AC 2008-2601: EFFECTIVENESS AND PROFESSIONAL PORTFOLIOS: A CONTENT ANALYSIS OF STUDENTS' PORTFOLIO ANNOTATIONS

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Effectiveness and professional portfolios: A content analysis of students' portfolio annotations

Abstract

The engineering education community is exploring activities that can support the learning from experience. One such activity involves having students construct professional portfolios consisting of: 1) a professional statement in which the student makes claims about her/his preparedness for professional engineering practice, 2) artifacts representing aspects of the experience, and 3) annotations of the artifacts that discuss the relevance of the artifact (and the related learning experience) to the claims about preparedness for engineering practice made in the professional statement.

Annotations are particularly interesting because they represent a key to an effective overall portfolio and also potentially significant activity from an educational perspective. This paper addresses three issues associated with effectiveness: the idea of whether there is a singular notion of an effective annotation, the issue of what counts as an effective portfolio annotation, and the extent to which students can write effective annotations without support. In addition, this paper uses the answers to these questions to comment on the educational significance of writing effective annotations.

Introduction

Because research tells us that "experience alone is a poor teacher," [1] the engineering education community is exploring activities that can support the student's making meaning (and learning) from their experiences. Recently, much attention has been devoted to having students construct portfolios—collections of artifacts, possibly annotated, put together to tell a story and/or support a set of claims. Such portfolios can provide students with an opportunity to reflect on their experiences, share their experiences with others, and see experiences as a building block for future activity [2,3]. In this paper, we focus on professional portfolios—portfolios in which the student makes an argument that they are prepared for professional practice.

Professional portfolios are particularly interesting from a learning perspective because of the potentially authentic way that they can help students look ahead to future and bridge their knowledge to the professional context. The possibility of authenticity comes from having students genuinely work on their portfolios with external audiences in mind (e.g., employers, future work colleagues, recruiters). An effective portfolio, in such a context, is one that convinces the external audience. These observations raise interesting questions. For example, how good are students at creating such effective portfolios and how do we help students create more effective portfolios? And, how might specific notions of what makes an effective portfolio help us, as educators, better understand the educational significance of constructing such portfolios.

This paper addresses questions related to effectiveness and educational significance in the context of one portfolio component—the annotation. While portfolios in contexts such as architecture may not include annotations, most portfolios created in engineering do. An

annotation can be defined as text that orients a reader to the artifact and explains how the artifact supports specific claims made about the portfolio author in the professional statement or in the annotation itself. Seen in this light, annotations can be key to the overall effectiveness of the portfolio by linking the elements together and by further explicating claims made about the author.

Our interest in the writing of annotations and understanding the link of annotation writing to learning has been motivated, among other things, by what we have heard students say about writing annotations when we have interviewed them about the process. The quote below, which was collected from an earlier study of student processes for preparing the portfolio, represents an example of students' comments about the challenges of annotation writing. In the quote, a student, who has been working on a professional portfolio, is commenting on the cognitive activity associated with writing an annotation for an artifact. In this case, the artifact is a persona, a description of a fictitious potential system user that is shared with designers as a way to help those designers incorporate user information into the design process.

> "I think I'm stressed about it [the writing of the specific annotation], because this is my chance to connect, you know, work that I've done with an argument of, yes, I can do the work. But it's also making decisions about how much explanation I should put in there…And I'm doubting myself and not sure how strongly I can say- how strongly I can promote something, you know, promote my work….Um, I, I don't know whether it's a well written persona, I mean I don't know whether usability professionals would call it a well-written persona. If I say it's a well-written persona and they say it's not, am I now deemed cocky?...So that, that really surprised me how just writing that sentence makes me think of all these concerns, about, oh, is that too strong, am I being cocky, will they deem [the artifact] as well written." 567-606

This quote reveals some of the many issues students must address in order to write effective annotations (e.g., "making decisions about how much explanation I should put in there," "how strongly I can promote something"). In this paper, we explore three such issues related to the writing of effective annotations: what are strategies that contribute to writing an effective annotation, whether there is a singular notion of what makes an effective annotation, and how well do students write effective annotations. We address these issues empirically through qualitative scoring and content analysis of a set of annotations created by junior-level engineering students as part of a required portfolio assignment in a manufacturing engineering class. Insight into these questions can help students improve the quality of their portfolios.

The quote also draws attention to some of the ways that the writing of annotations (specifically the thought processes that go into the writing of the annotations) could lead to learning. For example, the students comments of "my chance to connect, "I'm doubting myself," and "I don't know whether it's a well written persona" each suggest specific ways in which the writing of the annotation in question might have triggered learning. In this paper, we tackle this link to learning through theoretical analysis, comparing the types of content involved in writing effective annotations (the product of our empirical analysis) with the range of ideas that theory tells us are important for reflecting from experience and promoting transfer of lessons to new

contexts. Because this analysis is more conjectural, we address it in a separate "implications" section following the discussion.

The remainder of the paper is organized as follows. In the following sections, we provide additional definitions concerning portfolios (the next section) and ideas related to writing effective annotations (an analysis of annotation writing from a rhetorical perspective, the subsequent section). The method, results, and discussion sections are devoted to the questions related to effectiveness as introduced above while the implications section focuses on the links to learning. The conclusion highlights the contributions of the work and comments on questions for future research suggested by the analysis.

Professional Portfolios, Annotations, and Open Questions

A portfolio is a collection of work (typically represented by artifacts from that work) assembled for a purpose. While portfolios can be a collection of physical documents, electronic technologies have made it easy for people to put their portfolios online. Once online, portfolios often resemble a typical website with a main page and several supporting pages.

Different types of portfolios stem from the function for which the portfolio is created and the associated audience. For example, professional portfolios represent a collection of work assembled by an author in order to make an argument that they are prepared to contribute to professional practice. Professional portfolios are typically described as something that will be viewed by employers, recruiters, and/or others interested in how prepared an employee is. It is interesting to note that there is little reason to expect such audiences to have common expectations of a portfolio since portfolios are relatively uncommon and few people have formal experience in reading and evaluating portfolios. It should also be noted that if one were going to evaluate the effectiveness of a professional portfolio, it should be done by such authentic audiences rather than by educators in the context of education.

Annotations are a key element of most portfolios. Conceptually, an annotation could be anything (such as a title, a label, a paragraph) that draws attention to specific features of an artifact (e.g., a writing sample, a project report, a picture of something someone has built, an email exchange with professors, or a video clip). In this paper, an annotation is defined as the text that helps the reader know something about the artifact, particularly the claims that are receiving evidentiary support by the artifact. It is interesting to note that not all portfolios feature explicit annotations. For example, an architect's portfolio might contain images of recent projects with no text description. Such an approach may work if the reader of the portfolio knows what to take away from viewing the artifact. Even in such a case, though, the author of the portfolio may miss the opportunity to draw the readers' attention to certain features of the artifact and the related experience, particularly features that reinforce the professionals' abilities. In the engineering context, however, it seems that some type of explicit annotation is likely to be valuable (e.g., such portfolios may be less visual, engineering has less precedence for using portfolios and involves portfolios that highlight more cognitive skills).

