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Recommended Citation

Markovetz, Matthew R.; Sullivan, Sean; Clark, Renee M.; Swiecki, Zachari; Arastoopour Irgens, Golnaz; Shaffer, David W.; Chesler, Naomi C.; and Bodnar, Cheryl A., "A Grounded Qualitative Analysis of the Effect of a Focus Group on Design Process in a Virtual Internship" (2017). *Publications*. 5.
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This article is available at TigerPrints: https://tigerprints.clemson.edu/ed_human_dvlpmnt_pub/5

International Journal of Engineering Education Vol. 33, No. 6(A), pp. 1834–1841, 2017
Printed in Great Britain
0949-149X/91 $3.00+0.00
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A Grounded Qualitative Analysis of the Effect of a Focus Group on Design Process in a Virtual Internship*

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A key component associated with the development of an entrepreneurial mindset is the ability to understand customer needs and consider this when developing a product. This study sought to understand whether the inclusion of a customer focus group as part of a virtual internship created any differences in the design processes of sophomore engineering students (114 students). The Nephrotex virtual internship requires that students design a dialysis membrane by optimizing a selection of four components: membrane polymer, polymerization process, processing surfactant, and carbon nanotube percentage. We found that sophomores who engaged in a focus group during the virtual internship Nephrotex showed (statistically) equal focus on cost versus technical measures of design performance during the focus group. Despite this, design cost was lower in the section that participated in a focus group, with no decrease in product quality. This indicates that customer voice may be an important factor in decreasing product cost. We also found that sophomore students prioritized their interviewing of customers within the focus group towards end users, such as the patient and nephrologist. Qualitative analysis of sophomore responses demonstrated that they found utility in the focus group (30% of participants) but did not necessarily believe that the customers had useful knowledge of the relevant design attributes (17% of participants). Such realizations may have contributed to the equivalent quality and decreased costs associated with the designs of sophomores who participated in a focus group.

Keywords: virtual internships; customer voice; customer needs; design process

1. Introduction

Engineers in the workforce today must be more than technically proficient. They must exhibit an entrepreneurial mindset, demonstrated by the ability to work in a dynamic, creative, team-based environment while remaining aware of current and future market demands for a given class of products [1, 2]. Purzer and colleagues [2] note that this mindset translates to an awareness of the societal value of a product when the design task is approached from a self-motivated, leadership-oriented perspective. Accordingly, the need for engineers to embrace an entrepreneurial mindset is clear [2–4], and, a shift toward increasing the focus on entrepreneurial mindset instruction in undergraduate engineering education is underway [1, 5–12].

Training engineering students to exhibit entrepreneurial tendencies is important as it will help to drive development in the global market for products and services, as noted in [1, 6, 13–15]. Prior studies on the impact of entrepreneurship instruction at the undergraduate level have focused on the technical knowledge requirements of entrepreneurship [1] or marketplace awareness [13], while some specifically examined the importance of understanding customer needs [14]. Students' development of understanding customer needs and their importance in the design process has been limited within the literature and this work within a simulated work environment begins to address this gap.

2. Background

The concept of customer voice, first introduced by Akao in 1978, suggests that addressing customer needs is of critical importance to a successful design [16–18]. Producing a design that matches what a consumer has in mind remains one of the primary challenges for modern designers [19, 20]. However, students who are naïve to the realities of customer and marketplace demand and their importance to

* Accepted 20 June 2017.

successful design have only preconceptions to serve as a guide, which may often be incorrect [21]. These preconceptions can range from the nature of the final design to the precise meaning of design in a given field and can—include their conception of customer knowledge base. Any of the three forms of student misconceptions as suggested by Chi et al. [22], whether incorrect, inconsistent, or incompatible with the nature of customer needs and voice, pose an obstacle to effective customer focused design. An important goal, therefore, is to identify and correct correctable preconceptions (i.e., incorrect or inconsistent with prior knowledge), at an early stage in a student's progression. One way to identify misconceptions would be to monitor student perception of customer needs in a classroom over the course of play in a product-design focused digital environment or ''virtual internship''.

