Work In Progress: Methodological Considerations for Constructing Nontraditional Student Personas with Scenarios from Online Forum Usage Data in Calculus

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Introduction

Personas and scenarios each gained popularity as design tools within the fields of user-centered design (UCD) and human-computer interaction (HCI) during the mid to late 1990s. Unlike simple descriptions of real people, personas are fictional, "hypothetical archetypes" [1] constructed from purposeful research about product users. Personas help to communicate the goals, values, needs, and actions of targeted users and to develop empathy and interest for users during early stage design. Scenarios are narrative descriptions (i.e., "stories") of "typical and significant" user activities that help designers define specific product features that reflect a user focus [2]. Today, use of both personas and scenarios are widely recognized; designers may implement personas and/or scenarios in the context of product usage models that enable design teams to focus on the user throughout the entire product design cycle [e.g., 3].

While persona and scenario-based design approaches evolved separately, UCD and HCI scholars point to inherent benefits of combining personas *with* scenarios. According to Pruitt and Grudin [4], "scenarios are a natural element of Persona-based design and development." Adlin and Pruitt [5] argue that traditional scenarios are more compelling when "written around personas" because personas contain important social and cultural information that help communicate the impact of proposed design features. Putnam [6] suggests that scenarios written with personas as actors are more effective at "helping designers keep users in mind" — a key tenant of UCD—than traditional scenarios written around generic users. Nielsen [7] describes how normally "static" personas become "dynamic when inserted into the actions of the scenario"; scenarios bring personas to life by giving them a context, situation, and goal.

In this work in progress paper, we examine methodological considerations for constructing student personas with scenarios from an existing mixed dataset. The dataset documents how an interdisciplinary group of nontraditional undergraduates engaged in an asynchronous, online support forum for graded credit in distance-delivered calculus [project details are provided in 8, 9]. Our goal is to develop a set of nontraditional student *personas with scenarios* for translating and disseminating our research findings to science, technology, engineering, and mathematics (STEM) educators in an easily accessible and compelling form: that of an online forum *student usage model*. Recent work in engineering education provides precedent for the use of personas to communicate research findings [10-12]. Moreover, in communicating our findings using personas with contextualized scenarios that describe how the personas choose to actively engage (or not engage) with the online forum, we anticipate (a) improved transfer of contextual findings to a broad audience of STEM education stakeholders and (b) heightened motivation and confidence among STEM educators toward implementing online forums in order to increase participation of diverse, nontraditional undergraduates.

Prior Use of Personas and Scenarios in STEM Education

Over the last few decades, personas and scenarios have become popular tools for communicating complex, contextualized user data in memorable, empathic, and evocative ways [13, 14]. Recently, STEM education scholars have started to investigate how personas and scenarios can assist teaching practitioners and other curriculum stakeholders in the design of learner-centered educational experiences in STEM. For example, Lilley, Pyper, and Attwood [15] constructed and applied personas during the development of online learning experiences for undergraduates

enrolled in a distance education computer science program. Lilley, et al. [15] found personas to be important for understanding important pedagogical (e.g., normative peer feedback) and technological (e.g., mobile device access) needs of the distance learners in their program. In future work, they plan to supplement personas with contextual scenarios that reflect the distance students' approaches to learning. Turns, Borgford-Parnell, and Ferro [10] examined the effects of disseminating engineering student personas to (a) engineering curriculum stakeholders and (b) graduate students preparing to teach an undergraduate chemical engineering course. Their findings revealed personas to be flexible tools that were useful for prompting diverse audiences (e.g., teachers and students) to unpack biases and assumptions and reflect upon personal practices related to learning and teaching. Turns, et al. [10] also reported that access to "relevant," contextually specific personas (e.g., related to student diversity, engagement, or self-regulated learning) was necessary when assisting teachers with course design and that persona development took substantial time and benefitted from a carefully considered methodological approach. Others [11, 12] described use of personas to communicate research findings to engineering education administrators in order to promote change at higher institutional levels.

