Showcasing Interdisciplinary Capabilities: Employers' Perceptions on Reflective ePortfolios

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Abstract

Disciplines in isolation cannot furnish solutions to the world's complex problems. Trends within the materials science and engineering fields revealed materials development was slow to offer solutions for the practical needs of advancing technology. The Materials Genome Initiative (MGI), announced by the White House in 2011, recommended an interdisciplinary approach utilizing an informatics framework in materials discovery and development. With more employment opportunities brought about by the MGI, it is important to teach the next generation of engineers and scientists how to show employers their interdisciplinary capabilities. Creating an ePortfolio is a common, useful solution in engineering education. Students not only can display their learning experiences and research projects, but also can enhance their reflection ability, a critical skill for interdisciplinary education and research. However, few ePortfolio studies have indicated the perceived value employers have on a student's reflective ability. To fill the literature gap and provide suggestions on developing ePortfolios, our study investigated how a reflective ePortfolio enhances student's competitiveness for future positions from the perspective of employers. We recruited seven doctoral students from an interdisciplinary program designed at the intersection of materials science, engineering design, and informatics as a response to MGI's call. With the completion of two-year training, these students have finished their ePortfolio including personal profiles, learning experience, and reflection posts. We invited employers from the academia, industry, and national lab to review their ePortfolio and complete a survey. Based on the results, we presented comprehensive suggestions for developing an impactful ePortfolio.

Introduction

The utility of the singular disciplinary approach in higher education is dwindling, as solutions for today's most complex problems often require multidisciplinary and interdisciplinary perspectives. For instance, trends within the materials science and engineering fields suggest that materials development is slow to offer viable solutions for the practical needs of advancing technology [1]. To address these concerns, the Materials Genome Initiative (MGI), announced by the White House in 2011, recommended an interdisciplinary approach in engineering education by employing an informatics framework to further enhance materials discovery and development [1]. While such initiatives provide educators with guidelines for developing

interdisciplinary programs, there is an equal importance to teach the next generation of engineers and scientists how to thoughtfully showcase their interdisciplinary capabilities, especially to future employers.

Developing an ePortfolio may be one way to showcase such skills because students are able to display their learning experiences and research projects. Through this medium students can also enhance their ability to critically reflect, a vital skill for interdisciplinary education and research [2]. In regards to employers' perspective on ePortfolios, a study conducted in 2008 showed 75% of employers were not familiar with the purpose of ePortfolios [3]. The utility of ePortfolios has expanded and evolved rapidly over the past decade [4]. For instance, a recent study emphasized that, based on employer's opinions, the advantages of developing ePortfolios included the ability to (1) differentiate a candidate, (2) evaluate potential fit and future with a company, and (3) display a candidate's traditional application materials using new and unique online media within a website [5]. Such findings highlight the use of ePortfolios as a potential hiring tool for current employers.

The research also shows employers rated the About Me profile and the Academic Projects webpage as impactful [5]. Compared to traditional application materials (e.g., CV, resume), the About Me profile can reveal if the student's personality fits within the organization's work culture, while the Academic Projects webpage describes the student's completed work and experiences in greater detail. Although reflection is a crucial part in developing an ePortfolio [6, 7], few studies have investigated the perceived value a student's reflective ability has for/on employers. Therefore, more evidence is needed to understand the value of using ePortfolios to showcase students' interdisciplinary thinking and critical reflection, especially in consideration of current employer's needs.

This study aims to fill the literature gap and provide future engineers and scientists with suggestions on how to develop strong ePortfolios by exploring how a reflective ePortfolio enhances student's competitiveness for future positions from the perspective of employers. The three research questions (RQs) are: (RQ1) what is the value of an ePortfolio for employers? (RQ2) how does a student's ability to critically reflect and think interdisciplinarily within an ePortfolio influence their competitiveness for future positions? (RQ3) what are employers' suggestions on developing an ePortfolio?

