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Engineering Portfolios: Value, Use, and Examples

Dr. Vincent Wilczynski, Yale University

Vincent Wilczynski is the Deputy Dean of the Yale School of Engineering and Applied Science and the James S. Tyler Director of the Yale Center for Engineering Innovation & Design. As the Deputy Dean, he helps plan and implement all academic initiatives at the School. In addition, he manages the School's teaching and research resources and facilities. As the James S. Tyler Director of the Center for Engineering Innovation & Design he leads the School's efforts to promote collaboration, creativity, design and manufacturing activities at Yale's academic makerspace. His professional interests in Mechanical Engineering are in the areas of data acquisition/analysis and mechanical design. He is the Co-Chair of the Executive Advisory Board of the FIRST Foundation and is a Fellow of the American Society of Mechanical Engineering. Previously, he was the Dean of Engineering at the U.S. Coast Guard Academy and has had fellowships at the MIT Charles Stark Draper Laboratory, the Harvard School of Public Health and with the American Council on Education. He has also served as the Vice President of Public Awareness for the American Society of Mechanical Engineers and was the 2001 Baccalaureate College Professor of the Year by the Carnegie Foundation, the only national award that recognizes outstanding college teaching.

Mr. Patrick H. Knowles Jr., Cleveland Mixer

Patrick Knowles has had more than thirty years of increasing responsibilities in engineering design, engineering education, leadership & personnel supervision, financial & project management, and regulatory compliance. A registered Professional Engineer in Virginia, he recently accepted a position at a manufacturing firm with duties including engineering design, engineering research, and engineering sales support. Previously he was the Technologies Department Chair of Three Rivers Community College as well as Professor in Mechanical and Manufacturing Engineering Technology, and an Associate Professor at the U.S. Coast Guard Academy in the Mechanical Engineering Section and in the Naval Architecture/Marine Engineering Section. He is a retired Coast Guard officer with twenty years of active duty service.

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Abstract

An engineering portfolio is a valuable tool when applying to an engineering position in industry. Web-based portfolios compliment an applicant's résumé and provide insight into an engineering student's skills as a designer, creator, fabricator, and problem-solver. While the use of professional portfolios is well established in some fields, such as art, film, graphics design, and architecture, the concept is not commonly used within the engineering disciplines. This paper outlines the value and typical content of an engineering portfolio. A process to develop an engineering portfolio will also be presented. The paper will document the efforts of graduate and undergraduate engineering students to (1) archive professional academic work for display in a portfolio, (2) curate their archived collection to present a concise and cogent display of their professional skills, and (3) organize the portfolio to demonstrate job skills.

Introduction

Modern communication methods have dramatically changed yet some processes are grounded in the past. One of those processes is the employment application process, in this case for engineering positions. Typically this process involves an applicant responding to an open position with a cover letter and résumé (or curriculum vitae) often submitted electronically. It is proposed that an engineering portfolio format allows engineering students to showcase accomplishments and provides potential employers with greater insight into their competencies and abilities. The material presented in an applicant's professional portfolio may include research findings, artifacts from course work, results from extracurricular activities, and personal endeavors. It is proposed that an applicant with a high quality professional portfolio also has high degrees of creativity, innovation, and initiative, all of which may resonate with future employers and increase their employability competitiveness.

This paper examines the history of portfolios in the employment market and in engineering education, and presents a methodology for undergraduate and graduate students to develop their personal engineering portfolio. Modeled after approaches used in other creative professions such as art and architecture, the engineering portfolio is a record of an individual's skills documented by examples from projects they have worked on. In this context, the engineering portfolio can be viewed as a tool to demonstrate one's ability to solve engineering problems.

The use of engineering portfolios as a component of a job application addresses emerging trends in education and business. While the pursuit of an education is primarily an individualistic "self-centered" activity, employment within an organization is team-based. Also, much of the education process centers on the achievement of objectives (often by demonstrating what an individual knows) while industry focuses on applied problem solving. As such, applicants must shape their internal views of "what I can do" to align with industry needs of "what can you do

for our company." The traditional tools of the application process – the cover letter and résumé – require the employer map the alignment between an individual's skills and the company's requirements. An engineering portfolio makes this mapping more direct, with the applicant directly aligning examples of problem solving to the corporate needs.

A review of the employer's desirable factors in employees include an ability to work in teams, make decisions, solve problems, plan, organize and prioritize work, analyze quantitative data, and convey results to influence others.[1] This list of attributes highlight a desire for employees who can "do" tasks that help the organization, in turn, accomplish its mission. Often this mission involves "doing" and employers need to find (and hire) "doers." An effective engineering portfolio is an excellent tool to demonstrate an individual's potential contribution to an organization.

