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Integrating UX Journey Mapping with Systems Theory Behavior Over Time Graphs to Explore the Complexities of Identity Formation

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Mario Beruvides, Jason Tham, Diego A. Polanco-Lahoz, Md-Rashedul Hasan, Jennifer A. Cross, Kelli Cargile Cook
Texas Tech University

Abstract

Literature on professional identity formation is broad and complex. Currently, researcher identity development is an important topic that is beginning to be studied in different educational areas, including industrial and system engineering. Documenting researcher identity development is critical for designing student-centered programs. This is particularly crucial in doctoral students, as it may contribute to appropriate professional development support delivered by graduate programs. To properly analyze identity development, investigators have used tools from user experience (UX) methods such as journey mapping, which are invaluable. Journey maps document and visualize the steps that the "users" (in this case, novice researchers) take to achieve a goal, including the process that developing professionals undergo to become experts in their respective fields. Meanwhile, investigators have also used Behavior Over Time (BOT) Graphs in Systems Theory research, which assist in analyzing individual and organizational behavior trends over time. BOT graphs are also effective tools for tracking complex social behaviors. This paper proposes the potential to bridge gaps between UX and Systems Theory research methods, through their integrated application to understand researcher identity formation in doctoral engineering students. The integrated application offers a nuanced perspective on the formation of professional identity. This study benefits researchers by offering insights into new potential methodological approaches for mapping complex situations and behaviors. The examples in this paper focus on doctoral researcher identity formation but are not limited to this area. Practitioners and researchers can apply the proposed approach in various contexts, within and outside engineering.

Keywords

Researcher Identity Development, Journey Mapping, UX Methods, Systems Theory, BOT Methods

1. Introduction

The work presented addresses a possible avenue of research related to a new potential methodological approach for mapping complex situations and behaviors in the formation of identity in general and specifically in engineering doctoral student identity formation. The attention, over the last two decades, to engineering identity formation research has steadily grown [1]. This increased attention to this very specialized but highly critical area of academic pedagogy, must be tempered with the realization that still relatively little is available in the open literature about the process of how engineering research identity is formed [1,2,3]. The majority of the studies on engineering identity development published thus far are in the area of undergraduate education [4,5,1,3]. Though the research done in undergraduate engineering identity formation is good work and useful, it is nonetheless limited for the graduate and especially the doctoral level. At the graduate level, the study of professional identity may in part be a less-critical issue since for the most part the individual student has most probably formed a professional engineering identity – through previous coursework, assignments, and experiences (academic and on-the-job), [6, 7]. However, the formation of a researcher identity is a topic open for study and lacking in-depth analysis. Most university professors, in engineering or most any field within the modern university, will attest to the fact that although many of the new incoming doctoral students may be of high caliber in their potential to become researchers, the craft of doing research and the identity that goes with this very specialized field of endeavor must be developed. Those same professors will most probably agree that these skills and identity are not easy to obtain, are noticeable when obtained and their arrival is nonpredictable and varies from individual to individual. Thus, the need to further investigate this topic is real and could be beneficial in the development of these very specialized professionals.

2. Review of the Current State of the Art

The Concept of Professional Identity. Professional identity, which refers to "personal identification with the duties, responsibilities, and knowledge associated with a professional role" [8, p.631], is a specialized aspect of the

complex and highly nuanced concept of "identity" and the very relevant societal concern with the "sense of self or belonging," [9, 10]. Professional identity can be expressed as the personal recognition, or that of others (peers, mentors, etc.), that the individual acts, thinks and expresses themselves as an engineer, lawyer, musician, etc. Other distinguishing factors or characteristics of professional identity can be expressions of specialized skill sets, interests, and distinctive language usage. [11]. Some other studies [see 12 and 13] have explored STEM or engineering doctoral identity, which follows the line of professional identity studies. Where the critical gap in the literature is prevalent is in the area of researcher identity, which is the focal area of concern for doctoral students since as mentioned above, this group of individuals, doctoral students, likely already have an established professional identity due to their previous education and professional practice. However, the identity as researcher in nascent and their established professional identity may even impede the growth of a researcher's identity. The current studies underway by the authors focus on mapping and understanding researcher identity formation. Due to the nature of this research, an interdisciplinary approach is requisite to draw out the rich complexities inherent in this area of exploration. The research has led to mapping longitudinally the development of engineering doctoral students by logging the development of several critical characteristics drawn from what is currently known about general identity formation, as well as engineering and professional identity formation work found in the open literature. Two critical tools, from differing fields of study, have been engaged to map researcher identity formation. Specifically, journey mapping from UX (user experience) methods to capture complex human interaction, as well as Systems Theory (dynamics) BOT (Behavior over Time) graphs to assist in capturing and tracking longitudinal systemic behaviors to assist in mapping causal trains in the behavior of the systems under study.