In this exploratory research, we recruited seven students from an interdisciplinary doctoral program at a research-intensive university, designed at the intersection of materials science, engineering design, and informatics as a response to MGI's call. By the end of this two-year training, students are required to complete individual ePortfolios that include personal profiles, relevant learning experiences and outcomes, as well as reflection posts. We invited ten

employers across the industry, national laboratories, and academia to review the students' ePortfolio. Based on the results perceived by potential employers, we present comprehensive suggestions for students to develop an impactful ePortfolio.

ePortfolio Development

Within this interdisciplinary program, the ePortfolio is part of a required course that does not count towards a grade (e.g., zero credit). Students created their ePortfolios as part of the program's first semester program-based learning and writing communities (i.e., Spring 2017). The learning community's goal is to enhance a student's professional skills (i.e., critical thinking, interdisciplinary communication, interdisciplinary collaboration, ethical behavior, and organization/management skills), whereas the writing community focuses on improving academic and professional writing skills. Figure 1 presents a student's development of an ePortfolio aligned with their programmatic and education experiences.

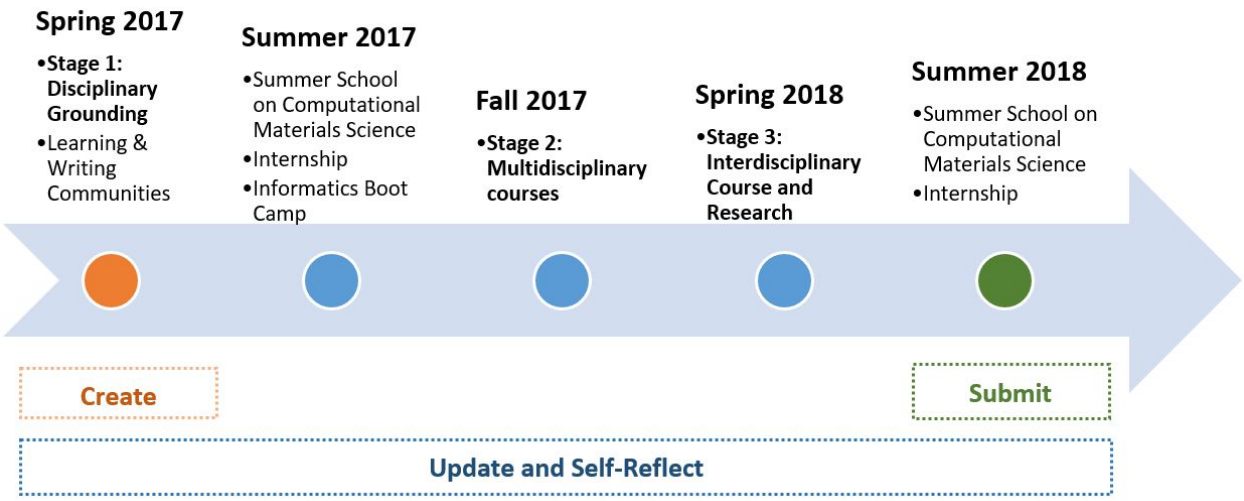

Figure 1: ePortfolio development

The ePortfolio platform students used was Google Sites. To minimize the tediousness of creating a website completely on their own, students were provided with an ePortfolio template, as well as detailed instructions on how to navigate and develop their Google Sites. Two major components of the ePortfolio include the personal profiles and learning portfolio (see Table 1). These sections allowed gave students the opportunity to introduce themselves and provide basic information about their personal lives. The learning portfolio was utilized to showcase their learning experience, learning outcomes, and self-reflection.

Table 1: Components suggested in the Template

Personal Profile	● Biography ● CV ● Skills
Learning portfolio	● Learning experience (e.g., Courses, Activities, Special Projects, Publications, etc.) ● Learning outcomes ● Reflection Posts

The ePortfolio development spanned three interdisciplinary training stages; disciplinary grounding, multidisciplinary courses, and an interdisciplinary course and research [8-12]. Students were encouraged to self-reflect on their entire learning and research experience. At the end of the last semester in the program (i.e., summer 2018), students were required to submit their ePortfolio. External reviewers representing potential employers were invited to give feedback. Students were encouraged to continue improving and developing their ePortfolio based on the feedback, even after completing the two-year interdisciplinary training.

Methods

Participants

Seven doctoral students and ten employers were recruited for this study. Each student gave written informed consent to participate in program-related research prior to acceptance into the current program, including permission for reviewers to access and review their ePortfolios. Additionally, each potential employer completed informed consent for this particular research. The doctoral students (Table 2) are trained by this interdisciplinary program. During the training (i.e., from spring 2017 to summer 2018), students are required to develop an ePortfolio to track and reflect on their learning progress and interdisciplinary research.