A similar shift in perspective (from a candidate's focus on what they know to what they have done) is underway within the college admission process. Under the umbrella of a new organization – the Coalition for Access, Affordability and Success – a new format for college admissions has been developed. In this new system, high school students assemble a portfolio of their experiences as a component of their college application. The portfolios are intended to cover experiences from as early as a student's first year. Students can share their portfolios with teachers, counselors and family members. It is hoped that this group provide advice not only on the portfolio but also on the student's educational trajectory by suggesting courses and activities that will best prepare the students for college.[2]

While the results of this new college application process will play out over the next few years, the students who participate in this process will soon be applying to jobs in industry with the benefit of previously using portfolios as a component of an application. This factor alone signals a need for engineering educators to become more aware of the value of engineering portfolios.

Engineering Portfolios: History and Applications

The portfolio concept has been used within engineering education in two distinct areas: outcomes assessment and as a tool for employment. Before presenting a methodology for engineering portfolio development, these areas of application are reviewed.

Williams suggests that portfolios of student work can be a valuable tool to document and assess student learning.[3] Principally driven by a need to assess the attainment of communication skills (needed for accreditation purposes), portfolios are presented as a tool to define educational objectives, correlate documented material to a program's educational objectives, facilitate an opportunity for students to reflect on their learning, and assess the attainment of objectives. While the author does not present the mechanics of assembling individual portfolios (over a student's academic career), the author illustrates how portfolios have been used to assess and improve the learning process.

Bhattacharya and Hartnett extend the use of student portfolios in engineering education beyond communications and into all aspects of engineering professional knowledge and skills.[4] The portfolio serves both as a collection of a student's best work and as a forum to encourage personal reflection. This perspective on portfolios also promotes portfolios as a mechanism that demonstrates the interaction between distinct components of an individual's education. Similar to the newly proposed college admissions portfolios, the engineering education portfolios can be used with peer review, feedback and improvement.

Wilczynski and Colella report on an approach to create "institutional portfolio" as a tool for programs to use when reviewing the curriculum's ability and performance teaching design skills.[5] The collected information, while useful for structuring course improvements, is also presented as a document to share with accreditation reviewers, benefactors, students and faculty members that illustrates a sequential accumulation of design skills. In this version of the engineering portfolio, design artifacts from courses throughout the curriculum are documented with the reflection component of the portfolio emphasized as a path for future improvements. This approach is similar to that reported by Kajfez, Kecskemety, and Kross who document how team-based electronic portfolios can be used by design groups to collaborate, share information with others, document the design process, and showcase work.[6] Examples illustrate how computer models, photographs, and text are combined to produce a team's portfolio. Student surveys document student awareness of the potential benefit of a course-based portfolio when applying for jobs.

The concept of engineering portfolios as a tool to increase an individual's competitiveness for industry jobs has been the subject of other reviews. Estell detailed the creation of interactive programming portfolios as a useful component of a résumé.[7] An interactive portfolio is proposed to engage reviewers in web-based applications that demonstrate the competencies and abilities of computer programmers. The interactive portfolio is described as including "graphical snapshots of programs in action and links to downloadable source code and executable files."

Online information technology (IT) focused portfolios were presented by Crowley and Miertschin as a means to increase student awareness of the IT profession. In addition to increased awareness, the use of portfolios amplified student understanding of connections between academic applications and professional goals.[8] As a result of this initiative, engineering faculty recognized the value of portfolios for assessing student skills. In this application, portfolio development was initially used as the basis of a term-long capstone project in the major before the concept was moved to become a sophomore level course. The components of an individual portfolio included a biography, statement of employment objectives, downloadable résumé, summary of technical skills, and documentation of projects that demonstrated the application of technical skills (and explanations of how the project demonstrates proficiency in specific skills). In addition to helping students compete for jobs, university-archived electronic portfolios were also proposed by Jwaifell as a mechanism for employers to search for employees.[9]

Creating Engineering Portfolios: A Four-Step Process

An engineering portfolio is a valuable mechanism to present materials, collected over a period of time, that demonstrate a person's ability within a specific subject area. This section identifies four-steps to create an engineering portfolio: collecting content, organizing content, creating narratives (including reflection), and displaying content. The authors do not favor either a specific format (hardcopy or digital) of the portfolio, leaving that decision to the individual applying to specific employers. For the sake of this discussion, the development of a web-based portfolio will be detailed, noting that the collected contents could be converted to a hardcopy format. This process was developed from personal experience and the review of best practices from a variety of resources.[10,11] An example of a typical engineering portfolio (entry page) is presented in Figure 1.