Virtual internships simulate the roles that a student may expect to assume in a professional setting [23]. In the case of product design, such experiences allow for students to request and receive expert feedback in real time about technical performance but also economic and marketing projections. Students can therefore learn about the workplace environment and culture while operating within the security of classroom space, which provides a known benefit to the development of engineering students [24]. Student submissions and resulting correspondence about the submissions can be kept on record for analysis during and after completion of the simulation, which allows researchers to study the development of customer focused preconceptions and student design process as students progress through the simulated internship [25].

In this work we analyzed the responses of students during play of the virtual internship Nephrotex [23]. At the virtual company Nephrotex, students role-play as interns who are responsible for the design of a dialysis membrane for therapeutic blood ultrafiltration. Students are part of design teams advised by a live design mentor and virtual employees over the course of the virtual internship, as described in Methods. The simulated design experience also requires a written and oral justification of final design selection.

Herein, we complement our prior quantitative analysis of the effect of a focus group in a virtual internship [26], including its effect on end-customer desired attributes (i.e. cost, technical performance), with a qualitative analysis of student design process. We have selected qualitative analysis as a research methodology to understand how and why students chose a certain design process and how it relates to customer voice. Furthermore, a qualitative description of student design process may help explain the quantitative effects observed from customer input as part of a focus group. In this work, we develop and use a grounded analysis framework in order to identify themes in student responses as a starting point for our analysis. Through this grounded analysis, we seek to answer the first research question (RQ1): is an external customer focus group within a virtual internship environment associated with specific product attribute or customer themes?

We also examine the differences in preconceptions of customers between sophomores and seniors. We evaluated students' selection of questions and responses to information gained from the focus group across academic levels. Specifically, we compared what types of customers were selected for the focus group and which questions were asked of focus group members by sophomores and seniors. We also compared the themes of their responses in order to answer the second research question (RQ2): do senior engineering students have different preconceptions of the customer vs. sophomore students?

3. Methods

3.1 Study design

Nephrotex was implemented in the spring semester of 2014 in two sophomore-level sections (57 students each) and one senior-level section (89 students) as part of a series of design courses in the Chemical Engineering undergraduate program at the University of Pittsburgh. The Nephrotex virtual internship requires that students design a dialysis membrane by optimizing a selection of four components: membrane polymer, polymerization process, processing surfactant, and carbon nanotube percentage [18] with input from virtual consultants at Nephrotex and external stakeholders within a focus group. The senior section and one of the sophomore sections participated in a focus group activity as outlined in Markovetz et al. [26]. In brief, students in the focus groups were able to ask two of five customer types (dialysis patient, nephrologist, Medicare assistant, hospital administrator, and industry thought leader) three questions from a list of ten possible questions for each specific customer type (see Fig. 1 from Markovetz et al., [26] for a diagram of the selection process). The virtual internship was played in-class for one hour per week for ten weeks of the design course. Unfinished tasks were completed outside of class time. This study was approved by the University of Pittsburgh IRB for work with human subjects.

3.2 Assessment of student submissions

This work focuses on qualitative differences in student design processes when they are exposed to customer voice by focus groups—differences that may ultimately lead to differences in design output. These qualitative assessments were performed via an analysis of student notebook submissions within the virtual internship Nephrotex. We also quantitatively reviewed each question asked during the focus groups. We counted the number of times each customer was selected by a student design team, and compared the normalized results between the sophomore and senior sections. A list of questions students were able to select from to ask customers is published in Appendix A of [26].

Students also submitted final designs that were assessed for quality according to the methodology in [26]. This allowed for determination of whether qualitative differences between groups were associated with quantitative differences in design performance.

3.3 Grounded analysis framework development

A grounded qualitative analysis was the primary methodology used in this work [27]. Grounded analysis frameworks are generated through iterative reduction of the set of observed themes in all analyzed responses. Recurrent or study-relevant themes are retained through subsequent iterations until a concise representation remains. In the case of this virtual internship, common themes are expected to be in line with technical terms found in dialysis. Thus, we generated a coding scheme that measures how interrelated the occurrences of specific themes are (e.g., membrane flux and customer knowledge).

