Alumni Feedback and Reflections on Industrial Demands and Transdisciplinary Engineering Design Education

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Abstract

This research paper is dedicated to questions related to transdisciplinary engineering design education. Contemporary product design has become highly transdisciplinary, as a collaboration of engineering specialists and designers from multiple disciplines is required for the development of integrated products such as automobiles. The new transdisciplinary nature of industrial design practice inevitably affects recent engineering graduates. Today, employers seek well-rounded engineering graduates with well-developed technical and professional skills. This new reality as well as industrial demands and employers' expectations should be properly reflected and accounted for in engineering design education system, which still often remains strongly mono-disciplinary. To enhance engineering design curriculum and account for industrial demands, one first needs to understand how it affects recent graduates when they enter the workplace and what difficulties they may encounter during the first few years of industrial practice.

This paper presents the results of the two focus group interviews with engineering alumni of the Faculty of Engineering from the University of Alberta who graduated in the last 8 years and are currently employed in various engineering companies. The focus group interviews are a part of the empirical research project entitled *Transdisciplinary Design Education for Engineering Undergraduates*, which goals are to establish a common understanding of the design processes across multiple engineering disciplines and develop a first-year transdisciplinary engineering design course to facilitate overall design curriculum enhancement. This paper presents and discusses alumni feedback and reflections regarding their early experiences in the workplace when they just entered the industry, the transdisciplinarity in the workplace and in design practice, their employers' expectations regarding the qualifications of the new graduates, and alumni suggestions for the curriculum enhancement. The results support the findings of other studies regarding graduates' knowledge base and qualifications that industrial employers look for today as well as what is missed in graduates' knowledge base, which points out to the gaps in the Faculty curriculum. In addition, alumni provided a fresh perspective on how to approach engineering curriculum enhancement in light of expectations of contemporary employers. These findings are important to consider when developing and/or re-designing engineering design curriculum to account for industrial demands as of today.

Introduction

This paper is one in a series from an empirical research study and regards engineering education and design theory, methodology and practical applications. The new transdisciplinary nature of industrial product design requires new forms of collaboration between different engineering disciplines for the development of integrated products such as automobiles [1]. The definition of *transdisciplinarity* was provided by Ertas, who defined it as "the integrated use of the tools, techniques, and methods from various disciplines" as it is concerned with what is "simultaneously between disciplines, across different disciplines, and beyond all disciplines", and was discussed with the general design process and transdisciplinary approaches to teaching design in the previous work [1,13,14]. In contemporary industrial practice, engineering specialists are required to work in teams, follow the same design process steps, effectively communicate, and exercise professional skills. A line of empirical research on transdisciplinary design processes revealed that industrial design specialists perform analogous steps and follow similar design processes in different disciplines and companies as well as recognize the importance of human cognition in design practice [2-5]. Yet, despite this new reality, many post-secondary institutions still exercise mono-disciplinary approach when it comes to engineering design practice [1,6-9]. Different engineering departments in their core design course tend to still focus on a single discipline and exclude knowledge from other disciplines in theory and practice. As reported by industrial employers, this mono-disciplinary approach leads to the lack of appropriate transdisciplinary knowledge, insufficient design skills, poor judgement and problem-solving skills, and, last but not least, undeveloped professional skills in students [1,10-12]. Industrial demands and expectations of employers, however, should be properly address and accounted for in engineering design education.

To account for the transdisciplinary nature of industrial design practice and keep engineering curriculum in line with industrial demands, an empirical research project entitled *Transdisciplinary Design Education for Engineering Undergraduates* has been conducted with a team of engineering design experts at the University of Alberta. The purpose of the project was to enhance engineering design curriculum by: 1. establishing a common understanding of the design processes across engineering disciplines and 2. developing the first-year common introductory engineering design course. In order to account for all relevant factors that play role in design curriculum development, a Transdisciplinary Engineering Design Education Framework (TEDEF) has been developed, which considers industrial and educational perspectives on engineering design, the best-practiced teaching methodologies, transdisciplinary analysis of design processes across multiple engineering disciplines, and interviews with involved stakeholders such as engineering design professors and alumni [1,13-15]. As part of TEDEF Framework, a focus group study was conducted with alumni of the Faculty.