Figure 1. Engineering Portfolio Example

Collecting Content – The portfolio is a collection of a person's best work that illustrates their competence in technical and soft-skill areas. Using this as a framework, the starting point for building an engineering portfolio is the creation of "digital storage bins" of potential portfolio content. This material will then be used to construct the portfolio. This source material can be collected in real-time (perhaps over a period of years) or after-the-fact. It is suggested that a repository be established and that digital artifacts be stored in this location without much forethought (as to a piece's future utility). Similarly, the organization of the digital storage bins can be loose, using time, project or skills as the means to initially assemble the collected information. Developers should view this collection as the raw material from which they will later build their portfolios, with the key aspect of this step being the collection of a large volume of potential portfolio content.

While collecting resources, it is key to view the portfolio as a collection of stories, with a blended combination of images and text telling each story. As such, images (including photographs, CAD models, circuit diagrams, and screen shots of graphical programs) are perhaps the most important items to collect. The collection of a large number of high-quality images will

facilitate the later stages of the portfolio assembly process. Saving potential portfolio content should be become a habit and occur as a normal aspect of each project.

Since the portfolio will be a collection of stories, the standard format of a narrative (having a beginning, middle, and end) should be kept in mind when raw information is collected. Details of an applied design process (or similarly the development and execution of an experiment), including initial concepts, preliminary sketches, computer models, analysis, testing and the final fabrication, are a rich source of images that can be used in an individual's portfolio.

Organizing Content –This step of the portfolio creation process organizes the bulk information previously collected into groups of similar content. Two approaches can be used: project-based organization and skill-based organization. A project-based portfolio uses the collection of completed projects as the primary narrative theme, with the reader then making the needed connections between the presented projects and their specific hiring needs. The skill-based portfolio presents material in a manner that is aligned with an employer's needs for specific skills and competencies. Each method has unique advantages with the project-based portfolios being more conversational and the skills-based portfolio being more direct (from the employer's perspective). A graphic illustrating the two portfolio organizational styles is presented in Figure 2.

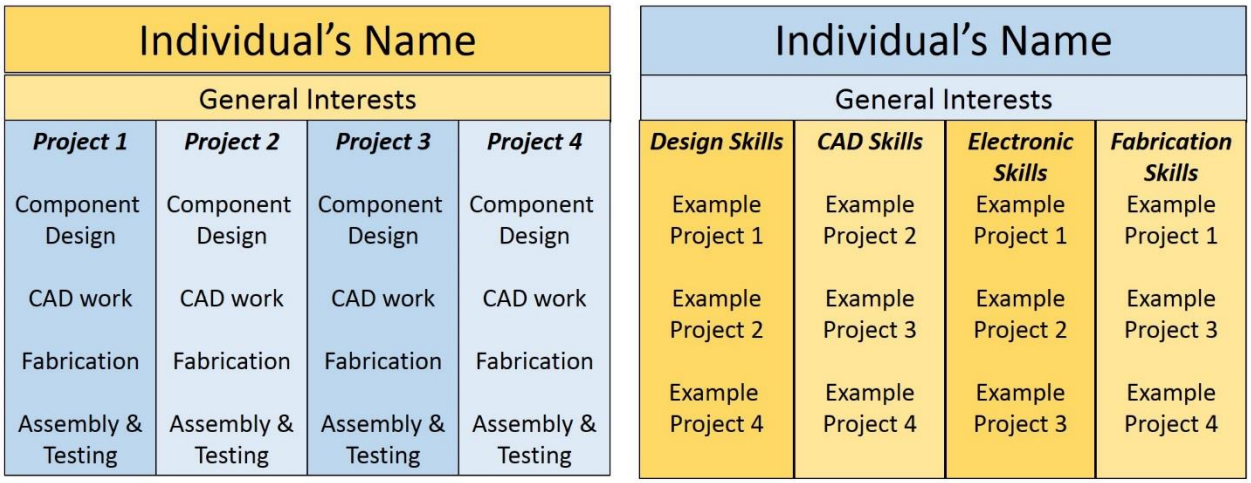

Figure 2. Engineering Portfolio Organization – Conceptual Models

As an example, a mechanical engineering student may elect to present a portfolio that lists a collection of projects that demonstrate their experience in the profession. Using this organization method, the presentation of projects should be grouped among themes (such as robotics, programming, and electronics) rather than being an uncategorized list of accomplishments. This same set of experiences could also be organized along specific skills, such as the steps needed to conceive of and design products. Using this method, aspects from individual projects would be organized to highlight competencies in idea generation, computer-aided design, analysis methods, manufacturing, experimental testing, and detailed design results.