Furthermore, this tool will be useful in understanding what student perceptions of the customer are regardless of academic level, and specifically between sophomores and seniors in this case. The perceptions could relate to value of information gained/to-be-gained or they could relate to the importance of the information gained relative to patient care supply chain whether this is end-users like patients or nephrologists or intermediate stakeholders like hospital administrators, Medicare providers, or third-party industry members.

The themes (also referred to as categories) for assessing student responses within the focus group activities as well as descriptions and quoted exam-

Table 1. Categories and subcategories with their notebook responses. Grammatical errors by students are denoted with [sic]

Category	Subcategory	Description	Example
Focus Group (FG)	Useful	Finds the FG useful	"The customer focus group was useful in determine [sic] what attributes are most important to the customer and therefore what we should focus on when designing our product."
	Not Useful	Did not find the FG useful	"Our focus groups did not address too much information."
Customer	Role	Student-perceived customer role as end user or otherwise	"[Patient] doesn't pay for his treatment but would love to use the best possible product."
	Needs	Identified customer needs as price or performance constraints	"The nephrologist is on more of a budget and will not spend more than 80."
Knowledge	High	Student believed insight could be obtained from customer	"[Patient] gave us knowledge on how often he had to have treatments. . ."
	Low	Student believed little knowledge could be gained from customer	"Half of the questions asked where [sic] outside of their expertise and was [sic] left unanswered."
Utility	Compared	Student compares the value of responses given by two or more customers	"Depending on if we focus on the in-home or clinical patient, some of these responses may not be valuable."
	High	Customer responses were useful to the student	"I found the industry leader more useful that [sic] the patient."
	Low	Customer responses were not useful to the student	"From the Medicare Government Assistant, she had no useful information other than that Medicare has an $80.00 coverage on dialysis cost."
Attributes	Technical	Technical attributes (e.g., BCR, Flux, or Reliability) were mentioned (counted individually)	"The industry leader was concerned with a balance between reduced pain and flux." (BCR and Flux)
	Marketability	Marketing and/or marketability were mentioned	"A low cost product may not be the best advice from a marketability perspective."
	Cost	Cost was mentioned	"It was clear from the responses that most of the customers care about the membrane being cheap and efficient."
Expectations	Met	Expectations of the FG or customer were met/exceeded	"This is what was expected by the internal consultants. They basically predicted each answer."
	Not Met	Expectations of the FG or customer were not met	"My responses are rather disappointing."

ples of occurrences of each theme in this study are given in Table 1.

Each student notebook response from the focus group activity was double-coded for quality purposes. The two coders were trained to categorize student responses according to the items in Table 1 by reviewing 10 randomly selected responses from the pool of 394 valid responses, reconciling differences, and retraining on another 10 responses. The remaining 374 responses were double-coded and used to determine the final counts and first-time inter-rater reliability (IRR), which was found to be substantial across all responses (Cohen's $\kappa = 0.669$) [28].

The frequency of each category or combination of categories of interest was recorded. Differences in frequencies between sections were assessed using z-tests of proportions and/or effect sizes measured by the odds ratio (OR), which in the context of this work is given by:

$$OR = \frac{odds\ of\ mentioning\ category\ one}{odds\ of\ mentioning\ category\ two} \quad (1)$$

4. Results and discussion

4.1 RQ1: is an external customer focus group within a virtual internship environment associated with a specific product attribute (i.e. BCR, flux, reliability, cost, marketability) or customer theme? In addressing this research question, we examined only the sophomore sections that played through Nephrotex with a focus group (FG).

We first categorized sophomore FG notebook responses using our grounded analysis framework in Table 1. Table 2 shows in descending order the raw count (as frequency) and repeat-subtracted percentage response for each category that was mentioned by students at least once during the FG module. These metrics are indicators of the students' focus on each particular category. The number of students who mentioned individual technical attributes (flux, BCR, and reliability) is also reported.