When present, annotations are particularly interesting since they may function as the glue of the portfolio, linking artifacts to the professional statement, and could be central to the portfolios'

effectiveness. Further, the production of the annotations may be a key to the learning opportunities associated with portfolio construction broadly since the production of the annotation involves some element of looking back on the artifact and the underlying experience that produced the artifact in order to determine what is important to say.

In our experience in working with students constructing portfolios, we have made several observations which suggest that a focus on annotation writing is warranted. For example, we have observed much variation in how students structure their annotations, such as variation in extent to which first person is used, the use of different types of sentence structures, and the use of different ways to allude to artifact. We have also heard many requests from students for examples or guidelines to guide the writing of effective annotations. We have also witnessed many different reactions to the annotation writing (e.g., a dismissive reaction that focuses on "if it is short, it won't take much effort", or an engagement reaction such as evidenced in the quote above). A concerted effort to understand what makes an effective annotation will be of value in addressing the issues revealed by these observations.

Ultimately, the issue of annotation effectiveness is an empirical one—since the effectiveness of an argument, of text in general, is determined by the audience of that text. However, concepts from technical communication and rhetoric can provide a baseline for such an empirical analysis. The next section discusses what we can infer about effective annotation writing by further analyzing the annotation from a rhetorical perspective.

Annotations: A Rhetorical Perspective

What might we already know about writing an effective annotation for a professional portfolio? Clearly, an annotation for a professional portfolio is an example of one's writing, and as such, it seems without question that the annotation should be well written from a grammar and style perspective. For example, we would expect an effective annotation to be free of spelling mistakes, simple to read, in active voice, and have an easy to follow structure.

But, what about an effective *annotation*? Given the absence of guidelines specifically targeted to this issue, we turn to fundamental issues of rhetorical analysis—exploring what is known about purpose, audience, and genre in order to infer what is likely to contribute to effectiveness [4]. For example, recall that the overall purpose of the professional portfolio is for the portfolio author to make an argument about his/her own preparedness for professional practice and that the function of the annotation is to link a piece of evidence, i.e., the artifact and the experience associated with the artifact into that overall argument. From this, we can imagine that an effective annotation would likely reference the artifact and make clear the nature of the evidence provided by the artifact, would likely use strategies to keep the reader's attention focused on the main argument—an argument about the author—and would likely involve strategies that add credibility to the claims being made. Also, while statements about how the artifact represents evidence of learning might advance the overall portfolio argument about preparedness, it is also likely that statements explaining the artifact as evidence of what one *knows* would be sufficient.

Similarly, we can explore likely characteristics of the audience and imagine the implications for the writing of annotations. As mentioned earlier, the most commonly identified audiences for

professional portfolios are employers and recruiters. Such audiences, and the contexts in which they might be viewing the portfolio, suggest that they would be pressed for time, possibly overloaded with information, and untrained in any thing resembling a "right way" to construct or view a portfolio. They might be looking for very specific information, but also looking for something to break the monotony of their task. Further, the specific task of this audience would be to decide to further consider the portfolio author. This analysis suggests the following potential implications for annotation writing: annotations should be short, make finding relevant information easy, may not need to be complete as much as the source of enticing information, and help demonstrate the portfolio author as fitting in but also standing out.

Finally, we can think more systematically about the genre itself (portfolio, online portfolio) and imagine implications for the writing of annotations. Many guidelines that might stem from the notion of what is expected of a portfolio or an online portfolio have already been mentioned above. For example, we have already suggested that an effective annotation would mention the artifact. We can, in this section, identify additional suggestions by thinking about an online portfolio as an instance of a website. Assuming the portfolio is online, we can turn to guidelines for writing text for informational websites. For example, websites can be traveled (and thus elements read) in any order. As a result, effective annotations will likely be relatively independent from each other and support reading in any order. In addition, website writing guidelines also reinforce the importance of succinct content, something mentioned above as also important for the audience.

The writing suggestions identified thus far in this section, suggestions stemming from purpose, audience, and genre considerations, are likely to be important to the writing of effective annotations. However, effectiveness is unlikely to be the linear sum of all of these ideas. Effectiveness is ultimately judged by the audience and is a complex judgment made by a reader from the audience. In other words, effectiveness is in the eye of the beholder. In making such a complex judgment, the reader does some sort of balance of the above issues (and possibly other issues). Some strategies may be better, or more detrimental, than others and this level of insight into the use of the strategies may be worth documenting. An additional complication here is the notion that "the writer's audience is always a fiction." [5] In other words, the author of a portfolio may not really be able to control who reads their portfolio. Thus, to understand something about effectiveness broadly defined, we really need to understand the views of multiple people in the intended audience.

These ideas collectively lead to three implications for an empirical analysis of annotation effectiveness (i.e., an exploration of the effectiveness of real annotations written by real students in an authentic context). First, an empirical analysis of annotation effectiveness can identify specific strategies for achieving effectiveness (e.g., how to "balance breadth and depth," "fit in but also stand out), find out if all of the suggestions mentioned in this section need to be followed in order for an annotation to be effective, and see what minimum combination of guidelines might be effective. A second contribution of the empirical analysis can be to explore whether there is such a thing as a uniform reaction to effectiveness. A final contribution of exploring annotation effectiveness empirically is that the results can be used to comment on whether students are able to write effective annotations.

Method

We address the questions of 1) what makes an effective annotation, 2) whether there is a singular notion of what makes an effective annotation, and 3) how successfully students can write annotations via data from a study conducted in the winter of 2006.

The portfolio

This study focused on having students create a course-based professional portfolio. Like any other professional portfolio, course-based professional portfolio is involves an argument about the author's preparedness for professional practice. The "course-based" label indicates that the artifacts are meant to be taken from the experiences associated with a single course. In our study, we asked the students to create the course-based professional portfolio via three required components: a statement in the student discussed his/her preparedness, three or more artifacts from the course that supported the claims made in the statement, and annotations for each artifact to explain what the artifact illustrates.

Procedure

Students were introduced to the assignment through a discussion in the second week of the ten-week term and another discussion in the ninth week. During these discussions, students were instructed that the artifacts for the portfolio might include work created in the course (such as homework and design sketches) but also materials that reflect broader aspects of their course experience (such as meeting minutes, team communication, pictures showing them interacting with equipment). The students were further instructed that their portfolios should demonstrate their understanding of the course, their engineering discipline, and their sense of how the skills and knowledge gained through the course have contributed to their understanding of their engineering discipline and their preparedness for engineering practice. Students were also told that the assignment should take around 5-7 hours to complete. The portfolio was due during exam week so that it could be constructed after the project experience was completed. The portfolios were worth 5% of the students' overall grades. Because the portfolios were constructed as a class assignment and received a grade, it is likely that the students considered the instructor as an important audience for the portfolio.

