Addressing the Barriers of Knowledge Transfer: Using ePortfolios to Enhance Student Reflection in Technical Courses

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***Abstract*—Education literature has long emphasized the compounding benefits of reflective practice. Although reflection has largely been used as a tool for developing writing skills, contemporary research has explored its contributions to other disciplines including professional occupations such as nursing, teaching and engineering. Reflective assignments encourage engineering students to think critically about the impact engineers can and should have in the global community and their future role in engineering. The Department of Electrical and Computer Engineering at a small liberal arts college adopted ePortfolios in a first-year design course to encourage students to reframe their experiences and cultivate their identities as engineers. Our recent work demonstrated that students who create ePortfolios cultivate habits of reflective thinking that continue in subsequent courses within our program's design sequence. However, student ability to transfer reflective habits across domains has remained unclear and encouraging critical engagement beyond the focused scope of technical content within more traditional core engineering courses is often difficult.**

In this work, we analyze students' ability to transfer habits of reflective thinking across domains from courses within a design-focused course sequence to technical content-focused courses within a degree program. Extending reflection into core courses in a curriculum is important for several reasons. First, it stimulates metacognition which enables students to transfer content to future courses. Second, it builds students' ability to think critically about technical subject matter. And third, it contributes to the ongoing development of their identities as engineers. Particularly for students traditionally underrepresented in engineering, the ability to integrate prior experiences and interests into one's evolving engineering identity may lead to better retention and sense of belonging in the profession.

In the first-year design course, electrical and computer engineering students (N=28) at a liberal arts university completed an ePortfolio assignment to explore the discipline. Using a combination of inductive and deductive coding techniques, multiple members of our team coded student reports and checked for intercoder reliability. Previously, we found that students' reflection dramatically improved in the second-year design course [1]. Drawing upon Hatton and Smith's (1995) categorizations of reflective thinking [2], we observed that students were particularly proficient in *Dialogic Reflection*, or reflection that relates to their own histories, interests, and experiences. In this paper, we compare the quality of student reflections in the second-year design course with those in a second-year required technical course to discover if reflective capabilities have transferred into a technical domain.

We discovered that students are able to transfer reflective thinking across different types of courses, including those emphasizing technical content, after a single ePortfolio activity. Furthermore, we identified a similar pattern of improvement most notably in *Dialogic Reflection*. This finding indicates that students are developing sustained habits of reflective thinking. As a result, we anticipate an increase in their ability to retain core engineering concepts throughout the curriculum. Our future plans are to expand ePortfolio usage to all design courses as well as some fundamental technical courses throughout the curriculum.

***Keywords*—ePortfolio; reflections; first-year design; transfer of learning**

I. Introduction

Transfer of learning is a central goal of education that occurs when acquired knowledge and skills are applied to new situations and contexts. However, students often struggle with transfer especially when the learning situation is considerably different from the new situation. Transfer is improved when information is organized into a conceptual framework where new learning connects with existing knowledge [3]. ePortfolios are becoming an increasingly popular tool on college campuses because they promote structures and habits of reflection on learning, which has led to their promotion by the AAC&U as highly effective learning practices [4].

Our Electrical and Computer Engineering Department has recently adopted ePortfolios in our first-year design course to give students an opportunity to explore different potential career paths in the discipline and practice reflection. Engaging in reflective practices assists engineering students in cultivating habits of reflective thinking, which also ultimately enhances their capacity to transfer learning effectively across different contexts. We were encouraged to find that this intervention yielded a notable increase in frequency, variety and thoroughness of reflection demonstrated in design assignment reports in the second-year design course [1] and wanted to see if this trend persisted when the context was more varied. Our research questions are: *Would we see a similar improvement in reflective habits in a second-year core technical course? Would the transfer of reflective thinking habits be diminished due to the larger shift in context and the struggle to connect classroom learning of core technical concepts to relevant, real-world problems?*

In this study, we analyze instances of reflection in lab reports submitted by students in a second-year core technical course to determine how well students were able to transfer reflective thinking across different course contexts. A quantitative summary of students reflective thinking is provided with comparisons to the results from the design course previously studied. We also present qualitative examples of student reflection for the technical course.

II. Literature Review

Reflection is a critical component of learning. Education scholar John Dewey [5] argued that reflection aided problem-solving through enabling students to collect, analyze and make connections between ideas. Another influential educational theorist, Donald Schon [6], championed reflection as a way of making one's own tacit knowledge explicit, enabling students to challenge their own thinking through the act of writing.

