

WIP: Visualizing Success: An AI-Enhanced Interactive Conceptual Timeline for First-Generation Computer Science Students

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Abstract—This work-in-progress innovative practice paper presents an interactive visual map tool called 1GenSuccess, designed for first-generation computer science students. First-generation college students are students whose parents or guardians have not attended college or earned a college degree. In the United States, first-generation students account for over 40% of first-year college students, making them a significant demographic in the engineering and computing educational field. However, due to a lack of parental familiarity with higher education, limited understanding of the college admissions process, financial constraints, internships, and the challenges associated with engineering and computing coursework, first-generation students in the field of engineering and computing frequently encounter distinctive obstacles across academic, finance, career, cultural, and social dimensions. Recognizing the difficulties these students face, this paper introduces 1GenSuccess, a novel roadmap web application developed specifically for first-generation college students in the engineering and computing fields. While numerous websites currently offer a range of valuable resources to support first-generation college students, a significant gap persists— a lack of a personalized roadmap explicitly crafted to meet the distinct needs and challenges they experience on their computer science educational journey. The primary goal of 1GenSuccess is to empower engineering students and facilitate their navigation through academia through a visual roadmap. In addition, by presenting a comprehensive suite of resources, support materials, and a personalized roadmap, 1GenSuccess aims to bridge the gaps in access and information that often impede the progress of first-generation college students in the computer science field.

Index Terms—Competencies Development, Diversity and Broadening Participation, first-generation students

I. INTRODUCTION

The transition from high school to higher education represents a challenge for many students, but it is particularly difficult for first-generation college students. These individuals often experience academic, social, and administrative hurdles without the navigational aids that familial experience provides. These students are disadvantaged in fields such as computer science and engineering, where curricula are rigorous and rapidly evolving alongside technological advancements. They may struggle with basic queries such as which courses to enroll in, the optimal timing for internships, relevant clubs and organizations to join, and the timeline for completing their

degree. These myriad choices can appear daunting without clear guidance or a structured path forward.

In response to these challenges, in this paper we introduce 1GenSuccess, which features a personalized conceptual timeline map tailored to the unique needs of first-generation students. The user's responses to an initial detailed questionnaire dynamically generate this map, which continuously refines through ongoing feedback and updates. The timeline visually represents the student's educational trajectory from high school graduation to achieving their career objectives. Each node on the conceptual graph is interactive, allowing users to view the year overview and explore in-depth semester-specific tasks. This visual roadmap reassures students of their progress toward a defined end goal.

We design and implement a visual mapping tool in React and JavaScript for the front end, while the back end uses the Python Flask framework and the ChatGPT model. To train our OpenAI assistant, which is a ChatGPT model, we gathered a substantial amount of data from various sources on the internet. We used an open-source tool from GitHub called gpt-crawler to collect related data from diverse engineering and computing education resources, which provided training data for the ChatGPT model. Subsequent testing confirmed the model's functionality, meeting our satisfaction. With 1GenSuccess, first-generation college students navigate academic, financial, and engineering interview career-related complexities. These features support success in their engineering and computing journey. The students can see how to reach their end goal in a step-by-step map.

The paper's contributions include presenting our user-centered design approach through contextual inquiries with first-generation students and an interactive design approach to create the conceptual map user interface and features. Second, we introduce an AI-generated personalized road map that visually guides first-generation students through their academic journey from enrollment to graduation. Finally, we provide details of our design and implementation utilizing Generative AI technology to generate personalized academic and career advice.

This paper will elaborate on the iterative design process, the application’s design and implementation, and the initial impacts observed from its use among first-generation computer science students.

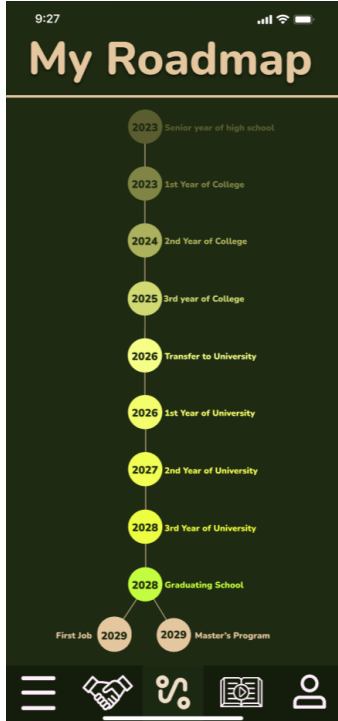


Fig. 1. Simple conceptual graph interface design for roadmap illustration.

