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Developing a CAD Portfolio to Advance Engineering Students' Professional Careers*

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This paper presents the important elements of compiling a student portfolio. In the field of engineering, there is often a wide gap between students' technical knowledge and their ability to communicate concepts to a broad audience. As a result, many new engineers enter careers without the necessary skills to clearly discuss their work with colleagues from different departments, peers from different organizations, and the wider public.

Some engineering education programs are attempting to incorporate more emphasis on writing and communication into their course curricula, but there are still few opportunities for building and testing students' skills in this area. This paper presents the purpose of a powerful portfolio in terms of what it can offer students, their educators, and their future employers. It also makes an argument for strong communication as a necessary skill in the engineering classroom, in R&D settings within a company, and across different departments and industries. It also offers some suggested guidelines for the process of compiling a portfolio, based on data and documents compiled from both educational institutes and engineering organizations. The intent of this work is to offer students and educators a brief overview of the portfolio process, with emphasis on organizing the components of such a collection so that a potential employer or peer would find them intuitive and easy to understand.

Keywords: portfolio; curriculum; communication; education; engineering; documentation; interview; career path; self-assessment; teaching tools; CAD; design; technical skills

1. Introduction

This section discusses the value and the purpose of a student portfolio. Although the rest of the paper emphasizes the field of engineering, much of the content is applicable to and draws on many other fields of study.

Student portfolios provide an adaptable tool for assessing and improving students' learning in any area of education, especially when demonstrating the value of hands-on tasks, independent work, or experiential learning methods used in the classroom. The concepts and trends in the literature review [1–29] conducted for this paper tend to agree with each other even across many documents [1, 2, 13, 27], fields of study [2, 7, 10], age groups [7, 8, 27], and career paths [10–12]: portfolios give both students and their instructors integral information about a student's knowledge of the study topics, the depth of their technical skills, level of organization and attention to detail, and their ability to communicate what they know effectively. In this case, the word "technical" is meant inclusively, encompassing concepts such as the technical knowledge of an engineer, but also referring to those such as the well-planned structure of a writing piece by a gifted communications student.

From architecture [5, 14] to literature [6, 18] to engineering [3, 4, 6, 9, 12, 15, 19], students, instructors, and administrators are respectively gaining feedback about their work, their teaching methods, and the effectiveness of the educational structure. As this information accumulates, students are able to better understand their own work, teachers are able to communicate better to their students, and administrators who are exposed to student portfolios become more aware of what is needed in the classroom.

In addition to providing good ground for academic growth, portfolios give a graduating student something very valuable: career material [14, 15, 20]. By learning to arrange and showcase their work well in the classroom, they are much better prepared for presenting their work to a manager, a meeting of colleagues, or an interviewer. By collecting their best pieces of work, they not only learn to distinguish what makes these pieces strong selections, but which pieces to discard or set aside. As many sources from conference proceedings [11] to books and journals [3–5, 8, 10, 16, 28, 29] to government literature [26, 27] indicate, knowing what *not* to include in a portfolio is just as important as knowing what *to* include. This comes naturally through creating a portfolio, receiving helpful feedback on it, and learning what information or work is truly necessary for the audience to see. The ultimate goal of the focus on portfolios in education is to help guide students into their career trajectories, understand what is needed in the classroom to convey information effectively, and gain insight into the

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strengths and weaknesses of the educational system.

In the context of the foregoing, this paper discusses the important elements of compiling a student portfolio. In the field of engineering, there is often a wide gap between students' technical knowledge and their ability to communicate concepts to a broad audience. As a result, many new engineers enter careers without the necessary skills to clearly discuss their work with colleagues from different departments, peers from different organizations, and the wider public.

The remainder of the paper is organized as follows. Section 2 presents the purpose of a portfolio. Section 3 discusses the content and organization of an engineering portfolio in general. Section 4 provides guidance on how to create a CAD portfolio specifically. Section 5 provides advice on the presentation skills of a portfolio. The paper concludes with Section 6.

2. The purpose of a portfolio

A portfolio, in a very basic way, is about communication. No matter how brilliant a thinker, designer, engineer, or philosopher a student or employee is, communicating is a crucial part of his or her work: "Studies done by the Department of Electrical and Computer Engineering (ECE) at the University of Arizona show that engineering firms...rank writing ability as the most important skill in determining engineers' success, *even above the much more obvious technical skills* [emphasis added by authors] that are the focus of much engineering education" [1].