Purpose and Motivation

To properly enhance engineering design curriculum, it is important to understand what effect it has on the graduates when they start in the industry and what difficulties they may experience in the first few years of industrial practice. Multiple studies, articles, and reviews suggest that engineering graduates often have trouble when entering the industry and list a number of factors that play a role in that as well as suggest the sources of those issues. Yet, there is a limited number of publications that report the first-hand information and alumni reflections regarding their industrial experience. This paper reports the results of the two focus group interviews with the alumni of the Faculty of Engineering. The purpose of the focus group study was to collect alumni feedback and reflections regarding their early experiences in the workplace and learn about any difficulties they encountered there as well as their opinion regarding their experiences during their undergraduate studies. The three main points of concern and the corresponding questions for the investigation through the focus group interviews were:

1. **Alumni Experience in Industry:** *How did the new transdisciplinary nature of industrial design practice affect alumni? Did alumni experience any difficulties when they entered the*

industry? What have been the major changes since alumni started to work in the industry? What do alumni think about the transdisciplinary engineering design precisely?

2. **Industrial Demands**: *Based on alumni experiences, what do contemporary employers expect from new graduates? What are the most important skills, abilities, qualifications that employers are looking for today? What do alumni think about technical and professional qualifications and skills of the new graduates?*

3. **Alumni Experiences with Design Education:** *What were alumni experiences with design courses during their undergraduate studies? Based on alumni feedback, how can we enhance engineering design education? What do alumni think about the first-year common design course and transdisciplinary capstone courses?*

As part of the project, the purpose of the focus groups was to collect the first-hand information from the Faculty alumni regarding their experiences in industry to properly enhance the overall design curriculum, account for the gaps in the knowledge base delivered to students, and develop a structured first-year introductory design course including alumni suggestions and recommendations. There was no formal hypothesis for the focus group interviews, however, the following observations were expected from the focus group interviews based on the literature review: 1) Alumni would support the previous findings that contemporary industrial design became transdisciplinary [1-9]. The new transdisciplinary nature of industrial practice and the lack of such design practice during undergraduate studies contributed to the difficulties alumni experienced when they were entering and adjusting to the industry. 2) Alumni would suggest that contemporary employers seek well-rounded graduates, who have both well-developed technical and professional skills and are capable of working in transdisciplinary teams. 3) Alumni would provide some suggestions on how to improve engineering design curriculum. Alumni would favor the creation of the first year common (transdisciplinary) design course and two semester-long transdisciplinary capstone projects/courses, both with the equal emphasis on technical and professional skills.

Methods

Participants

An invitation email was sent in April 2018 to all alumni of the Faculty of Engineering from all departments, who graduated up to 8 years ago (since 2010). Alumni were asked whether they would like to participate in the focus group interviews to provide their feedback regarding their experiences in the industry and with undergraduate studies. 53 alumni expressed their interest in participating. They were divided into 2 groups. First group consisted of alumni who graduated up to 4 years ago and who did not yet have their Professional Engineering status and license (P.Eng.), the second group included alumni who graduated between 5 to 8 years ago and were all already professional engineers as per the Association of Professional Engineers and Geoscientists of Alberta (APEGA) requirements. Therefore, Group 1 was called "*experienced graduates*" and Group 2 was called "*recent graduates*". The reason that two groups were divided in terms of 0-4 and 5-8 is primarily due to the structural nature of the engineering profession regulation in Canada. Engineers Canada regulates the engineering profession through a structured progression of engineers in a mentored environment after their graduation. The graduates do not gain the title of Engineers by the virtue of their degree and must follow a mentored program of 4 years after which they must sit for an exam to attain the title of Professional Engineer (P.Eng.). The time spent before the P.Eng. restricts their ability to lead a team and make independent decisions on engineering design aspects. Completion of the exam and demonstrated experience of 4 years under a qualified P.Eng. supervisor allows the younger engineers to apply for the P.Eng. qualification and, thus, gives them the authority to practice Engineering in a leading position. Due to this specific aspect, the division was made on 0-4 and 5-8 years.

As the focus of the study was on transdisciplinary engineering design, it was decided that in each group, representation from different disciplines be ensured to allow for a transdisciplinary discussion. Therefore, one representative from each of the engineering disciplines from each graduation group was randomly selected and invited to the interview. Table 1 shows that the number of focus group participants, their disciplines and graduation year range. The dates for the focus group interviews were selected through the group vote with alumni in May 2018. Once the dates were set, participants were emailed the arrival instructions. Due to the ethics protocol and confidentiality agreement, no more personal or work-related information can be revealed about participants.

