Using Personas as Curricular Design Tools: Engaging the Boundaries of Engineering Culture

[1]Desen Sevi Ozkan, [1]David Reeping, [1]Lisa D. McNair, [2]Tom L. Martin, [3]Steve Harrison [2]Luke Lester, [2]Ben Knapp, [4]Matthew Wisnioski, [4]Annie Patrick, [1]Liesl Baum,
[1]*Engineering Education*, [2]*Electrical and Computer Engineering,*
[3]*Computer Science*, [4]*Science, Technology and Society*
Virginia Tech
Blacksburg, VA
desenoz@vt.edu

Abstract—**This innovative practice paper introduces the use of personas as a design technique to guide the large-scale curriculum reform of an Electrical and Computer Engineering (ECE) program at [University X], a large Mid-Atlantic research-intensive institution. The team has created five personas to explore the potential breadth of the curriculum and expand the faculty perspective on who could be a successful ECE student in the department. The concept of personas originated in the field of human-computer interaction to represent subsets of potential users as abstracted sets of characteristics. Drawing from qualitative data including observations of team meetings and document analysis, this work describes the ethnographic inquiry designers used to develop profiles not solely based on their biases. Responses to personas during implementation show that they can be used to engage the boundaries of culture, bringing to light not only characteristics of students who are not typically present in the program, but also faculty members' assumptions about characteristics needed for success.**

Keywords—*electrical engineering education, computer engineering education, curriculum development, engineering students*

I. INTRODUCTION

This innovative practice full paper addresses current issues that revolve around dismantling the power that gatekeepers have in determining who participates in engineering. Traditionally, the electrical and computer engineering department at [University X], has had limited appeal to students with varied needs and desires. The students who progress through typical curricular programs are largely homogeneous in their career interests and demographics as a result, which also reflects the discipline at large. A cycle is created in which efforts in diversifying the student population of recruited students are followed by the failure to retain groups not belonging to the norm throughout the engineering curriculum.

Substantial interest at the intersection of engineering education and federal policy lies in broadening participation in engineering [1]. Efforts to include underrepresented minorities in the field exist to encourage enrollment, but the students are matriculating into a fundamentally unchanged system. Although a substantial amount of effort is placed on recruitment, the tools for retaining students from a curricular perspective can be limiting. Recruited, but not retained—if recruited at all. Developing inclusive curricula is a task beyond the scope of traditional frameworks of curriculum design, perhaps because inclusivity is not inherently curricular. An inclusive curriculum is intentionally designed with supports in place for students of varying backgrounds to succeed embedded within a culture that values the breadth of student experiences [2].

The push for inclusivity necessitates a method for engaging in concrete discussions about where boundaries in the culture can be pushed. Although significant progress has been made at both ends of the engineering curriculum to foster inclusivity, the first year and capstone, little attention has been placed on the middle years in the literature [3]. The dearth of literature inspired the Revolutionizing Engineering and Computer Science Departments (RED) grant awarded by the National Science Foundation [3] to provide funding to departments poised for significant reform. Following change management literature [4]–[6] that posits "*organizational structure and reward systems*" [3] are highly influential to the success of change, the RED grant structure requires the power of the department head as the principal investigator. Despite the administrative support, there is bound to be resistance to change. This work concerns one method of curricular design to begin addressing the often broadly posed task of recruiting and retaining a diverse engineering class despite such resistance.

II. BACKGROUND

A. ECE as a discipline

As the field of Electrical Engineering has expanded, there have been two directional changes – the first, a horizontal division in which subfields and specialties fragment the field. The second, a vertical division segments the field by technical complexity, such that electrical engineering can have sub-disciplines based on increasingly abstract layers of technical work [7].

Electrical Engineering as a discipline was first established in the late 1800s following the Morrill Land Grant Act of

1862, when agriculture and the mechanical arts became prominent in higher education curricula. Initially, programs were largely housed in Physics Departments. Mechanical engineering was the other close connection. At Cornell, students would take the same classes until their fourth year and then specialize in either mechanical or electrical engineering [7]. By 1900, universities were starting independent Electrical Engineering programs as enrollments for electrical engineering began exceeding mechanical or civil engineering [7], [8].