This is a bold statement, highlighting the more subtle importance of writing and presentation skills even on a level with the technical knowledge that is obviously crucial to engineering work. Writing projects have slowly been integrated into engineering curricula per recommendations made by educators, intending to bridge the gap between students' technical abilities and their communication skills. These are meant to bring students through the steps of documenting projects in a way that does not exclude relevant technical information, does not include confusing or irrelevant details, and sets the reader up to understand the goals and process of the project described.

A portfolio, therefore, is meant to both demonstrate a student's work—and a thorough background understanding of the subject matter—*as well as* his or her ability to communicate it to an outside audience. Portfolios used in a classroom context often give the instructor a sense of how well students have understood their goals and their work, and what they have taken away from the course. Portfolios in the context of career advancement, such as a job interview, give managers, supervisors, and potential employers a sense of both an engineer's technical abilities and his or her ability to clearly present work to others. This last observation cannot be overstated.

Content is only one important element of the process. A good portfolio is developed upon the ability to communicate specific ideas to a range of audiences, discuss a clear purpose, and create an introductory piece such as a cover letter to set the stage for the outside reader—regardless of the student's field of study. A portfolio is meant to send a specific message to a specific audience, and it is therefore important for the writer to make sure that he or she has a strong understanding of both the audience and the message.

Of course, it is easy enough for a smart interviewer to see through a great presentation and observe a lack of content, if a job applicant is not actually qualified for the position he or she is applying for. In order to best depict a student's skills, the portfolio needs to show the range of technical ability using carefully-chosen, strong samples of their design, manufacturing, or research work.

One often-overlooked value of a portfolio is that it helps to create connections beyond the initial creation purpose of securing a job. This can help with career advancement far beyond an initial job interview or even a regular internal review.

These connections happen in contexts as broad as the global body of engineers, and contexts as narrow as a single company [1, 4]. Different specializations are intimately connected; for example, manufacturing cannot be isolated from design and testing; mechanical, electrical, and biomedical engineers might all be needed in order to build a complex robotic device that interacts with live people; and engineers developing new fabrication processes need to be aware of the existing challenges in fabricating certain devices in order to actually address problems with existing procedures. In order for engineers at all stages of product development to do their jobs well, they must understand what those on either side of them are doing.

These good communication skills, put to use in the workplace, are especially vital for collaboration in a global economy [3, 6, 10, 11]. In the many arenas in which engineering education has been discussed around the world in the last twenty years, enhanced communication skills and teamwork have been a common theme. In describing the "engineer of 2020,", Senator Jeff Bingaman remarked:

> ". . . he or she must be educated to have a truly global perspective. Technology transactions of the future will essentially be seamless across many countries, lan-

> guages, and cultures. As part of this flexibility, future engineers must appreciate the nature of the global teams they will work with. They must know how to communicate effectively and think multiculturally; they must have analytical skills that can integrate information from team members who are in Bangalore, Sao Paulo, and Seattle as if they were all in the same room.'' (Bingaman, 2006)

In this context, a portfolio becomes much more than a job application. For students and new engineers as well as perhaps seasoned engineers, the process of creating a portfolio becomes an opportunity to engage in a global engineering context, consider the real goals and questions raised by their work, and lay out problem-solving efforts in a clear way. It forces conscious awareness, and becomes a way to create dialogue among engineers with different specialties, share findings, and generate collaboration that bridges the gaps between intended goals and eventual achievements through involving many skills and perspectives [1, 2].

In a historical context, portfolio content is also being used by researchers to understand and respond to students' perceptions of education and the workplace and the differences between them, gauge attitudes, and promote desired outcomes for learning [3]. Under scrutiny, it is now material used for studying how students learn and transition from theoretical knowledge to applied practice [4]. Educators are using this information to improve and build educational curricula that evolve alongside the field of engineering, preparing students for future work in research and development.

3. Portfolio content and organization

An often-unintended side effect of putting a portfolio together is that it tends to give students a better understanding of their own experience and work. The self-assessment that happens naturally through the portfolio development process allows the writer to truly see the breadth and scope of his or her own work, skills, and limitations, because they have had to organize it in a way that someone else can understand [2, 5–8].

As students compile and organize work samples, they are forced to decide with each one: *Does this belong in the portfolio? Is this my best work? What does this tell the audience about me and about what I can do?* And in answering these questions, they may discover things they hadn't noticed about their styles, knowledge, strengths, and limitations. The next sections will discuss this awareness in more direct detail, as they offer intuition on the content creation and selection process.