Contemporary education scholars have elaborated upon the numerous benefits of reflection. Some have noted the positive impacts on self-efficacy and belonging in the classroom, enabling students to draw upon their own funds of knowledge from their personal histories [7]–[10]. Others have highlighted the potential for better student support, since these reflections may alert professors and administrators of the challenges students are facing in the university environment, such as financial stress, personal relationships, etc. [11]. Still others have highlighted the way that reflection aids students' sense of agency, encouraging them to think critically about the world and recognize the power of their own actions toward change [12]. Although reflection is used most commonly in the humanities and social sciences for developing writing skills, professional disciplines such as nursing [13], teaching [2] and engineering [14] have used reflection as a tool to develop critical thinking, intuition, and professional identity.

In this paper, we are focusing specifically on the positive correlation between reflection and learning transfer. The term "transfer" in education literature refers to students' ability to recall and apply knowledge learned in one context to another context [15]. Students often struggle with transfer due to the contextual nature of learning. Students learn new concepts in a particular type of environment, with a particular teacher, for application in particular scenarios. When they leave this context behind, the knowledge remains unconnected to future contexts unless it is specifically anchored to other knowledge they have previously acquired. Reflection, and a related skill, metacognition, are often cited as important tools for helping students organize and transfer knowledge [3], [15], [16]. Although the terms "reflection" and "metacognition" are often used interchangeably in the literature, we want to distinguish metacognition as a particular kind of reflection in which students are thinking about their learning process, including self-assessments of which learning strategies work best for them. Ambrose [16] has suggested that metacognition most commonly refers to students making plans for how they will learn in the future, as opposed to simply reflecting on past learning.

There are several models to assess the quality of student reflection. Kember's [17] assessment of "reflection-in-action" captures an individual's ability to reflect in the moment, an important skill in many professions where intuitive knowledge is valued, such as medicine. Reflection on past experiences, or "reflection-on-action" [6], [18], can be measured through qualitative assessments of written work [2], [19]. Hatton & Smith [2] outlined four levels of reflective writing: *Descriptive Writing*, *Descriptive Reflection*, *Dialogic Reflection*, and *Critical Reflection*. *Descriptive Writing* is not reflective, it is simply a neutral account of facts and events. *Descriptive Reflection* consists of students evaluating and explaining their rationale, for example, supporting an argument from the literature. *Dialogic Reflection* indicates a discourse with themselves, wherein students explore their own opinions or weigh multiple options. Finally, *Critical Reflection* entails a rationale that connects the topic with broader historical, political or cultural contexts. Each of these four levels may be valuable in different contexts.

Many universities in the United States are adopting ePortfolios as a tool for encouraging student reflection. ePortfolios, one of the AAC&U's eleven high impact practices for higher education [20], enable students to integrate all of the experiences they may have during college, from individual courses, to student organizations, to athletics, to internships [21]–[24]. These digital platforms may ultimately generate new forms of reflection as students creatively curate different types of media, such as video, concept maps, and social media [25]. Through the creation of multiple ePortfolios, which may be public or private, students develop habits of reflective thinking through consistent practice of synthesis and sensemaking. ePortfolios, as reflective activities, may ultimately result in improvements in students' ability to transfer knowledge across contexts.

III. Methods

A. Classroom Context

We are seeking to cultivate habits of reflective thinking in our electrical and computer engineering (ECE) department. The study took place at a small liberal arts college in the northeastern United States. In Spring 2022, students in our program completed an ePortfolio assignment at the end of their first-year ECE design class, which encouraged them to connect the skills and experiences they learned in the class with their personal histories, interests, and goals for their futures. We had several goals in providing this early exposure to reflection: 1) to prepare students for similar reflective activities later in their coursework, 2) to facilitate transfer of knowledge between courses, 3) to provide a platform for critical thinking about technology, and 4) to aid in the development of their professional identities as engineers. In Fall 2022, these students took courses with other professors who commented on the excellent reflections they were reading in students' lab reports. We designed an experiment to compare lab reports from two cohorts of students: those who had completed the ePortfolio and those from the previous cohort who had not. In a previous paper, we found that students' reflection quality significantly improved between class years [1]. However, this was a comparison of two similar learning contexts: both were design courses.