Data collection

In the study broadly defined, we collected the students' portfolios and their perceptions concerning possible assignment benefits via surveys. We also interviewed a subset of the students to better understand their perspectives. In a previously published paper, we reported on some of the results from the surveys and interviews [6]. In another manuscript, we are focusing on what the professional statements from the portfolios reveal about the students understandings of their engineering discipline [7].

In this paper, we focus only on annotations contained in the portfolios we collected. While 35 students participated in the overall study, we were able to collect portfolios from only 27 of these students. Further, two of these portfolios did not contain usable annotations because the students had failed to follow the portfolio creation guidelines. The remaining 25 portfolios contained

seventy four usable annotations (one portfolio only had two artifact/annotation pairs). The analysis of these 74 annotations proceeded via the following three steps.

Data analysis

Our data analysis proceeded in a three step fashion, in accordance with the driving questions:

Step 1—Score for effectiveness: In the first step, the three authors of the paper scored each annotation as having high effectiveness (H), moderate effectiveness (M), and limited effectiveness (L). Among the three authors, two have professional engineering experience, all three have professional experience, two have experience in hiring, and all three have expertise in technical communication. Because this scoring process was meant to capture the perspectives of people untrained in what a portfolio *should* look like, we did this scoring without any a-priori effort to come to a shared understanding of what an annotation should like. Subsequently, we report not only the scores that were assigned to the annotations (in order to give a sense of the students' performance in writing the annotations) but also the level of agreement among our scores. The agreement results address the issue of whether there is a universal notion of "the effective annotation" or whether different people will interpret annotations differently. We refer to this process as scoring, rather than coding, to reinforce the idea that we were not functioning as researchers trying to achieve rigorous (i.e., highly reliable) results, but rather as audience representatives passing the kind of in-the-moment judgment that would be likely in authentic interactions with a portfolio.

Step 2—Use content analysis to determine guidelines for what makes an effective annotation: Upon completion of the scoring activity, we each reflected on own scoring results and prepared a tentative set of guidelines concerning what contributed to an effective annotation (i.e., what features caused us to assign a high score). We then met as a group to discuss the individual sets of guidelines, looking for commonalities and discrepancies, and to understand how these guidelines played out in the annotations in our dataset. The final set of guidelines emerged more as the union of the sets of guidelines rather than the intersection of the sets of guidelines. This came about because we discovered that if our guidelines differed, it was more often a difference of emphasis. For example, two of us found a lack of explicit mention of the artifact to be highly problematic while the third person found explicit mentions to helpful but did not find a lack of explicit mentions to be particularly problematic. The guidelines resulting from this discussion are included in the results section along with examples of annotations that represent the ideas present in the guidelines.

Step 3—The final step of the approach was to compare the guidelines about what content/structure contributes to the effectiveness of an annotation with the theories of learning reviewed in the background. The product of this analysis is included in the discussion.

Results

Part 1: Scoring

The results of the scoring process are presented in Figure 1. This figure captures a sense of the overall effectiveness of the annotations based on averaging the three scores assigned to each

annotation (the x-axis). The figure also captures the level of agreement across the three scorers. This is captured by the stacked bars make it possible to identify the number of annotations receiving the same score across all three scorers (complete agreement) and the number of annotations receiving a particular score by way of either minor or radical disagreement among the scorers.

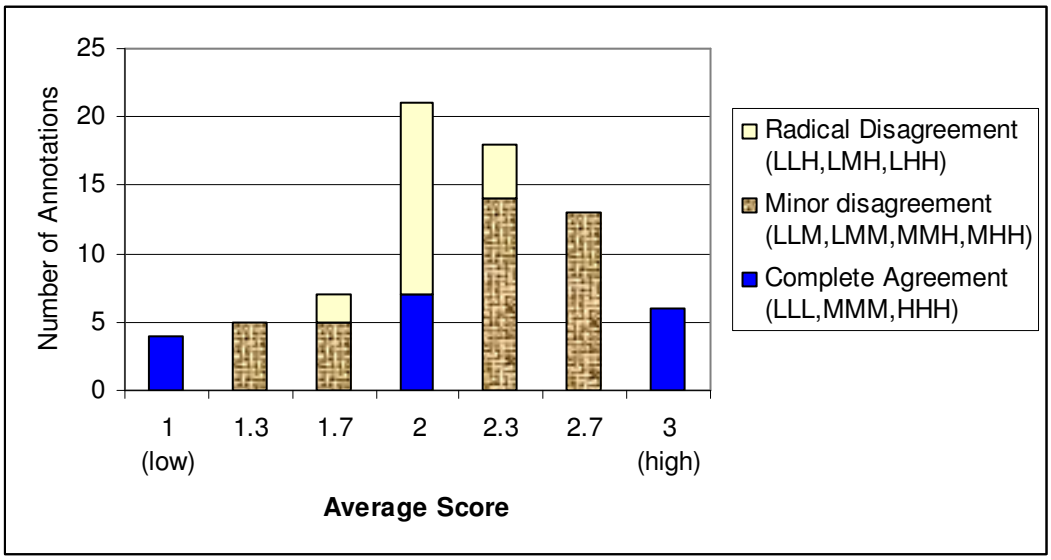

Figure 1. Distribution of the annotation scores.

As captured in the figure, our scoring process revealed a great deal of disagreement in what counts as an effective annotation. In total, we had 17 instances where complete agreement across three scores, 37 instances where there was only a one increment difference (either low and medium, or medium and high), and 20 instances of more radical disagreement (there was a two increment difference between two of the scores). This result suggests that a singular notion of what makes an annotation effective may be inappropriate.

Our scoring results also revealed a great deal of variability in the effectiveness of the annotations produced by the students. We determine an annotation's score by quantifying the scores assigned to each annotation (1 for limited effectiveness, 2 for moderate effectiveness, 3 for high effectiveness) and then averaging. The distribution suggests a tendency toward slightly better annotations, but still suggests room for helping students write better annotations.

Part 2: Guidelines and examples

Many of the annotations had strengths and weaknesses, even those we all rated as "H" or "L". Our discussion of these differences led to the eight annotation writing guidelines that are summarized in Table 1 and discussed in more detail below.

In this section, we discuss these guidelines and show examples of annotations that illustrate how these guidelines help to make an effective annotation. In showing example annotations, we have underlined the parts of the annotation that support the points that we are making. In addition, the annotations are each labeled with a participant number and also a letter that uniquely identifies

which of the participant's annotation is being discussed. In order to ensure anonymity, we have replaced any sensitive information (e.g., proper names, course numbers) with bracketed text. In the limited number of cases where we have used an annotation to illustrate multiple guidelines, we have chosen to repeat the entire annotation in the text in order to preserve the holistic nature of the annotations.