User Experience (UX) Methods & Methodology. UX design and research methods became popular due to the rise of technological innovation and personal computing in the 20th century [14]. With technology titans like Microsoft, Apple, and IBM expanding their empires beyond the hype of mainframe computers, it was this time when computers moved from institutional establishments to common homes that these companies began to realize they needed to cater to non-specialist users who are not necessarily trained to handle digital interfaces. Even today, technology designers are still concerned about how everyday users interact with complex interfaces that need to be easily understood, quickly learned, and error-free. UX methods aim to identify how people perceive new or familiar experiences, how they resolve challenges, and how they can contribute to the design of future experiences. For instance, UX designers and researchers use various methods to collect user needs, define design goals, and ideate desirable products [15]. Naturally, UX methods become a useful tool for exploring human experiences beyond interactions with technology. Methods like contextual inquiry and journey mapping have been used by businesses to capture what customers expect in particular scenarios and how they approach different issues [15]. In academia, UX methods have been used to inform programmatic design and pedagogical development, including course modules, learning activities and lessons, mentoring programs, etc. [16]. Of note, journey mapping has been considered a viable UX tool for understanding and engaging students as users of academic programs.

Journey mapping serves to document the end-to-end experience of an individual's interaction with a certain product or service over time. Organizations use journey mapping to gain insights into the user's emotions, motivations, pain points, and touchpoints at various stages of their interaction [17]. Journey maps are created from the user's (in our case, the engineering doctoral student's) perspective. These maps outline the steps and interventions individuals are exposed to throughout an entire engagement with the process of accomplishing a goal (be it completing a purchase, solving a problem, or in our case, developing a researcher identity). In most cases, journey maps capture multiple stages that an individual experiences to accomplish their goals. The various touchpoints with internal and external interactors can capture emotional, conceptual, and integrative data that may reveal struggles and opportunities to enhance the user's (doctoral student's) experience. Journey mapping is often coupled with qualitative interviewing, surveys, and focus groups to generate richer data about the UX of a given context. For us, these data can be visualized and coded to inform prospective programmatic decisions.

Systems Theory Behavior Over Time (BOT) Method & Methodology. Systems Theory has its origins back in the first third of the 20th century when critical questions emerging from the ever-growing complexity of systems (natural, societal, educational, economic, etc.) were taxing the limits of our engineering, business, scientific, and other areas of knowledge. There was an evident need to better understand complex systems, especially complex sociotechnical systems. The work of Ludwig von Bertalanffy [18] in his seminal book, *General Systems Theory*, provided a theoretical structure to better address systems scientifically and specifically the complexity of systems. "A system is a group of interacting, interrelated, or interdependent components that form a complex and unified whole," [19]. One of the radical basic approaches of systems theory is that it does not assume independence when conducting

research studies on any system. In fact, it assumes that systems components are interacting, interrelated and interdependent, [18, 19, and 20]. Thus, critical to the study of systems is first to study the "nature of the beast," that is, map and understand not just the system components, but especially the critical interactions between components in the system and the masking effects of delays in those interactions that hide the behavior of the system.

To assist in the mapping of systems components, early systems theorists developed several tools to better understand the complexity of the systems under study (BOT graphs, Stock and Flow Diagrams, and Causal Loop Diagrams, CLDs). The current study will present the work done in the use of BOT graphs; the use and incorporation of the other systems tools and Systems Dynamic modeling are the premise of future studies. All structures generate patterns of behavior (growth, decrement, cyclical patterns, etc. in such things as sales, quality defects, population patterns, and school drop-out rates, to mention a few). The tracking of systemic behavior (see the example provided in Figure 1) is used to decipher the behavior of the system. Graphs of this general nature are used in a myriad of situations in many fields of endeavor. Where system's BOT graphs differ is that what is critical is not just to capture the behavior of the system characteristics, but to graphically assist in locating and defining where interactions may exist in the system behavior that are not immediately obvious. This is done by not just tracking the data of the behavior but by mapping where known changes occurred in the system's past behavior that might indicate delayed interaction effects. In addition to graphing the behavior of a system's characteristics, lines of demarcation are prominently accentuated when changes in the systems have either occurred or are the result of individual or organizational implementations. An example of implementation within a system may be something like a major change in a critical software package or new procedures in the inventory control of a warehousing unit.