After Electrical Engineering Departments were established, the variety of course offerings continued to grow. Industry served as an orienting factor for curricula through the late 1800s to the early 1900s [8]. The continued diversification of curricula kept electrical engineering intact as one field by "*preserving its disciplinary integrity*" [7, p. 4563]. Yet, educators argued for a common set of courses that all students take as the different specializations in electrical engineering increased. By the 1950s, Electrical Engineering education emphasized more fundamental science and engineering science in the curriculum. Terman, a notable electrical engineer and administrator at Stanford, suggested a curriculum that included a 'basic core' followed by specialization. However, the discipline was continuing to fragment, which made it difficult to provide students with a standardized education in electrical engineering in the four-year curriculum [7].

B. ECE at [University X]

[University X] was no exception to the historical trends. In the 1890s when the department began, funding was largely from local, state, and national corporations. Following World War II, in the Cold War era, the Electrical Engineering departments across the nation were undergoing large-scale changes with regard to funding sources—federal government—and curriculum structure—fundamental science and engineering science [9]. Prior to the change enacted through the RED grant, the curriculum had largely stayed the same since 1971. Through the 1960s and 1970s, societal changes brought women and African American students into the curriculum. However, only through years of reform initiatives intended to change university and departmental culture do women make up 14% and underrepresented groups, 10%, of the undergraduate population.

Starting in the 1970s, Computer Engineering research become a prominent intersection between Electrical Engineering and Computer Science research. At [University X], 1989 marked the first year in which students graduated with a computer engineering degree (CPE). The number of students and faculty expanded to make up a significant portion of the department. By 1997, the department had changed its name to ECE to include a focus CPE.

C. ECE department-specific RED goals

The vision of the RED grant was to attract a broader range of students and prepare them for a wider variety of careers. Achieving the RED vision requires changing the traditional, narrowly focused two tracks in the department (electrical engineering and computer engineering) so that students had freedom to choose from multiple pathways to a degree, pathways that could be tailored to their own interests and professional goals. The multiple pathways led to the use of personas as a means of communicating the possibilities to put student needs first.

D. Personas

The concept of personas originated from Alan Cooper's *The Inmates Are Running the Asylum,* a text about high tech gadgets. Representations of users have long been used in marketing practices; however, Cooper introduced personas in the design and development stage to include different groups of users intentionally throughout the process. Personas are described as fictional people who represent subsets of stakeholders. The profiles help designers conceptualize scenarios in which their products are used by specific groups of people. They serve as a design tool, but have been used differently by various practitioners in different contexts [10].

According to Pruitt & Grudin, personas are most beneficial when they are rooted in ethnographic and qualitative inquiry.

> *"Personas used alone can aid design, but they can be more powerful if used to complement, not replace, a full range of quantitative and qualitative methods. They can amplify the effectiveness of other methods"* [11, p. 3].

Similarly, academics and practitioners alike have noted that for personas to be effective, they "*need to be based on sound field research.*" Partly, because personas will be better representations of the client or user, but also because when they are derived from research methods, they become "*associated with methodological rigor and data*" [10, p. 440]. The perception that personas are a tool rooted in 'rigorous' research strengthens the use of the tool, perhaps to improve buy-in from the design team. Overall, there are still no agreements on the benefits of personas as a tool of design [11]–[13].

In addition to being used as a research tool in which user groups are better understood, personas also offer a platform for communication. According to Alan Cooper, personas ease communication among designers and their clients [13]. Decisions becomes clearer when design choices are rooted in distinct persona goals. Because personas are fictional characters, their goals and characteristics can be subjective and interpreted differently by designers. Additionally, the Interaction Design Foundations makes the distinction that a persona is "*not the same as an archetype or a person*" [14]. The portrayal of a persona is presented in the context of the design. Consequently, the persona represents a fragment of the person who is envisioned, which can be a limitation with respect to the longevity of the design.