Table 2. Categorized notebook responses. Frequency represents the number of times a particular code occurred throughout the student entries keeping in mind that students may have mentioned one type of code more than once. The metric "% of Students with Response" quantifies how many students (out of 54) mentioned the category at least once

Code Category	Frequency	% of Students with Response (/54)
Attributes—Cost	49	78%
Customer—Needs	43	74%
Attributes—Technical	36	67%
– Flux	24	44%
– BCR	25	46%
– Reliability	9	17%
Customer—Role	20	35%
Attributes—Marketability	9	15%

We found that there was a higher percentage of students that had cost-related responses compared to technical (78% vs. 67%), but the difference was not significant ($p = 0.20$, z-test) and the effect size was small (OR = 1.77 calculated using equation (1)) [29]. Additionally, cost and technical attributes were mentioned together 48% of the time as exemplified below.

- "In summary, the customer focus group concluded that flux and cost are the most important values to them {attributes—flux, attributes—cost}."
- "Cost and flux were the two most important concerns cited by the customer targeting session {attributes—flux, attributes—cost}."
- "The manufacturing engineer completely agreed with the nephrologist because he thinks that cost and reliability are most important {attributes—reliability, attributes—cost}."

The findings that two-thirds or more of students mentioned technical or cost attributes and that responses like the ones above were given by approximately half of the students indicate that no substantive difference in student focus between cost and technical matters existed. This demonstrates that while cost may be an important individual design parameter to the sophomore students, it did not outweigh overall technical performance in terms of student focus.

Using data gathered from sophomore FG student sections, we previously found that the number of questions that a given student asked about cost during the focus group had no relation to the final cost of the product, but exposure to customer voice during a focus group was associated with lower cost designs [26]. Our current finding that those same sophomore students did not have increased interest in cost relative to technical attributes coincides with our previous assessment that customer exposure alone is associated with lower cost designs as assessed quantitatively. There was, however, significantly ($p < 0.0005$) increased interest in cost over each individual technical metric, with medium to large effect sizes (OR = 4.38 and OR = 4.05) for flux and BCR, respectively, and very large effect size for reliability (OR = 17.5). Thus, there was no significant difference in sophomore students when balancing cost with overall technical performance, however cost was prioritized over individual technical performance elements.

As both cost and technical performance are known to be important factors to the customer,

Table 3. Frequency mentions of both customer needs and a design attribute in tandem

Combining Code	Frequency of Category	% of Students (/54)
Customer—Needs Attributes—Technical	50	61%
Customer—Needs Attributes—Cost	55	67%
Customer—Needs Attributes—Marketability	8	10%

we also evaluated the number of times students mentioned either cost or technical attributes in the same submission as customer needs. Examples of this occurring are given for mention of customer needs alongside technical attributes, cost, and marketing, respectively below with coding for each excerpt in curly braces:

- "They [nephrologist] would not be happy with a lower flux because with so many patients they need a dialysis that can be completed in an efficient amount of time {attributes—flux, customer—needs}."
- "The nephrologist said that they were willing to spend no more than $80 per membrane {customer—needs, attributes—cost}."
- "They also posessed [sic] no brand loyalty at all. This is very valuable data, because now we need to establish a brand name {customer—needs, utility—high, attributes—marketing}."

We found that sophomores tended to associate customer needs with both cost and technical aspects of the design more so than marketability, as presented in Table 3.

The difference between the number of times cost or technical attributes were mentioned in combination with customer needs was not significant (p = 0.28, z-test), and the effect size was small (OR = 1.09). Sophomore students also mentioned cost or technical attributes in combination with customer needs far more than marketability and customer needs (OR = 6.7 and 6.1, respectively), possibly because students believe cost and technical performance are more important than marketability during the design process.

4.2 RQ2: Do senior engineering students have different pre-conceptions of the customer vs. sophomore students?

The results of the analysis of focus group customer selection are given in Fig. 1.

