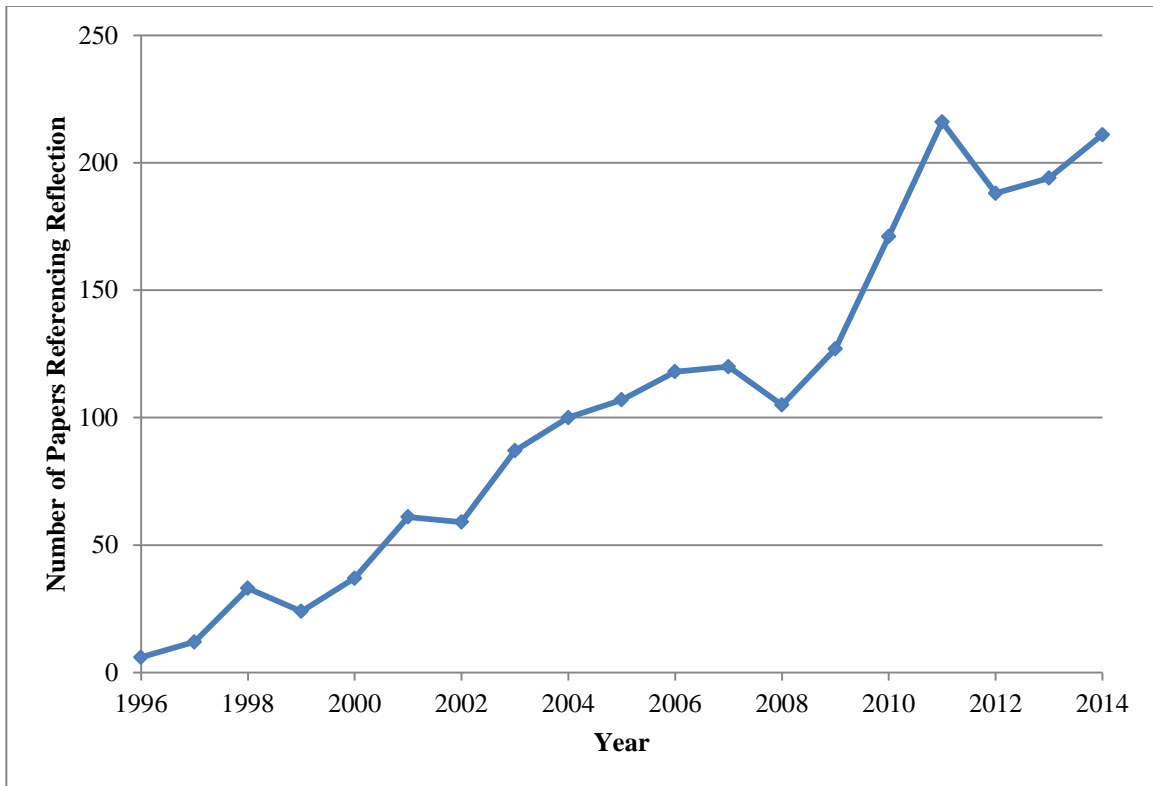
Finally, to further broaden our understanding of the way reflection was mentioned in the literature, we reviewed how reflection was operationalized for each publication. Although reflection can be accomplished without a structured activity in which reflection is the primary goal, it is often supported through a variety of activities.<sup>16</sup> We wanted to get an idea of how reflection was being facilitated with activities, what those activities were, and how reflection was being discussed if an activity wasn’t explicitly mentioned.

The four types of reflection emerging from the pilot study helped to guide researchers through the coding process. The four types of reflection used to categorize each paper were: an activity using portfolios, an activity using essays, another type of activity that supports reflection, and not an activity. At the conclusion of the data collection, the results were tabulated to examine the various trends in reflection.

Papers categorized as “other activity” fell into two other main categories: surveys and discussions. Finally, papers that were marked as “not an activity” were those that discussed the importance of reflection generally, but did not use an activity to support reflection.

## Findings

In total, about 3500 papers were reviewed from the ASEE conference proceedings in the years of 1996-2014. Each paper was reviewed and coded as specified in the methods section. It can be observed that the number of publications discussing reflection as per our parameters, increased significantly in the years between 1996 and 2014, from an initial value of 6 relevant papers to a final value of 211. (See Figure 1) While the extent to which reflection was discussed varied in each publication, the overall trend upward trend remains. The overall trend can be investigated and broken down further upon examination of how the word reflection is operationalized. Both the scope of reflection and the type of reflection were examined in similar ways.