Having laid out the advantages and purposes of a portfolio, we now discuss the contents of a portfolio. This section includes guidelines on what can or should be included in a portfolio and information on ordering and preparing a collection of work for an audience.

In particular, the suggestions that follow stress the importance of categorizing, choosing the best selections to include based on the context of the portfolio's intended use, and invites students to carefully document their work as they create it in order to make the portfolio selection easier.

3.1 Documenting work from the very beginning

Regardless of the field of work, it is generally a good practice to keep track of ALL the work an engineer does during their studies, whether or not they expect to use it in a portfolio at some point. As one author put it, ''Taking care of your work is the most important professional activity you [may] ever do'' [3]. In order to choose content wisely, the student first needs to have a record of it. Organizing his or her work *as it is created* will save a lot of time and trouble later.

As students build content during work and studies, it doesn't hurt to suggest that they make notes of any particularly good pieces—and tag them for later. **This is the first crucial step to building a portfolio: good documentation habits.** This might involve physical hard copies, organized computer folders that maintain a structure where everything is easy to find and in a format that's easy to quickly print, backup drives of files, or any combination thereof.

3.2 Categorize

Students should make sure that they won't need to sort through a list with too many items in it whenever they search for a particular piece. Dividing work by subject or project type seems obvious, but really saves a lot of trouble. Here are a few different ways in which students might categorize their work:

- Course or project.
- Date, but this requires labeling well.
- Collaborative vs. individual projects.
- Application-specific projects, e.g. ''Electrical,'' ''Mechanical,'' ''Prosthetics,'' ''Medical Sensors''.
- Industry focus or manufacturing method, e.g. ''Injection-Molded Parts,'' ''3D Printing,'' ''Industrial-Scale Machinery''.

Different methods suit different organizational styles and one is not necessarily better than another; hence, it is important for individual students to choose a method that works for them.

3.3 Selecting and compiling content

Having discussed the basics of a portfolio's purpose and structure, we now move on to strategies for choosing content. There are a few key strategies to compiling content for a portfolio. This section is directed at the student or portfolio creator.

Firstly, students should include only their best pieces. A portfolio is *not a record of everything the student has ever done*. This too cannot be overstated.

If a student includes all of his or her work from every topic and project, no one flipping through the portfolio will have time to look at every piece nor will they want to. And the audience will see older, less polished work that the student might not want potential employers to examine.

It is always important, when creating a presentation collection, for students to put themselves in the shoes of their audience in order to determine what they will need to see—while keeping in mind that the audience may know nothing about them, and there is limited space and time to make an impression. A handful of spectacular pieces will go farther than a thick stack of decent ones.

Sound advice from an architecture handbook neatly sums this up: "In a professional situation, especially if there is an economic recession and greater competition for work, very often if you do not capture in the first few pages of your portfolio the imaginations [or attention] of the people who are looking at it, they may not even get all the way through your portfolio. That means you will need to edit the portfolio . . . to include only the best, the most engaging, and sometimes the most provocative, work" [2, 5, 9, 10].

With this in mind, students will want to make sure that they include pieces that:

- Stand out from the rest of their work. Anything that stands out from the typical work done by someone of their experience and education should be included.
- Show both the depth and breadth of their knowledge and skill set. However, this point is obviously subject to discretion, especially when applying for a very specialized position. The pieces should show specific strengths, not only the basic fundamentals of the skill they're demonstrating.
- Communicate their purpose visually and quickly—in the case of computer models, applicants should make sure that the piece is relevant to the work they want to do and doesn't take much effort and study for a stranger to understand.
- Have clearly labeled drawings with the appropriate layout views.
- Show good examples of what students have to offer, and that they are proud of; if they're handing this out to potential employers, they should feel comfortable with it.

Example: If a student is preparing for a job interview for a position as a CAD designer or engineer, he or she will want to have a portfolio that shows a range of design capabilities in the modeling software. Depending on the student's background, he or she should tailor the portfolio to their unique skill set as well as to the type of job they're looking for. A mechatronics engineer will want to show a range of work with mechanical and electrical systems, while applicants for specialized positions in rapid prototyping will want to demonstrate strong knowledge of design for additive manufacturing.