The effectiveness of personas correspond with how well they are integrated throughout the entire design process. Other fields have taken personas and adapted them to their own uses. Yet, overall, the main effect that personas have are that they act as a communication tool for design teams. By creating a fictional character profile that designers can point to, conversations around who is and is not at the table can become more precise and arguably more useful to the design teams. Personas have become a boundary object [15] that helps teams negotiate the features and characteristics of their designs with personas characteristics in mind [16]. Of course, by creating specific personas for groups of people, there is the limitation that not all groups can be identified and represented by a persona. As a result, it must be emphasized that personas

should be used as an evolving tool that is adapted to the environment as it changes.

E. Personas in engineering education

In engineering education, personas have played supporting roles in larger research projects. In one example, Matusovich and Streveler used personas to depict findings from interview and survey data. They created pictorial personas to "*mitigate biases and test hypotheses*" in their research regarding the influence that student beliefs had on their choice to pursue engineering degrees [17, p. 11]. Personas were used as a tool to confer between researchers as well as a way to test ideas throughout the research process. Other studies show similar generalizable characteristics that pertain to engineers. Loshbaugh and Claar noted some of the proud traits, "*geeks, nerds, and dorks*" that undergraduate engineering asserted about themselves [18, p. 6]. The authors discuss the characteristics as narrow definitions engineering that can be damaging for students who do not hold such identities.

In instances where curriculum designers are overloaded with the task of redesigning their engineering curriculum, personas can act as a successful tool to remind the design team of more diverse student profiles [19]. Chalmers University of Technology in Sweden redesigned their electrical, computer, and software engineering undergraduate programs in response to the diminishing number of female students and applicants. Curriculum designers at Chalmers collected data from "*faculty and alumni, industry representatives,* [and] *journals from working engineers*" to create nine personas [19, p. 2]. The program at Chalmers has a larger emphasis on industry ties than most US engineering programs. Students study for three years at Chalmers and then work for two years with an industry partner to obtain their bachelor's degrees. As a result, the personas created by Chalmers faculty were solely focused on postgraduate career options.

It must be acknowledged that personas are a tool to be used by designers rather than being an end product. In one of the collaborative persona-related exercises, Chalmers faculty wrote in differing comments about the female and male personas such that the women had "*unrealistic workloads and that working under such pressure will lead to sickness*" [19, p. 11]. For the male equivalent personas, no such comments were written. The use of personas in the case of Chalmers served to reveal different biases among the faculty which could then be acknowledged and disrupted. Accordingly, personas can serve as a revealing tool of design. However, for them to be effective, they must be revisited and reevaluated as the design process unfolds.

III. RESEARCH AIMS

This study seeks to answer the overarching research question—how have personas been used to aid a process of departmental change? This study has been guided by three specific research questions:

RQ1: How have personas been used in the communication among ECE stakeholders?

RQ2: How have personas been used to influence curriculum design decisions?

RQ3: How have personas been used perceptions of student populations?

IV. METHODS

This work adopted a qualitative case study approach. Cases are said to be bounded by space and time, so this case was bound by the duration of RED grant in ECE at [University X].

A. Data collection and analysis

The data collection consisted of meeting recordings of the RED executive team and ECE faculty, field notes from the meetings by RED executive team members, and informal interviews with them to fill in contextual gaps - and as a measure of research quality. The sections of the meeting recordings pertaining to the personas were transcribed by the first author. Lastly, internal reports generated by the executive team and an external grant evaluator were used to trace the use of personas over time and triangulate data across stakeholders.

The transcripts and internal documents were initially coded to describe the setting in which the personas were used, which personas were used, and to which stakeholder group they were used with. In the second cycle of coding, the persona-use was coded in relation to specific curricular changes or student pathways specific to the intended stakeholder group with which they were being discussed. As a measure of trustworthiness, sections from the findings were member-checked with individuals on the RED executive team. This was to ensure that the analysis from the recordings or notes were not misconstrued.

B. Limitations

However, as a limitation, the data collected is largely through the perspective of the RED executive team and lacks the first-hand perspectives of ECE faculty, current students, advising team, or Industrial Advisory Board members. Additionally, this innovative practice paper reflects data largely collected from the faculty on the RED executive team who are from a variety of different departments that operate at smaller scales than ECE at [University X]. Issues regarding department size underly many of the other issues that surface through the multiple sources of evidence.