Methodological Considerations for Persona Development

Types of personas. Personas are commonly categorized as either "ad-hoc" or "data-driven" [5]. Ad-hoc—or "fiction based" [16] —personas are constructed solely from personal assumptions and "embedded knowledge" about the traits and actions of product users [1, 5]. Ad-hoc personas are often constructed early in a design cycle to expose designer bias, to create empathy for product users, or to motivate expensive data collection for further persona development [1, 5, 14]. Because ad-hoc personas are more effective at uncovering existing assumptions about users than challenging or changing these preconceptions [5], user-centered designers often move beyond ad-hoc personas to create data-driven personas. Data-driven personas are constructed from research data that describe the needs/values/goals and observed actions of potential users.

Data and data collection. Developers regularly use mixed (i.e., quantitative and qualitative) data to create data-driven personas. Some construct personas based on quantitative data first since quantitative data are often readily available from census and marketing segmentation surveys [4, 5]. Often, these "big data" are later supplemented with qualitative data to develop more precise personas [4, 5, 17, 18]. Qualitative data collected via open-ended surveys [e.g., 15, 19, 20], focus groups [e.g., 21], and interviews [e.g., 15, 22, 23] are useful because they are able to directly address target user needs, values, and goals. However, because interviews and surveys may not always directly address what users do, observation of targeted user actions/workflow can also provide valuable data [e.g., 24, 25, 26]. Recently, electronically stored textual data of actual user interactions (i.e., online chat transcripts) have been leveraged to build personas [27].

Analytic methods. Persona construction is an inductive, analytic process that continues to be researched and documented within a growing body of literature. Generally, persona developers seek to identify patterns of behavior, needs, and goals within user data, and then use these patterns to creatively construct fictional yet representative personas. Terms such as "qualitative clustering" (QC) [5, 28] and "qualitative coding" [29] describe this general process of inductively grouping like data. In practice, ad-hoc persona developers often participate in manual QC as teams via hands-on workshops. During these workshops, developer teams engage in card sorting exercises, known as "affinity diagramming" [5] or "The KJ Method" [30]. Individually,

developers use their experience and assumptions to generate product user data, on cards and then work collaboratively to group or "cluster" like behaviors, needs, and goals into descriptively labeled categories. They may choose to further segment some categories into subgroups. Developers use the groups and subgroups to form persona "skeletons" that become full personas as details are added [5]. Critiques of "manual QC" include the (a) need for specialists to use expert judgment during clustering [28], (b) perceived lack of developmental rigor, compounded by difficulty documenting how persona characteristics trace back to data [5, 31], and (c) time/expense of collecting qualitative data when quantitative data is available [4, 28].

While manual QC predominates in the persona literature, its critiques are leading persona developers to explore "semi-automated" clustering approaches [28]. These emerging, statistically-based approaches include Cluster Analysis (CA) [e.g., 26, 27], Factor Analysis (FA)/Principal Component Analysis (PCA) [e.g., 20, 31], and Latent Semantic Analysis (LSA) [e.g., 22, 32]. Both CA and FA/PCA are robust statistical techniques capable of reducing large quantitative datasets. While CA reduces multivariate data domains by segmenting them into a predefined number of clusters, FA/PCA reduce/combine data by identifying the underlying structure (factors) within the dataset [18, 28, 33]. Use of either CA or FA/PCA requires developers to gather data in (and/or convert their data to) numerical form. In contrast, LSA is a semi-automated qualitative clustering technique that compares similarity among word groupings by comparing textual documents (i.e. interview transcripts) against each other. Outputs of all semi-automated clustering techniques (i.e., CA, FA/PCA, and LSA) are quantitative; use of semi-automated clustering requires developers to have knowledge of statistical procedures, as well as experience in interpreting statistical results and converting them into a textual form [22, 28, 32]. Proponents of semi-automated clustering suggest that these techniques may help to overcome critical drawbacks of manual QC, namely human subjectivity and cognitive processing limitations, a need for qualified experts, and cost/time requirements [17, 20, 28, 31].