Sophomores demonstrated increased ($p < 0.05$) focus on end-users (i.e. patients and nephrologists) compared to seniors, as shown by the frequency of focus group questions asked. Additionally, the expected fraction of questions asked was 0.2 for each external stakeholder given the five customer types, assuming zero bias going into the focus group. However, sophomores asked a significantly different ($p < 0.05$) proportion of questions to each stakeholder except for the industry thought leader (p = 0.13), with the larger proportions dedicated towards the end users of the product. Seniors asked more evenly of each stakeholder, only asking the patient an increased fraction of the time (p = 0.02). This may indicate that seniors have an increased awareness of the full scope of a product's customer base or supply chain. Recognizing the diversity of customer needs is important to understanding the customer within the design process. This finding may indicate that senior students have developed that recognition to a greater extent. Understanding the source of this difference in focus could reveal a method to develop students' recognition of the entire consumer base at an earlier stage of their

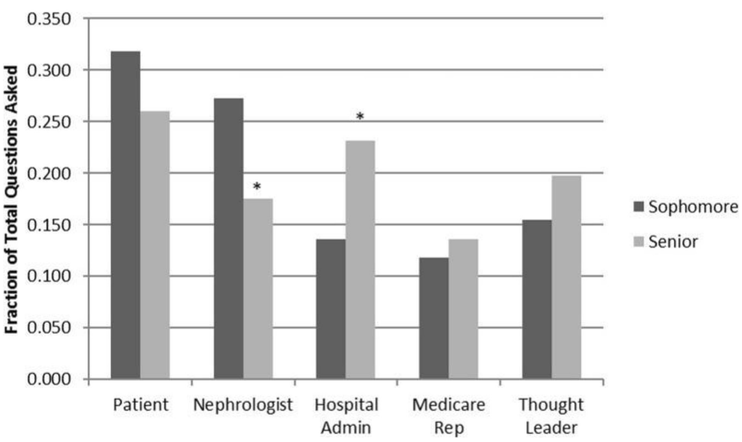

Fig. 1. The distribution of customers interviewed. Each bar represents the fraction of times each customer was interviewed relative to the other stakeholders. Differences between sections were significant in the case of the nephrologist and hospital administrator ($p < 0.05$).

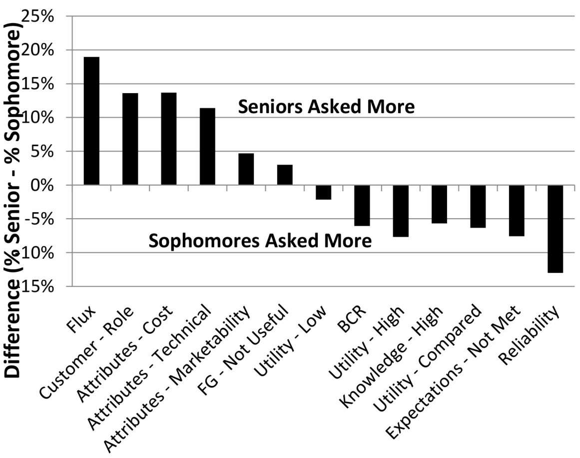

Fig. 2. Responses that demonstrate significantly different proportions between senior and sophomore students that participated in a focus group.

education. To further explore this hypothesis, we categorized senior submissions using our grounded analysis framework. This allowed us to compare the design processes used by seniors and sophomores, as well as their preconceptions of the customer base. The frequency of occurrence of each theme that demonstrated statistically significant differences between seniors and sophomores based on a z-test for proportions is shown in Fig. 2.

Seniors addressed important design attributes, including cost, technical, or marketability, to a greater extent than the sophomores did. Technical emphasis by seniors was primarily focused on flux, with decreased emphasis on BCR and reliability. Seniors did not find the focus group or its participants as useful or as knowledgeable as the sophomores when comparing the fraction of responses that stated FG utility was high. This may be because seniors enter into the virtual internship with more knowledge and/or experience regarding product design than sophomores, and thus already had a more developed design concept going into the focus group. This supposition may be valid given that, in the case of the seniors, their expectations were *not* met relatively less (i.e. their preconceptions were less often wrong). For example, some responses to that end are given below:

- "The industry thought leader's answers confirmed much of what I already knew {expectations —met}."
- "[The focus group] was of some value but the cost could have been assumed front [sic] he [sic] beginning {attributes—cost, expectations—met}."