V. FINDINGS

A. The development of personas

The five student personas were created in a collaborative effort among the VT RED executive team to test the boundaries of the new curriculum with respect to the new types of students matriculating into the department. Following a discussion regarding the students' lack of choice in ECE, two faculty members from the team populated bundles of personal and career characteristics outside the current model electrical and computer engineering education at VT. The major options for students prior to the departmental change efforts were directly tied to the nine existing research areas. After the first iteration of the personas, the two faculty introduced their rough drafts to the larger RED executive team as "*a set of representative people who are impacted by the [RED] project.*" The initial idea was to have several personas for students and faculty such that the team could "*identify the main needs, frustrations, and behaviors of personas per program.*" Most importantly, the team used the creation of personas to "*capture the traits of students that the program does not currently serve.*" Initially, the distinction meant career trajectory, such that personas could be used to represent ECE students who would go into

different positions either not often held by graduates or not considered by faculty, such as patent law, finance, a tech startup, or sustainable technology in smart homes.

The final persona bundles were created from a detailed matrix of student characteristics. The characteristics ranged from qualities such as first-generation, out-of-state, international, transfer student to a representative of the current student population. The larger categories were then iterated on further to include specifics about each student characteristic. The subcategories were then detailed further with questions of quality, to add nuance to the specific issues that the characteristics might raise with the larger stakeholder group of ECE.

The final version of the personas was a combination of the specifics detailed in the group iteration and qualities derived from real ECE students from other institutions. Many of the student attributes detailed by the group were detailed further drawing from real-life examples of students at aspirational peers. For example, one article told the story of a student who combined fashion and electrical/computer engineering through a 'smart' fashion show as the final design product.

Other persona bundles were established by drawing on the 15-20 years of experiences among the ECE and CS faculty on the RED executive team to outline desirable characteristics in the wider range of students. In past work at a school with a large South Asian student population, one faculty member noted cultural differences regarding teamwork, which had led the US school to rule many of the students' collaborations as honor code violations because of the differences in what "cheating" meant. As a result, one of the personas includes qualities that draw them towards collaborative engineering work in their career. Another persona was developed to represent the most widely recognizable student in the department, which included students who are from a metropolitan area a few hours north of the university. In contrast, another persona was created to represent students who are from a rural area.

From the initial eight personas created by the two faculty, five personas were established by the larger team. A detailed description of each of the final personas are listed below in Table 1.

TABLE I.   PERSONAS

Name	Details of Each Persona
	Persona Description
Brad	Brad is from northern [State X] and wants to work at a defense contractor after getting a master's degree. He would like to use his math and physics skills. Both his parents are engineers. He is an A/A- student, but he's not comfortable with ambiguity.
Gabrielle	Gabrielle is a first-generation college student from [Capital city in State X] and wants to help older people live better lives by designing smart homes for assisted living. She's not sure whether she should major in gerontology, architecture, or engineering to be able to pursue her interests.
Bethany	Bethany is from rural [State X]. She had a great science teacher in high school who inspired her and helped her to develop an interest in biomedical research, particularly for veterinary

Name	Details of Each Persona
	Persona Description
	applications. However, she did not have a good math teacher, so her preparation is uneven.
Steven	Steven was born overseas but has been in the U.S. since middle school. His parents told him to be an engineer. He likes to work in teams and wants to work at Google, Facebook, or some other trendy company after graduation.
Mackenzie	Mackenzie is from northern [State X]. She is interested in electronic music, has the initiative to double-major in arts and engineering, and is comfortable with ambiguity. In high-school, she built a Theremin from instructions found on the internet and played it in her band. Mackenzie feels unfulfilled by the available choices for pursuing a degree at [University X] and is unsure whether understanding the fundamentals underlying the technology is essential to her professional goals.

B. Personas in-use

Personas with ECE program experience committee. The first time that personas were presented by representatives from the RED executive team to the ECE overall program experience working group, comprised of faculty and advising staff, there was a consensus that Brad was representative of many of the students in the current program. According to the faculty, the program prior to curriculum change "*serves Brad very well. All the other personas are not served at all by the program.*" The use of the personas helped the RED executive team start the conversation of who was served by the current ECE curriculum. By bringing the personas to the working group, the team sought to make the faculty-driven curriculum redesign more student-focused. At this point in the grant, there is a focus on the changing the structure of the curriculum rather than individual courses. The personas are perceived as a way to drive structural change by creating a student interface for faculty to engage with in the redesign. The RED executive team views the personas as an ongoing communication tool among themselves, the faculty, and other stakeholders of the grant.