II. RELATED WORK

This section reviews the existing research on first-generation student challenges, technology-enhanced learning environments, AI personalization in education, and equity through technology.

In [1], authors study the specific challenges to first-generation students, including a diminished sense of belonging, particularly in STEM fields. The crucial initial stages of higher education exacerbate this phenomenon, which can deter these students from pursuing and persisting in such disciplines. Our work addresses these challenges by gathering and integrating the user’s goals through the questionnaire into a customized interactive roadmap. Similarly, [4], [5], and [22] discuss the systemic disadvantages faced by first-generation and other computer science students due to a lack of insider knowledge, which can steer them away from successful educational pathways. Effective support systems are crucial for the success of first-generation students. In [6], authors emphasize the role of social and cultural capital in student success.

Integrating AI in educational contexts shows promising results in enhancing engagement and personalizing learning experiences. Studies such as [3], [12], [18], and [19] investigate the benefits of AI tools in making educational content more accessible and tailored to individual learning styles.

Furthermore, authors in [20] show how generative AI can transform education into a personalized learning experience, a method that this paper employs using the OpenAI Assistants API. For example, [7] discusses how cloud-based AI can offer personalized feedback and adapt to individual learning styles. 1GenSuccess leverages similar technologies, using the OpenAI Assistants API to create dynamic, user-specific academic road maps.

The significance of technology in leveling the educational playing field for first-generation students is well-documented [2], [9], [10], and [11]. 1GenSuccess also provides solutions to mitigate these disparities by providing a platform that connects students with mentoring resources and professional development opportunities.

Effective support systems are critical for the success of first-generation students. In [6], authors discuss the importance of social and cultural capital in student success, noting the potential hindrance caused by its absence. [5] further explore the issues first-generation students experience due to limited access to resources and mentorship. In 1GenSuccess, we address this limitation by connecting students with mentoring resources and professional development opportunities. Equity through technology is an important theme in our work [8], [15], [16], and [17]. We synthesize this existing research into a practical, user-friendly application to integrate AI technology to support under-represented educational communities. By focusing on the specific needs of first-generation college students in computer science, the project contributes to a broader effort to ensure that all students have the resources they need to succeed.

III. METHODOLOGY

This section outlines the methodology for developing 1GenSuccess. The methodology includes a user-centered design approach, technology selection, development processes, and user interface design.

A. Design Approach

We developed 1GenSuccess using a user-centered design approach to ensure the application meets the needs of first-generation college students. Initial research included interviews with 30 first-generation students and five faculty members specializing in computer science education. These interviews helped identify challenges like navigating academic pathways and integrating into the academic community.

We also conducted two contextual inquiries with first-generation students to understand the course and financial aid navigation process. We selected two main participants for their diverse backgrounds and the challenges they represent in the first-generation student population. Participant A is a mother of two who balances her education with significant family responsibilities. Participant B is an immigrant who is navigating the complexities of the educational system alongside financial and career-related challenges.

We conducted Participant A’s interviews over Zoom, which allowed for a comfortable and engaging setting. The interviews

revealed the critical balance between her academic pursuits and family responsibilities.

Participant B's journey reflects the immigrant experience, transitioning from human development to computer science while managing the repercussions of a gap year and unexpected international conflicts. Her inquiry involved observations during classwork, Zoom classes, and career planning activities, providing a comprehensive view of her daily academic life.

Across the interviews, several common themes emerged that impact the educational experiences of first-generation students: First, participants expressed challenges with financial management, especially concerning tuition and access to scholarships. The cumbersome process of applying for financial aid was daunting without prior familial knowledge or support in navigating these systems. Next, there needs to be more awareness and utilization of available academic and psychological support services, which could improve their educational outcomes. Participants were either unaware of or found it challenging to access these resources due to poor advertisement or lack of guidance. Third, the lack of clear academic and career guidance was a recurrent issue. Participant B's experience with ineffective counseling at a previous institution highlights the need for reliable and accessible academic advising.

These insights directly inform the design of 1GenSuccess, emphasizing the need for enhanced resource visibility, simplified financial aid navigation, and personalized academic roadmaps. In the next section, we discuss how we incorporate these findings as features in the application.