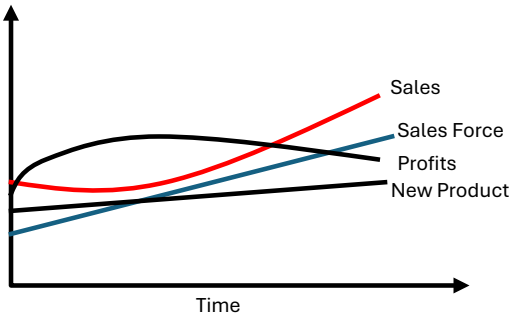

Figure 1: Example of a BOT graph. [Source 19]

Possible Interaction Between UX and BOT) Approaches. UX techniques (such as journey mapping) are of much value and their continued use attests to the validity of this family of research and applied techniques. The same can be said for BOT graphs in the systems modeling world. What is uniquely of value in the proposed approach is combining these two tools to better map and understand complex human systems, such as researcher identity formation. This research explores the use of these two tools in investigating complex behavioral patterns that have never been deeply analyzed. Not only mapping the journey of researcher identity formation but in addition, trying to map where some of the complex interaction effects are situated in the individual's trajectory as a researcher to better understand where leverage points might exist and be activated to thus expedite the identity formation desired.

Notably, journey mapping emphasizes the qualitative experience of participants to complement the traditionally quantitative nature of documenting experiences. While BOT graphs could plot the change-over-time correlations across several variables, journey maps collect verbatim responses and reflections from participants, creating a humanistic layer of data that could enrich our understanding of doctoral students' experiences in a program. This sort of data could reveal insights about students' attitudes, emotions, perceptions, expectations, and other situated psychosocial dimensions of their journeys that may not be numerically represented.

3. Challenges

The challenges related to UX methods are diverse. For the purposes of this study, journey mapping was one of the crucial methods used to measure research identity. Although suitable, four major challenges came up when using journey mapping. First, the output needs to be acted upon. This methodology takes time, and the result is not a quick answer, but raw data to analyze further. Journey mapping offers a raw product such as unfiltered data that needs detailed analysis to draw conclusions. Second, for an accurate analysis, there is a need for multiple maps to build a clear pattern to analyze. A single response does not have the same value as multiple responses, such as those collected

in a longitudinal study. If the procedure is not well designed, many of the responses from these participants can be nullified if they do not understand how or what they have to answer, or if the design is tedious to answer. Fourth, most of the data to extract is qualitative data, which means that the analyses need to be as thorough as possible.

The proposed integration of UX techniques, such as journey mapping, with BOT graphs in Systems Theory research presents several challenges. First, these research approaches come from different scientific backgrounds and have differing goals and procedural approaches. They may not easily fit together due to varying assumptions, data collection methods, and ways of analyzing information. One key challenge lies in aligning the qualitative nature of journey mapping, which focuses on individual experiences and emotions, with the quantitative approach of BOT graphs, which emphasizes patterns and trends. Combining qualitative and quantitative data requires careful integration, analysis, and interpretation [21]. Ensuring consistency between the data collected for journey mapping and BOT graphs is crucial. Misalignment in data can lead to misinterpretation of experiences and behaviors. Integrating journey mapping with BOT graphs to make accurate predictions about future systemic behavior can also be challenging. Developing effective predictive models requires a deep understanding of historical behavior patterns and the ability to adapt to changing circumstances [22]. Doctoral students' journeys often span multiple channels, both online and offline. Aligning journey maps with behavior across these diverse channels can be complex.