We were curious whether the improvements would be sustained in lab reports from a content-focused technical course. We anticipated that there may be barriers to transfer of reflective habits to a technical course due to the different learning context. In addition, students' perceptions that personal reflections may not be appropriate in a purely technical course could hinder their openness in these types of writing assignments.

B. Research Design

In this paper, we have repeated this experiment between two cohorts enrolled in a second-year technical course. The first cohort, the "Control Cohort", did not complete an ePortfolio reflection in their first-year design class, and therefore had minimal prior exposure to reflective thinking in their first-year coursework. The second cohort, the "Experimental Cohort", completed an ePortfolio assignment and did transfer reflective thinking habits to a subsequent design class [1]. Data from the second-year design course is also provided in this paper for comparison with the technical course. Demographic information for all four classes is shown in Table I. We wished to discover whether the Experimental Cohort retained the habits of reflection they learned in a design course in the context of a technical course.

The reports submitted for this class varied in format, but most contained the following major elements: 1) a wiring diagram, 2) responses to specific questions from the professor, and 3) a reflection section. Some students also chose to include additional elements, such as circuit diagrams, truth tables, measured current tables, and photographs of their circuit board. Although these reports were submitted in teams of two or three students, each student wrote their own independent reflection. For this study, we focused exclusively on each student's individual reflection for our data analysis.

This lab report was the first one assigned in the class, which makes it an ideal case study for the transfer of reflection skills from the prior course. Students had created their ePortfolios during the spring semester of their first year and this course followed in the fall. While students did receive new (brief) instructions to reflect on their activities in the fall technical course, it is a reasonable hypothesis that they might also retain the reflective habits they developed the previous spring.

TABLE I
DEMOGRAPHICS OF STUDENT COHORTS

Demographics	2nd Yr. Tech. Course		2nd Yr. Design Course	
	Control	Experimental	Control	Experimental
Cohort Size	20	30	7	14
Men	15	25	4	12
Women	4	5	2	2
Nonbinary	1	0	1	0
White	11	21	6	12
Students of Color	9	9	1	2

Reflection is a subjective skill, which takes on different meanings in different contexts. Most of the educational literature on reflection has been written in humanities and social science contexts, which may or may not be applicable to engineering. For this reason, we chose to use inductive methods, creating our own codebook based on the reports we had in hand, and then compared that codebook to established literature. Inductive methods are useful at clarifying what subjective terms mean in a specific context [26], [27], for example, what counts as "quality reflection" in an engineering department.

Amongst our small team of faculty, we began by reviewing a small sample of lab reports from the Control and Experimental Cohorts. During first cycle Descriptive Coding [28], we read each lab report together as a team and described what we felt were examples of "good reflection" in these reports. Each suggestion was discussed as a group, and if agreed upon, added to the codebook. We next compared these codes to the educational literature and found that our codes corresponded most closely to Hatton and Smith's [2] four levels of descriptive thinking: *Descriptive Writing* (Not Reflective), *Descriptive Reflection*, *Dialogic Reflection*, and *Critical Reflection*. We sorted our codes into these four levels (see the Appendix).

Using this codebook, we coded all remaining lab reports (23 total) using NVivo qualitative data analysis software. Following consensus coding techniques [29], [30] , two members of the research team independently coded all lab reports and met regularly to compare results. Discrepancies were discussed and resolved by consensus, which contributed to intercoder reliability [31].

For the purposes of this paper, we have opted to quantify, or "count", our coding instances to visually show shifts in students' reflective thinking over time. The code quantities were normalized to correct for differing class sizes, reporting the number of codes per individual student. Although code counting tends to detract from the richness of qualitative data, we feel that this helped us communicate key results in a short paper. In future publications, we will explore the qualitative data in-depth.

