DIGITAL 2024

Advances on Societal Digital Transformation

June 30 - July 4, 2024

Porto, Portugal

DIGITAL 2024 Editors

Júlio Monteiro Teixeira, Universidade Federal de Santa Catarina, Brazil

DIGITAL 2024

Forward

The Advances on Societal Digital Transformation 2024 (DIGITAL 2024), held between June 30th and July 4th, 2024, continued a series of international events covering a large spectrum of topics related to digital transformation of our society.

The society is continuously changing at a rapid pace under digital transformation. Taking advantage of a solid transformation of digital communication and infrastructures, and with great progress in AI (Artificial Intelligence), IoT (Internet of Thinks), ML (Machine Learning), Deep Learning, Big Data, Knowledge acquisition and Cognitive technologies, almost all societal areas are redefined.

Transportation, Buildings, Factories, and Agriculture are now a combination of traditional and advanced technological features. Digital citizen-centric services, including health, well-being, community participation, learning and culture are now well-established and set to advance further on.

As counter-effects of digital transformation, notably fake news, digital identity risks and digital divide are also progressing in a dangerous rhythm, there is a major need for digital education, fake news awareness, and legal aspects mitigating sensitive cases.

We take here the opportunity to warmly thank all the members of the DIGITAL 2024 technical program committee, as well as all the reviewers. The creation of such a high-quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and effort to contribute to DIGITAL 2024. We truly believe that, thanks to all these efforts, the final conference program consisted of top-quality contributions. We also thank the members of the DIGITAL 2024 organizing committee for their help in handling the logistics of this event.

We hope that DIGITAL 2024 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of societal digital transformation. We also hope that Porto provided a pleasant environment during the conference and everyone saved some time to enjoy the historic charm of the city.

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Exploring the Utilization of Generative Artificial Intelligence Tools with Design Students

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Abstract— **This research is part of an investigation into the use of Generative Artificial Intelligences (GenAI). Through a case study, we analyze the application and abstention of these tools by students in the creative industry during the resolution of a graphic challenge. The study addresses the need to develop competencies in emerging technologies that promote creative solutions. The central question investigated is how GenAI tools are employed in the co-creation process and the development of design solutions. The initial hypothesis suggests that GenAIs are primarily used as support tools in the conception and creation of graphic projects. However, the results indicate that, despite their potential, these tools are still underutilized by students in this particular case.**

Keywords: Generative AI; Artificial Intelligence; Hackathon; creative industry.

I. INTRODUCTION

Generative Artificial Intelligences (GenAI) are significantly changing work processes across various economic sectors, allowing for opportunities to explore its utilization. In this sense, this research aims to investigate how students utilize GenAI as an innovative tool to address and solve design challenges. This article presents a case study on an event held in the format of a hackathon, conducted in a digital innovation project discipline, in a bachelor degree program at the Federal University of Santa Catarina (UFSC). The event consisted of a challenge where 10 students were divided into 5 groups of 2 participants. Each group was required to deliver two graphic solutions: one without the use of Generative AI and the other with its application.

The central theme of the challenge revolved around the United Nations' 13th Sustainable Development Goal - Climate Action, with the main challenge being: "How to promote awareness about the preservation of the Amazon Rainforest?". The event featured an evaluation of the deliverables by a jury, with predefined criteria for selecting and awarding the deliverable that best met the challenge, according to the criteria. The initial hypothesis was that

students in the creative industry are reshaping their work methods through creation with Generative Artificial Intelligences (GenAI). In this regard, the research aims to analyze how Generative AI is being incorporated into their creative tasks.

Accordingly, this research utilizes the Case Study methodology to examine qualitative data gathered through a structured form filled out by the participating students of the Hackathon. The goal is to analyze the experiences, perceptions, and outcomes reported by the students, providing an understanding of the factors that contributed to the success or failure of the event's challenges. The paper is structured as follows: In Section II, we present the theoretical framework underpinning our study, exploring prior research related to AI in the creative process. Section III details the methodology employed, including the research design, data collection, and analysis techniques used to gather and interpret the data. In Section IV, we provide a comprehensive analysis of the findings, discussing the implications and significance of the results. Finally, Section V shows our conclusions.