The guidelines that emerged from our study are compiled in Table 1 and are each discussed below. Roughly speaking, the first four guidelines address issues of content which the last four guidelines address issues of how that content is written.

Table 1. Guidelines for writing effective annotations

1. Emphasize yourself in a positive way
    - 1.1 Writing in the first person makes it easier to see that the argument is about you.
    - 1.2 Narrative about the experience that gave rise to the artifact shows that you were there.
    - 1.3 Connecting the experience to past experience is an effective way to emphasize self.
    - 1.4 Avoid mentions of prior ignorance as a way to showcase current knowledge.
    - 1.5 When including information about the class, be certain to keep the emphasis on you.
    - 1.6 Include claims about what you know, not just claims about what is important.
2. Make choices with the audience in mind
    - 2.1 Fit in yet stand out
    - 2.2 Remember that your audience wasn't there
    - 2.3 Anticipate your audience's concerns
3. Link specific phenomena to general engineering principles
    - 3.1 Explicitly state both the general claim about engineering practice and the key engineering concept
    - 3.2 Contextualize the key engineering concept through explanatory text.
    - 3.3 Use the key engineering concept to make a more nuanced understanding of the general claim.
4. Connect to the future
5. Provide details to add credibility, while acknowledging space limits.
6. Work within the genre
7. Acknowledge the artifact
8. Make your annotation polished and professional in terms of grammar, style
    - 8.1 Avoid spelling mistakes, poor stylistic choices, and grammar mistakes
    - 8.2 Establish key points and avoid meandering text

1. Emphasize yourself in a positive way

The annotation serves as an argument about your preparedness to future engineering practices, and thus the reader should easily be able to understand what is being argued about you. The annotation is an argument that you are knowledgeable and that you are ready to contribute. Below are some examples of ways to do this and ways to avoid. `

1.1 Writing in the first person makes it easier to see that the argument is about you.

The following annotation includes first person statements that help the reader see that the argument is about the student.

> TEAMWORK
> This artifact depicts me, [my partner], and [the instructor] standing behind the finished Stirling engine. An important and beneficial part of working as a team is the ability to double-check oneself, and to be able to bounce ideas off the other person. In working together, [my partner] and I served as mutual checking devices, constantly being on the lookout for the mistakes of the other. Some of the work that we did was a division of labor, however, most of the machining and designing of process plans we did together. This allowed us to remain on the same page, and always to understand what the other person was doing and why.
>
> An important part of teamwork is compatibility. My partner and I were fortunate enough to work well together, however, this may not always be the case. In the engineering world, personality screenings are often done to determine which people should work together on a team, and which should not. When personality screenings aren't done, it is important to be able to work together nonetheless, and to focus on the project goals as opposed to personal differences. Many people learned this lesson while working on this project – and produced a successful Stirling engine. (1B)

The following annotation does not include any first person statements, which makes it difficult for the reader to necessarily know what the student is claiming that they know.

> CONCURRENT ENGINEERING
> Many mechanical engineers will design and create products for a career. By using concurrent engineering, the time and cost of manufacturing can be reduced along with improving the quality of the part. This is done by considering how the product will be manufactured when designing the product, which is concurrent engineering.
>
> During the designing process, mechanical engineers should consider what materials are available, how easy it is to form the product, and which machines can be used. This will significantly reduce the time and cost of manufacturing the product because changes can be made during the design process. Without concurrent engineering, changes are made in the manufacturing process, which means another product must be made after the design is changed, costing the company more money and much more time. (12A)

1.2 Narrative about the experience that gave rise to the artifact shows that you were there.
This example shows the students' involvement and experience in troubleshooting, therefore makes this piece of writing credible.

> TROUBLESHOOTING
> When working with different teams each creating a different part of a system, it is possible that many adjustments must be made when fitting all the pieces together. This became evident when working with tight tolerances. During assembly week, it was discovered that some pieces needed to be modified to work properly. The fan we produced made loud noises which we narrowed down to being a certain number of things: loose bearings and oversized holes in two different moving parts. This allowed us to understand what was wrong without the help of the original manufacturers. An adequate solution was applied and the fan ran perfectly. The ability to troubleshoot and understand parts that we didn't produce helped keep the fan on schedule for presentation.

The following example fails to provide any narrative about the learning experience, and as a result, it is unclear whether the student was actually in the experience.

> MATERIALS
> Part size and shape may be defined well by the diagram of a part, but an important thing to consider is the part material. Knowing how to work with different material, and why to choose such material is very important.
>
> Working with different materials through this lab, we needed to know cutting speed of the tool, or how fast we needed to remove material from the piece. Removing material at incorrect speeds could result in a built up edge or an imperfect surface finish.
>
> In class we studied how to calculate speed from different material properties, and we also used this information in manufacturing of our parts. (10B)

1.3 Connecting the experience to past experience is an effective way to emphasize self.
In the following annotation, the student connects the learning experience not only to future activities but also past activities (thus situating the lesson in a continuity of experience). This technique really reinforces the skills/contributions of the student and is convincing that the student really understands what they will do with the new insights.

> MACHINE SHOP SKILLS
> When I did an internship at […] in Munich, Germany I recall a number of times that I was sent downstairs to the machine shop floor where I had to interview the machinists. I had to determine things such as, "what are the dimensions of the wrench they plan on using for this task?" or "is this procedure feasible?"
>
> Before [this class] I had only a vague idea of what a mills and lathes were. However, being required to complete a project using these tools quickly taught me much about these machines. I learned how they operate, what they are capable of, how time consuming they are, and how much effort it takes to make a part. With this new found first hand knowledge of the machine shop, the next time I am required to speak with a machinist I will much more effectively be able to ask questions of them and make use of their responses.
>
> The attached artifact is a picture of a stirling engine fan. While it is extremely similar, it is not actual engine built in the course. However, the picture still demonstrates the machine shop skills acquired in order to build such a fan. (21B)

1.4 Avoid mentions of prior ignorance as a way to showcase current knowledge.
In the following three excerpts, the students draw attention to their new insights by characterizing the limits of their knowledge prior to the class. While such a technique is not inherently bad, it does remind the reader of the students' naiveté. What is salient is that none of the students needed to so strongly portray their ignorance in order to draw attention to the lesson in the annotation.

> MACHINING PROCESS

The machining process is an important part of any engineering process, and this class was really the first instance where I've actually implemented it and carried it out. (4B)

PROCESS PLANNING, TEAM WORK, AND THEORY
At first, creating process plans seemed like an unnecessary step. (16A)

BULK DEFORMATION
Bulk deformation is a commonly used manufacturing process that we learned about in class. This topic was of particular interest to me because I previously didn't know much about it. (19C)

The following example shows how a slight tweak in language can get at the same thing without so starkly alluding to ignorance.