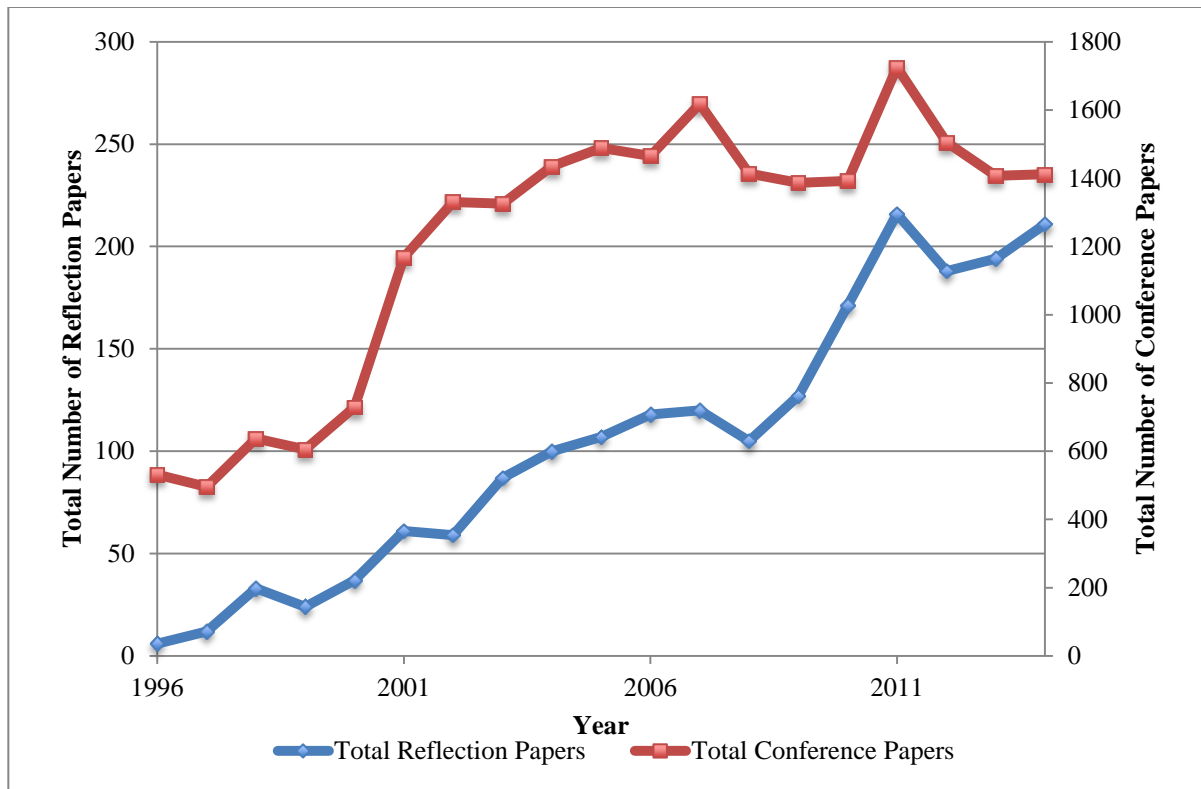


**Figure 1 - Trend of Reflection**

Additionally, the number of papers explicitly mentioning reflection was also compared to the overall number of conference publications for each year. The ASEE provided us with the total number of publications for each year, and it was found that a similar upward trend is established. (See Figure 2)

### *Scope of Reflection*

The majority of papers discussed reflection in a more casual way as opposed to using reflection as the main focus. Of the papers that discussed reflection as the main focus, over 80% of them operationalized reflection as an activity. The most common scope of reflection was found to be “casual mention”, comprising over 60% of all relevant papers. Papers that discussed reflection as a serious thread comprised over 25% of the total relevant papers. (See Figure 3)