Table 1. The number of the focus group participants and their background information.

Group	**Group 1:** ***Experienced Graduates***	**Group 2:** ***Recent Graduates***
Graduation	5-8 years ago	0-4 years ago
Number of People	5	5
Disciplines	Mechanical, Electrical, Materials, Engineering Physics, Chemical	Computer, Engineering Physics, Chemical, Mechanical, Civil

Interview Procedure

The interviews were held on campus in a large meeting room, light refreshments were provided for alumni to create semi-formal conditions. The interviews took about 1 hour each. The discussions were run by the research assistant with a background in Psychology. The research assistant met alumni and provided them with the nametags, scrap paper, and pens. All alumni were given a nametag with their disciplines to address each other during the interviews. Participants were debriefed about the purposes of the focus group and asked to sign the consent forms. Then the recording began. The focus group questions were shown on the screen via PowerPoint presentation; the same presentations were shown to each group. The interviews were chosen over the surveys because a number of factors that may affect recent graduates in the workplace are already stated in the literature [1,6-8,14], but it was essential for the study goals to get as much of the first-hand information and feedback relevant to the Faculty from the domestic alumni in a form of open-ended answers.

There were several topics that were discussed with alumni. First, alumni were asked about their experiences in the workplace when they just entered the industry and what they think about the current engineering design practice. They were asked to comment on the changes in the industry since they started working in terms of new demands, challenges, and the skills that are important today. After, alumni were asked about the design process they use in industry today as well as to comment on the transdisciplinary engineering design practice. Alumni were asked if they have and follow a common design process in the workplace and describe its stages. Then, alumni were asked to describe any difficulties they encountered after their graduation when they entered the workplace. Alumni were also asked to comment on how they adjusted to the workplace, the design practice within their companies, and lack of any specific skills and qualifications. Further, alumni were asked to describe the situation in the industry today in terms of what kind of professionals are needed and what qualifications employers are looking for in recent graduates. Lastly, alumni were asked to describe their experiences during undergraduate studies in terms of design experiences and design courses. They were asked if they remembered when they were first introduced to the design process and whether it was too early or too late. Then, alumni were asked about any difficulties they could have had with the design courses they took. In addition, alumni were introduced to the idea of the first-year transdisciplinary design course and asked to comment on it. Alumni were asked if they would consider such course useful and provide their reasoning. They were also asked to provide their overall reflection on their undergraduate experiences and suggest any ideas for the curriculum enhancement.

When answering the questions, all alumni had the questions shown in front of them. First, a "set" for the questions was given to establish the theme for an upcoming question providing a short background or the literature review summaries. Then, the questions were shown and read aloud by the research assistant. In the end, alumni were given an opportunity to add any other information they thought was critical but was not covered in the interview questions. The responses of alumni were recorded using a microphone and a laptop, then transcribed into the written text format, and the audio files were destroyed. For the purpose of confidentiality, the individual answers were anonymized. Finally, the transcriptions were examined and summarized.

Results and Discussion

The interview results and alumni response are summarized and reported below. The responses are reported individually for each group and each question first; then, a brief comparison between the two groups is discussed. Where appropriate, verbatim quotes from the participants are provided to show the focus group's view. The comments are reported as per the order of their discussion.

Group 1 – Experienced graduates

1. Workplace commencement, first experiences and challenges, and recent changes

When it comes to the workplace transition and challenges, the first challenge that Group 1 named was communication: *"…communication is the biggest one…knowing your role in the process stream and be able to effectively communicate to clients as well as owners and everyone in the stream of the process."* Another challenge that they mentioned was technical communication: *"…explaining the technical details to end consumers from an engineering stand of point is difficult…especially for new people coming into the industry."* This group also claimed that teamwork, working effectively in teams and ensuring that all departments talk to each other, is very important. One participant said: *"…working effectively in teams in the sense that, when you're communicating what you've done to others, you're also seeking their input and making sure that everybody's had a chance to speak on your team…"* According to Group 1, communication and teamwork are the soft skills essential for each engineer because their lack may result in various *"people"* problems. All alumni agreed upon the following statement: *"All the projects that I've been involved in, the biggest challenges have never been technical, they've always been people problems…The real challenge has been finding ways to work together and work through disagreements…as engineers, we're technical people, not people-people, so we like to focus on the technical details and just lead with technology in our solutions. I think sometimes you actually have to lead with the soft skills and the people side."* Group 1 also highlighted the importance of contract law knowledge: *"…having a basic understanding of law and contract law…is really important. And that's something where I didn't get that at all in my undergraduate education."* With regards to the major changes in industry g, Group 1 named volume of information increased, making sure everyone is on board, communication between departments, and leading with soft skills.