The contents of a technical portfolio like this would ideally show:

- Problem-solving skills and ability to creatively meet criteria.
- Mastery of certain CAD programs, including different 3D features and 3D modeling techniques.
- Attention to product specifications.
- Use of many different design techniques in the part documents, e.g. surface techniques, electrical routing, welds, design for injection-molded or rapid prototyped parts.
- An understanding of manufacturing tolerances.
- An ability to create clean, readable drawings. Generally, drawings should include the appropriate views, labels, and comments that show familiarity with different manufacturing techniques. The portfolio should also show an ability to present work in a way that is easily understood by an outside viewer.
- Brief, visual reports where relevant—the portfolio doesn't need to be only composed of drawings. Some guiding reference or explanatory material that doesn't take a lot of work to understand is often helpful.

3.4 Ordering content

Another element to consider when assembling a personal CAD portfolio is the order in which the samples are presented. The student may not want to present the audience with a lot of complex parts all at once. Rather, when he or she is applying for a more general design position, it may be helpful to ease in, beginning with the most simple and evolving through the most complicated pieces. When demonstrating knowledge of different design techniques, manufacturing practices, or industry-specific devices, it is important that the student organizes and classifies these well; for instance, an electrical routing project should not be mixed in with welded part drawings unless it's actually relevant.

3.5 Cover letters

There is quite a range of material available to help students and other job applicants put together a stellar cover letter, so we won't belabor those points here. However, here are a few key considerations that are frequently overlooked by those writing cover letters:

- *Make sure it's clear that you, the applicant, have actually read the job description.* It's astonishing how often this happens: someone copies and pastes a cover letter from another application and changes, or even forgets to change, details like the addressee and the job position title. Prospective employers want to hire someone who actually wants the job, and takes the time to show that they've paid attention to the description.
- The cover letter should be relatively short, but should tell the reader who the applicant is, why he or she is a good fit for the job, and what he or she will contribute to the company and the product. It is important to make sure to actually include the name of the job title the applicant is discussing.
- Clear, attractive-to-the-eye contact details go a long way, as does a resume that's easy to read. Some jobs receive so many applicants that messy resumes are discarded without being read carefully. If it takes a hiring manager more than a moment to find the section he or she is looking for, the resume may need some re-organizing.
- If the portfolio was requested along with the job application ahead of the interview, it's a good idea to mention the portfolio in the letter. This should give the reader a quick summary of what he or she will see upon opening it: the modeling programs or processes used, that pieces demonstrate an understanding of the engineering design workflow, and for which devices and industries the pieces are relevant.

For more considerations to take into account when writing a strong cover letter, the free sample letters and guidelines on many career websites offer a good place to start.

4. CAD portfolios

This section is meant to give some specific examples and suggestions for portfolio content that will help students best present technical work for a job interview. It will touch on some common modeling concepts used by CAD designers in the industry, but is by no means an exhaustive list of everything that can be done with design software. Depending on students' different specialties, certain points may apply to the needs of some students, while others may not. However, many of them are useful to consider for a range of design jobs. Note: while this section at times refers specifically to the SOLIDWORKS® software, the information translates easily to similar CAD platforms.

4.1 Three-dimensional (3D) features and modeling techniques

The CAD/CAM area is an important part of both engineering education and industry practice. Students acquire valuable 3D modeling skills required by many companies. Companies depend heavily of CAD/CAM technologies in their daily design and manufacturing tasks. There are many CAD/CAM courses that exist today with different foci: geometric modeling, design applications and manufacturing applications. Geometric modeling techniques vary in complexity and power. CAD systems provide a wide range of 3D features to aid designers in creating simple CAD models, such as an extrusion, to free-form sophisticated models such as a molded chair. Engineering students must be aware of them, and how and when to use them. There is a finite set of 3D features that CAD systems offer. They are extrusions, revolves, lofts and sweeps. In terms of modeling techniques, there are free-form splines, 3D curves, and surfaces. In terms of a CAD portfolio, students need to include models that utilizes lofts, sweeps, splines, 3D curves and surfaces as these are the more comprehensive features and techniques. They show in-depth understanding of CAD technology and should provider potential employers with the modeling skills of students.

Design applications span many analysis techniques, the most popular are mass property calculations, finite element modeling and analysis (FEM/FEA) and fluid flow simulation. FEM/FEA can be applied to single parts or assemblies. Assembly FEM/FEA is much more complicated than single parts because the assembly mates produce flexible structures that must be modeled correctly. For example, mechanical modeling elements such as spring, dampers and bearings are typically used. In terms of a CAD portfolio, students need to include stress analysis of assemblies and highlight how the assembly mates are modeled.

Manufacturing applications cover geometric tolerancing and dimensions, CNC machining (such as turning, drilling, milling and EDM), and injection molding for plastics. There are two types of geometric tolerances: conventional and geometric. Geometric tolerances require the use of advanced concepts such as datum features. In terms of a CAD portfolio, students need to include sample geometric tolerance parts, CNC milled parts, and injection molds for plastic parts.