II. THEORY

AI tools are increasingly being used in the design and creative industry, with a focus on content creation, information analysis, content enhancement, information extraction, and data compression [1]. It has also been transforming visual processes through creating concepts, styles, and aesthetics [2].

The literature presents different cases within creative domains especially in design [3][6], art [2][7] and architecture fields [8]. However, while investigations within creative industries and professional contexts presents insights over increased productivity and enhanced creativity [5], studies on the impact of AI focusing on students of creative areas seems comparatively less researched. Moreover, considering the recency of Generative AI, there is still considerable scope for further investigation.

III. METHODOLOGY

This research constitutes a case study [9] and is fundamentally qualitative. The primary data collection instrument used was structured questionnaires about the event, administered to participants post-event. To enrich the discussion, these data were supplemented with participant observation by the researchers and document analysis of the jury's evaluation.

At the beginning of the Hackathon challenge, participants were provided with basic instructions regarding the deliverable: The file format was restricted to JPEG or GIF and only free images repositories or images created by themselves were allowed. The students were organized into five groups. Each group had access to one computer to perform the tasks, with a time limit of one hour for each proposed challenge.

In the first challenge, students were allowed to use any software tool to create, as long as it did not incorporate any AI functionalities. For the second challenge, various AI tools were recommended to assist the students, including Adobe Firefly, Copilot, Gemini, Midjourney, Photoshop, Illustrator, and ChatGPT. Each challenge lasted for one hour with a 10 min break. The theme of the challenge was "How to promote awareness about the preservation of the Amazon Rainforest?" for both deliverables. This format was chosen to allow for a direct comparison and to assess the differences in the scores of the deliverables created with and without the use of GenAI, focusing on the same thematic issue.

The jury, composed of three individuals, including two designers and one advertising professional, consisted of two doctoral students and one master's student. They assessed the materials in a separate room using a Google Forms questionnaire. The evaluation interface categorizes the projects according to three criteria: Visual Communication, Clarity of Message, and Originality and Innovation, with scores ranging from 1 to 5. Additionally, to ensure an impartial evaluation of the relationship between participants and judges, the teams and the deliverables were anonymized. Works were submitted to the judging panel under randomly assigned letters from A to J. The jury was not informed about which deliverables were created with the use of AI. This decision was made to ensure impartiality in the evaluation process, allowing the judges to assess each submission based on the pre-defined criteria.

Participant observation, conducted by the researchers, also formed part of the conclusions in the study. This approach offers the observer the opportunity to avoid solely perceiving elements that conform to their implicit or explicit hypotheses, thus leading to a genuine questioning [9]. Therefore, by exploring the significance and utilization of the elements and distinguishing its applicability, the observer improves their analytical framework [9]. In this context, the researchers were able to identify how the AI tools were used and not used by the students, which significantly influenced the final product outcome.

After the event, the instrument for collecting qualitative data from the students was distributed. This collection tool consisted of seven questions, the answers to which will later be discussed in relation to the experience of the event. In conclusion, the participant observation experience complemented the qualitative analysis of the data collected through the forms. Specific aspects observed, such as the decision to not use AI tools to generate content at certain stages of the process, were highlighted and later clarified by the students in the forms.

IV. ANALYSIS

After the judge's evaluation, we obtained a partial average for each of the projects considering the three analysis categories (Visual Communication, Clarity of Message, and Originality and Innovation). Both the highest-rated project and the one with the lowest score were completed without the use of AI Generation, whereas the projects that scored closest to the average of our sample were those using AI Generation. However, the project with the highest overall average was the only one where the deliverable was in GIF format; the other projects were in JPEG format. This raises the hypothesis for future research on the establishment of a unique format for deliverables to ensure that the evaluation is even more free from bias by the judges. Table l represents the average score and the category of each of the project, analyzed by the jury:

TABLE I. JURY EVALUATION

Jury Evaluation		
Deliverable Code	Average grade	Category
A	5.5	Without GenAI
B	6.8	Without GenAI
C	8.4	Without GenAI
D	6	With GenAI
E	6.2	With GenAI
F	4.6	Without GenAI
G	5.7	With GenAI
H	6	With GenAI
I	5.3	Without GenAI
J	5.7	With GenAI

The work with the highest score, achieving an average of 8.4 among the judges, was done without the use of GenAI. Conversely, the work with the lowest score, also without the aid of GenAI, reached an average of 4.6. These results constitute a standard deviation of 0.97, which suggests that the evaluations were relatively consistent. As mentioned, after the event, a structured questionnaire was submitted to the participants, containing the following questions:

1. Were you already familiar with generative AI tools for use in design processes? If so, which ones?

2. At what stages of the process/challenge did you use AI? Please describe which tools you used and how you utilized them.
3. What are the main tools you typically use in your traditional creation processes?
4. What were the main challenges you encountered in the task without the use of AI?
5. What were the main challenges you faced in the task with the use of AI?
6. After completing the challenge, did any new questions arise about the use of generative AI in the design process?
7. What did you think of the activity? Please leave your overall feedback.

From the responses to the questions mentioned above, the students highlighted some difficulties within the event, among which are notable:

- The limited time available for completing the challenges;
- The students' low level of prior knowledge regarding the use of GenAI in design processes;
- A lack of experience in constructing prompts;
- Limited familiarity with generative AI interfaces.

The qualitative analysis of the data from this questionnaire, along with the participant observation, provides insights for several key inferences.

Firstly, regarding the students' complaints about insufficient time to complete the challenges, participatory observation revealed an acceleration of the process in the initial stages of ideation and drafting. In the final phases, the students showed little interest in exploring new images with the remaining time. Indeed, three of the five groups completed the activity before the initially scheduled deadline. It was also observed that participants had limited knowledge about GenAI tools, with only two of them stating they had prior experience with these types of technologies. The others reported a basic familiarity with some tools, such as Adobe Firefly and Photoshop Beta, but had not effectively used them previously.

One of the main challenges identified both in the questionnaire and in the participant observation was the students' lack of prior knowledge in formulating appropriate prompts for image creation. This specific challenge was also identified in previous literature about GenAI content creation with students, where the need for further research in developing effective prompt engineering strategies is highlighted [10]. For instance, one participant entered the input expecting the GenAI to produce a literal representation of the final challenge result. This approach was also observed in other groups. Three respondents mentioned using ChatGPT to refine the prompts before inserting them into the GenAI. From this perspective, we observed students cannot expect AI tools to produce fully polished results; rather, these creative process outcomes must be refined by human intervention. This also aligns with existing literature that emphasizes the role of AI as a tool or collaborative assistant for creativity, rather than a sole creator of original work [1][10]

Secondly, comments from students, such as "I did not get exactly what I was imagining" and "the images did not turn out as we wanted", expressed in the answers of question 05, illustrate the difficulties encountered in constructing and refining prompts. Similarly, question 06 highlighted their low familiarity with the interfaces of the tools, as expressed in comments, such as "How to use the tool correctly so that it produces art more faithful to the ideas we have" and "I feel I need to practice more with the tools to learn to think about prompts more effectively".

For example, one group stated that Adobe Firefly was used for creating campaign images, while attempts to utilize generative AI within Illustrator for refinement were ultimately unsuccessful, leading to the creation of a new artwork from scratch, supplemented by text from Canva. Another group decided not to use GenAI for the graphic stage of the second deliverable, preferring more traditional tools because they felt more confident in their use. Therefore, this group used ChatGPT exclusively for immersion and idea generation, abstaining from using AI in the creation of the final deliverable.

Overall, participants found generative AI useful for idea generation and structuring, but encountered challenges when using it for final image creation, preferring traditional design methods or tools for achieving desired outcomes. In summary, despite the initial hypothesis that GenAIs are utilized as supportive tools in the conception and creation of graphic projects by students, the results of the experiment indicate that these tools are still underutilized by students in the creative process. However, the students showed interest in deepening their knowledge of the tools and developing their skills to enhance their performance in using them.