IV. RESULTS

Our findings suggest that the ePortfolio experience increased students' reflective habits in both technical and design

TABLE II
TECHNICAL LAB REPORT LENGTH AND CODE FREQUENCY BY COHORT

	Range		Average	
	Control Cohort	Experimental Cohort	Control Cohort	Experimental Cohort
Report Length	3–7 pages	4–9 pages	4.56 pages	5.86 pages
Number of Codes	0–12 codes	4–16 codes	2.45 codes	4.10 codes

TABLE III
FREQUENCY OF REFLECTION TYPES BY COHORT

	Range of Codes		Average No. of Codes	
	Control Cohort	Experimental Cohort	Control Cohort	Experimental Cohort
Descriptive Writing Codes	0–3	1–2	0.85	0.73
Descriptive Reflection Codes	0–1	0–2	0.10	0.53
Dialogic Reflection Codes	0–7	1–9	1.25	2.37
Critical Reflection Codes	0–2	0–5	0.25	0.47

courses. Although overall second-year students provided less reflection in the technical course than the design course, the frequency, variety, and depth of reflections in technical lab reports increased significantly. Similar to the design course the average report length increased by more than a page, as shown in Table II. The Experimental Cohort showed a significant increase in the overall average number of codes per student reflection. The Experimental Cohort had a maximum of 16 codes referenced in a single report, whereas the Control Cohort only had a maximum of 12 code references. Our final codebook had 14 different codes, of which only 10 were identified in the Control Cohort reports, while 12 were identified in the Experimental Cohort reports.

We analyzed the trends between our two cohorts based upon the four categories of reflective writing developed by Hatton and Smith [2]. Fig. 1 contains the results of the first two categories *Descriptive Writing* and *Descriptive Reflection*. Fig. 2 contains the results from the third category *Dialogic Reflection* and Fig. 3 contains results from the last category *Critical Reflection*. For a brief description of the codebook see the Appendix. We found an increase in the average number of codes per student in the Experimental Cohort when compared to the Control Cohort for three of the four categories of reflection, as presented in Table III.

In the technical course, the *Descriptive Writing* category was the only one that showed a decrease. Hatton and Smith include *Descriptive Writing* as a category that reports events and processes but is not reflective. We will argue in the Discussion section that this result suggests that students in the Experimental Cohort are utilizing higher levels of reflection and going beyond simply reporting events. The least frequently identified code category for the Control Cohort in both courses was *Descriptive Reflection* with only two instances of these codes used in both the design and technical course. The Experimental Cohort shows a more even distribution between the *Descriptive Writing* and *Descriptive Reflection* codes in the technical course and few instances of *Critical Reflection* which is the least prevalent code category in their technical lab reports. *Dialogic Reflection* has the greatest number of codes, accounting for half of all of the codes identified in our codebook. This category is the most common type of reflection that we encountered across both cohorts for both courses. The frequency with which *Dialogic Reflection* and *Critical Reflection* were coded increased significantly and with similar percentages between the two cohorts although the *Critical Reflection* had a limited number of instances in both cohorts. This result was different from what we saw in the design course where the frequency of *Critical Reflection* remained the same. *Descriptive Reflection* saw the largest percentage increase between the two studied cohorts, though again with the limited number of instances in the Control Cohort this improvement may be overinflated.

The combined instances of *Descriptive Writing* and *Descriptive Reflection* codes are presented in Fig. 1. The only *Descriptive Writing* code included in our codebook is "Learned a Skill." Most reports in both courses demonstrated at least one instance of *Descriptive Writing*. In the design course, there was one report in each of the cohorts where no instances were coded and in the technical course all reports included *Descriptive Writing* except for one Control Cohort report that failed to include a reflection section. However, in the technical course, the Experimental Cohort used fewer instances of this code in each report when compared to the number of students contributing, with eight individual students not including a specific skill learned. Instead, this cohort more frequently reflected in ways which fit into the *Descriptive Reflection* category specifically in the "Evaluative Description of Work and Environment" code which pertained to students identifying and explaining their experiences during the lab with electronic components, wires and measurement tools. The other *Descriptive Reflection* code, "Evidence of Iteration or Non-required Work" never appeared in any of the Control Cohorts reports for either course and appeared only once in the coded reports for the technical course.

In the technical course the Experimental Cohort had a higher adjusted frequency for five of the seven Dialogic Reflection codes when compared to the Control Cohort as shown in Fig. 2. The codes that were used less frequently by the Experimental Cohort are "Recognition of Deficiency" and "Description of Collaboration with Others" while the frequency in which "Metacognition" was coded remained approximately the same. The *Dialogic Reflection* codes used most frequently in the Experimental Cohort reports were "Personal History" and "Emotional State" which also were the highest percentage increases when compared to the Con-