This may indicate that seniors have an experiential knowledge base from which to draw when designing a product, which could have been gained either through coursework or co-op assignments or internships (hence their reduced perception of focus group utility).

We assumed the seniors' relative knowledge base provides an advantage in terms of final design quality and the ability to meet customer needs. However, we find no differences between final design performance of the seniors and sophomores. The sophomore section had nearly equivalent cost ($112 vs. $111.3) and quality (15.3 vs. 15.6) as the seniors did, whereas we have reported previously that students that did not perform a focus group have increased cost for similar quality [26].

5. Study limitations

The study presented is limited by sample sizes. The sophomore class had 54 students recorded responses allowing for ten sophomore teams. The senior class had 82 students, which resulted in 15 senior teams. Thus, analyses performed on team-generated results are more limited with regard to sample size.

Another limitation of this study is that all analysis was performed with chemical engineering class sections that participated in Nephrotex during the 2014 spring semester at one university. That is, students in multiple disciplines were not considered; differences between institutions (or types of institutions) were not investigated; and no year-over-year, qualitative analysis of the impacts of focus groups on student design processes and outcomes was performed. For these reasons, as well as the small sample sizes, the results may not be transferable.

In order to more meaningfully characterize the differences and similarities observed between sophomores and seniors, a study tracking the state of students' perception of customers performed over the duration of their engineering education is warranted. This could include research into the effects of solely classroom or industrial experiences and the two in combination to improve our understanding of how best to address customer needs as part of developing an entrepreneurial mindset in undergraduate engineering students.

This study was also limited by the transferability of results obtained from coding of student responses. The themes that were observed were in some cases very specific to the elements associated with the virtual internship Nephrotex. However, the use of focus groups as tools to expose students to customer voice within a virtual internship has merit and the current results provide a basis for continued research in this area.

6. Conclusions

In this work, we developed a grounded analysis framework to investigate differences in design processes that occur with the introduction of a customer focus group to a virtual internship. Through analysis of student responses based on this framework, we have shown that sophomores who engage in a focus group during the virtual internship Nephrotex showed (statistically) equal focus on cost versus technical measures of design performance during the focus group. Despite this, design cost was lower in the section that participated in a focus group, with no decrease in quality. This indicates that customer voice may be an important factor in decreasing product cost.

In terms of other differences in the design processes that occurred with the focus group sections, we found that sophomore students prioritized their interviewing of customers within the focus group towards end users, such as the patient and nephrologist. Furthermore, qualitative analysis of sophomore responses demonstrated that they found utility in the focus group (30% of participants) but did not necessarily believe that the customers had useful knowledge of the relevant design attributes (17% of participants). Such realizations may have contributed to the equivalent quality and decreased costs associated with the designs of sophomores who participated in a focus group.

Acknowledgements—The authors thank Andrew Glowacki, Timothy Knab, Andrew Kozbial, Jason Lee, and Melissa Lash from the University of Pittsburgh for their role as virtual design advisors for the classes studied herein. The work performed was supported by a University of Pittsburgh Innovation in Education grant as well as an NSF Research Initiation Grant in Engineering Education (RIGEE EEC#1340426), for which the authors are also grateful.