V. CONCLUSION

GenAI have made significant advancements recently and have captured the interest of the academic and scientific community due to their disruptive potential, which reinforces the relevance of research on the subject. In this study, we investigated how students in the creative field use AI tools in graphic challenges. Based on our sample, the students are still not familiar with the techniques and GenAI tools in their daily workflows. This provides an opportunity to the development of training programs that enable them to effectively appropriate these technologies to optimize their creative processes.

It was observed that, although there was an initial advance in the ideation and drafting phases, the students faced considerable challenges due to a lack of prior knowledge and experience both with the technology itself and with formulating effective prompts for image generation. This often resulted in unsatisfactory outcomes, as highlighted by the students' comments about the discrepancy between their expectations and the images produced. Therefore, the implementation of GenAI tools in

educational contexts requires a well-structured strategy that includes both technical and creative preparation, ensuring that participants can effectively use these tools.

This initial experiment on the use of GenAI within the context of creative challenges provides some insights to the development of future theoretical-methodological stages. For future studies, the objective is to expand the sample size to enhance the robustness of the findings. Moreover, academic research can use this case study to replicate the experiment in different creative domains for comparative purposes.

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Ideating and Designing Mobile Apps for Immigrants from Shared Experience

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Abstract—**Mobile apps have become part of our daily lives. We use them for all kinds of tasks and rely on them for important information and services. However, there is a lack of apps to help people from underserved communities with tasks that are important for their specific needs, and one reason for that may be that such apps need to be needed/requested by the target population and then co-ideated and co-designed with them. This paper describes a program through which a group of computer science students had the opportunity to develop mobile apps for a specific population. The students were all immigrants or children of immigrants, and their goal was to ideate, design, and develop an app that would have helped their parents or themselves when they moved to the USA. Seven apps were developed, and the variety and uniqueness of the apps show the importance of shared experiences in the ideation and design of the apps.**

Keywords-computing for good; mobile apps for social impact; mobile apps for immigrants; co-ideation; co-design; shared experience

I. INTRODUCTION

Mobile apps have become part of our daily lives. We use them for all kinds of tasks and rely on them for important information and services. Our group has more than ten years of experience developing apps for social impact [10][11], more specifically to help organizations that operate in low-resource areas embrace technology. Our apps are the result of collaborations with these organizations, as they understand the communities they serve and their needs.

As we focus on developing apps for organizations, and we interact with people from low-resource communities, we have noticed that there is a lack of apps to help people, particularly people from under-served groups, with tasks that are very particular for their specific community. These apps are hard to develop, because to even know what to develop to help specific communities, we need to understand their context and specific needs. In the past, we have developed apps for homeless people [12][13] and for refugees, and we learned in that process that we did not know what exactly to do and/or how to do it, and those experiences taught us the importance of co-ideating and co-designing.

This paper reports on our experience with a summer program through which a group of computer science students is provided with the opportunity to develop mobile apps for a specific population. In Summer 2023, the theme was immigrants, and the goal was to develop apps that could help immigrants when they move to another country. Since all the students were either immigrants themselves or children of immigrants, we encouraged them to think about what could have helped themselves, their parents, and their family, and to talk to friends and family members about their immigration struggles.

This paper describes the seven apps developed as an example of how technology may help people in specific situations, but it also shows the importance of including the target population in the ideation and design of a mobile app. As the students were themselves part of the population for whom they were developing the apps, co-ideation and co-design happened naturally through shared experiences, and the result was a set of appropriate and useful apps.

The remainder of this paper is organized as follows. Section II describes related work. Section III describes our summer program. Section IV describes the mobile apps developed. Section V discusses the results and concludes. The acknowledgements close the article.

II. RELATED WORK

The impact of technology and, more specifically, of mobile apps on underserved communities has been studied extensively. Several groups have developed mobile apps for different underserved communities and have reported on the development process and on the effectiveness of these apps. We provide some examples below.