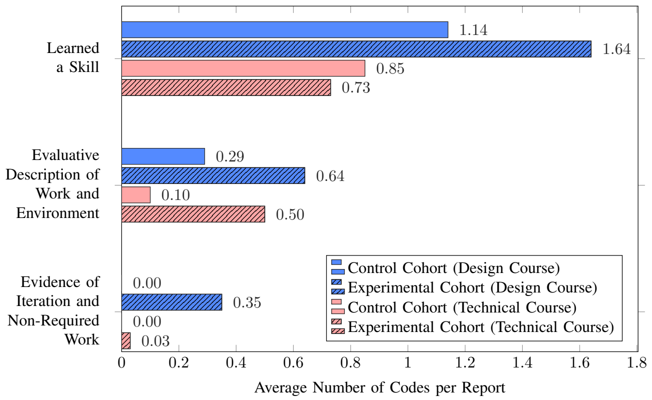

Fig. 1. Comparing Control and Experimental Cohorts for codes categorized as *Descriptive Writing* or *Descriptive Reflection*

trol Cohort. Similar to the findings in the design course, the Experimental Cohort reported a much wider range of emotional states than the Control Cohort. While the Control Cohort wrote only about confusion, the Experimental Cohort expressed both positive and negative reactive feelings towards the lab, including frustration, tedium, boredom, enjoyment, fun, and the lab's benefits in helping them gain comfort in new knowledge and competence. Both cohorts exhibited more personal reflection shown by the significant increase in usage of both the "Personal History" and "Personal Interest" codes and also a significant increase utilizing the "Desire for Expertise" code.

Overall, students used *Critical Reflection* with less frequency in technical lab reports than in the reports for the second-year design course. Fig. 3 illustrates that the *Critical Reflection* codes used in the technical course focus solely on the labs relevance to the student's future engineering endeavors and did not consider any connections or impacts beyond the discipline. "Transfer to Other Engineering Courses" was the only *Critical Reflection* code identified in the technical course lab reports for the Control Cohort. The Experimental Cohort reports utilized this code almost 50% more frequently than the Control Cohort and also added a few instances of *Critical Reflection* coded as "Alignment with Engineering Career".

V. Discussion

A. Modest Improvements in Reflective Habits in a Technical Course: The Good, The Bad, and the Messy

Our results indicate that while there is a notable improvement in reflective thinking in the technical course, it is not as pronounced as the improvements we saw in the design course. This result was what we expected to find due to the known difficulties in transferring across course contexts. Students in the Experimental Cohort demonstrated significant improvements in *Dialogic Reflection*, bringing elements of their personal histories and personal interests into the reflection. They were also more likely to reflect on their emotions during the assignment. To provide an example of the difference

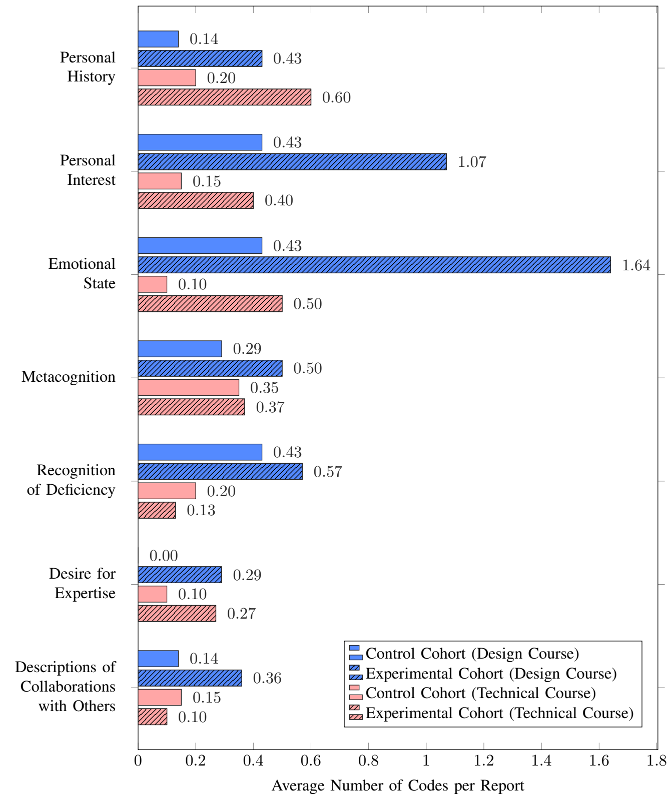

Fig. 2. *Dialogic Reflection* codes frequency comparison for the Control and Experimental Cohorts

between the Control and Experimental Cohorts, consider the following excerpts from the "Emotional State" codes:

> CONTROL: "The first time I built the circuit with one logic gate, which was the AND [gate], I thought it was confusing. But then with some consideration you see the patterns follow along…"

> EXPERIMENTAL: "Nonetheless, there were parts of this lab that caused some frustration, such as working out the initial issues we had with our physical circuit. Additionally, the noise in our circuit—a result of unused pins being left free as opposed to being tied to ground—made our measurements feel somewhat uncertain, which I did not particularly appreciate. I am not as comfortable with application and using equipment as I am with the theory behind it all, thus the slight bouncing around of our readings made me feel less confident in our process and my skills using the AD2."

In the second statement, there is a more consistent engagement with emotion throughout the paragraph (i.e. frustration, uncertainty, comfort, confidence), and greater elaboration about what is causing their emotions. Students in the Experimental Cohort also included a wider range of emotions than the Control Cohort, ranging from "tedious", "boring", and "confusing" to "fun", "exciting" and "entertaining".

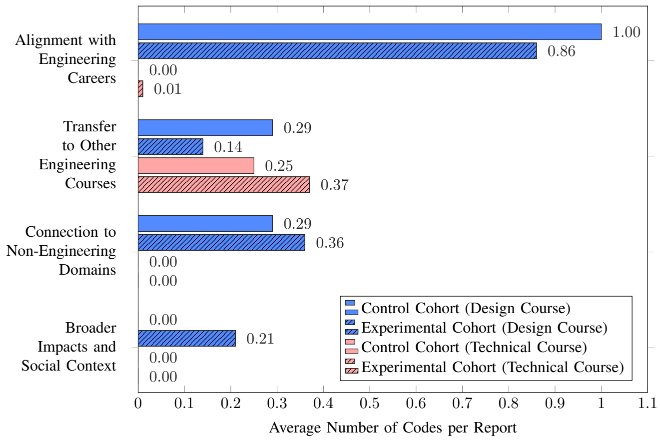

Fig. 3. Average number of codes per report for each of the *Critical Reflection* codes

Dialogic Reflection was strongly encouraged in the ePortfolio assignment of the first-year design course, but we had hypothesized that students might decide it was inappropriate for a technical course. Although we did see a decline in this kind of reflection between the design and technical contexts, there were clear improvements between the Experimental and Control Cohorts, suggesting that some students have become more comfortable including these personal elements in their reflections, despite the context as a technical course.

However, there was a significant drop in students' *Critical Reflection* in the technical course. Students did not consistently relate what they were learning in class to the broader social context. This is consistent with other scholar's findings that engineers tend to bracket off social issues from technical ones [32], [33]. The second-year design class struggled in this category as well, and we noted this as an area for future growth. However, we did at least have representation in all four *Critical Reflection* codes in the design class. In the technical course, we had one area in which we saw a marked improvement in comparison to the Control Cohort: students were more likely to project how these skills might be useful in future classes, essentially laying the mental pathways through which transfer can occur. This is an exciting and significant improvement.

Nonetheless, there was no mention of the connection between this material and contexts outside of engineering classrooms, and only one student connected it to their future career. This is likely due to the course being a technical course, in which both students and professors struggle to connect course content to relevant, real-world contexts. Although *Critical Reflection* may be less relevant for a technical course, this indicates a consistent gap in students' reflective habits and the department could focus more attention on developing this kind of reflection in the future.

In addition, there are a few categories in which the data became a little "messy". The Control Cohort of the technical course outperformed the Experimental Cohort in several categories, including "Learned a Skill" and "Recognition of Deficiency". Similarly, "Metacognition" remained about the same between cohorts. Qualitative inquiry can shed some light on these discrepancies.

Our hypothesis, which will require additional analysis in a future paper, is that there may be a developmental hierarchy of reflective thinking, wherein students in the Experimental Cohort are shifting towards higher level skills. The four codes "Learned a Skill", "Recognition of Deficiency", "Metacognition", and "Desire for Expertise" are closely related and often overlap. In the first category, students simply state that they have learned something new. This category is classified as *Descriptive Writing* because it is low-hanging fruit for students and does not require in-depth reflection. In the second level, students recognize that they are struggling with a particular skill. In the third level, students assess their learning to try to understand why they are struggling. And in the fourth level, students envision a future in which they are able to improve on the skill. Consider the following excerpts from student reports:

> CONTROL: "In the past professors usually provided us with enough information so that I did not learn how to find information by myself. And now I know how to find information through a data sheet. I never used a real gate before so all I know about a gate is only the input and output in the form of true and false."