4.2 Material selection

Material selection is a very important design decision because it decides all downstream manufacturing and production activities of a product design. The questions raised in this section are not identical to those that an engineer would ask himself or herself when choosing features to model a part, but are meant to be a nudge in the right direction and are analogous to other tasks in the design process.

Demonstrating some knowledge of material selection, for instance, whether to use steel or aluminum for a part and why, will show a student's background knowledge of mechanics and design. Engineers should be prepared to defend a material choice if necessary, and make sure that when choosing a material for a part, they have taken the following into account:

1. How much do the size, weight, and material properties matter for the part?
   (a) It goes without saying that if an engineer is designing something that has to function in a high-temperature environment, it shouldn't melt at the operating temperature. Properties that change under certain conditions—such as under applied electric currents or magnetic fields—can be of great benefit when used well and creatively and are a great way to show knowledge of materials. However, they can also be a hazard if overlooked; engineers should make sure that they've chosen the material based on informed predictions of its response under realistic loading and other operating conditions.
   (b) Is the part going to experience high stresses? Is it large enough or heavy enough to withstand the strain, vibrations, heat, or electric load? While simulations can help a lot with verifying designs, students and new engineers should be able to show that they can design within the limits of realistic specifications.
2. The manufacturing technique used: Is the part machined? Rapid prototyped? Injection molded? Engineers should show that they've designed realistically for the right fabrication process in addition to the intended use of the part.
3. Will the part be mass-produced or are only a few copies needed? This will affect the overall cost of the design; students should make sure they can show that they've taken into account the effective costs of their choices and chosen the right balance between cost and functionality. If it's to be mass-produced, is it easy to miniaturize? This affects cost a great deal.

4.3 Part and feature design

Given the range of capabilities of many CAD software environments, students will want to make sure to include part designs that show a broad scope of skills: modeling techniques such as splines, surfacing, features, bodies, Master Modeling specific to SOLIDWORKS, assemblies with correct mating conditions, and patterning are some of the fundamentals that they may want to demonstrate familiarity with when presenting their work to someone else.

Over-designing is a hazard. Showing clean, well thought-out designs is a very important part of putting together a portfolio. Students should ask themselves certain questions; employers will want to know that these questions can be answered by their prospective hires. Does the part need to be as large as it is? Does the shape minimize the amount of material used or wasted during manufacturing? How expensive and cumbersome will this be to make? These are just a few examples. But these sorts of questions are one way students can show potential employers that they understand the entire R&D process, and that their CAD skills fit in well with the company's workflow needs [10–15].

4.4 Application-specific modeling techniques

For certain jobs, students will want to show familiarity with a more unusual range of part design techniques. The decision of what to include is up to the student's best discretion, but it is specific to the type of work they are hoping to do.

For example, for a job at a company that routinely uses sheet metal in their products, an applicant's portfolio should include pieces showing the use of sheet metal design in the preferred CAD program. When applying for an electrical engineering job, students should make sure to show competent design of circuitry and include electrical components among the pieces they present.

Injection molding, weldments, sheet metal, and routing, for example, are all available in the SOLIDWORKS software, as are several physics simulation and analysis options to virtually test parts under the different boundary conditions. These can be very helpful for showing an ability to study, analyze and predict whether a design will hold up to the intended operating and loading conditions.

4.5 Details and drawings

Nothing irritates a technician more than a drawing with inconsistent dimensioning, impossible-to-read