Table 2. Doctoral Student Participants Chart for Gender and Fields.

Participants	**Gender**	**Fields**
1	Female	Chemistry
2	Male	Materials Science and Engineering
3	Female	Materials Science and Engineering
4	Male	Materials Science and Engineering
5	Male	Physics
6	Male	Mechanical Engineering
7	Male	Materials Science and Engineering

Ten potential employers (Table 3) representing industry, national labs, and academia were invited to review and give feedback on students' ePortfolios. Two participants representing academia are identified as assistant professors, a position that does not typically serve as the faculty search chair. However, this position reviews application materials, interacts with candidates, and contributes feedback in a faculty search process.

Table 3. Employer Participants Chart for Gender, Employment sector, Job field, and Job title.

Participants	**Gender**	**Employment sector**	**Job fields**	**Job title**
1	Female	Industry	Data Science and System Design	CEO
2	Male	Industry	Materials, Chemicals, and Informatics	Head of Community
3	Male	Industry	Materials	Manager
4	Male	National Lab	Manufacturing and Industrial Technologies	Chief
5	Male	National Lab	Materials	Director
6	Male	National Lab	Materials	Engineer
7	Female	Academia	Engineering Education	Director
8	Male	Academia	Materials Science and Engineering	Professor
9*	Male	Academia	Mechanical Engineering	Assistant Professor
10*	Male	Academia	Materials Science and Engineering	Assistant Professor

*Qualified insiders.

Data collection and Analysis

To answer the research questions (RQ1-RQ3), we created a review form for the invited employers. The review form consisted of open-ended survey questions that are included below. The following three survey questions were aligned with RQ1 (i.e., what is the value of an ePortfolio for employers?) and RQ2 (i.e., how does a student's ability to critically reflect and

think interdisciplinarily within an ePortfolio influence their competitiveness for future positions?).

1. Please describe the value of an ePortfolio from the perspective of a potential employer in your field. Note. Provide the response based on where you are (e.g., academia, industry, national lab, or other place).
2. How does a student's ability to critically reflect within the ePortfolio influence their competitiveness for future positions? Note. Provide the response based on where you are (e.g., academia, industry, national lab, or other places).
3. How does a student's ability to think interdisciplinarily within the ePortfolio influence their competitiveness for future positions? Note. Provide the response based on where you are (e.g., academia, industry, national lab, or other places).

For each student's ePortfolio, employers were invited to point out the strength(s) and areas of improvement(s). Inputs for the following two survey questions answered RQ3 (i.e., what are employers' suggestions on developing an ePortfolio?).

4. What are the strengths of this student's ePortfolio? Note. Provide the response based on where you are (e.g., academia, industry, national lab, or other places).
5. Based on your expertise in the workforce, what improvements could be made to the current ePortfolio to enhance the students' overall competitiveness? Note. Provide the response based on where you are (e.g., academia, industry, national lab, or other places).

A qualitative approach was selected for this study because of this analytical method's ability to examine context and interpret attitudes [13, 14]. We employed deductive content analysis to determine notable themes throughout each reviewer's comments. Open coding methods were utilized to categorize emerging and recurring themes [15].

Results

The value of an ePortfolio (RQ1)

Most invited employers from industry, national labs, and academia provided positive comments on the value of developing an ePortfolio. Their respective comments are included below.

Industry

All employers (n=3) from industry valued the use of an ePortfolio. Reviewers indicated ePortfolios provide valuable information for hiring employees.

“Within an enterprise, data is an asset.”
“[An ePortfolio contains information about a candidate’s] body of work, thought process, and career direction.”
“An ePortfolio provides concrete evidence of someone's accomplishments and applications of concepts they've learned during their studies.”

One employer especially emphasized that an ePortfolio absolutely can be a useful tool for the hiring process. The full quote is listed below:

“As a CEO, and previous CTO of a Fortune 50 company and hiring manager of > 1000 scientists and engineers, I can assure you that written communications, and in particular how one creates and utilizes shared digital communications, are absolutely critical in the final assessment of a future employee. The employer will examine the written output, as well as assess technical and interpersonal skills, critical thinking, creativity, and professionalism and team vs individual contributor tendencies. The student should not underestimate how creative they can be in setting up their ePortfolio tool to reflect their unique skills and interests, as well as to enable ease of use by the target audience.”