Mobile apps for immigrants have been discussed in several papers. Using technology for helping immigrants' integration was discussed in both [9] and [21]. In [17], the effects of social media apps were investigated, and a study on the support for language learning was presented in [18].

Mobile apps for refugees have been proposed, and the impact of technology on that population has been studied by several groups. In [1], the author discussed apps that were developed to help refugees deal with the trauma caused by their situation, and a study case on the same topic in Germany was reported in [29]. In [8], the authors discussed mobile learning apps that were developed for refugees. A study case in Sweden was reported in [15], which describes how social computing apps may be an important resource for refugees' integration. Another study case in Vienna [20] discussed the importance of mobile devices for refugees.

Mobile apps for homeless people have been addressed by several papers. In both [16] and [24], the authors evaluated the use of technology to promote health and wellbeing among people experiencing homelessness. In [4], the authors evaluated a mobile app that addresses emotional needs of

homeless people, and in [31], the authors discussed how technology can help homeless people stay safe.

Accessibility is a major area of concern for disabled people, and it has been studied extensively. In [2], the authors analyzed accessibility in native mobile apps for users with disabilities. In [19], the authors analyzed the inclusiveness of mobile healthcare as disabled people should not be excluded from access to these services. Also, new apps have been proposed to help people with specific disabilities. In [7], the authors proposed a mobile travel-assistant app for people with intellectual disabilities, and in [23], the authors proposed an app to help people with disabilities search accessible shops.

Mobile apps to help people in rural areas obtain access to information and services have been proposed and studied by several groups. In [6], the authors addressed questions related to the impact of the limited availability of rural digital infrastructure, and studies on the use of technology for education [5], healthcare [27], and healthcare education [25] in rural areas have been presented.

Both co-ideation and co-design have been explored in the development of mobile apps for specific communities, as understating the context and needs of users is crucial to develop apps that might actually be used and helpful. In [3], the authors presented the experiences on running International Innovative Labs, which focus on co-ideating and co-creating innovative smart and sustainable solutions for local challenges.

Several projects have been the result of including potential users in the ideation and design phases, particularly in the healthcare area. In [26], the authors presented guidelines to address the main challenges of co-designing mHealth systems. In [32], the authors presented a mobile app developed with hospital staff and patients for heart-failure self-management. The paper described the process and the results that showed that co-designing can be achieved through meaningful partnerships. In [22], the authors presented the co-design of a consultation audio-recording mobile app for patients with cancer, which enables patients to audio-record their medical consultations so that they can relisten to them at home and share them with family members.

Solutions to help specific populations have relied on input from people with certain conditions and/or from people that are their caregivers. Some examples were reported in [28], which discusses using co-ideation to develop new technology to help stroke survivors, in [14], which addresses the co-design of a mobile app for people living with dementia, and in [30], which presents assistive tools to support social interactions defined through co-ideation activities with members of the deafblind community.

Although not always reported, mobile apps that aim to help specific populations are often developed by software designers and engineers who have someone with that specific need in their family. This shared experience factor leads to solutions that are appropriate and helpful. This paper adds shared experience to co-ideation and co-design as an instrumental factor to the development of appropriate and helpful apps since, when developing applications for social impact, the closer the developer is to the target community, the higher is the chance that the application will be useful and possibly used.

III. THE SUMMER PROGRAM

Our summer program provides a coding experience for students from Ohlone College, a local community college in the San Francisco Bay Area. The students must have programming experience to participate, but mobile programming is not a requirement, and usually mobile development is not something they have done. The students work in groups that are usually formed by themselves, and they are given a theme.

The 10-week program is divided into three parts: proposal, wireframe, and functional app. After learning about computing for good and seeing examples of mobile apps developed for social impact, they are given a theme and have one week to propose and present an idea. After the idea is approved, they develop and present an initial wireframe. With our feedback, they improve and present a final wireframe, which is the basis of the mobile app. As they code with the help of teaching assistants, they present their progress weekly and, at the end of the program, they are expected to have a final functional mobile app.