Personas with RED executive team. When the persona conversation was brought back to the RED executive team, questions about how to help students figure out how their interests align with the curriculum and then pursue the nontraditional options were raised. Creating space in the program is one aspect of the problem's solution, but guiding students through is more intensive than changing the structure of the ECE curriculum. The difficulty of cultural change persists, as change signifies a curriculum that will value the student pathways represented by personas other than Brad. In the team's discussions concerning the purpose of the personas, their legitimacy as interpreted by faculty culture, and the curricular space by which students are exposed to the breadth of ECE lingered.

For students to follow in the pathways outlined by the personas, the RED executive team spoke of the real examples that students needed to follow. The discussion pointed out that even if students are offered nontraditional choices in their courses, their paths may not deviate from tradition if there are not tangible examples of success. For engineering students to pursue a cause like social justice through engineering, there must be examples of engineers who exemplify social justice in their work. Similarly, for a consistent number of ECE students to integrate the arts and engineering, they must have

examples of how engineers can interface with the arts. The point of engineering legitimacy brought the RED executive team from the curricular change discussion of flexibility back to the issue of departmental culture change. The former is constrained by university level deadlines for course and program approval, the latter is an amorphous construct that is slow and difficult to change. The discussions circled back to how the faculty perspectives largely resonate with the Brad persona.

Consequently, there was a perceived need to "*disrupt pathways that hold (sic) student in the ECE curriculum, so that they can select more of their path*." Meanwhile, across the university, top-down initiatives of cross-disciplinary collaboration are beginning to take form. The potential partnerships allow for an alternative path for students who seek nontraditional ECE applications. Yet, difficulties lie with perspectives that are behind efforts to change the curriculum as it has been accepted as needing revisions, but also view several personas as representing students who do not belong in ECE.

At this point in the grant's timeline, the RED executive team used the personas to think about the interests of students that the new ECE would serve. In some sense, the personas exemplified the end goal for the grant. With the personas, the team asked the question of "*how to prepare a support system for students to be the personas that* [they] *have mapped them into, but also how will* [they] *prepare faculty to be aware of the variety of industry options that exist*" and guide them into the new spaces. In the discussions around the objective of the personas with the ECE faculty, the team made it clear that they needed to "*provide students a space to engage in the persona-relevant spaces, but also to provide students the permission to do so also.*" The persona needs outlined by the RED executive team were twofold: 1.) "*you have to attract people who are not Brad*" and 2.) "*you have to help people not become Brad by default*" as a result of this program. In past years, students who did not resemble the Brad persona coming in, "*had to become Brad in order to survive.*" The different opportunities that the department can create with the aid of RED must also become valued by the department culture such that students who have these different interests are no longer outliers.

Personas with ECE faculty. Following the introduction of the personas to the overall program structure working group, the personas were presented to the faculty at large at the annual retreat before the beginning of the academic year. The personas were described for the entire faculty during a presentation on the progress on the RED grant. Later in the day, during a breakout session solely focused on the proposed new program structure from the program experience working group, groups of faculty were assigned a particular persona and asked to evaluate the existing program structure and the proposed program structure from the perspective of that persona. A particularly telling comment from one of the groups concerned Mackenzie, with a faculty wondering if she belonged "*under the ECE tent*", and if so, what were the "*parameters of the tent*".

Following the yearly faculty retreat session among the ECE stakeholders, including the ECE faculty and RED executive team, conversations using the language of personas seemed to shift to student pathways. The specific pathway outlined by each persona occurred less frequently in team discussions. The Brad persona, (the persona that is representative of the majority of successful students), largely dictated the conversations surrounding personas when they did occur. For many, the personas devolved into Brad and Non-Brad as representative pathways for students.