PROCESS PLAN
Engineering problems can be approached in several ways. Approximations can be made; complex equations can be written and solved; and, even guessing the answer can work sometimes. Yet, in this class, I learned a more organized and more efficient approach that can save me significant amounts of time and effort. (7C)

1.5 When including information about the class, be certain to keep the emphasis on you.
A portfolio author needs to keep in mind that the reader of the portfolio is trying to learn something about the student, not about the class, or about engineering in general. As a result, the annotations need to make it clear what the reader is learning about the student. In the following example, a casual reader reading the first part of the second paragraph might jump to the conclusion that the point is going to be about the class. Fortunately, the student does bring the attention back to himself in the third sentence.

MANUFACTURING PROCESSES
When an engineer designs a product, he/she has to know how to manufacture the product economically. Many great inventions have been made, but they are not produced. Why? Because they are too expensive to build! That is why a great invention has to be relatively cheap to manufacture.

The artifact below is a portion of the syllabus of the course. The objective of this course is to provide us students with an overview of the many manufacturing processes. I learned that there are actually many ways to manufacture the same product. For example, you can manufacture a steel cube by machining or by bulk metal deformation. Machining is typically gives more precise result than bulk deformation, but is usually more expensive. This cost and quality factor is very important especially when you are manufacturing huge quantities of products. (5C)

The following example shows how an annotation can inadvertently emphasize something other than the student.

MIDTERM #1
This gives an indication of the kinds of things we are expected to remember on a midterm exam. The first problem is part of a machining process that we needed to diagram for two different cases. The middle two problems are examples of parameters we would be expected to calculate numerically. The last problem requires us to explain qualitatively how factors in machining affect the outcome of the part. The tests were closed-book, closed-note to reflect the importance of memorizing the

integral manufacturing concepts. For most of the students in the class, the concepts covered will be used as a background to allow them to specialize in other areas directly unrelated but inextricably tied to manufacturing. For most of the students in the class, the concepts covered will be used as a background to allow them to specialize in other areas directly unrelated but inextricably tied to manufacturing. (9A)

1.6 Include claims about what you know, not just claims about what is important.
The following example includes such explicit claims about what the student knows:

MACHINING
Machining was the theoretical topic covered in the class that we also gained hands on experience performing. We built a sterling engine powered fan, and one of my tasks was to build the power cylinder. In the process of building this part, I learned the basics of how to use a lathe, a mill, saws, grinders, and various other tools commonly used in a machine shop. Learning the how to use these tools will help to minimize the amount of mistakes I make in the future when designing parts that will need to be machined. For example, because of the hands on experience I gained in this class, I have a good idea about what types of cuts are possible on lathes and mills. Therefore, I will be able to avoid designing parts using shapes that are not capable of being cut on a lathe or mill if I know that those machines will be used for manufacturing the part. (19A)

Whereas this example shows an absence of claims about what the student actually knows:

MATERIALS
Part size and shape may be defined well by the diagram of a part, but an important thing to consider is the part material. Knowing how to work with different material, and why to choose such material is very important.

Working with different materials through this lab, we needed to know cutting speed of the tool, or how fast we needed to remove material from the piece. Removing material at incorrect speeds could result in a built up edge or an imperfect surface finish.

In class we studied how to calculate speed from different material properties, and we also used this information in manufacturing of our parts. (10B)

2. Make choices with the audience in mind

The typical audience for a professional is busy, often looking at a lot of portfolios in succession. Given this context, you need to fit in with their expectations yet stand out, you need to provide sufficient context for your learning and for the artifact and you need to anticipate factors that the audience could consider important.

2.1 Fit in yet stand out
While an effective annotation clearly needs to address core issues of concern to the reader, that very reader may get fatigued if confronted with page after page after page of similar text. As a result, variations in writing style can be one way to make the text stand out, and thus increase the likelihood that the reader will engage just a bit further. The following example shows how a distinctive conversational tone can attract the reader's attention:

MANUFACTURING PROCESSES

When an engineer designs a product, he/she has to know how to manufacture the product economically. Many great inventions have been made, but they are not produced. Why? Because they are too expensive to build! That is why a great invention has to be relatively cheap to manufacture.

The artifact below is a portion of the syllabus of the course. The objective of this course is to provide us students with an overview of the many manufacturing processes. I learned that there are actually many ways to manufacture the same product. For example, you can manufacture a steel cube by machining or by bulk metal deformation. Machining is typically gives more precise result than bulk deformation, but is usually more expensive. This cost and quality factor is very important especially when you are manufacturing huge quantities of products. (5C)

2.2 Remember that your audience wasn't there

By its nature, the portfolio task is about using your prior experience to provide evidence of some future ability. It is possible, however, to talk about that experience in a way that alludes to details a reader may not understand, and care needs to be taken to avoid this situation. In the following example, the student has referred to two people by name, people who the reader would be unlikely to know (note that we have used pseudonyms in the example).

PROCESS PLANNING, TEAM WORK, AND THEORY

At first, creating process plans seemed like an unnecessary step. However, once we wrote them, their importance was very apparent. Process plans outlined what we did and did not know in machining. Seeing what we did and did not know, by writing it down, helped us become humble and very dependent on Bill and Susan. Process plans also helped us remember what we were working on, since we were only able to go to the lab twice a week. Since this was our first experience with the machines, it is very easy to get lost and/or confused with the machines. Process plans were a great reminder to help us remember where we left on and what we should do. Process plans also helped us keep a time frame of what we were doing. There was a chart where we would put how much time we spent on each process. This time frame showed me that the amount of time it takes to do a process is about three times longer than what we originally thought. The process plans also helped keep us on track because we could see how many more steps we had to go before we finished that process. (16A)

2.3 Anticipate your audience's concerns

Another strategy for writers might be to address the readers concerns. In the example below, the student is acknowledging that a feature of their assignment—being given rather inadequate drawings—is actually likely to be a characteristic of future work experiences rather than simply a difficulty imposed arbitrarily by the instructor.

FAN PROJECT

1. The Fan Project - Teamwork, Machining, Process Planning

The single most important part of this course was the fan lab. This lab provided us with what seemed to be rather inadequate drawings for a project that we were to complete with a team of students that were not even working along side each other. This was a great representation of industry and the communication and collaboration that is required in order to complete a task for a customer by utilizing ideas such as outsourcing, plant specialization, and offices with multiple locations. It takes a great deal of meticulous detail from everyone on the team in

order to have a functional part in the end. If one part of the team is in error, the entire project fails. (27A)

3. Link specific phenomena to general engineering principles

Annotations serve to connect the specific (a particular artifact) to the more general claims about preparedness for engineering practice found in the professional statement. An effective annotation makes this connection explicit first by highlighting a key engineering concept or phenomenon associated with the artifact, and second by relating this concept or phenomenon with larger constructs, such as values or norms in "real world" engineering practice.