Persona forms. After constructing behavioral groups and subgroups, developers work to recombine them into distinct personas that reflect the data. Adlin and Pruitt [5] recommend limiting the number of personas to three to five. To trace the development of each persona back to the data, footnotes are often added support each persona characteristic with data excerpts [4, 5]. Pruitt and Grudin [4] also recommend developing a "foundation document" to serve as a "storehouse" for information/data about that persona. Citing data directly within the final persona is not common; developers may momentarily transcend data during the persona writing process in order to emphasize a new empathetic stance obtained from a deeper understanding of the data [21]. Most often, personas take the final form of a biographical narrative or a dashboard of attributes, goals, and needs [10]. Narratives consist of a written synopsis detailing a persona's life, goals and motivations while a dashboard persona may include a short introductory paragraph with attributes and demographic information being provided using bullet points. Photo images and representative quotes are used to add depth to personas. Posters, flyers, handouts, and promotional items are alternative methods used to communicate personas broadly [4, 31].

Assessing personas. Persona assessment (also called "persona validation" [5]) is important for identifying flaws or missing information in personas, as well as for evaluating a persona's potential for usefulness and impact. Common methods for assessing personas include dissemination to stakeholders with feedback [e.g., 4, 15], asking potential product users if/how

they identify with personas [e.g., 10, 21], comparing personas to subsequent data gathered after persona creation [e.g., 20, 22, 27], and employing personas as design tools [e.g., 10, 25].

Methodological Considerations for Scenario Development
Within HCI, the purpose of scenario-based design is to first imagine and then describe how a computer-based product will be used so that the end product meets user needs. "Scenarios are stories" that depict contextual, situated, and sequenced product "usage episodes" [2, 13]. Scenarios make "envisioned possibilities more concrete" [13] by depicting product use explicitly. Rosson and Carroll [13] suggest that scenarios can be constructed quickly; scenarios merely require setting, one or more actors with specific goals or objectives, plot, and outcome [2]. Ease of construction has helped make scenarios a popular way to "[rapidly communicate] usage possibilities and concerns among many different stakeholders" [2]. Forward-looking product scenarios describe the actions users are envisioned to take and, therefore, do not hinge on access to user data; available data can be used to build scenarios depicting current user actions to brainstorm new features/functions that are compatible with, or improve, user workflow [34].

Proposing a Methodology for Constructing Student Personas with Scenarios
About our Data. Our mixed dataset was gathered from 26 undergraduate participants enrolled in distance-delivered Calculus I during Fall 2014 and 13 undergraduate participants enrolled in Calculus II during Spring 2015. Seven of the 13 participants from Calculus II were also study participants during Calculus I. Data consists of exam scores, quantitative demographic and attitudinal survey responses, textual online forum posts, written field notes from classroom observations, and written transcripts from one-on-one follow-up interviews conducted with a smaller student sample at the end of each class [8, 9]. The multi-faceted nature of our dataset, which documents participants' behaviors, goals, needs, and actions,, is advantageous for developing both personas and scenarios. The size of our participant sample and existence of repeated measures, however, restrict our persona analytical approach to manual QC.

Procedural Next Steps
    1. Construct Ad-Hoc Persona with Scenario. As a research team, we will employ a manual QC approach for creating ad-hoc personas with scenarios. We will (a) generate typical STEM undergraduate ("user") data from our embedded knowledge and assumptions; (b) cluster like data into groups and subgroups of behaviors, needs, goals, and actions; and (d) construct 1-2 ad-hoc student persona(s), each with 1 scenario. We will develop foundation documentation with footnotes and both narrative and dashboard forms of the ad-hoc persona(s) and experiment with ways to incorporate scenario(s) into each form. During ad-hoc persona development, we will fine-tune our persona development process, as well as expose and reflect on our latent biases related to behaviors/needs/goals/actions of "typical" STEM undergraduates.
    2. Construct Data-driven Persona with Scenarios. Using the manual QC process refined during Step 1, we will construct 3-5 personas, each with 2-3 scenarios, from the nontraditional student calculus dataset. The configuration of the data-driven foundation documents, personas, and scenarios will be informed by the results of the ad-hoc persona development.
    3. Compare Ad-Hoc and Data-Driven Personas with Scenarios. As a research team, we will internally assess our usage model by comparing and contrasting the two types of personas with scenarios and identifying/naming the differences/biases we find present across our representations of "typical" and nontraditional STEM undergraduate behaviors/needs/goals. We