2. Industrial engineering design process and transdisciplinary practice

All members of Group 1 agreed that there is a common engineering design process that all departments within their companies follow from project to project. This process is structured and is based on the standards that are imposed by a regulator. They said that it is not practically possible to diverge from the process as too many people are involved in it and diverging can course problems: *"…our own design process I think is pretty structured and…based on whatever standards are…"* Another member stated that *"…in today's industry there are so many moving parts for so many different parties that you can't really diverge too far from the standard engineering design process because it would negatively affect too many people."* Group 1 claimed that the biggest problem in the industry is *"defining a problem"* and *"having a client actually agree on what they want."*

All members of the group agreed that *transdisciplinarity* is present in every company. They said that there is a design phase, where transdisciplinarity comes in with a stage-gate process: *"…gating process essentially guides you into talking to those departments and making sure that they're included."* Another person said: *"we have stage-gate process almost identical to what you're talking about."* This process ensures that departments communicate, stay within the process and on track, and no party is left behind. They compared this process to an *"…engineering version of scientific math, where there's a tried, tested, and true process that happens and affects everybody."* However, there are few complications with the application of the transdisciplinary process. Communication between departments can sometimes be limited or not properly established, which can cause disagreements, unfulfilled requirements, or misunderstandings between departments. According to alumni, one of the reasons is that departments within companies begin discussing the transdisciplinary project matters almost at the end: *"…our communication system is often quite rushed at the end of the design process."* Also, with regards to transdisciplinary work, one participant said: *"…I'm mechanical but the majority of my job is software and electrical…"* Group 1 mentioned that there is a lot of design recycling and not a lot of original design due to the time constraints, which is why often the final product becomes a modified “copy-paste” of the earlier solution. To avoid “*reinventing the wheel”,* some companies “*standardized or templated”* their drawing packages for the most common problems, which is useful when it comes to *“mass production”* of specific products on the *“assembly line*”. One alumnus mentioned: *“…it’s the industry demand that’s outside of the engineering industry that is pushing for such faster turnaround times. There is no time to do your full due process…”*

3. Workplace adaptation, post-graduation difficulties, and major difficulties

Experienced graduates stated that one of biggest difficulties that they experienced in the industry after graduation was reading technical drawings: *“Some of the difficulties that I had on my first few jobs was the lack of knowledge for reading technical drawings. I mean you understand the theories and the concepts and the fundamentals, but to see real drawings for the first time…”* Participants explained this as due to the differences between drawing being shown in class and in real-life projects. Creating drawing is one of the most essential skills, especially for transdisciplinary design practice and communication. For example, one alumnus said: *“…creating drawings was a pretty interesting process. I’m 5 years into that specific role in my job and still don’t have enough information on it.”* Alumni suggested giving students assignments to produce different drawings for practice and negotiating with industrial companies on sharing real-life problem samples: *“…if you’re envisioning transdisciplinary projects linked to industry or business…then get students to produce drawings. Maybe it’s not the discipline they end up working in but at least it’s something…all drawings have standard symbols…Once you’ve learned it you can work in any industry.”*

Alumni also suggested giving students interdisciplinary projects, especially those that would force students to search and apply codes and standards. Since most of the drawings have standard/common symbols, a basic knowledge of such symbols would give an advantage to students when searching for a job, even in a different discipline. In addition, alumni suggested that bringing in other alumni to talk about standards or industrial processes would have been beneficial for them during their undergraduate studies: *“...And honestly, if some of the classes during the design program actually brought in alumni or industry professionals to talk about standards for the certain discipline that'd have been super helpful.”* Group 1 also said that there is a lot of demand and expectations of new employees and being unprepared means asking many questions, especially about drawings, and that is not always possible or comfortable. They also said that a basic knowledge of manufacturing processes and their applications in real life would be a great asset. Lastly, alumni said that the presence of a mentorship program is often an advantage, but these programs are not always available in every company*: “…my first job actually had a great mentorship program...Had I not had the experience from my first job then that second job would have been a struggle for me.”* With regards to the qualifications of the new hires, one person said: *“…even though you are hired in the different discipline from what you studied, they are looking for that broad range of skills.”*