Note that as they develop the wireframe, they start learning about mobile development, and the learning happens in parallel as they develop the app.

IV. THE MOBILE APPS

We have hosted our summer program twice, but we will focus on the summer of 2023, when seven applications were developed for immigrants, each of them solving a specific problem and/or helping a specific group of people, as shown in Table I. Three of the apps were ESL (English as a Second Language) apps, but they had specific goals, as we show below.

The students interviewed family members and friends, as they ideated, designed, and developed the app, to assess its effectiveness. Involving potential users in every aspect of the process led to apps that might actually be used by this specific population as they were built to cater for real needs.

TABLE I.   MOBILE APPS

Legal Ease	Help with forms
Order Simulator	Help order food
English Advantage	Help with casual language
Easy Tracker	Help keep track of expenses
Tiger Tutor	ESL, stories for children
ESLearn	ESL, conversational language
Fluent Focus	ESL, exercises for adults

A. Legal Ease

Legal Ease was developed to help people complete the form to apply for a Social Security Number (SSN), which according to the students was hard for their parents and other family members. These forms are complicated and

intimidating for immigrants, particularly for non-fluent English speakers. Therefore, an app that helps people deal with forms, such as the SSN one, can be extremely helpful.

The app is bilingual (English/Spanish), and it shows instructions in both languages. It offers a step-by-step guide to assist users in completing the SSN form accurately. This guide provides explanations, examples, and any necessary instructions to help users understand each section of the form. The app also shows the form and explains how to complete each field, as shown in Figure 1.

As explained by one of the students, "the app's inspiration was from interacting with grandparents and parents who are immigrants and were unfamiliar with the vocabulary written in the fine text of legal forms. Talking to them and helping them fill out important legal documents by translating and breaking down vocabulary and phrases served as the inspiration behind this project."
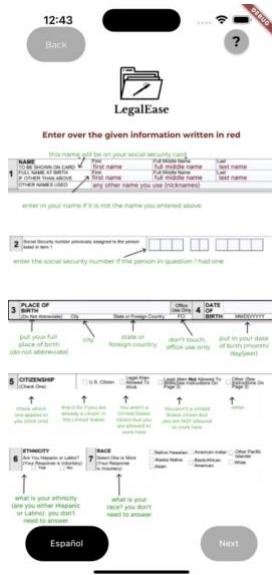

Figure 1. Legal Ease.

B. Order Simulator

Order Simulator was developed to help people order food in cafes and fast-food restaurants, where customers are expected to be effective and order quickly. According to the three students that developed it, this is intimidating for non-fluent English speakers, particularly when they come from places where these stores are not available or popular. One of the students shared the following: "I was familiar and had experienced the fear when facing unwelcome stares from cashiers and other customers due to my inability to order food in English. The discomfort and embarrassment I felt in such situations motivated me to develop a mobile application aimed at empowering individuals in the similar situation."

As it is shown in Figure 2, the app helps users in two ways. It enables users to pre-compose their orders to protect them from getting confused when talking to the cashier, and it generates ready-to-use sentences that guide them in their

interaction with the cashier. Furthermore, the app translates these sentences into the user's native language, enhancing comprehension and encouraging language learning.

Figure 2. Order Simulator.

C. Easy Tracker

Easy Tracker helps people keep track of their expenses. According to the students, dealing with a different currency can be overwhelming for immigrants, particularly when the relative values of things are different in their countries. Therefore, there is a need for a tool that enables them to control how much they are spending in what, so that they can adjust their spending to the new reality, and an app to help with that can be extremely helpful.

Figure 3 shows that Easy Track enables the user to both enter incomes and expenses within different categories to keep track of how the money is spent. The students made sure to have a simple and straightforward interface to encourage older adults and non-tech users because, according to them, they are the ones who need such help the most.

D. English Advantage

English Advantage is an application to help immigrant young adults learn English in a non-academic way so that they can connect with their peers casually. The goal is to teach slang and help people with common grammar mistakes made by English learners, as shown in Figure 4.