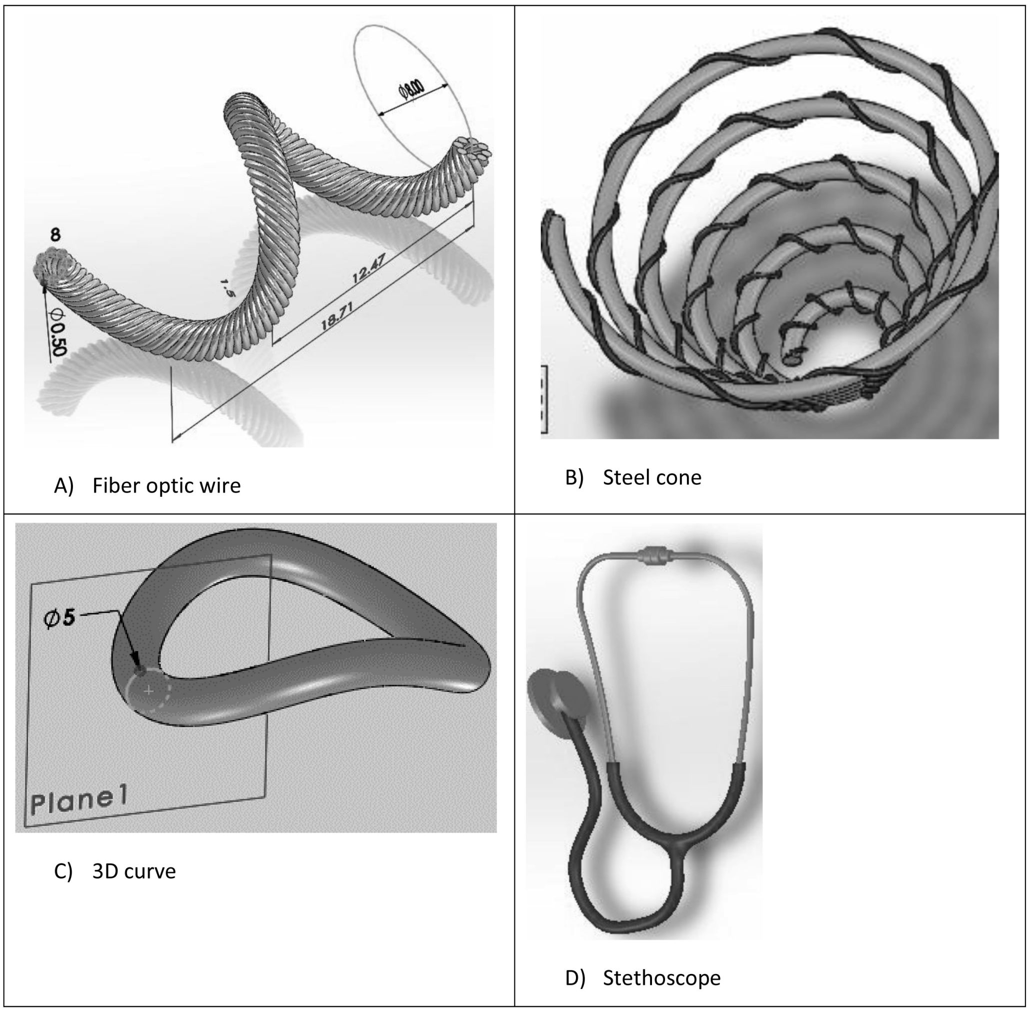

Fig. 1. 3D CAD parts.

labels, or a part that can't actually be machined. When creating a portfolio, students should make sure that it includes up-to-date, clean part documents.

We now show sample CAD parts that can be included in a good student CAD portfolio. Fig. 1 shows 3D parts illustrating different 3D modeling skills. These parts are created by students in a CAD class as part of course open-ended assignments. This ensures that the parts reflect the creativity, ability, and motivation of each student. Figs. 1(A) and 1(B) illustrate the skill of superposing a helix onto a guided shape (spline in Fig. 1(A) and a cone in Fig 1.B). Figs. 1(C) and 1(D) illustrate the skill of using the projected curve method to create 3D curves that can be used, in turn, to create complex sweeps.

Figure 2 shows a different class of object that illustrates the mastery of using surfaces together with 3D curves to create advanced models. The common modeling theme is to create multiple 3D curves, then blend a lofted surface to connect them. These objects represent the ultimate modeling power that CAD/CAM systems offer today: combining 3D curves and surfaces.

Figure 3 shows sample sheet metals and weldments. Fig. 3(A) shows a metal frame made by bending a flat sheet along different types of flanges. Fig. 3(B) shows a bike frame made from welding different types of pipes. Lastly, Fig. 4 shows injection molds of plastic objects. Each figure shows the mold two halves and the final injection molded (a funnel and a bottle).