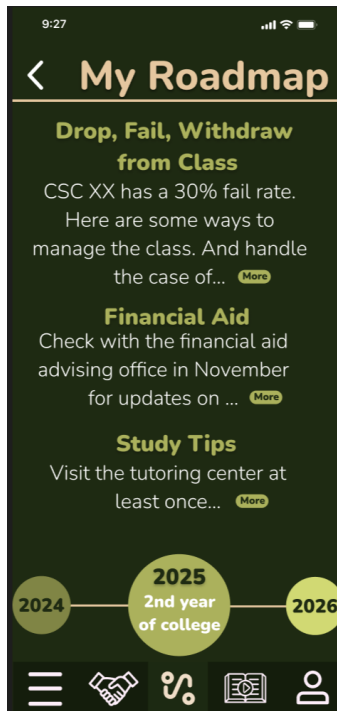


Fig. 2. Each node in the conceptual roadmap provides details on demand.

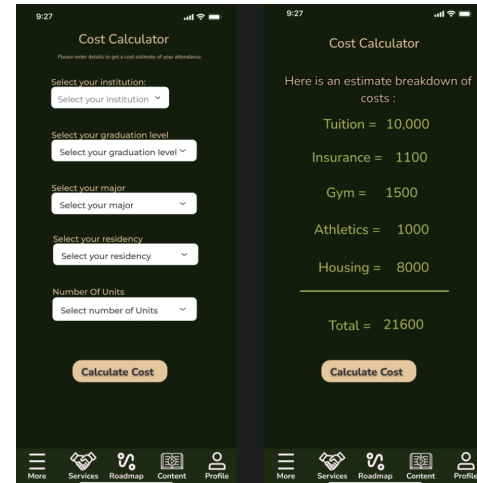


Fig. 3. Cost Calculator feature allows students to incorporate the cost of education into their timeline quickly.

B. Walkthrough of Features

Following the initial research phase, multiple idea-generation sessions discussed design, educational impact, and computer science educational pathways. These collaborative sessions utilized sketching, storyboarding, and prototyping techniques to develop concepts that could solve the identified problems effectively. We refined the design through several iterations, with continuous user input and heuristic evaluation, to ensure the solutions aligned with our goals.

1) *Initial Personalizing*: The initial login of 1GenSuccess prompts a comprehensive questionnaire of 25 questions to gather crucial information about first-generation college student's academic and career aspirations, challenges, and support needs. This feature, shown in Figure 4, is the foundation for developing personalized academic roadmaps that guide students through their educational journey. We designed the questions based on interview data and contextual inquiries.

After completing the questionnaire, the application generates the conceptual map, shown in Figure 1. Based on the user's goal of a graduation timeline, industry goals, and computer science specialties, the conceptual graph's initial view shows each year as a node. Selecting one node in the graph expands to embedded nodes with more refined options and semester suggestions on coursework, internships, clubs, and other goals to aim for each year. Each node on the conceptual graph is interactive, allowing users to explore deeper—from a yearly overview to semester-specific tasks—offering detailed guidelines and actionable goals, shown in Figure 2.

In summary, the main contribution to the user interface design is a visual, conceptual map-based UI, which provides users with a graphical representation of their academic and career pathways. We designed this feature to be intuitive, using affordances and icons that are easily recognizable to reduce cognitive load and enhance user engagement.

2) *Resources and Cost Calculator*: We include features that display available academic and financial support services,

ensuring that students are aware of and can easily access these resources. Following the initial setup through the questionnaire, 1GenSuccess offers a cost calculator to help students manage their financial planning related to their academic pursuits. The cost calculator is shown in Figure 3. Students can modify the variables to see how changes in their financial aid, part-time work, or living arrangements could affect their overall educational expenses.

C. Technology Stack and Development Process

The application utilizes a modern technology stack. We chose React for its efficiency and libraries, which facilitate dynamic user interfaces and responsive design. We selected Python Flask for the backend due to its simplicity and flexibility. The OpenAI Assistants API, utilizing the GPT-3.5-turbo-1106 model, generates personalized academic and career roadmaps based on user inputs.

To provide data to our OpenAI assistant, we gathered substantial data from various sources, including Sacramento State University, computer science educational, and career websites. We used an open-source tool from GitHub called gpt-crawler to collect related data from these diverse websites, which the GPT model utilized. Subsequent testing confirmed the model’s functionality, meeting our satisfaction.