The three students that developed English Advantage immigrated to the United States when they were in elementary/middle school. They explained that the English they learned in school did not help them in a social context: "Recognizing that traditional ESL classes often teach overly formal English that doesn't help in casual, social interactions, our app focuses on teaching contemporary slang and addressing common grammar mistakes. This practical approach helps users connect with their peers more naturally."

According to one of the students, "to ensure relevance, we interviewed friends and younger siblings about the terms that should be added to the app. Our goal was to help new

immigrants quickly adapt to social settings and gain a practical understanding of spoken and cultural English, moving beyond the limitations of textbook language to better connect with local young adults."
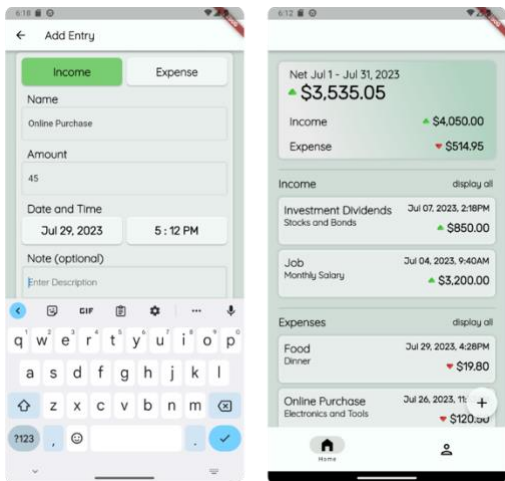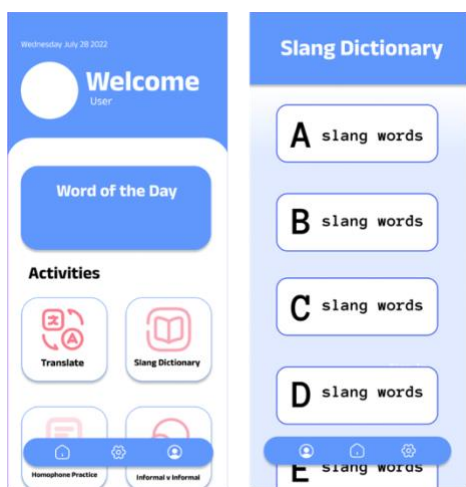

Figure 3.   Easy Tracker.

Figure 4.   English Advantage.

E. Tiger Tutor

Tiger Tutor is an ESL app to help children learn English through interactive stories. As shown in Figure 5, it has reading and comprehension exercises on short stories that can be read or listened to. This app was meant for children and was inspired on the students' siblings and other family members.

The interface provides an audio button to enable children that are still learning to read to listen as they read. The students did an amazing job developing the stories used in the app.
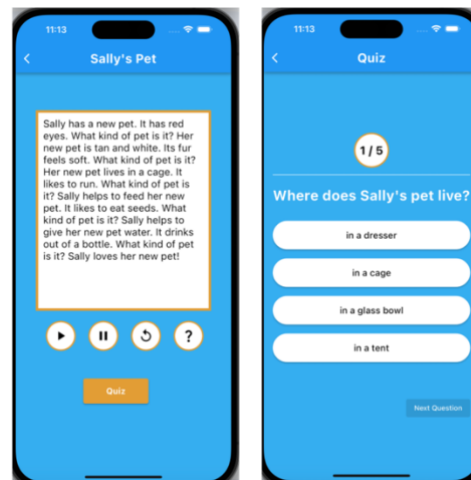

Figure 5.   Tiger Tutor.

F. ESLearn

ESLearn is an app developed to help users develop their conversational language across various daily scenarios, such as shopping, dining, and working, as shown in Figure 6. The students included support for nine languages, as they live in a very international and diverse area in the Bay Area. They also included a text-to-speech feature, to help ESLearn users learn common phrases, fostering their confidence in the ability to interact with English-speaking people in different situations.