5. Presentation skills

Some final thoughts: students must take care to strike the right balance of positivity and honesty. Any good product essentially sells itself, and a student's work should do the same when presented the right way. Although it's important to not go into an interview or application of any kind trying to "sell" or over-sell oneself, it is crucial to present skills and experience with confidence. Even if an applicant is nervous, he or she can prepare them-

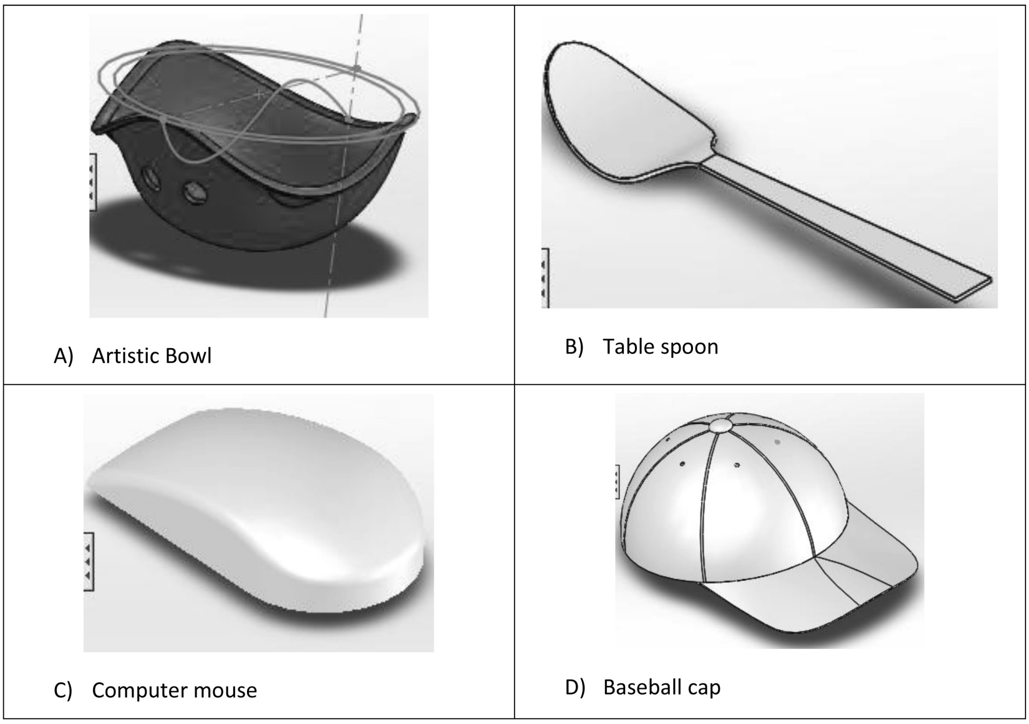

Fig. 2. 3D CAD parts created using surfaces and 3D curves.

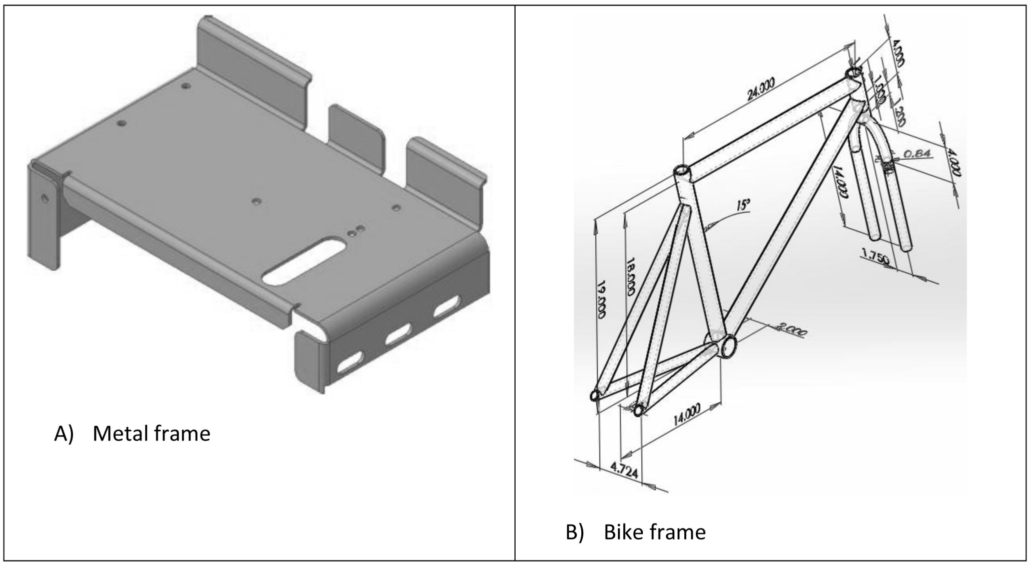

Fig. 3. Sheet metal and weldment CAD parts.

selves ahead of time to offer something that doesn't sell themselves or their work short, and also doesn't exaggerate their real comfort level with their skills.