After the user submits their questionnaire answers, the application’s backend receives and processes these responses. The application stores the responses in a database. Due to its lightweight nature, the backend utilizes SQLite as the database management system. The backend retrieves the necessary data from the database and incorporates it into the query for the OpenAI assistants API. Then, this query guides the GPT model in generating a personalized response. For example, the query includes details about the user’s academic standing, major, challenges, and specific questions or topics of interest. After generating the response, the GPT model sends a response to the backend. The backend processes the output, such as post-processing, and generates the conceptual interactive map.

The development of 1GenSuccess followed an agile methodology, allowing for iterative testing and feedback integration throughout the process.

IV. PRELIMINARY DATA COLLECTION AND ANALYSIS

We conducted preliminary usability tests through observation notes and interviews. We interviewed 12 first-generation participants. In the interview we asked two questions: 1. Did the questionnaire help represent you as a student and your goals? 2. Was the initial conceptual map presented to you relevant to your goals? Figure 5 and Figure 6 show participants are satisfied and find the tool useful.

We would like to explore engagement metrics from the application’s deployment for future work. For example, We would like to collect quantitative data regarding task completion time and analyze it using qualitative analysis to identify common themes.

Fig. 4. Sample Questionnaire to help personalize the conceptual map.

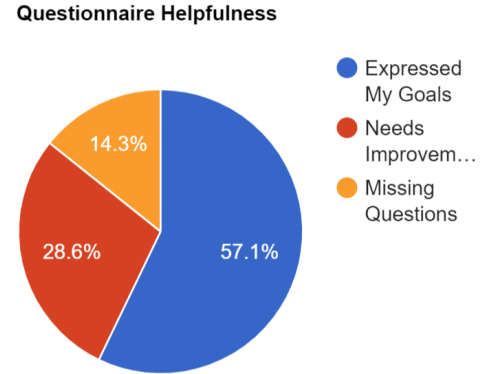


Fig. 5. Preliminary data on the question: Did the questionnaire help represent you as a student and your goals?

V. CONCLUSION

In this paper, we use a design-centered approach, employing contextual inquiries to understand the needs of first-generation students. This initial research facilitated the development of an interactive conceptual map interface. We integrate generative AI into the personalized roadmap that visually navigates first-generation students through their academic journey from enrollment to graduation. This dynamic tool adapts the educational trajectory based on responses from an initial detailed questionnaire.

The preliminary deployments of 1GenSuccess show promising results, indicating that the application enhances users’ ability to comprehend and navigate their educational and professional options. The current work-in-progress involves deploying 1GenSuccess at Sacramento State University, where we will integrate it into the existing student advising. This deployment will be a pilot program to assess the application’s

Map Relevance

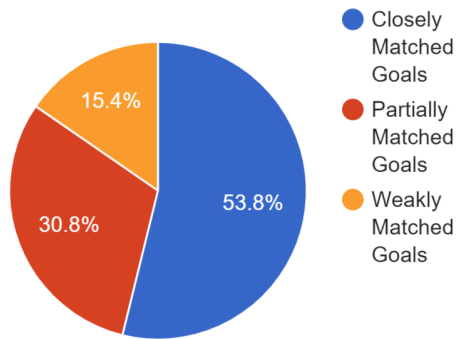


Fig. 6. Preliminary data on the question: Was the initial conceptual map presented to you relevant to your goals?

scalability and effectiveness in a real-world educational environment. Introducing 1GenSuccess into a university setting will allow us to observe the impact on first-generation students and gather data on its usage and effectiveness.

Concurrent with the deployment, we will conduct comprehensive usability studies to evaluate the effectiveness of 1GenSuccess in assisting first-generation students in navigating the complexities of college life. These studies will investigate how the application aids in advising students through the uncertainties of their academic journey. By tracking users' progress over several semesters, the project will analyze the sustained benefits of the application in helping first-generation students 'see the light at the end of the tunnel.' We will collect metrics such as measuring academic performance, retention rates, graduation rates, and confidence levels, providing a robust evaluation of the application's impact.

Through these focused efforts in UI enhancement, targeted deployment, and detailed usability studies, the application 1GenSuccess aims to contribute to broader educational equity and success.

While we designed 1GenSuccess for the challenges faced by first-generation college students, its personalized features make it a resource for all students pursuing higher education. The tool's ability to customize academic and financial planning based on individual user inputs ensures that every student, regardless of their background, can effectively navigate their educational journey and achieve their career goals.

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