National Labs

All national lab employers (n=3) pointed out the advantages of using an ePortfolio. These reviewers indicated an ePortfolio offers insights and information beyond a typical CV or resume, such as furnishing a more personal perspective on how the individual processes information, organizes thoughts, and expresses themselves.

“The ePortfolio provides insights beyond the typical CV or resume that would be presented during a candidate search”
“It provides another, more personal, perspective on how the individual processes information, organizes their thoughts, and expresses themselves.”

Academia

Although one participant (n=1) stated an ePortfolio might not be considered in academia, the other reviewers (n=3) underscored the importance of self-reflection for emerging scholars.

“[An ePortfolio] may not be considered of value in academia.”

“[An ePortfolio] would provide information about the level of introspection of the student.”
“[An ePortfolio] could be helpful in evaluating the self-motivation and introspective abilities of say a postdoc applicant.”
“[An ePortfolio] allows aggregation of your profile in one place. In academics, we do a similar thing when it comes to tenure & promotion. ”

Why Showcase Critical Reflection within an ePortfolio (RQ2a)

All ten invited employers, regardless of employment sector, highlighted the importance of critical reflection. Their comments are included below.

Industry

Employers (n=3) indicated critical reflection is necessary for interdisciplinary work. For example:

“Critical thinking is a key skill in handling the multidisciplinary environment of industrial research and engineering to support data-driven decision making and drive new directions.”
“[Critical reflection] can tell a story, articulate challenges, describe collaboration, and present their working style through the lens of a finished project.”

National Labs

Likewise, reviewers from national labs (n=3) agreed upon the importance of critical thinking, a skill often difficult to ascertain based on a CV alone, and how an ePortfolio provides more opportunities to showcase.

“[Critical thinking] is often difficult to judge based on a CV alone and the portfolio provides more opportunity to showcase.”

Academia

Potential faculty employers and colleagues (n=4) perceived critical reflection important for any professional activity.

“I think self-knowledge is incredibly important in any professional activity.”
“[Critical reflection] teaches them how to articulate what they know and why they know it.”
“[Critical reflection] provides greater insight into how a student is able to assemble disparate pieces into a congruous whole.”

Why Showcase Interdisciplinary Thinking within an ePortfolio (RQ2b)

All ten invited employers across industry, national labs, and academia underlined the value of interdisciplinary thinking. Their comments are included below.

Industry

Thinking and communicating interdisciplinarity across the hiring process was considered important to potential employers (n=3) representing industry.

"Students should be able to integrate knowledge across disciplines and demonstrate an ability to learn and apply knowledge from new disciplines."
"The capacity to think, operate and communicate interdisciplinarily is one of the most critical factors in assessing potential employees and predicting their future performance."
"Students should take every opportunity to maximize their use of ePortfolio to develop and demonstrate their proficiency in operating interdisciplinarily and effectively communicating their unique insights and knowledge."

National Labs

Similarly, potential national lab employers (n=3) stated interdisciplinary thinking had become an important hiring factor (n=3).

"Interdisciplinary is a critical skill in MS&E (Materials Science & Engineering)."
"Interdisciplinary thinking is certainly becoming more important in all the technical fields as all become more digital."
"Being able to demonstrate that (interdisciplinary thinking) through an ePortfolio does provide value."

Academia

Interdisciplinary skills are also in high demand in academia (n=4).

"If a student shows that they are interdisciplinary minded in the ePortfolio and, more importantly, in their own research this will contribute to their advancement."
"The current and future workforce require working together from multiple disciplines to conduct convergent research"

Employers' Suggestions on Developing an ePortfolio (RQ3)

After reviewing employers' comments and suggestions on each student's ePortfolio, we found there are no significantly different patterns among industry, national labs, and academia.

A number of valuable components could be considered in an ePortfolio across each sector. These recommendations included **Biography, Skills, CV or Resume, Research, Courses and Training, Publications, Key Presentations, and Special Projects.** Lastly, doctoral students can demonstrate their **Reflection and Experience** on ethics, personal and professional growth, problem solving, cross-institutional collaborations, interdisciplinary collaborations, research, teaching, service, presentations, publications, academic courses, etc.