As the English Advantage app, ESLearn was designed to help immigrants communicate with local people with whom they need to interact in day-to-day activities. According to one of the students, "ESLearn was born out of a deeply personal inspiration drawn from our parents, who immigrated to the United States and faced the daunting challenge of navigating a new country without knowing English. Despite numerous hardships, their dedication to learning the language through adult school enabled them to provide a better future for us, their children."
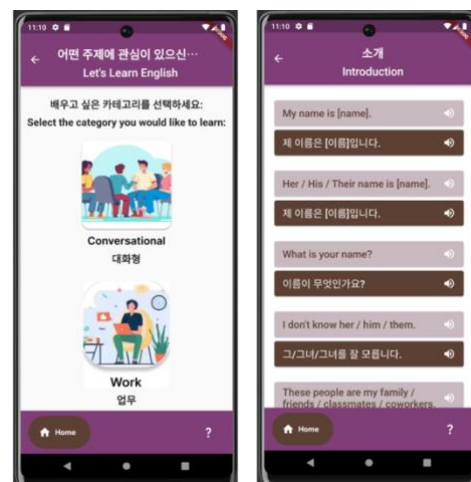

Figure 6.   ESLearn.

G. Fluent Focus

Fluent Focus is the third ESL app. It has a very different focus as it provides daily quizzes at different levels to engage the user in an educational curriculum. It provides statistical feedback and review options to aid in the learning process.

As shown in Figure 7, Fluent Focus aims at helping adults improve their English. It operates like a mobile English class, and it enables users to learn at their own pace.
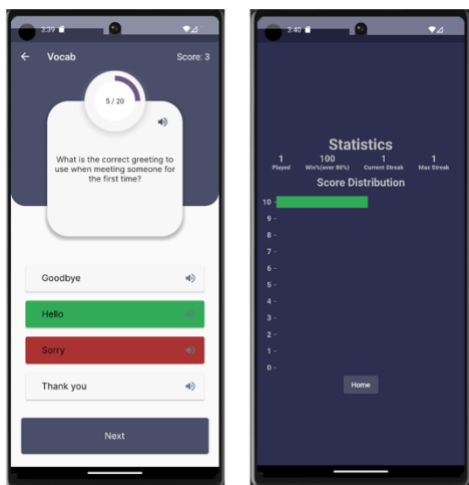

Figure 7. Fluent Focus.

V. RESULTS AND CONCLUSION

Our summer program was an excellent exercise on the development of mobile apps for a specific community. The apps developed by the students turned out to be unique and to reflect the real needs expressed by themselves and by their families and friends, showing the importance of working close to the target population via shared experience, co-ideating, and co-designing.

Through the ten weeks, as the apps were developed, we had several discussions on difficulties encountered by immigrants and on how technology might be able to help. These discussions on shared experiences guided the development process and enabled the students to see how mobile apps can be designed to help specific users overcome certain obstacles.

Although shared experiences proved to drive the development of solutions for real/existing problems, our setting does not represent a typical software development setting, and relying on shared experiences is not always possible. This shows a gap between the need and the solution in the software development process.

Most papers that describe solutions developed for social impact, do not explain how the project started and/or who had the idea for the app. Several papers discuss including the target population in the co-ideation and co-design phases, as discussed in Section II, but usually they do not mention what happened before that, i.e., who decided the app was actually needed. In healthcare settings, it is clear that hospital staff and/or caregivers might be the ones providing the ideas for

apps that could help their patients. Also, apps for refugees may have been suggested by people that work in refugee camps, and apps for homeless people by organizations that provide them with services. However, populations that do not typically rely on specific organizations may be left out, as they do not have a champion to convey their needs.

Our Global Digital Transformation Clinic at Santa Clara University has been working with low-resource organizations that serve underserved communities for about ten years. We develop mobile apps that are usually requested by them, because we believe the need should trigger the process, and since they understand their community well, they can identify their needs and context, leading to apps that are useful and impactful. However, this summer experience showed us that it may be necessary to find a path to develop mobile apps for populations that are not specifically served by organizations. Our future work will focus on establishing a path for helping these populations, and the first step will entail identifying them and determining a process to educate them on how technology can be helpful so that they can be the ones conveying their needs and requesting mobile apps.

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