From personas to student pathways. Much of the language regarding students specified that students could follow multiple pathways modeled by a faculty member on the curriculum redesign team that pushed a more interdisciplinary option as an ECE major. In discussing the possibility, the RED executive team largely referred to the interdisciplinary option using the faculty member's last name, thereby modeling their curricular vision under faculty who exist in the department instead of the personas. The RED executive team discussed the option at length, where they identified structural and cultural barriers. For instance, the lack of a major checksheet is the first issue that came up but was followed by a discussion around the lack of faculty members who the hypothetical major would map onto. Past majors have always mapped onto clearly outlined research areas. In addition, communication strategies were discussed for conveying the validation of such a pathway to students and advisors to ensure the major would not be viewed as the "*easy option*" for those who were 'less serious' about ECE. The questions brought up in talking through the nontraditional major option brought the team back to issues of departmental culture, in that, even if students are presented with choices on what to study, much of the difficulty lies in which of those choices are deemed credible ECE by the faculty and departmental culture. Even with an increase of major and course options for students, the culture's normative influence could inform many of the choices that students are given permission to make.

The original intention of personas was to expand the boundaries of who would pursue an ECE degree. In effect, personas are a tool to bridge departmental culture change with curriculum redesign, for they paint portraits of ECE students who are not yet served by the program on both accounts. Currently, the personas other than Brad represent outliers who seek out nontraditional ECE opportunities in spite of opportunities and ECE culture. The RED executive team noted this issue through the Gabrielle persona, who "*already knows about smart homes*" but "*doesn't know to major in ECE.*" In one scenario, Gabrielle would choose to major in architecture and pursue smart homes through built-in avenues; in another scenario she would major in ECE and must find avenues outside the department to pursue her interest, thereby adding to an already full workload.

Another cultural issue that was raised in the curricular discussions involving personas was that "*there are going to be students who know about smart homes and wearables, but there are more who do not know the breadth of what they can do.*" For the students who do not bring in outside interests intersecting with ECE, the departmental culture will shift their pathway to resemble that of Brad.

Personas with the Industrial Advisory Board (IAB). Personas have been used more readily with other ECE stakeholder groups. In discussions with the department's industrial advisory board, the department head has used the five personas to outline the types of students that the revised ECE program is intending to graduate. Feedback from the IAB has been mostly positive in that they are "*much more on board with getting things going and helping.*" However, the IAB was skeptical of any persona that did not exhibit a clear majority interest in the traditional technical domains of ECE. Transdisciplinarity or multidisciplinarity at the undergraduate

level was not viewed as being dedicated enough to the degree program given its perceived level of difficulty. The IAB members are largely alumni and parents who "*want to help keep the momentum going*" especially because they get frustrated "*when tuition goes up and there is no change in the curriculum*." Perhaps because the interests of the IAB stakeholders as future employers and current parents are focused largely on students, the curriculum initiatives aimed at students are easier to elicit buy-in. For other stakeholders, like faculty amid competing constraints coupled with seemingly ambiguous change efforts, enacting change quickly can be daunting.

Mid-grant evaluation. A similar point was raised by the external evaluator who came to visit the department. Regarding enacted change, the evaluation shed further light on the juxtaposition between changing the culture and curriculum. The concrete deadlines for course approval took precedence over working through the ambiguity of changing departmental culture, such that the "revolutionary" departmental change has split into two prongs. The formerly feared "*divorce between culture and curricula*" was made clear in the evaluation and is partly if not fully due to institutional requirements (course approval) outside the control of the ECE department and RED executive team. The revitalization of personas offers a way to remarry the two prongs of change. The creation of new career pathways (curriculum) alongside a departmental shift that values these changes (culture) can ensure that the transformative change is centered on students through a focus on faculty.

Personas outside of ECE. The tool of personas has been used differently across many stakeholder groups relating to ECE. For the RED executive team, personas have acted as a communicative tool by which to represent their aspirations for the department, such that the bounds of who becomes an ECE student and ultimately graduates are different than it is currently. For the entire faculty group, personas have served to shed light on many of the faculty-held beliefs concerning the legitimacy and belonging of those represented by the non-Brads. For the industrial advisory board, personas have been fuel that the constituents have bought into and supported. Finally, the personas have been used outside of the ECE project with peripheral initiatives at the university.