Furthermore, not all ePortfolios may attract a hiring manager's attention. Our invited employers provided students with tips and advice to optimize an ePortfolio.

- **Consider your audience**
    - "Enable ease of use by the target audience"

- **Make your ePortfolio more graphical and interactive**
    - "Nice graphical representations of scientific work allow quick communication for purpose and impact of the effort"
    - "Visual examples on some of pages and/or more links to documents and example work products could enhance the value of the ePortfolio to a potential employer"
    - "Less text more graphics with focus on key learning and contribution"
    - "Succinct communications, visually appealing, and professional"
    - "Graphical content and embedded documents make technical background easy to access"

- **Provide a clear and friendly navigation**
    - "As a hiring manager, I would likely not take the time to click through each tab. Consider structuring each page with more than one subcategory per page"
    - "There are many subpages. If I was reviewing this portfolio as part of a job application, I would likely not have time to review"
    - "Reduce redundancy by providing links to relevant information/knowledge"

- **Great summary of work on the homepage**
    - "If I was reviewing this applicant's fit for a job, I would quickly be able to assess that on the homepage"

- **Avoid very brief or list-centric content**
    - “Some of the content in portions were either very brief, or list-centric (Ethics portion, as well as Courses, Activities, under the Academic section etc.), I'm not sure this provides much value beyond what's in a typical CV, perhaps these sections could be omitted”
    - “There is a lot of whitespace on many pages that suggests either more information/figures could be included or maybe the organization could be compressed”

- **No typos! No missing/incomplete sections! Provide functioning links!**
    - “Broken links would likely discourage someone reviewing an application where this portfolio was linked”
    - “When viewing from iPad, I encountered issues accessing her CV via Google docs”

- **Relationship with CV**
    - “If you don't have a CV prepared at this stage (rather than just a detailed LinkedIn profile), please prepare one”
    - “For academia, the CV is likely the most important document”
    - “Direct links to the publications - making it easy for the employers to access and assess”

- **Strong writing skills are essential**
    - “Use some editing to sharpen the story the student was trying to convey”
    - “Clearly written, well organized content”
    - “Use a careful proofread”
    - “Include more examples”
    - “Make sure your points, comments, and ideas are consistent throughout the ePortfolio”

- **Provide personal reflections**
    - “The personal reflections and assessments throughout the portfolio provide a deeper understanding of how the student has progressed during the doctoral program that don't typically come across on a CV”
    - “Some additional thoughtful reflection would expose potential employers to the reasoning and personality of the student”
    - “Personal touches are nice”

- **Improve the depth of reflection on research**
    - “A bit more critical thinking and introspection could have improved the ePortfolio”
    - “Introduce how you would contribute to a research team”
    - “Spend more time considering responses to content to better represent thought process and approach to research”
    - “Demonstration of multidisciplinary approach and interdisciplinary research”
    - “Spend more time reflecting on research struggles (experimental, collaborative, or otherwise) lead to breakthroughs”
    - “Reflection regarding how different disciplines collaborate differently and even have unique tools to enable smooth communication”
    - “Honesty and frankness in some topics (e.g. Conflict Resolution) are valuable”

Discussion

Recent research indicates the disadvantages for college graduates using ePortfolios, such as a demanding effort required for the candidate and employer, too much information presented to the employer, and the tool being unsuccessfully utilized during the initial screening process [5].Our results reveal all ten employers representing academia, national labs, and industry positively commented on the value of developing an ePortfolio, particularly because of elements like interdisciplinary thinking and critical reflection. Overall, the findings of this study affirmed contribution to ePortfolio literature and practice in the following five ways: doctoral student context, expanding potential employer scope, communicate interdisciplinarity, importance of self-reflection, and a valuable tool for potential employers.

First, prior studies investigated employers’ opinions on ePortfolios primarily at the undergraduate level [3, 5, 16], while this research was focused at the doctoral level. Relative to the lower level of complexity for a job attractive to undergraduate applicants, employers hiring doctoral students request more evidence to determine how an applicant conducts interdisciplinary research and develops their thoughts. To that end, our invited employers unanimously advocated the importance of self-reflection and recommended students reveal more about their research. These insights are likely not able to be discovered in traditional application materials; therefore, employers would appreciate candidates who can provide such reflection and key research presentations in their ePortfolios.