In the following annotation, the participant begins with general statements about the value and utility of teamwork in engineering practice. Going from the general to the specific, the participant then describes a key element of teamwork – coordination between sub-teams – and the positive impact it had for the course group project.

TEAMWORK: ANNOTATION 2

A very important aspect of engineering is teamwork. Very rarely does an engineer work alone on a project. Instead, engineers must work and rely on each other to complete a project. This aspect of engineering was taught to us during the [course] lab.

Throughout the quarter, students of [this course] worked on building a sterling fan. We worked together as different sub-teams. Each team was responsible for specific parts of the fan. This taught us teamwork. We all had one goal, yet we all performed separate tasks to achieve our shared final goal. Coordination with different sub-teams was paramount for our sterling fan to operate correctly. Strict tolerances required exact dimensions and modifications to plans required communication between the different members.

In the end, using we made a magnificent sterling fan that required cooperation and effort from everyone in the class. (20B)

What about this juxtaposition of general statements of engineering practice and the specific details of personal experience made this annotation so impactful for the reviewers? The answer to this question leads to the following sub-principles.

3.1 Explicitly state both the general claim about engineering practice and the key engineering concept

The above annotation includes:

a) General claim about engineering practice – "Instead, engineers must work and rely on each other to complete a project."
b) Key engineering concept – "Coordination with different sub-teams was paramount for our sterling fan to operate correctly."

3.2 Contextualize the key engineering concept through explanatory text.

In this example annotation, the participant provides enough detail for the reader to understand the presence of sub-teams and the need for coordination.

Throughout the quarter, students of [this course] worked on building a sterling fan. We worked together as different sub-teams. Each team was

> responsible for specific parts of the fan. This taught us teamwork. We all had one goal, yet we all performed separate tasks to achieve our shared final goal. Coordination with different sub-teams was paramount for our sterling fan to operate correctly. Strict tolerances required exact dimensions and modifications to plans required communication between the different members.

3.3 Use the key engineering concept to make a more nuanced understanding of the general claim.

The author of this annotation begins with the claim that teamwork is valued in engineering practice, noting that engineers "must work and rely on each other to complete a project." The key engineering concept statement further elaborates the reader's understanding of teamwork by introducing the idea that teams themselves must collaborate with one another in service of a higher purpose.

In terms of educational value, it is important to note that these rhetorical qualities also assist the instructor to evaluate the relative quality of a students' portfolio. The key engineering concept with its explanatory text can serve as the "lesson learned," while the general claims about engineering can serve to illustrate the student's ability to link current learning to the wider professional context.

It is interesting to note that those reviewers who felt that an effective annotation needed to explicate key attributes of the related artifact found this annotation to be highly effective when it makes no mention of the artifact at all.

4. Connect to the future

An effective annotation links the participants' current work with their future engineering practice. Either in academia or industry, it's always good to ask "What's next?"; it is the same case with professional portfolios. And in this context, readers might be interested in "so what?"; "what does it have anything to do with your future engineering practices?"; "are you prepared for your career?" Therefore, a look into the future may make all their past efforts worthwhile, and make the portfolio a whole story, as illustrated by the following example:

> MACHINING
> Machining was the theoretical topic covered in the class that we also gained hands on experience performing. We built a sterling engine powered fan, and one of my tasks was to build the power cylinder. In the process of building this part, I learned the basics of how to use a lathe, a mill, saws, grinders, and various other tools commonly used in a machine shop. Learning the how to use these tools will help to minimize the amount of mistakes I make in the future when designing parts that will need to be machined. For example, because of the hands on experience I gained in this class, I have a good idea about what types of cuts are possible on lathes and mills. Therefore, I will be able to avoid designing parts using shapes that are not capable of being cut on a lathe or mill if I know that those machines will be used for manufacturing the part.(19A)

Here are another two cases that we thought orienting to the future makes an annotation effective:

> IMPORTANCE OF TEAMWORK

> The stirling fan produced by the class is a perfect example of how teamwork, when effectively orchestrated, can result in a finely tuned piece of machinery. Numerous groups had to work together, and within themselves, to make individual parts that would seamlessly mesh with one another. Communication was very important in this situation, considering the tolerances associated with several parts. One part within the assembly made incorrectly affects the entire project, usually catastrophically, and leads to down time. Tight teamwork helps to eliminate potential downfalls and increases productivity. These skills will help students to become valuable assets to a company in the future. (3A)

For the last sentence of the above annotation, we thought it was a very nice conclusion by summarizing that benefit of the skills learned in the lab to their future career. Though linking their annotation to the future may not necessarily demonstrate participants' preparedness to the future career, it does give readers a sense that they are in the process of getting prepared.

On the whole, thinking into future demonstrates participants' horizon of knowledge, adds the evidence of their preparedness for the future career; therefore, makes annotations effective.

5. Provide details to add credibility, while acknowledging space limits.
Detail is a means of adding credibility in an argument, in this case an argument that you know something, that your knowledge is evidenced by your artifact, and the experience it came from. In the context of annotations, at least three types of detail are possible: details about the experience, details about the artifact, and details about the concept/skill being linked to. What came out of our scoring activity was that we, as audience representatives, did not necessarily expect a single annotation to have all three types of detail but that it was important for an annotation to touch on at least one of these. In fact, given the salient constraint of space in writing an annotation, it might be difficult to address all three types of detail while acknowledging the space constraint. Below is an example containing details about the engineering concept/skill being claimed.

> FAILURE ANALYSIS
> To be effective in failure analysis, an engineer must have a sound understanding of mechanical theory and processes. Depending on the component application, the engineer may need to possess knowledge about other disciplines as well.
>
> When components break, it is often up to the Mechanical Engineer to determine the cause of the failure. The Mechanical Engineer may also be expected to offer insight on how to correct and improve the failed product.
>
> There are numerous causes of failure that can range from crack propagation, fatigue, or corrosion among other things. And normal wear and tear will occur with products. However, there are times when products may fail sooner then expected. This may occur due to imperfections that stem from poor manufacturing. For example, a component that was manufactured through a casting process may fail by cracking due to small voids left in the cast. This is called porosity. These voids reduce the strength of the material and the component will be susceptible to lower stresses.
>
> Understanding the casting process and the theory behind it is one of many manufacturing processes that a Mechanical Engineer needs to be well versed in.

To the right is an artifact of a Casting PowerPoint lecture by [the instructor]. (18C)

6. Work within the genre

While this analysis has focused on the annotations individual, each annotation is part of a larger whole—the overall portfolio. Allusions to other parts of the portfolio (such as in the example below) can serve to unify the portfolio and create a holistic product.