In the context of donors, the personas have been used to demonstrate "*different kinds of people that companies want.*" The student archetypes represent more than race or ethnicity but show these efforts coupled with ECE related interests that fit outside the current curriculum. Moreover, because of the scale of the ECE department in relation to the rest of the university, the change efforts that are being carried out affect other programs at the university. In one example, the "*personas were reused for a pitch for a potential donor*" in the Honors College. Ironically, in this iteration of persona use, the Gabrielle persona, who has the interest in smart homes for aging populations, "*was put into Architecture due to the current state*" of the ECE curriculum.

Reflecting on the personas with the RED executive team. In a meeting following the mid-grant evaluation, the team reflected on how the personas have been used throughout the first half of the grant. When the personas were used with larger groups, RED faculty noted that the intention was muddled for "*the more people you got to, the more challenges you end up with.*" With larger groups there was a sense that the group's impression "*gravitated towards the mean, but with*

one to two people, they could have an impact." The team noted how the communication tool of personas was to be handled differently based on the particular audience.

VI. DISCUSSION

Personas have served a variety of functions over the course of the RED grant, some of which have yet to be revealed. Used with different stakeholders, personas have been both highly motivating and misunderstood as a marketing strategy. With the ECE faculty group, who hold the most power in terms of influencing departmental culture, reactions to personas have revealed barriers to expanding the boundaries of ECE, seen in comments deeming music technology or smart infrastructure for aging populations as not for "serious" ECE students.

Originally, personas were created by the RED executive team to expand the boundaries of who could be an ECE student. However, when they were used with the faculty gatekeepers of the department they shed light on the individual beliefs that explained why nontraditional student pathways have only existed as outliers. In the context of generating faculty buy-in, the personas had been created to show an end goal of who is in ECE, but rather, have identified points of issue that need to be addressed. The message is that students who are recruited into ECE under the premise of studying music technology, patent law, or a sustainable technology are not deemed outside the bounds of ECE by departmental culture.

The use of personas has signified that there is a disconnect between who they represent and many of the ECE faculty. Brad is by far the most commonly referenced persona, partly due to the prevalence of this student in the department, but also due to the resemblance of the persona to the faculty. In one example, an ECE faculty member from the curriculum team reflected on his educational history of having gone to a large public high school, then large research universities for undergraduate, master's, and doctorate degrees. For him, "*there is no shame in the commodity university*" to which he notes, "*I have my own biases.*" The implication that a department produces students as a commodity is antithetical to the original objectives of RED sought through persona-use, which is to design for multiple users and user needs. In contrast, a commodity university implies that students come out uniformly, through quality checks that ensure that learning processes are identical. Presumably, without representation of a variety of personas in the faculty population, the advocacy for different pathways will not be valued or sustained.

Largely, the personas that are less frequently referenced in curriculum design conversations are ones that do not have faculty either from RED or ECE at large advocating for them. As an example, the two ECE faculty on the RED executive team are examples of people who interface with music, fashion, and smart homes. The examples of faculty who fully buy-in and support personas are the ones that push the needs of these represented students. Perhaps in some ways, each persona needs a faculty champion to pave and normalize the pathway. Additionally, a faculty member from the curriculum committee has also advocated for a nontraditional major option that allows students more flexibility. Yet, when referring to this option the RED executive team always refers to the idea with the particular faculty member's last name. Even in this small act, the team has signified that initiatives are more powerful when they are tied to faculty in the department.

In Chang and Stolterman's discussion of how personas are shaped, they discuss the designer's assumptions. For some, products are built to solve the designer's own problems. Others maintain that the ideal development of personas is through user studies. The authors show the variety of ways practitioners have developed personas and whether or not they used them in the design process [10]. In the case of faculty who may not have bought into each of the personas as representations of successful students, many of their curriculum design choices might revert to themselves as the student—the user.