Second, for engineering fields, around 75% of doctorate recipients in 2017 pursued their career in industry, while others selected academia, national labs, and additional places [17]. Prior ePortfolio studies only interviewed employers from industry [3, 5, 16], whereas we included the opinions from industry, national labs, and academia. The results highlighted the perceived value of developing ePortfolios can be different across these employment sectors. For example, when compared with industry and national labs, academia was more research-oriented; specifically, academia viewed interdisciplinary mindsets and critical reflection as factors advancing future research. Feedback from industry and national lab reviewers indicated the information in an ePortfolio is valuable and could help employers hire a candidate who is a good fit for their work area.

Third, this study highlighted the element of interdisciplinarity in an ePortfolio, as the future engineering workforce must work with multiple disciplines to solve complex problems. Our qualitative findings showed a student's ability to showcase interdisciplinarity is not currently accessible within traditional hiring materials. Therefore, employers expressed an appreciation for job candidates to provide an ePortfolio, because valuable information like a candidates' interdisciplinary experience and ability to critical thinking are perceived as key factors in the hiring process.

Fourth, similar to the previous research [5], this study also suggested a number of valuable components for an ePortfolio, like biography, cv, research, experience, projects, etc. The main difference of this study's findings compared to previous research is how our invited employers value the importance of self-reflection, which we believe is attributed to the doctoral student sample. The self-reflection of personal and research experiences increases the personal touch and enables employers to assess candidate's critical and interdisciplinary thinking. These results support an ePortfolio can be a tool for employers to gauge the potential interdisciplinary work ability and future impact.

Fifth, people suspect whether employers will take time to review an ePortfolio [18]. In this study, one invited CEO emphasized the information from an ePortfolio will be absolutely critical in the final hiring process. Other potential employers mentioned several factors influence their own willingness to review the ePortfolio, such as an unfriendly navigation and structure, broken links, incomplete sections, too brief content, less graphics, unclear content, etc. To help candidates attract employers' attention, this study summarized the tips and advice for developing an impactful ePortfolio.

One major limitation of the current exploratory research is the sample size. Empirical studies require large sample sizes with the hopes of generalizing findings to the population. Compared with the prior studies inviting around one hundred [3] or five thousands employers [16], this

study only investigated fewer employers (n=10). However, some qualitative scholars suggest that a sample size of 20-30 is appropriate, while others indicate that as little as 10 may be adequate for study [19]. While ePortfolio is well-documented in the literature, this exploratory research fills a specific and notable gap associated with potential employer perspective, so we believe any sample size is perceived as valuable. Additionally, two of academia reviewers are junior faculty and might not yet have chaired or served on a faculty search committee. We still invited them because of this faculty position's involvement and contribution in the hiring process: interaction with candidates individually and with other faculty, review of application materials, attending hiring and pedagogy seminars.. These faculty perspectives are also valuable for this study.

Concerning future and practical implications, we will use the findings to signal reflective ePortfolios as a job preparation investment for a doctoral students. Anecdotally, some students approached this required tool as an assignment or even additional work because the career development value was not detected. This study provides evidence that creating and maintaining a reflective ePortfolio has the potential to improve job competitiveness across industry, national labs, and academia sectors. Based on the findings, we will incorporate potential employer recommendations into this interdisciplinary doctoral program and encourage students to discover the long-term value and impact of an ePortfolio. Given that this study only focused on one tool (i.e., ePortfolio), future studies can focus on various tools to find out the best way to showcase interdisciplinary capabilities. For example, LinkedIn could be one potential platform to help employers search a candidate who is a good fit.

Addressing the complex problems in today's world demands an interdisciplinary mindset and ability to critically reflect [20], and also prompts STEM employers to hire engineers or scientists who demonstrate these capabilities and organizational fit [21]. The ePortfolio literature and our findings reveal traditional job application materials may not provide enough information to potential employers to determine an applicant's ability for interdisciplinary research. Therefore, we believe developing an ePortfolio is a worthy vehicle to showcase a doctoral student's interdisciplinary capabilities.

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