Creating Narratives – During this step, text is developed to support the visuals (organized by projects or skills). The images and text combine to provide the reader with insight on the applicant's talents and abilities, with the narrative being the format that connects the projects (or skills) to the employer's needs. The narratives have three purposes: highlighting key aspects of the presented information, identifying the individual's contribution to the project, and reflecting on the value of the experience. The narratives provide the context for each particular project. Two paragraphs at most should be used for each of the three purposes. The narrative begins with an overview of the overall project (or skill set), with this section written to demonstrate why the example was included in the portfolio. This description should direct the reader's attention to specific information that highlights the most important details for the reader to focus on and understand about the presented example.

It is likely that many of the examples will have been projects completed by a group of students. The second part of the narrative should detail one's specific contributions to the overall project. A statement such as "my responsibilities included" removes ambiguity and allows the reader to focus on the appropriate segment of the project. The reflections component of the narrative provides a chance to summarize the lessons learned from the experience and, if appropriate, alternate solutions for refining the work.

The reflections component of the narrative should be used to highlight the accumulation of skills over time and be written in a format that allows the reader to apply the presented information to future projects. The reflections section should not include a list of reasons why things did not work (and especially so given the portfolio's role to showcase one's best work), but rather this section should demonstrate a high level of disciplinary maturity and personal development.

Displaying Content – Considering the perspective of the reader is imperative when designing the portfolio's layout. The layout should be clear, engaging, and connected in style and purpose. The most effective portfolios clearly illustrate one's potential with images and text. The images and text should be displayed with a consistent layout with the images dominating the presentation as the means to showcase an individual's best work. Each image need not have a caption but the provided text should clearly explain the important components of the presented images.

It is proposed that engineering design principles be used to construct an individual's engineering portfolio. Based on the engineering design process, a series of portfolio prototypes should be created and reviewed, then selecting the best method to display information. During this design process of the engineering portfolio, the prototype designs should be shared with others to solicit feedback and improve the presentation.

An internet search for "engineering portfolios" will yield a large number of examples to review. These online examples provide a benchmark that can be used as models for an individual's own engineering portfolio. Reviewing the work of others can lead to the discovery of creative and effective formats. There are a number of commercial platforms that provide templates and themes to build and broadcast individual portfolios (with the costs and services of each site widely varying). Some platforms also provide a hosting service to house portfolios. Online platforms typically offer instruction, software tools, and a basic template to work from. Such

software applications provide a mechanism to arrange the graphics (and potentially video) and text, with the templates serving as examples to build off of.

Observations and Conclusions

Two workshops (one to graduate students, and the other to undergraduate students) were developed to introduce the concept of using an engineering portfolio at the Yale University School of Engineering. Examples of some of the portfolios created for and within those workshops are archived in the reference section.[12,13,14] These examples show how the presented steps were used to create visual stories that illustrate personal competencies. While these examples are web-based, the information could be documented in a format that could be privately shared (thereby eliminating the need to have a particular portfolio publically displayed). It is emphasized that an engineering portfolio does not replace the need for a résumé, but rather complements the résumé. Along that line, it is suggested that the résumé include a link to the online portfolio, and that the portfolio include a link to an individual's online résumé.

The volume of work available to profile may be a concern for individual students and academic programs. While the capstone design project provides portfolio-worthy material, it is suggested that a competitive engineering student would also have a collection of other experiences to draw portfolio examples from. That work could involve term projects from other design courses, such as high quality introductory courses, as well as design components from fundamental courses that include open-ended problems solving assignments. Students that have taken additional design, fabrication, and experimental testing courses have additional resources of available portfolio material. In addition, summer internships and engineering related extra-curricular activities provide experiences that can be included in an engineering portfolio. Should an individual student not have enough material to construct a portfolio, that student's academic program should review their curriculum to determine if the correct variety of courses are offered that allow students to enter industry.

While this paper has presented the concept of engineering portfolios as a tool to benefit students, it is suggested that the collection of a large number of individual engineering portfolios may be a useful tool that can be used for engineering accreditation. In this application, the individual portfolios can serve as an assessment instrument where the experiences are reviewed to assess the achievement of specified student outcomes (such as those detailed in Criterion 3 of the ABET Guidelines). [15]

The engineering portfolio is an important tool for new engineers not only to secure a first position, but also as a mechanism to use for future positions, with the original experiences augmented with industrial experiences. It is expected that engineers be life-long learners, and the engineering portfolio is an excellent forum to document that learning process.

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