VII. CONCLUSION AND FUTURE WORK

In the creation of any representation there are limitations in that not all groups can be identified and represented. With personas, there is the danger of perpetuating stereotypes. As a result, personas need to be recognized as a heuristic - a tool that simplifies a complex problem. However, because of the evolving nature of design, the tools will undergo a similar progression based on the context in which it is used. Among the various stakeholder groups, the impact that personas have had ranged from revealing implicit beliefs about who belongs in personas to representing the end goal of departmental culture change. The different ways in which personas have 'landed' with different stakeholders perhaps show more about what subsequent steps need to be taken to address the revealed insights rather than letting the personas speak for themselves. Using the personas as an evolving tool can be an adaptive strategy that informs iterative design in its environment as it changes and promotes continuous improvement.

REFERENCES

[1] G. Lichtenstein, H. L. Chen, K. A. Smith, and T. A. Maldonado, "Retention and Persistence of Women and Minorities Along the Engineering\nPathway in the United States," Cambridge Handb. Eng. Educ. Res., pp. 311–334, 2014.

[2] M. Nind, "Introduction: Models and practice in inclusive curricula," in Curriculum and Pedagogy in Inclusive Education, Nind, Melanie and K. Simmons, Eds. Routledge, 2013, pp. 13–22.

[3] S. M. Lord and J. C. Chen, "Curriculum design in the middle years," Cambridge Handb. Eng. Educ. Res., pp. 181–199, 2014.

[4] C. Henderson, A. Beach, and N. Finkelstein, "Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature," J. Res. Sci. Teach., vol. 48, no. 8, pp. 952–984, 2011.

[5] L. H. Jamieson, J. R. Lohmann, J. L. Melsa, S. a. Rajala, and J. P. Mohsen, Creating a Culture for Scholarly and Systematic Innovation in Engineering Education, vol. 98, no. 3. 2009.

[6] R. Spalter-Roth, N. Fortenberry, and B. Lovitts, "What sociologists know about the acceptance and diffusion of innovation: The case of engineering education," Am. Sociol. Assoc. Retrieved August, vol. 25, p. 2007, 2007.

[7] B. K. Jesiek and L. H. Jamieson, "The Expansive (Dis)Integration of Electrical Engineering Education," IEEE Access, vol. 5, pp. 4561–4573, 2017.

[8] F. E. Terman, "A brief history of electrical engineering education," Proc. IEEE, vol. 4, no. 8, pp. 1399–1406, 1976.

[9] M. H. Wisnioski, Engineers for change: Competing visions of technology in 1960s America. Cambridge, MA: MIT Press, 2012.

[10] Y. Chang and E. Stolterman, "Personas: From Theory to Practices," in 5th Nordic conference on Human-computer interaction: building bridges (NordiCHI '08), 2008, pp. 439–442.

[11] J. Pruitt and J. Grudin, "Personas: Practice and theory," Proc. 2003 Conf. Des. user Exp. San Fr. CA, pp. 1–15, 2003.

[12] J. Pruitt and T. Adlin, The persona lifecycle: keeping people in mind throughout product design. Elsevier, 2010.

[13] A. Cooper, Inmates Are running the Asylum: Why High-Tech Products Drive Us Crazy and How to Restore the Sanity. Sams Publishing, 1999.

[14] L. Nielsen, "Personas," The Encyclopedia of Human-Computer Interaction, 2nd Ed. Interaction Design Foundation, 2013.

[15] S. L. Star and J. R. Griesemer, "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39," Soc. Stud. Sci., vol. 19, pp. 387–420, 1989.

[16] L. D. McNair, M. Davitt, and G. P. Batten, "Outside the 'comfort zone': impacts of interdisciplinary research collaboration on research, pedagogy, and disciplinary knowledge production," Eng. Stud., vol. 7, no. 1, pp. 47–79, 2015.

[17] H. Matusovich and R. A. Streveler, "Pictorial Personas : A Way to Look at Longitudinal Qualitative Data Center for the Advancement Authors • Research Context • Challenges with Methods • Pictorial Personas – Development and Use," in Ethnographic and Qualitative Research, Annual Conference, 2009, pp. 1–15.

[18] H. Loshbaugh and B. Claar, "Geeks are chic: Cultural identity and engineering students' pathways to the profession," in Proc. ASEE, 2007.

[19] A. Yström, L. Peterson, B. Von Sydow, and J. Malmqvist, "Using Personas To Guide Education Needs Analysis and Program Design," CDIO Montr., 2010.