> EXPERIMENTAL: "I think it was really valuable to reinforce multiple of the different concepts that we have learned in class relating to different logic gates and applying those to real life circuits and chips that are built to perform the actions of an AND, OR, NAND, etc. gates. I think that reading through the data sheets of each and learning the different pieces of information that are relevant was really helpful as I can compare to what I've learned in other classes, like ECEG201. The main challenges that I faced in this lab was that I wasn't feeling too great during the lab, and that impacted some of my learning... Although difficult and frustrating, this has increased my confidence in troubleshooting in the future, and it's a very important skill to have as an engineer... I'm excited to see how my skills improve and what types of circuits and digital systems we can create in future labs and projects."

The Control excerpt was coded for "Learned a Skill", "Recognizing Current Deficiency" and "Metacognition". The student has understood that they had never learned how to find information on their own before, assessed what may be contributing to that problem, and as a result, has acquired this skill. In contrast, the Experimental excerpt was only coded for "Metacognition" and "Desire for Expertise". Rather than describing the skill itself, the student spends more time analyzing why he struggled and anticipates a future wherein he improves his skills. Therefore, while the numerical data gets a little murky, a decline in the categories "Learned a Skill" and "Recognition of Deficiency" may be a positive indicator that students in the Experimental Cohort are developing higher level reflection skills in comparison to the Control Cohort, as a result of more practice in developing reflective habits.

B. Limitations

This paper has several limitations. First, the sample size is small, and as such, we should exercise caution in making generalized claims, as this experimental design may yield different results outside the context of our own department in a liberal arts setting. Student personalities and cohort cultures are additional variables that may result in significant variations between cohorts. Future research should verify consistent results across multiple cohorts.

In addition, the instructions for the lab report in the technical course contained one small change between the Experimental and Control years, which may have influenced what students chose to include in their reflections. The Control Cohort received the following instructions: "In one paragraph, individually reflect on this lab: what did you learn and why is it useful? Were any of the learning goals not met?" The Experimental Cohort's instructions added additional prompts: "What was difficult? frustrating? easy? Anything you are still unsure about?" We believe these instructions resulted in code increases in two categories: "Evaluative Description of Work and Environment", and "Emotional State". The word "frustrating" appeared in five reports and the word "unsure" appeared in three reports, illustrating the students' reaction to these instructions specifically. We anticipate these codes would be less frequent without these instructions. However, we decided not to remove these instances from the results because there were significant qualitative improvements in students' comments in both of these categories. We elaborated upon this qualitative shift in the Discussion section and suggested that these shifts may be evidence of an improvement in students' ability to communicate their frustrations as a result of the ePortfolio assignment. Furthermore, these categories were only two amongst several other categories in which improvements were noted, and thus, we argue that our overall findings remain consistent with a positive correlation between ePortfolios and sustained reflective habits.

VI. Conclusion

This paper examines the influence of an ePortfolio in a first-year design course on students' reflective habits as they progress through the department's curriculum, specifically by analyzing lab reports from a second-year technical course. We compare these results with previous results for a second-year design course [1] to compare differences between students' ability to transfer reflective thinking habits between courses with different contexts - between two design courses versus transferring between design and technical domains. To assess students' reflective abilities, we developed a codebook using inductive methods and categorized the codes into four established reflection categories: *Descriptive Writing* (Not Reflective), *Descriptive Reflection*, *Dialogic Reflection* and *Critical Reflection*. Reflections from a previous cohort of students with whom the ePortfolio assignment had not been implemented were compared with the subsequent cohort who had the ePortfolio experience. For the technical course, the frequency of coded instances of reflection showed improvement in the three categories that are reflective, particularly in *Dialogic Reflection* which aligns well with our findings from the design course. Unlike the design course, we observed a small number of *Critical Reflection* codes but a considerable percentage increase in frequency between the two cohorts.