4. Approach

One key to overcoming the challenges noted is to recognize that intrinsically both approaches are mapping complex behaviors over time (longitudinally). Where they differ is in the goal and focus. Journey mapping is documenting exactly as its name states: the specific journey (of valuable characteristics and experiences) of the individual. This is not a continuous data collection methodology but provides critical snapshots. These behavioral snapshots comprise a longitudinal pattern that captures rich data on the growth, decrement, or stability of the individual (system). Traditional BOT graphs can make use of continuous or non-continuous data sets, but this longitudinal graphing technique intends to overlay the different data sets on one graph to assist in visualizing where possible interactions occur. This approach allows a systems analyst to build a CLD to describe the complex interactions and delays, which can then be used to build a systems dynamic simulation model using software packages such as VENSIM. Inserting journey mapping information (data) in a BOT structure allows analysts to visualize possible interaction effects occurring in the individual's "journey" including such questions as, "Are the interactions of these two or three experiences causing a growth that is suddenly noted on a third factor under measure?" Such visualization can assist the UX analyst in potentially designing a secondary survey or interview scheme to explore the possible interaction effects. See Figure 2 below for an early version of the application of this procedure currently being conducted by the authors in the study on engineering researcher identity; it must be noted that the figure is still under construction awaiting the final classification of the journey mapping data. Figure 2 shows how three different participants (i.e., participants X, Y, and Z) present positive and negative experiences over time. It is important to note that these experiences are taken from the participants' perspective and what they consider important in the development of their own identities (i.e., engineering research identity) [26]. As shown, in the third semester participant Y had very positive experiences, while the other semesters were not that impactful. On the other hand, participant Z presented overall good experiences over time with only two negative experiences, which happened in the first semester studied.

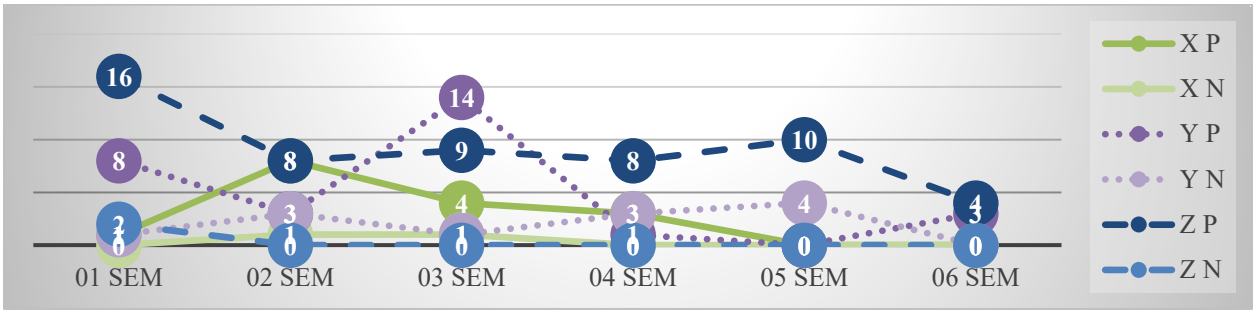

Figure 2. Behavior over time of positive and negative experiences for three different students.

Collaboration between UX experts and Systems Theory researchers allows the creation of a shared framework, including qualitative and quantitative methods. This collaborative strategy aims to simplify the integration process and better capture the diverse aspects of doctoral students' journeys. Standardizing data collection methods [23] and ensuring temporal alignment [24] between journey mapping and real-time behavioral data is crucial for maintaining

consistency and avoiding misinterpretation. Additionally, a continuous iterative process is necessary to refine the integrated methodology [25]. Finally, recognizing the unique features of various fields and subjects and applying insights beyond engineering doctoral students will contribute to the broader applicability of findings. Additional information about this methodology can be seen in other studies [26,27,28].

5. Summary and Review

The majority of studies on engineering identity development published thus far are in the area of undergraduate education. In addressing doctoral students, a basic truth must be recognized, they likely already have an established professional identity due to their previous education and professional practice. However, the identity as researcher in nascent and their established professional identity may even be an impediment to the growth in a researcher identity. Thus, this preliminary study explores two critical tools, from differing fields of study, that have been engaged to map researcher identity formation. Journey mapping serves to document the end-to-end experience of an individual's interaction with a certain products or services over time. The main focus of study of systems is to first study the "nature of the beast," – that is, mapping and understanding not just the system components, but especially the critical interaction between the critical components in the system and the potential masking effects of delays in those interactions that hide the true behavior of the system. Collaboration between UX experts and Systems Theory researchers allows the creation of a shared framework, including qualitative and quantitative methods.

Though the combined UX-BOT technique is still in the development stage, it is providing promising early insights into engineering researcher identity formation. If confirmed to be of significant value, the use of the methodological technique is not restricted to this particular research context and may prove of value to differing applications. There also exist the potential to extend this technique to the development of systems stock and flow mapping and CLDs for systems dynamic modeling. Future research involving an operational approach should focus on the development of operational definitions for the variables mentioned (e.g., experiences from users, identity, and behavior). The inclusion of information regarding the validity and reliability of the metrics should be addressed as well.

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