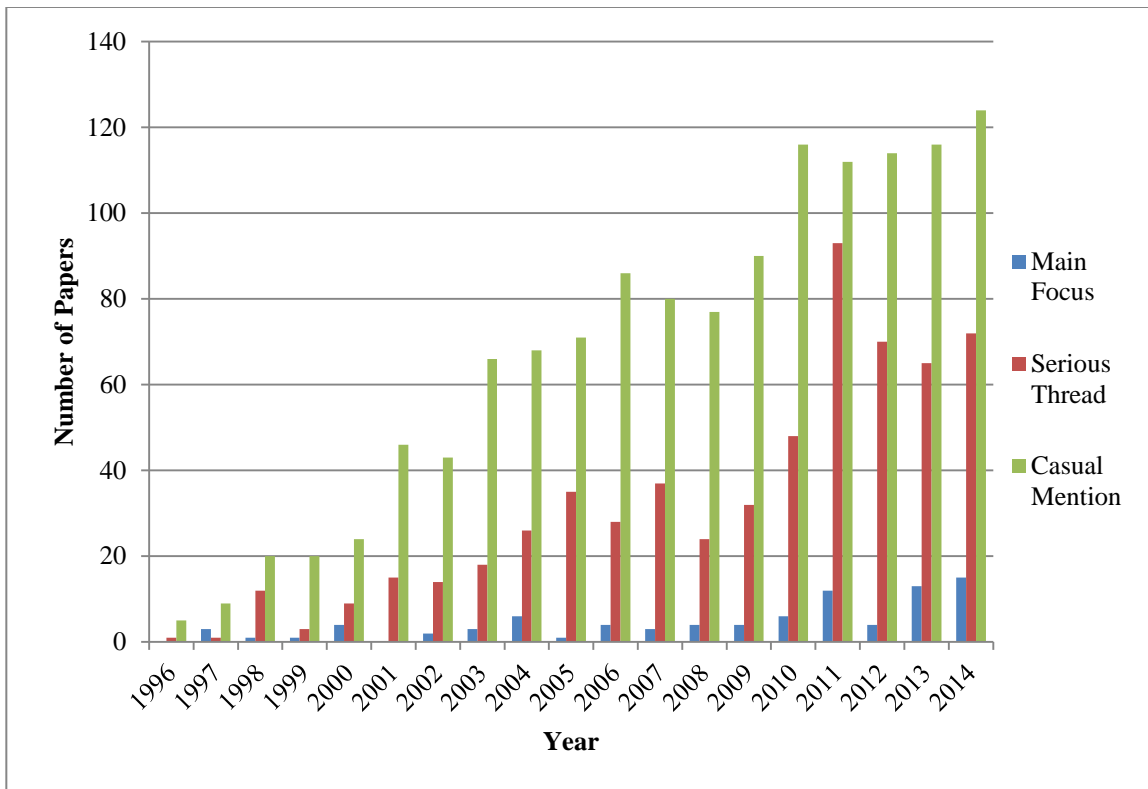
**Figure 2 - Total Number of Conference Papers and Total Number of Reflection Papers**

It was seen that authors of papers that discussed reflection generally, used it in a casual voice in instances where students were briefly asked to reflect, or where educators included opportunities for reflection. For example, in a paper entitled, “Using Rapid Feedback To Enhance Student Learning,”<sup>17</sup> reflection is casually referenced as, “Students are given time to reflect on the question posed, discuss it with their peers, and then must select from the possible solutions.” Whereas reflection is discussed as the main focus in a paper entitled, “A Personal Account on Implementing Reflective Practices,”<sup>18</sup> and is referenced to throughout the text.

Understanding the scope of reflection can lend insight into the type of attention that reflection is receiving in scholarly work related to engineering education. The trends revealed in our systematic review find not only that the topic of reflection is increasing with respect to the amount it is referenced, but is also increasing in the depth to which it is discussed.

### ***Type of Reflection***

Reflection was operationalized in a variety of ways ranging from intensive activities to simple discussions. In total, over 70% of all relevant papers had some activity associated with it. After identifying papers that discussed reflection as an activity, the data was further analyzed for those marked as “other activity” to determine what the “other activities” were. (See Figure 4) Examples of some of the activities that fell into the “other activity” category included reflective journals, specific activities created by educators, and a variety of other miscellaneous activities.