4. Employers’ expectations and current industrial demands

According to experienced graduates, it is extremely important to have field experience. Only when engineers experienced the field work, saw how things are done and built in real life, and mastered *"answering questions in real-time",* they can transfer to the office and design things on paper. As per Group 1, building things on paper without knowledge of the field work and considering actual environment is "*not acceptable"*: *"…if you've just graduated and you're not married and you don't have kids, you go to the field immediately! It's different for every job, but only when you've actually been in the field and you've seen it built, and you understand how it works, and you've had to answer questions in real-time…you can go into the office and start managing projects and managing people."* Another participant stated: *"If you don't know the process of how it's going to be built, how can you effectively make drawings? If you don't know the process at the very beginning in the practical stages, you're working without any tools for success right off the bat. And you'll lose the respect of the people that are in the field, that are actually doing the front-line…"*

Group 1 claimed that *"the industry knows how ill-prepared new graduates [are]"* and they try to get them on board very quickly. There is a learning stage and some time is normally given for adaptation and *"to get up and stuff"*. However, alumni suggested that students would benefit from learning more about what to expect after the graduation: *"So, giving students…leg up by having some of that knowledge beforehand would be huge…"* Group 1 said that new graduates do not know the real-life design processes and *"what gets built first and what the next step is"*. Alumni claimed that employers today look for well-developed soft skills because they *"can't have enough time to take a risk on somebody and train them, and invest the money to train somebody, who can't be effective in a team environment, or to be able to communicate right away with clients"*. They said that *"employers expect that they have to do a whole bunch of technical training"* but not the soft-skills training because they *"can't really train the soft skills into someone as easy as the technical knowledge."* Thus, employers look for communication, adaptability, initiative, business skills, drive for results, effectivity, inspiration, ability to work with CAD, and leadership skills in recent graduates. Alumni suggested that the best way to adapt to the new workplace is to continuously "*ask more questions"* and "*ask for work*" to gain more experience faster instead of avoiding it.

5. Undergraduate experiences, design education, and a first-year design course

With regards to the design process knowledge, Group 1 stated that they *"honestly can't remember"* when they were formally introduced to the design process and that most of the design courses involved just theory and no hands-on practice. For example, one person said: *"…in chemical it was all theory-based and there wasn't much follow-up…I think that's what we're lacking – not having that capability to actually see what we have designed."* Alumni also discussed the development of the key professional skills in students such as time-management: *"…something that we don't get exposure to is reading charts and project scheduling. That was new to me and it was definitively a surprise to have these kinds of deadlines with seeing where the critical path was in that methodology."* Other group members complained that their design experience was too *"limited"* and consisted of just one capstone course: *"…(my capstone was) one semester too and it wasn't long enough to be totally honest. You didn't get a chance to actually build a prototype to see if it fails."*

One participant suggested more transdisciplinary practice for students, saying *"it would be best if the university thinks about doing transdisciplinary courses as capstones, where you have* *your electrical team can work with a mechanical team and that's already training communication skills…and expanding the scope of what a capstone project can do."* Alumni also suggested that *"having industrial design students and people outside of engineering and sciences in general"* is interesting and beneficial for communication skills development. .One group member suggested that the university could cooperate with the industry on training students on how to use some equipment and tools: *"… if you link them up with industry, then you can utilize their shops, their tools, and build a relationship there"*. Another participant commented: *"…I felt like the projects were not supported as strongly as they could've been and maybe that's because we weren't tied to industry, it was just like here's the generic design process, now pick your project and go design it."*

With regards to the first-year design course Group 1 alumni agreed that it *"would be helpful"* to introduce the design process and disciplines and, therefore, help students to choose the discipline. One participant commented: *"I think for a first-year course, learning about the design process, in general, would be good. Scheduling would be helpful and some Project Manager 101 type concepts. Just so people can get familiar with how you plan a project."* One more person commented: *"…the first-year design is learning not the technical skills but more of the leadership and soft skills and be able to manage your time."*