We conclude that the introduction of a single reflective ePortfolio experience has a positive impact on students, fostering a greater inclination towards reflective thinking that transfers to subsequent courses in more than one context. Reflection has the potential to provide various benefits to students, such as stimulating metacognition, which in turn improves their information retention and recall abilities. We anticipate that students who develop a habit of reflective thinking will enhance their capacity to anchor and integrate fundamental concepts throughout their educational experience. The positive correlation we have identified between ePortfolios and sustained reflective habits have encouraged plans to expanded usage of ePortfolios across our department's curriculum. Our department will also focus more attention on developing *Critical Reflection* skills that further encourage students to transfer the course content to other courses, their future careers and broader social context.

Appendix

The attached supplementary table shows the codebook we developed with a description of each code. An example of each of the 14 codes found in either a design or technical course student report is also given.

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Code	Code Description	Example of Coded Segment
	Descriptive Writing—Not reflective, reports events and processes	
Learned a Skill	Felt the acquisition of the skill was important	I learned how to find and read data sheets, how to use "and" and "or" gate in a circuit, and how to read the output in led and computer. *(Technical Course)*
	Descriptive Reflection—Reflects upon the efficiency and effectiveness of their procedure	
Evaluative Description of Work and Environment	Reflects upon their struggle and the impact of the work environment	The biggest challenge I personally faced was how to set up the circuit on the breadboard and organizing the wires. This was mainly because we had difficulty using the 7804 (AND Gate). Once we knew how to use it properly, setting up the second circuit was easy except when we had a bit of trouble with the LED. *(Technical Course)*
Evidence of Iteration and Non-Required Work	Additional actions were taken in the design process, above and beyond expectations, usually as a result of failed attempts	I started off with some soldering practice on some old damaged PCBs and then I used the manual solder paste nozzle to carefully apply solder paste to the Bucknell B PCB. *(Design Course)*
	Dialogic Reflection—Reflects upon their personal performance, learning, and interests	
Personal History	Links to their own past experience	I had some prior knowledge and experience with logic tables but I had never worked with the physical components before. *(Technical Course)*
Personal Interest	Links to their intrinsic interest in the topic	I had a great interest in the physical components part of electrical engineering, but I never tried it. After this week's assignment, I realize I like this part of ECEG. *(Design Course)*
Emotional State	Indicators of emotional state during the activity	I found the empty PCB to be somewhat overwhelming at first, and it took a little bit of time to settle in and feel confident in each step I took. *(Design Course)*
Metacognition	Articulates the thought process they used to solve the problem, assesses what learning strategies worked and did not work	I believe that the best solution to these challenges is to not rush through labs and read all the text carefully as I'm going. I also feel that calling over my professor during the lab to clarify any parts I don't fully understand will help me greatly in the future. *(Technical Course)*
Recognition of Deficiency	Reflection upon personal traits or lack of skill that contributed to struggle	I think it will take some time for me to hone my skills and become comfortable in using equipment in the Maker-E as well as general tools for applications of electrical and computer engineering *(Design Course)*
Desire for Expertise	Mentions a desire to further build skills in this area	I'm excited to see how my skills improve and what types of circuits and digital systems we can create in future labs and projects. *(Design Course)*
Description of Collaboration with Others	Mentions working with others and how this impacted their learning	I had a really good partnership with my lab partner so it enabled me to still participate and still be able to do a lot more of the computer based and circuit creation tasks so I wasn't straining myself. *(Technical Course)*
	Critical Reflection—Reflects upon this lab's relation to the wider social context	
Alignment with Engineering Careers	Mentions that this skill will be helpful in an engineering job	The process of printing a PCB, placing, and soldering components is hugely applicable to many things in ECE. PCBs are in just about everything in modern electronics. *(Design Course)*
Transfer to Other Engineering Courses	Mentions this skill will be useful in other engineering domains	I think that reading through the data sheets of each and learning the different pieces of information that are relevant was really helpful as I can compare to what I've learned in other classes, like ECEG201. *(Technical Course)*
Connection to Non-Engineering Domains	Mentions this skill will be useful in other NON-engineering domains	Soldering is a skill that I can carry with me throughout my life and apply to my job as a Technical Assistant in the Theatre, creating circuits to accomplish tasks in the technical theatre space. *(Design Course)*
Broader Impacts and Social Context	Links to larger societal context importance	While it is important to focus on things that can be great for society, the planet, or your wallet, taking some time to do creative things opens our minds and allows us to be better in every field. Creativity leads to new solutions to problems, and practicing different art forms, especially utilizing our learned skills, can change the way we approach problems in every aspect of our lives. *(Design Course)*