References

1. C. A. Bodnar, R. M. Clark and M. Besterfield-Sacre, Lessons Learned through Sequential Offerings of an Innovation and Entrepreneurship Boot Camp for Sophomore Engineering Students, *J. Eng. Entrep.*, **6**(1), 2015, pp. 52–67.
2. S. Purzer, N. D. Fila and K. Nataraja, Evaluation of Current Assessment Methods in Engineering Entrepreneurship Education, *Adv. Eng. Educ.*, **5**(3), 2016.
3. E. Ortiz-Medina, Leovigilda, Fernández-Ahumada, P. Lara-Vélez, A. Garrido-Varo, D. Pérez-Marín and J. E. Guerrero-Ginel, Assessing an Entrepreneurship Education Project in Engineering Studies by Means of Participatory Techniques, *Adv. Eng. Educ.*, **4**(2), 2014.
4. P. Centobelli, R. Cerchione, E. Esposito and M. Raffa, The Evolution of Engineering Management Education, *Int. J. Eng. Educ.*, **32**(4), 2016, pp. 1813–1822.
5. M. Täks, P. Tynjälä, M. Toding, H. Kukemelk and U. Venesaar, Engineering students' experiences in studying entrepreneurship, *J. Eng. Educ.*, **103**(4), 2014, pp. 573–598.
6. T. Byers, T. Seelig, S. Sheppard, and P. Weilerstein, Entrepreneurship: Its Role in Engineering Education, *Bridge*, **43**(2), 2013, pp. 35–40.
7. A. Iborra, B. Alvarez, P. Sanchez, J. A. Pastor and T. Suarez, ICT Entrepreneurial Ecosystem for Engineering Education, *Int. J. Eng. Educ.*, **32**(5A), 2016, pp. 2033–2047.
8. K. M. Rogy, R. M. Clark and C. A. Bodnar, Examining the Entrepreneurial Mindset of Senior Chemical Engineering Students as a Result of Exposure to the Epistemic Game 'Nephrotex', *ASEE 2014 Annual Conference and Exposition*, Indianapolis, Indiana, June 15–18, 2014.
9. A. Shartrand and P. Weilerstein, Strategies to Promote Entrepreneurial Learning in Engineering Capstone Courses, *Int. J. Eng. Educ.*, **27**(6), 2011, pp. 1186–1191.
10. M. Schar, S. Sheppard, S. Brunhaver, M. Cuson and M. M. Grau, Bending moments to business models: Integrating an entrepreneurship case study as part of core mechanical engineering curriculum, *ASEE 2013 Annual Conference and Exposition,* Atlanta, Georgia, June 23–26th, 2013.
11. A. Huang-Saad and S. Celis, How Student Characteristics Shape Engineering Pathways to Entrepreneurship Education, *Int. J. Eng. Educ.*, **33**(2A), 2017, pp. 527–537.
12. G. B. Da Silva, H. G. Costa and M. D. De Barros, Entrepreneurship Education: A Literature Review, *Int. J. Eng. Educ.*, **31**(6A), 2015, pp. 1701–1710.
13. T. Litzinger, L. R. Lattuca, R. Hadgraft and W. Newstetter, Engineering Education and the Development of Expertise, *J. Eng. Educ.*, **100**(1), 2011, pp. 123–150.
14. K. Kriewall and Timothy J. Mekemson, Instilling the Entrepreneurial Mindset Into Engineering, *J. Eng. Entrep.*, **1**(1), 2010, pp. 5–19.
15. B. Antoncic and R. D. Hisrich, Clarifying the intrapreneurship concept, *J. Small Bus. Enterp. Dev.*, **10**(1), 2003, pp. 7–24.
16. Y. Akao and G. H. Mazur, The leading edge in QFD: past, present and future, *Int. J. Qual. Reliab. Manag.*, **20**(1), 2003, pp. 20–35.
17. R. B. Woodruff, Customer value: The next source for competitive advantage, *J. Acad. Mark. Sci.*, **25**(2), 1997, pp. 139–153.
18. G. Pahl, W. Beitz, J. Feldhusen and K.-H. Grote, *Engineering design: a systematic approach*, Springer, London, 2007.
19. M. C. Lin, C. C. Wang, M. S. Chen and C. A. Chang, Using AHP and TOPSIS approaches in customer-driven product design process, *Comput. Ind.*, **59**(1), 2008, pp. 17–31.
20. D. A. Norman, *The Design of Everyday Things, Revised and Expanded Edition*. Basic Books, New York, 2013.
21. M. Newstetter, Wendy, McCracken, Novice conceptions of design: Implications for the design of learning environments, in *Design Knowing and Learning: Cognition in Design Education*, Elseveir, Oxford, 2001, pp. 63–77.
22. M. T. H. Chi, R. Glaser and M. J. Farr, *The nature of expertise*. Lawrence Erlbaum Assoc., Inc., Hillsdale, NJ, 1998.
23. N. C. Chesler, G. Arastoopour, C. M. D'Angelo, E. A. Bagley and D. W. Shaffer, Design of a professional practice simulator for educating and motivating first-year engineering students, *Adv. Eng. Educ.*, **3**(3), 2013.
24. F. Dehing, W. Jochems and L. Baartman, Development of an engineering identity in the engineering curriculum in Dutch higher education: an exploratory study from the teaching staff perspective., *Eur. J. Eng. Educ.*, **38**(1), 2013, pp. 1–10.
25. N. C. Chesler, A. R. Ruis, W. Collier, Z. Swiecki, G. Arastoopour and D. W. Shaffer, A novel paradigm for engineering education: Virtual internships with individualized mentoring and assessment of engineering thinking, *J. Biomech. Eng.*, **137**(2), 2015, pp. 1–8.
26. M. R. Markovetz, R. M. Clark, Z. Swiecki, G. Arastoopour, N. C. Chesler, D. W. Shaffer, C. A. Bodnar, Influence of End Customer Exposure on Product Design within an Epistemic Game Environment. *Adv. Eng. Educ.*, **6**(2), 2017.
27. K. A. Neuendorf, *The content analysis guidebook*, Sage Publications, Thousand Oaks, 2002.
28. J. R. Landis and G. G. Koch, The Measurement of Observer Agreement for Categorical Data, *Biometrics*, **33**(1), 1977, pp. 159–174.
29. G. M. Sullivan and R. Feinn, Using Effect Size—or Why the P Value Is Not Enough, *J. Grad. Med. Educ.*, **4**(3), 2012, pp. 279–82.