MACHINE WORK
As discussed at length in my statement, learning how the other side lives, so to speak, is a very good thing for mechanical engineers. I got first hand experience in the difficulties inherent in machining parts, which definitely increased my appreciation in what the people that do that for a living bring to the table. It takes a meticulous attention to detail as well as a keen problem solving mind to figure out how to machine something, and especially how to machine something right. Another striking aspect of working in the shop was how long even the most seemingly mundane tasks take to complete. (22C)

Because the portfolios are implemented online, they inherit considerations appropriate for online content. One such consideration is that the reader cannot be assured that the content will be read in any particular order. As a result, it makes sense to avoid allusions to a particular order, such as is present in the following example.

TEAMWORK EXPERIENCE
Teamwork experience is another thing I gained from the fan project (lab session). The project, from building and assembling the fan to fine-tuning, is done by a large group of students. Students are divided into several sub-teams. Each sub-team is responsible to making some parts. All parts are the essential components of the fan and they need to fit other parts well in order to function well. Therefore, communication between groups is important because misunderstanding between groups will cause parts does not fit or malfunctioning of the fan. Intra-group communication is also important. For example, my teammate and I have a good understanding of whom is responsible of obtaining tools, measuring dimension, controlling the machine and cleaning up the space, so we were able to finish our parts early. Also, when one of us made mistake, we would not blame on each other, instead, we helped each other out and speed up our process to makeup the time we lost. In the fine-tuning process, all of the team members bring up possible solution. This helps to find the best solution in a short period of time. Ultimately, we built a well-running and beautiful fan as shown in the picture as a result of good teamwork. (24A)

7. Acknowledge the artifact

An effective annotation acknowledges the artifact itself. A primary function of the annotation is to give sufficient explanation about the relationship between the artifact and the claims that are being made about the student.

Here is an example of an effective description of the artifact:

PROCESS PLAN
The development of process plans in this class created an understanding of the thought process behind both manufacturing a part in a shop, and the value of having a detailed plan for any procedure. Included is the

> first process plan that we wrote. It was quickly realized that making the part had to be broken into very small steps. This allowed us to accurately budget time. To ensure that the part was produced correctly, adding explicit detail also became necessary. Ideal process plans included tool speed and type, desired depth of cut, how to clamp or hold the work piece, how to lubricate and many other pieces of information. This kind of detailed plan can easily be carried over into the workplace in work instructions, assembly instructions, or product development plans. While the plan included was an unrealistic and rather limited attempt from the beginning of the quarter. This class built the ability to make a useful and concise plan for implementing any procedure. (8C)

8. Make your annotation polished and professional in terms of grammar, style

If the professional portfolio is an opportunity for a student to create and communicate professional competence, the portfolio itself becomes a surrogate for that competence. The reviewers found that the quality of the writing itself became a persuasive aspect of professional preparedness.

8.1 Avoid spelling mistakes, poor stylistic choices, and grammar mistakes

In product development, for example, researchers can encounter "showstoppers," product bugs that limit or nullify the product's usability. Similarly, several annotations in this study contained enough spelling errors or poor stylistic choices that reviewers rated them as being of low effectiveness regardless of the content. As a result, even though the student was not actually trying to make a statement about their communication skills, the student nevertheless did. The following example was contains a number of such spelling and grammatical errors:

> One thing learned in the class room was the science behind Machining. This picture shows a diagram of turning on a lathe and a shaper moving through apart. We learned about calculating the amount of energy required to remove a cretin amount of material, how to increase production wile maximizing tool life, and how heat effects the efficacy of a cut.
>
> The picture shown is a diagram taken directly form [the instructor]'s lecture and labels some of the terms used in machining such as feed, face, chip, tool, and cutting motion. It help to learn this terms in the class room and then use them in the shop.

8.2 Establish key points and avoid meandering text

Another annotation quality that undermined the effectiveness of the annotation was the existence of text that meandered around a subject, without a clear take-away for the reader. It is difficult to judge an annotation effective when you simply do not understand the point or points being made. The following annotation illustrates this point:

> HOMEWORK
> This aspect of the class was very similar to other engineering classes I have taken, although slightly more conceptual. Most classes in our degree are strictly computational with little or no 'writing.' However looking at these homeworks, there is a blend of conceptual topics and calculations. This is the first step in the whole design process. It is the basic building block or foundation that is necessary to design something. For example the theory of machining must be known in order to make a drawing because it defines the limitations in the machine shop. In addition the stresses and strengths must be calculated initially to begin with dimensions and materials. So the design process begins with this category and couldn't go forward without it. Mistakes in this area would

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greatly increase cost and decrease efficiency by requiring the more
testing and production.
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Here the reader may be confused about the subject of the annotation and how that subject is an indication of the student's professional preparedness.

Seen through the lens of instructional assessment, the professional portfolio can reveal much about the student's knowledge of engineering and its application in a professional setting. These annotations, however, suggest that some students are not prepared for the professional communication requirements of industry: writing reports and proposals, preparing presentation slides, etc.

But to what extent are our engineering schools committed to ensuring that undergrads are well-versed in such preparation? How are schools working with students to bring their communication skills up to a level of competence acceptable for industry?

Discussion

In this paper, we have reported on the results of 1) a scoring exercise to determine the effectiveness of artifact annotations taken from professional portfolios written by engineering students and 2) a thematic analysis to determine the qualities of the text that contributed to the judgments of effectiveness. We engaged in these activities in order to more deeply understand what is entailed in writing an effective annotation and also to explore the link between writing such effective annotations and the opportunities for learning afforded by the activity.

The results revealed a great deal of variability in the scoring of effectiveness across scorers. While the conditions of the scoring may have contributed to this result (scorers were instructed to score the annotation according to their "gut" and annotations were scored out of the context of the overall portfolio), such conditions were not considered inappropriate for the underlying issue in question (whether readers will view effectiveness similarly). This result of variability suggests that a binary notion of annotation effectiveness across all audiences may be inappropriate—rather different readers may have different impressions of effectiveness, there is no one right way formulate an annotation. This result is not altogether surprising given the conditions noted in the background—readers are unlikely to have much experience and/or training in how to review a portfolio and readers may be quite variable in what they are looking for and expect. If we imagine that a determination of effectiveness involves a complex, composite judgment that combines several features of the annotation, then we can imagine that the differences among scorers is less a difference in what might be considered in the complex judgment but rather a difference of priorities. The implication of this result for grading of portfolio annotations is to be careful about suggesting to students that there is one right way or prescribing a template for writing annotations.

The scoring results also revealed a great deal of variability in the annotation scores. This result suggests but does not necessarily imply that variability in student *ability* to write effective annotations. Given the students created the annotations with minimal commitment of time, with minimal instruction, and may have had difficulty disambiguating the authentic audience of a professional portfolio from the salient audience of the portfolio (the instructor), it is possible that

the effectiveness of these annotations is not completely indicative of the students' ability to write effective annotations. Nonetheless, the variability in effectiveness scores suggests that students would benefit from support to help them write effective annotations, something we sought to address via the thematic analysis and the resulting guidelines.