will ask ourselves "What is missing?" [5] and make changes as required. One important outcome of this procedural step will be to ensure that differences between the ad-hoc (traditional) and data-driven (nontraditional) personas are clear, distinguishable, and representative of the data. These actions will enable the data-driven personas with scenarios to serve as "edge cases" that can be used to promote a broader, more diverse student population to participate in STEM.

       4. <u>Assess the Potential Usefulness of Data-driven Personas with Scenarios.</u> We will externally assess the usefulness of nontraditional student personas with scenarios in two ways. First, we will ask 5-10 undergraduate STEM instructors at our university to first review and then compare the ad-hoc ("typical") and data-driven (nontraditional) student personas. We will ask instructors 3 questions: (1) What similarities/differences do you see between the two sets of personas? (2) What do these differences tell you generally about nontraditional students behaviors, goals, needs, and actions? (3) What is missing in the personas? We will then go back to our data and analysis to determine if the perceived differences and missing elements are present in our data. We will make revisions to the data-driven personas as appropriate. Second, we will electronically disseminate the data-driven personas with scenarios to STEM instructors and students (both traditional and nontraditional) at our university. We will survey these groups, via an online questionnaire, as to (a) how they do/do not relate to the nontraditional student personas and scenarios and (b) how they can envision personas with scenarios being used as tools to broaden participation and inclusion in STEM. Survey results will inform new approaches for employing the online forum usage model in STEM education.

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Appendix: Persona Methodology Literature

Author/Title [ref]	Purpose of the Work	Persona Type	Analytic Method	Data	Persona Form (Number)	Validation Techniques
Adlin and Pruitt (2010). The Essential Persona Lifecycle [5]	Taking into account how the user navigates software and design software to that users need	Ad-hoc, Data driven	QC	Census data (QUAN) Interviews, focus groups (QUAL)	Narrative and Dashboard (3-6 recommended)	Site Visits, dissemination
Antle (2006). Child-based Personas: Need, Ability, and Experience [25]	To assess a framework for child-user abstractions that combine theory, empirical data, and goals for child experiences that is suitable for use during the design of interactive technologies for children	Data Driven	QC (pattern analysis informed by framework)	Interviews, observations, sessions with child experts (QUAL)	Narratives with images (6)	Implement framework to develop child personas and revise
Cooper (2004).The Inmates are Running the Asylum: Why High Tech Products Drive Us Crazy and How to Restore the Sanity [1]	To develop a precise description of a product user and their goals for use in technology product and software design	Ad-hoc	Not Applicable	Not Applicable	Narrative with an image (3-12 recommended)	Anti-persona
Cornell University Library Web Vision Team (2007). Cornell University Library Personas [23]	To develop a set of personas based on primary clients of an academic library (faculty, graduate students, and undergraduates) to inform the design of the academic library's online access platform	Data driven	QC	Interviews (QUAL)	Combined narrative and dashboard with an image and quotes (3-4 per case)	–
Goodwin (2008). Getting from Research to Personas: Harnessing the Power of Data [24]	To design interactive products with a user focus	Data driven	QC	Interviews, Observations (QUAL)	Narratives	–
Lilley, Pyper, and Attwood (2012). Understanding the Student Experience Through the Use of Personas [15]	To develop a set of distance learner personas to guide online curriculum development in a distance-delivered computer science program	Ad-hoc, Data driven	QC	Surveys, interviews (QUAL)	Dashboard format with images and quotes (5)	Dissemination and feedback from staff and developers