A final helpful question for students to ask themselves is: Would you hire yourself for the job that you're applying for? If the honest answer is 'no', this is a good thing to recognize ahead of time—it gives the applicant a chance to revisit their approach and see where they'd like to make some changes to the material.

Often overlooked, the presentation of a portfolio is a finishing touch that can make a big difference in how an interviewer perceives the applicant. Appearing professional sends a positive message of awareness, responsibility, and dependability.

With each job interview or application, the managers sitting at the other end of the table want to know if the applicant has the skills they're looking for and will fit in with their team. If they care about an employee's organizational strengths and atten-

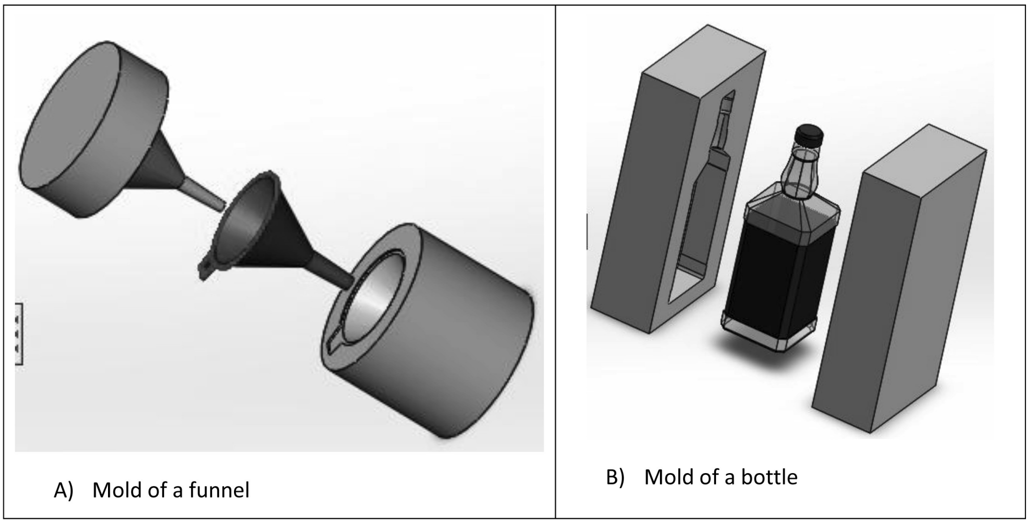

Fig. 4. Core and cavity of injection molds.

tion to detail, the physical presentation of a portfolio will tell them a lot [15].

Students' portfolios tell the story of who they are as workers and engineers. They want the person reading the story to understand where every chapter is (partly through making sure the pieces are categorized and well-named), what everything is, and be able to intuitively string together accurate conclusions about their skills: She has a collection of strong CAD designs specifically for additive manufacturing, and a range of large, small, simple, and complicated parts that demonstrate many different features; therefore she will be able to create good designs for new parts that we need. His drawings are well-oriented and dimensioned correctly with clear labeling; therefore, he knows how to organize his models in a way that our specialists and technicians can easily interpret. These conclusions and the way the applicant presents himself or herself will reflect well on their level of preparation and readiness for the work world.

6. Conclusions and further work

The criteria and information just discussed are meant to help students and teachers keep in mind the overall goals and structure of a portfolio during its creation process. The most crucial elements of a portfolio all surround good communication: ensuring that the best selection of pieces is included; organizing them intuitively so that an audience can follow the progression—and in the case of a CAD engineering portfolio, this includes making sure that each piece falls in the correct section and highlights the intended aspects of the student's skills; and making sure the portfolio provides the correct structure and information so as to include the needed details but not include irrelevant or weak work.

As the discussion of the elements of a portfolio has demonstrated, this process includes considering the context the portfolio will be shown in when selecting work to include; attention to organization; correct categorizing and ordering of content; writing a good cover letter; and recognizing a portfolio as not only a tool for teaching and self-assessment or as a demonstration of a student's skills, but as a powerful method of communication. With a strong understanding of these concepts, students, teachers, and administrators of the education system will be able to better equip themselves to present their work, direct their instruction, and ensure that effective methods are being used in the classroom.

Finally, the paper offers suggestions for future work as follows. It provides clear possibilities for using the portfolio as a means of assessment and self-assessment, as an instrument in experiential and active learning, and as a tool for improving the students' communication skills. It also offers the opportunities for research which comes in conjunction with the development of a portfolio. Also, the practically orientated content of the paper is of immediate benefit to students and to lecturers in many domains. Furthermore, the paper should engage those involved in engineering education research or the psychology of learning.

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