Group 2 – Recent Graduates

1. Workplace commencement, first experiences and challenges, and recent changes

Recent graduates believe that both *"technical and professional skills are important today"* and pointed out that the data collection and verification, analytical skills, knowledge of, and an ability to learn quickly in the rapidly changing environment are crucial. Group 2 also said that all "*verbal, written, and drawing-wise"* communication skills are important and specifically noted the technical communication, CAD knowledge, an ability to read technical drawing: *"…everything involves CAD now…I wasn't really taught a lot of that…communication is such a key part into getting the information that you need, into knowing whom to talk to…I've struggled sometimes with design drawings, and I did not understand what the drawing says. That should not be the case."* Group 2 also claimed that the knowledge of regulations is critical. One person said: *"…few things…that slapped me in the face when I first started design were…Regulations. I had no idea that I have to be regulated through life…especially working with electrical, utility, there's a lot of regulations and government bodies that dictate your work…"* As per Group 2, the nature of the products changed as new technologies are being utilized on a daily basis. To add on, there is an emerging field of *"professional"* software development, which imposes new regulations such as *"security background check".* One participant mentioned that *"there are changes in terms of new products that are on the market": "I didn't have exposure to all these products when I was in school… I was just introduced to it at work…"*

2. Industrial engineering design process and transdisciplinary practice

Recent graduates said that *"the modern standard is very quick iterative cycles to get the end product in front of an end user, or a stakeholder, as fast as possible to get their feedback."* Two group members mentioned the use of the Waterfall Methodology for engineering design, which was standardized and adapted to the needs of the companies. Alumni said that companies move away from the Waterfall Method, especially in software engineering but keep the essential idea of the stages and gates or stage-gate process part of it: *"…we have a very formalized version of that. We have all the checks and balances you know like there would be … gates."* To note, this group stated that they did not learn enough of the engineering design in school and, therefore, had to learn the majority of the design knowledge from the industry: *"…my understanding of engineering design is limited to what I have experienced with a company…most of it I learned working for the company rather than in school."* As per Group 2, *"the need for a project comes from a regulator"* and often projects involve feasibility and design phases, iterations, and execution. Group 2 claimed that the following stages are often present in the industrial design process: *Planning, Concept Development, System Level Design, Detailed Design, Implementation and Testing, and Production* and that all disciplines have stages as *Establishing a Need* and *Concept Generation.*

Group 2 highlighted the importance of standards and specifications as they affect the product design and mentioned the design recycling: *"...engineers have kind of custom fitting to a specific project or to a specific scope. But some of it is copy and paste and that's where some errors come in*." All members agreed that from project to project the design process is normally the same. As per Group 2, some companies are still arranging themselves into departments, and after that is done, the product goes from department to department. These departments work separately, but at the end, they all come to the transdisciplinary stage, which normally falls onto the detailed or execution design stages. One alumnus joked: *"… everything changes in execution. Start putting it together and things go wrong."* Another alumnus said: *"In my company each group is separate. We do have a civil engineering group, an electrical group, and so forth… within the detail design stage there are design reviews, where all engineers involved in a project would come in with their drawings. And you have input into each other, their comment, and how that affects yours, and how yours affects theirs. And, hopefully, that catches what needs to be caught. So, that's where the transdisciplinary happens."* Group 2 suggested that *"the difference between a good engineer and a bad engineer was the transdisciplinary portion*" and an ability to forecast, which comes with experience and in a sense that different departments should always stay in touch to avoid design flaws and iterations.

3. Workplace adaptation, post-graduation difficulties, and major difficulties

Group 2 claimed that the most difficult thing for them was to make the first step into the industry. As per Group 2, *"a lot of new engineers when given a problem were either too afraid or just didn't have the experience in just starting the first conceptual design…In school, we get taught all of the calculations and all of the things that go into the background, like all the detailed design. But when it comes to the actual functional units of things, we're sort of missing."* In addition, alumni said that in school students learn a lot of calculus, but when it comes to industry, they do not know the appropriate times to use different calculations. One of the important things that alumni stressed out was that graduates are lacking system-level thinking and data-analysis skills. They claimed that undergraduate studies prepare students to design sub-systems or smaller systems, but not the larger systems: *"An overall system level…Undergrad feels like you're always doing a subsystem or a really small system. Your first day on the job you're sitting there and it's this big system that's bigger, and you can't hold it in your head."*