**Figure 3 - Breakdown of Scope of Reflection**

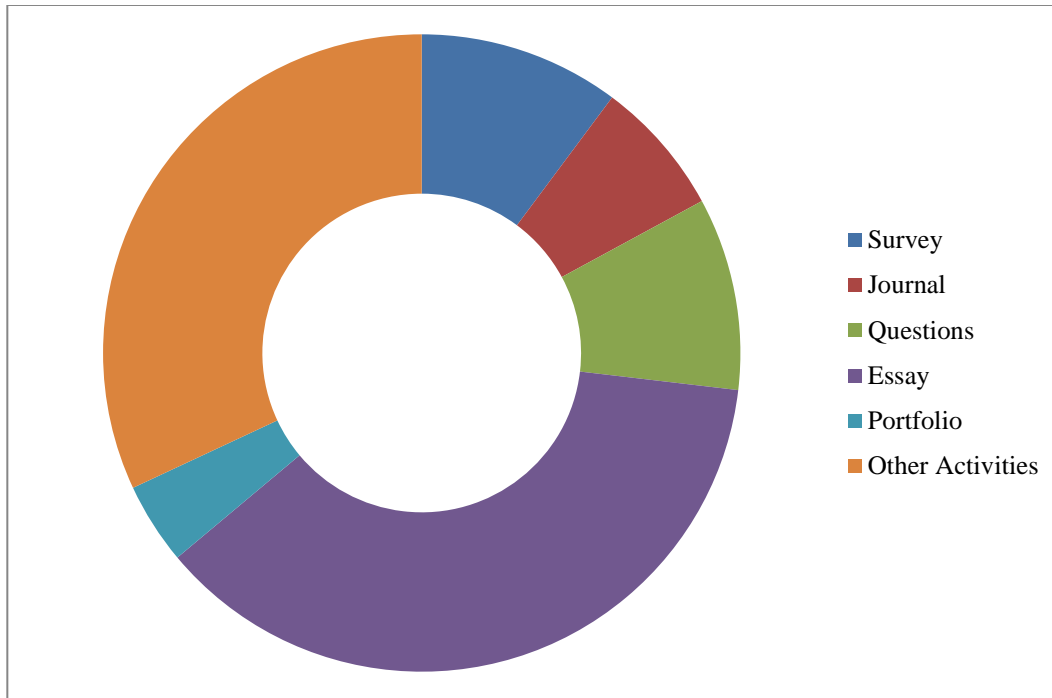
### *Essays*

Essays were the most common type of activity identified, and constituted over 30% of the activities across all 18 years. Overall, many types of writing assignments are being used to support reflection. However, they range from explicitly mentioned essays to smaller writing assignments. Most of the smaller writing assignments, such as short reports or one paragraph responses to a reflective question, are grouped as “other activities.” The prevalence of essays as tools to support or facilitate reflection led us to the conclusion that essays are the most popular singular way to support reflection within the constraints of our systematic literature review.

### *Portfolios*

Only 6.5% of all activities highlighted portfolios as the major activity used. In the early years of the publications we examined, students would create paper portfolios, whereas in the more recent years, portfolio development has transitioned to an e-Portfolio platform. Portfolios can be used to facilitate professional identity development in students<sup>19</sup> and oftentimes, they contain a reflective element. Portfolios are also helpful in aiding students to achieve “synthesis and evaluation ... which requires reflection.”<sup>20</sup> We found that the conference papers used portfolios in several ways<sup>20,21</sup>, but generally consisted of a reflective section in which students wrote to reflect upon their experiences and skills. Portfolios were also used as a way to reflect upon their paths of becoming engineers.<sup>21</sup>





**Figure 4 - Breakdown of Activities by Type (2008 - 2014)**

### *Surveys*

Surveys occurred more frequently in the recent years as compared to earlier years of the ASEE. Some surveys included a few prompts and the students were free to write as much or as little as they wanted.<sup>18</sup> Other surveys asked participants to rate certain aspects of their education or projects.<sup>22</sup> Another group of surveys were studies that discussed the design of student surveys such as, “Incorporating The Design And Use Of Surveys With Other Engineering Assessment Methods Under Criteria 2000 Guidelines.”<sup>23</sup> Oftentimes surveys were conducted at the end of the term as a meta-reflection of the entire term.

### *Discussions*

Several papers used in-class or group discussions as another form of reflection activity. These activities value the opportunity of providing a space for engineering students to share their thoughts with each other.<sup>24</sup> In some cases, the discussions were held online and students could post their thoughts for everyone to read and respond.<sup>25</sup>

### *Not Activities*

Papers that discussed reflection that did not operationalize it as an activity were still recorded as relevant, although mentioned reflection in more of a discussion format. These papers generally discussed reflection as an integral part of student learning. Noticeable themes included references to the Kolb Learning cycle, citing “reflective observation” as a step in the learning cycle.<sup>26,27</sup> Other papers such as, “Integrating Reflection into Engineering Education,”<sup>4</sup> were not exemplary of a specific activity, but were extremely relevant in the search for literature that discussed reflection and its importance.

## **Discussion**

Our findings reveal that reflection has seen an increase in its explicit, named attention within the ASEE conference publications. Our findings indicate that many of the papers discussed reflection in conjunction with an activity. Essays were the most popular activity, followed by a smattering of other activities including portfolios, surveys, and reflective discussions.