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Author/Title [ref]	Purpose of the Work	Persona Type	Analytic Method	Data	Persona Form (Number)	Validation Techniques
Maness, Miaskiewicz, and Sumner (2008). Using Personas to Understand the Needs and Goals of Institutional Repository Users [22]	To develop personas of potential institutional repository users in order to inform the design of an online repository for an academic institution	Data driven	LSA	Interviews (QUAL)	Narrative with image (4)	–
McGinn and Kotamraju (2008). Data-Driven Persona Development [31]	To describe a quantitative method for persona development, based on factor analysis of a statistically significant sample of qualitative data	Data driven	FA QC	Task surveys (QUAN) Interviews (QUAL)	Poster with image (11)	–
Miaskiewicz, Sumner, and Kozar (2008). A Latent Semantic Analysis Methodology for The Identification and Creation of Personas [32]	To describe a quantitative persona development methodology, based on latent semantic analysis of textual data, that is used to develop personas of institutional repository users at an academic institution	Data driven	LSA	Interviews (QUAL)	Narrative with image (1)	Interviews, surveys
Mulder and Yaar (2007). The User is Always Right: A Practical Guide to Creating and Using Personas for The Web [17]	To describe the development and use of personas during website design	Data driven	QC CA	Surveys, interviews, observations (QUAL) Usage Surveys Site traffic analyses (QUAN)	Narrative	Verify personas using log file user data and more surveys
Norman (2004). Ad-Hoc Personas and Empathetic Focus [14]	To describe the development and use of personas during product design	Ad-hoc	Not Applicable	Not Applicable	Narrative (1)	–
Pruitt and Grudin (2003). Persona: Practice and Theory [4]	To describe the development and use of personas for software design and evaluation	Data driven	QC	Market segmentation (QUAN) Market user research (QUAL)	Foundation documents with images, narratives, posters, flyers, handouts (3-6)	Dissemination Anti-persona

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Author/Title [ref]	Purpose of the Work	Persona Type	Analytic Method	Data	Persona Form (Number)	Validation Techniques
Sinha (2003). Persona Development for Information-Rich Domains [20]	To develop personas for use in designing an online restaurant finder in the Bay Area using quantitative market data	Data Driven	PCA	Market segmentation surveys, Market user research (QUAN)	Narrative with image and quotes (4)	Interviews, observations (QUAL)
Tempelman-Kluit and Pearce (2014). Invoking the User from Data to Design [27]	To design user-centered academic library services	Data driven	CA	Coded text-based online chat transcripts (QUAL>>QUAN)	Dashboard with image and quote (4)	Surveys, interviews, demographic trends
Tu, Dong, Rau, and Zhang (2010). Using Cluster Analysis in Persona Development [26]	Case study describing the development of personas used to improve online travel services using QUAN (primary) and QUAL (secondary) data	Data driven	CA QC	Survey (QUAN) Interviews, observations (QUAL)	Combined narrative and dashboard with an image (2)	–
Turns, Borgford-Parnell, and Ferro (2015). Exploring the Usefulness of Personas in Engineering Education [10]	To improve learning experiences in engineering education; to translate research data to engineering education stakeholders	Data driven	Not reported	Not reported	Narrative and Dashboard	Course design sessions with faculty and graduate students
Van Rooij (2012). Research-based personas: Teaching Empathy in Professional Education [21]	To employ persona development, related to the design of a website for the parents/ families of children with special needs, to teach empathy to graduate students in an instructional design program	Data driven	QC	Focus groups (QUAL)	Narrative (1)	Survey of parent panel
Volentine, Whitson, and Tenopir (2013). Portraits of Success: Building Personas from Scholarly Reading Patterns [19]	To determine patterns in scholarly reading among successful young academics in the UK	Data driven	QC	Demographic Surveys (QUAN) Surveys (QUAL)	Narrative (3)	–