Matthew Markovetz. His interest in both engineering education and technical engineering research developed while studying Chemical and Biological Engineering at the University of Colorado at Boulder. Matthew's research in education

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Sean Sullivan graduated with a Bachelor's Degree in Chemical Engineering at the University of Pittsburgh in April 2017. During his undergraduate career, he gained valuable experience in the University's co-op program, having two rotations with Air Products and Chemicals, Inc. and one rotation with Thar Energy LLC. Sean is also a Sergeant in the United States Army.

Renee Clark, PhD, has 23 years of experience as an engineer and analyst. She currently serves as the Director of Assessment for the University of Pittsburgh's Swanson School of Engineering and its Engineering Education Research Center (EERC), where her research focuses on assessment and evaluation of engineering education research projects and initiatives. She has most recently worked for Walgreens as a Senior Data Analyst and General Motors/Delphi Automotive as a Senior Applications Programmer and Manufacturing Quality Engineer. She received her PhD in Industrial Engineering from the University of Pittsburgh and her MS in Mechanical Engineering from Case Western while working for Delphi Automotive. She completed her postdoctoral studies in engineering education at the University of Pittsburgh. Dr. Clark has published articles in the *Journal of Engineering Education*, the *Journal of Engineering Entrepreneurship*, and *Risk Analysis*.

Zach Swiecki. His area of study is Learning Science. Before entering into education research, Zach studied mathematics and physics at the University of Alabama-Tuscaloosa. During his studies, he became interested in education through his work as a physics and math tutor. Zach is currently in the Epistemic Games Group working on the development of engineering internship simulations

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Naomi Chesler graduated with a BS in general engineering from Swarthmore College and then obtained an MS in mechanical engineering from MIT and a PhD in medical engineering from the Harvard-MIT joint program in Health Sciences and Technology. Professor Chesler not only seeks to improve diagnoses and prognoses for heart failure by studying vascular biomechanics and hemodynamics, but also to diversify the engineering workforce through innovative mentoring and curricular change strategies.

David Williamson Shaffer. Before coming to the University of Wisconsin, he was a teacher, teacher-trainer, curriculum developer, and game designer. Dr. Shaffer studies how new technologies change the way people think and learn, and his most recent book is *How Computer Games Help Children Learn*.

Cheryl A. Bodnar. Dr. Bodnar's research interests relate to the incorporation of active learning techniques in undergraduate classes (problem based learning, games and simulations, etc.) as well as integration of innovation and entrepreneurship into engineering curriculum. More specifically, she is focused on evaluating the effectiveness of games for increasing student motivation and learning within the classroom environment.