Papers that discussed reflection as their main focus and as a serious thread included some discussions about the definition of reflection as well as an overview of reflection literature. However, in the casual mention category, we noticed that except for a few papers, other papers did not provide any definition for reflection. Since reflection does not have one agreed upon definition by all scholars, we suggest that providing a brief definition could benefit both readers and researchers on their understandings of reflection. This finding also confirms Baumer et al.'s<sup>6</sup> review of research on systems designed to support reflection where only a few papers clearly defined the concept of reflection.

Many may question why reflection is an important concept to consider as a part of engineering education. Mann et al.<sup>7</sup> note that “reflective practice is part of a change that acknowledges the need for students to act and to think professionally as an integral part of learning throughout their courses of study, integrating theory and practice from the outset.” It is in this same spirit that we continue to study and promote the prominence of reflection in engineering education.

The increase in named reflection over the last 18 years in the ASEE conference publications suggests that engineering educators are recognizing the importance of reflection as a vital part of the learning experience, and are making strides towards incorporating it into classroom activities and discussions amongst colleagues. What once was an underexplored and under-mentioned topic in engineering education is becoming more prevalent with quality literature to support both its development as a concept and its operationalization as a classroom activity in engineering classrooms.

### ***Possible Limitations***

Throughout our process of searching for papers based on our syntax of words relating to reflection, researchers encountered limitations of the search engine such as inconsistent search engine results when using exact search terms. To address this issue, we repeated the search multiple times and used the number that appeared most often.

Additionally, in some years, the same paper is listed under different titles. To address this issue, we searched for the duplicate paper on the Internet to verify the correct version. In rare cases, searching for the paper would only refer us back to the ASEE and the correct version could not be located. In these cases, the paper was discarded from our analysis.

### ***Future Directions***

There are several areas for which we would like to suggest next steps. The breakdown of the “other activities” included many different types of activities that could be grouped into more general categories such as, “writing,” or “personal reflection.” With so many entries, we made

the decision to take a higher-level approach, and suggest that further research could categorize other activities to gain a finer vision of the specific activities that comprise the “other activities.”

Our findings are specific to examining the overall trends of reflection in engineering education in the ASEE conference proceedings. This foundation is a springboard for many other endeavors including topics such as:

- What are the trends of reflection associated with other bodies of scholarly work?
- Are there trends associated with reflection specific to academic institutions?
- In what fashion has reflection, as a part of engineering education, propagated throughout the nation?
- How can the activities identified as “other activities” be further analyzed?
- Will the reflection trend continue?

Investigating the above topics will only broaden our understanding of how reflection plays a role in the education of an engineer, and how it has the possibility to positively affect engineers for many years after graduation.

One way that we are promoting the incorporation of reflection into engineering education at the Center for Engineering Learning and Teaching (CELT) at the University of Washington is through the Consortium to Promote Reflection in Engineering Education (CPREE) funded by the Helmsley Charitable Trust. The goals of CPREE are to (1) understand how engineering educators are supporting students in reflection and (2) to promote the use of reflection activities in engineering education. We are doing these activities through working closely with twelve campus partners. In the first year of CPREE, we are collecting instances about reflection activities educators use in the classroom in the form of field guide entries that will be in campus specific field guides and eventually compiled into a national field guide: “Using Reflective Techniques to Encourage Student Learning: Background Examples.” In the second year of CPREE we are supporting campuses as they encourage educators to use reflection activities in their classrooms. Additionally, we are evaluating what happens when educators use reflection activities in their classroom.

## **Conclusion**

In seeking to answer the question: *how much explicit, named attention has reflection received in engineering education scholarship and how do we interpret these results*, we have found that the upward trend sheds light on the scope of reflection, type of reflection, and overall prevalence of reflection in engineering education in the last 18 years. There has been a significant and recognizable upward trend in the explicit attention of reflection across the publications. As evidenced by our systematic literature review, reflection can be incorporated into engineering education in a variety of ways. Portfolios, essays, journals, and other innovative activities are ways that students can be exposed to reflective activities, which help them to monitor their learning process and concretize concepts.<sup>28,29</sup> As a result of these findings, we have laid the current landscape of engineering education to provide a framework of reference for educators and scholars alike. Our data shows that more attention is being directed towards the theme of reflection across scholarly work and classroom techniques. Understanding the trends of reflection across literature can help us to further analyze its prevalence and utilization in the engineering education community. In this paper, we only reviewed the papers published in the

ASEE conference, which is the most prolific conference with a large volume of publications. We hope that this study helps to shape research trajectory and we would like to invite subsequent researchers to extend and contribute to this effort.

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