They also stated that the presence of mentorship programs within a company is beneficial, especially *"if people are generous with their knowledge"*, however, *"sometimes that's not easily available in companies and some people are very stingy with their knowledge."* Group 2 noted that knowledge of codes and standards and their applications and the use of appropriate libraries are very important for success in the industry. Another thing that was noted is that the capstone projects that students work on may define their future in the industry as those capstone projects serve as a portfolio that affects employers' judgement: *"…people graduating with the same degree have different knowledge base depending on what your capstone project was, and that's your basis."* Thus, alumni suggested creation of portfolios for graduates to facilitate better job search and stressed out the importance of the professional work experience through co-op program*: "…every single employer expects you to essentially have a portfolio of stuff you've done…If you don't have that, or professional work experience through the co-op program, you're gonna have a really difficult time finding a job."*

4. Employers' expectations and current industrial demands

Group 2 said that *"multidisciplinary knowledge"* is *"the biggest thing"* and the most critical for success in the industry. Group 2 said that *"everybody graduates with the same base line"*, but the way people behave and *"carry themselves, how they talk"* – their soft skills – *"that's what sets them apart"* in the hiring process. For example, one person said: *"…what qualifications my employer looks for is good communication."* Other important skills that Group 2 alumni stressed out were risk assessment and business skills. For example, one person said: *"…in every single industry risk is huge. That's probably one of the reasons I got my job is because I understood risk."* Alumni suggested that *"there should be a little bit less focus on strictly calculations and more focus on tools of the trade".* They advised giving students more practical and real-life examples from outside the classroom, for example, teaching students some *"really basic…transdisciplinary equipment…applicable to every discipline…"* Recent graduates claimed that they would prefer having more of the hands-on practicum relevant to the industry than theoretical examples to be more successful. They suggested training students using tools that are normally used in industry rather than shown in class. For instance, one person suggested, when teaching students how to measure distance and units, to show them how to use both measuring methods – both by *"chain and by GPS units"* – on practice, as opposed to showing "chain" on practice and "GPS units" in theory only.

5. Undergraduate experiences, design education, and a first-year design course

Group 2 alumni said that their design experiences started *"way too late in the process"*, which negatively impacted their design knowledge base. Alumni also said that most design courses were theory-based and lacked building phase, thus, they claimed that *"completing the design loop and actually seeing if the thing (they) designed would work in some way is what was missing in design courses."* They suggested that *"exposure to the process way earlier would've been really, really helpful"*, and that the co-op program benefited them: *"…because I did my co-op, it made the design course so easy."* With regards to the capstone courses, alumni suggested that they should be two semester-long, transdisciplinary and involve actual hands-on experiences to obtain a complete learning experience. Another participant commented on the transdisciplinarity of capstones and the business aspect of the design: *"…by the fourth year it'd be nice to do interdisciplinary stuff. In the first year, second year, third year, build up projects with groups…I know that during labs and stuff you're doing group work. But it's not framed in the way that you're selling this product. I think that it'd be useful…even if the product is stupid…You need to be able to sell it."* Regarding the first-year introductory design course, Group 2 said that *"…you almost must have a multidisciplinary design course that…forces you to get exposed to each of those disciplines…it gives you a better idea of what you wanna go into…a little bit of a taste…and if you're gonna do projects, you could make them very small scale…it doesn't have to be that complicated."* In addition, they suggested things such as engineering clubs and *"meet a person"* nights to expose students to different disciplines.

Between-group Comparison and Alumni Suggestions

The results of the focus group interviews portray the situation in the industry today, describe the design processes and employers' expectations as well as the "gaps" in the engineering education system that they have been subjected to during their undergraduate studies. The two groups often gave similar answers to the same questions and mentioned similar things with each topic, which was one of the expected outcomes of the focus groups. Regarding alumni experiences in the industry and with the engineering design process, both groups gave similar answers. In particular, both groups named communication skills, technical communication and CAD tools, various soft skills and knowledge of contract law and regulations as the most critical and challenging for entering the industry. Also, both groups agreed that there is a common structured stage-gate engineering design process that exists in their companies, which all engineers would follow, that strongly relies on governmental regulations and standards. Both groups mentioned that transdisciplinarity exists in the process and often falls onto the detailed or execution stages. Recent graduates also noted that the ability to account for transdisciplinarity and timely communication is what distinguishes a "good" engineer from "bad". These are the gaps, which were not previously addressed in the Faculty design curriculum. In addition, both groups recalled that, due to the time constraints and market demands, the design recycling became common and companies now create their own standardized temples for particular design problems. However, when it comes to the difficulties of workplace commencement, experienced alumni suggested that reading technical drawing and knowledge of libraries of codes and standards are critical today. In contrast, recent graduates suggested the ability to apply theoretical knowledge on practice, specifically, the creation of conceptual designs and larger system designs. They claimed that recent graduates lack the system-level thinking and ability to work with larger systems. Interestingly, both groups suggested and recommended giving students more interdisciplinary projects, providing an opportunity to create various discipline-specific technical drawings, introducing students to the basic technical libraries, creating portfolios, and, last but not least, utilizing the mentorship programs.