We used thematic analysis, guided by the effectiveness scores, to identify guidelines for writing effective annotations and illustrated these guidelines via positive and negative examples. In this analysis, we paid particular attention to understanding why we sometimes had complete agreement concerning the effectiveness of an annotation and sometimes had radical disagreement concerning the effectiveness of an annotation. The resulting guidelines point to features of the annotation (e.g., content, structure, style) that were found to contribute to effectiveness, although such features were not always considered necessary by all scorers. The eight high level guidelines that emerged from this analysis are listed below:

1. Emphasize yourself in a positive way
2. Make choices with the audience in mind
3. Link specific phenomena to general engineering principles
4. Connect to the future
5. Provide details to add credibility, while acknowledging space limits.
6. Work within the genre
7. Acknowledge the artifact
8. Make your annotation polished and professional in terms of grammar, style

One caveat to these results is that they are based on the writing of annotations for *course-based professional portfolios*, and one may wonder about their appropriateness for other types of professional portfolios. We, however, can think of no reason why the guidelines would not be generally appropriate.

Educational Significance

The final issue we address in this paper is how the writing of annotations, specifically effective annotations as defined by the guidelines above, can support educational goals within engineering. Because we did not collect pre-post data concerning learning outcomes, this analysis does not focus on what did happen but rather the space of what could have happened. Instead, we connect theoretical issues to the guidelines to make inferences about how the writing of the annotations would lead to learning. For example, at a fundamental level, practice is widely recognized to lead to learning. Clearly, the writing of effective portfolio annotations involves practicing certain communication skills such as thinking about audience (linked to guideline #2), working with portfolio and online formats (linked to guidelines #6 and #7), adding appropriate amounts of detail (linked to guideline #5), and simply writing polished sentences (linked to guideline #8); and thus we can make inferences that students writing annotations consistent with such guidelines would have the opportunity to improve their communication skills as a result of the annotation writing. Below, we address two more profound issues we believe that annotation writing might support: increasing the students' ability to transfer their learning to new contexts and contributing to the development of engineering identity.

As stated by Lobato in a special issue of the Journal of the Learning Sciences devoted to transfer of learning [8], "A central and enduring goal of education is to provide learning experiences that

are useful beyond the specific conditions of initial learning." p. 431. Stated broadly, helping students generalize what they have learned is often considered key to increasing the likelihood of the transfer of that learning to future activity. Turning to the guidelines, we can see that guideline #3 involves connecting specific experiences to general engineering issues, and thus students would need to grapple with how to generalize the lessons from their experience in order to write annotations that conform to this guideline.

In a recent study of transfer, Engle [9] has argued that "transfer is more likely to occur to the extent that learning and transfer contexts have been framed to create what is called intercontextuality between them" and that "intercontextuality occurs when two or more contexts become linked" p. 456. She further argues that ways to accomplish this include 1) helping learners see the two contexts as temporally related and 2) "framing learners as authors who are engaged with a broad community of people" p. 257. Again, these issues can be mapped to specific guidelines. For example, guideline #4 advises a student writer to explicitly connect to the future in their annotation. In doing so, a student's attention would be drawn to connecting the present and the future, and thus could contribute to establishing the linkage between these two contexts. Guideline #2 involves issues of audience and specifically draws attention to the role of an annotation as being a place where a student shares their knowledge with someone else, someone likely outside of academia. A student, following this guideline, would be engaged in sharing their knowledge with the broader community (beyond the classroom and the university) as highlighted by Engle.

In summary, by writing annotations that conform to guidelines #2, #3, and #4, a student's attention would be drawn to generalizing their knowledge, establishing intercontextuality between the present and their engineering future, and framing their knowledge as relevant to a broader community, and, as a result, the writing of the annotations could actually impact the potential for the transfer of the learning to future engineering activity.

Turning to identity, recent work in engineering education has focused on the issue of identity development as a key issue in engineering education. Identity has to do with belonging and inclusion. Identity development is of interest in engineering education because students are not just learning the knowledge and skills associated with being engineers; they are also supposed to be becoming engineers. To use the terminology of Gee [10], while we are mostly concerned with engineering students becoming engineers in an institutional sense (they will get certified as engineers and accepted in society as engineers because of their degree), we are also concerned with them understanding why they are ready to have the institutional identity of engineer (they themselves think they are ready, they know why they are ready). According to Sfard and Prusak [11], identity can be thought of as "a set of reifying, significant, endorsable stories about a person" and that "learning may be thought of closing the gap between actual identity and designated identity, two sets of reifying significant stories about the learner that are also endorsed by the learner" p. 14. Using this language, "engineer" is the designated identity and engineering education is about helping students take on this identity.

Applying these ideas to the writing of effective annotations, we can note that students can achieve an institutional engineering identity by being hired as an engineer and the writing of effective annotations, particularly annotations conforming to guidelines #1-#4, can help this

process by helping audiences see why students should be hired. In particular, annotations written according to guideline #1 would have the form of stories about the student, specifically "reifying, significant and endorsable stories" about the student. Further, these stories will be about the student in terms of his or her qualifications relative to the designated identity of engineer (linked to guideline #3). Finally, by making these arguments with the audience in mind (linked to guideline #2) and connecting to the future (linked to guideline #4), the annotations can play a key role in helping someone with hiring authority to understand the student's potential value and thus may contribute to the student's chance of getting a job and being allowed to have the institutional identity. In a shorter term, the writing of such annotations may serve to help the student understand his or her own readiness to work as an engineer. Further, if the making of these arguments helps students to self-identify holes or gaps in their knowledge, gaps that they can take initiative to address on their own, then this could contribute, in turn, to ongoing identity development.

Conclusion

This paper was motivated by issues of helping students create effective professional portfolios and the educational significance of that activity. To narrow the issue, we looked specifically at the effectiveness of annotations of artifacts included by engineering students in engineering professional portfolios and reported on a multi-rater scoring of effectiveness and the writing guidelines that emerged from a discussion of the scoring results. We then interpreted the results collectively with an eye toward the learning opportunities that could be afforded by the writing of effective annotations (and the learning opportunities that might be missed when students are focused on creating annotations to persuade their audience rather than document learning). Overall, the results provide an understanding of how professional portfolios may be seen by readers, a benchmark of students' abilities to write effective annotations with limited guidance, and resources to help the students (and educators) succeed. Ultimately, we believe the results provide additional support for the potential learning benefits of having students create professional portfolios as a legitimate learning activity and set the stage for future research to document such learning opportunities more definitively.

Acknowledgments

This work has been supported by the National Science Foundation through grant REC-0238392, "Using portfolios to promote knowledge integration in engineering education." The authors wish to thank all of our research participants. The authors also wish to thank the members of the Laboratory for User-Centered Engineering Education and the anonymous reviewers for providing comments that helped to shape this paper.

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