Regarding the current industrial demands, experienced alumni stated that having a field experience is crucial for the successful performance in the office workplace and claimed that employers expect recent graduates to lack some knowledge and are ready to provide some technical but not soft skills training. They suggested that giving students some information about what is "really" going to happen once they enter the industry would have been beneficial. Both groups also said that employers look for engineers with both well-developed technical and professional skill. On the other hand, recent graduates suggested that multidisciplinary knowledge, as well as communication and risk assessment skills, business knowledge, and knowledge of the most common transdisciplinary equipment are essential for success. Experienced graduates recommended future graduates to continuously ask questions and for more work to speed up the adaptation process. Recent graduates suggested providing students with more hands-on practice relevant to the industrial projects as well as some knowledge of other disciplines.

Finally, regarding alumni undergraduate experiences and the first-year design course, both groups described their design experiences as *"limited"* as most of them had their design courses in the last year as capstones, which were only one semester-long and did not provide them enough time to experience the building and troubleshooting phases of the design. Recent graduates also highlighted the benefits of the co-op programs, which allowed them to be exposed to the design earlier than in the curriculum. They stated that transdisciplinary capstones would be helpful, especially with hands-on practice to complete *"the design loop*". Interestingly, both groups suggested having students outside of engineering and linking the design project to the industry by incorporating the business aspect of it – selling the product. Both groups agreed that the first-year design course would be *"useful"* to introduce students to the basics of design and other disciplines. They suggested having transdisciplinary teams and bringing in students from different disciplines to work on the same project to boost their soft skills. Group 2 also highlighted how the first-year course helps to better choose the future discipline for the first-year students.

Overall, the results of the focus group study supported the expected outcomes. Alumni supported the previous findings that contemporary industrial design became transdisciplinary. The new transdisciplinary nature of industrial practice and the lack of such design practice during undergraduate studies contributed to the difficulties alumni experienced when they were entering and adjusting to the industry. In addition, alumni claimed that contemporary employers seek well-rounded graduates, who have both well-developed technical and professional skills and are capable of working in transdisciplinary teams. Lastly, alumni suggested improvements for the engineering design curriculum as well as supported the idea of the first-year common transdisciplinary engineering design course and 2-semester long transdisciplinary capstone projects.

Conclusion

This paper presented and discussed the results of the focus group study with two groups of alumni of the Faculty of Engineering who graduated up to 8 year ago and were employed in various disciplines, companies, and research labs. Alumni's industrial experiences with the engineering design process as well as transition challenges and recent industrial changes were discussed. Alumni provided their reflections on industrial demands and current employers' expectations of the recent graduates. Lastly, alumni commented on their experiences with the design courses and overall design education and provided a few suggestions for education improvement. The expected outcomes of this study were supported by alumni reflections on the above topics and pointed out things that course be further enhanced in the curriculum such as the quality of the capstone projects, industrial connections, knowledge of the law and regulations, technical communication and CAD knowledge, etc. In addition, both groups of alumni agreed that the first-year introductory design course would be beneficial to introduce students to the engineering design and engineering disciplines. However, the limitations of this study should be considered as the focus groups consisted on the limited number of participants and not all disciplines were equally present in each group as well as the natural limitations of the focus groups study and procedures. Although, this paper is a part of a large transdisciplinary teaching enhancement project performed to review and enhance the overall design curriculum at the Faculty and considering that these results are primary and specific to the University of Alberta, the reported alumni feedback and reflections are relevant and can be useful for other engineering schools and post-secondary institutions as a reference. In the future, it would be interested to replicate this study with the larger groups of alumni or include more groups and disciplines and possibly implement surveys. The results reported are important to consider for the development and/or re-design of the engineering design curriculum to account for industrial demands as of today as well as overall program enhancement.

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