Assessing the Effectiveness of Educational Interventions on Digital Skills for Middle Schoolers in Underserved Communities. The TechSpark Immokalee Case Study on Digital Upskilling in the Construction Industry

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Abstract

This research project examines the impact and challenges of a digital education intervention developed for middle school students from an underrepresented community within Southwest Florida. A four-week workshop was developed for three grade levels to enhance awareness and interest in developing digital skills required for future technology-driven careers. Supported by the Microsoft TechSpark program, these interventions provide students with hands-on experiences involving emerging technologies. The primary focus of this intervention is to nurture the digital skills necessary for utilizing and managing these technologies in future professional roles. The project's first stage contextualizes the educational experiences of future construction jobs, given the need for this industry to attract talent and continue its modernization to support economic development in our society. A pre and post-evaluation was given to measure the effectiveness of these interventions based on achieving three key objectives: (1) Increasing awareness of digital skills, (2) Enhancing understanding of anticipated job transformations fueled by technology in the future, and (3) Stimulating interest in potential careers within the construction industry. The research methodology involves collecting student surveys, and subsequent statistical analysis will compare the students' pre- and post-intervention responses. The study's significance lies in its potential to identify the effectiveness of these interventions, which can inform future support or enhancements. The results show that students experienced a notable increase in familiarity with the technologies discussed in the workshops. However, there was less certainty regarding the increase in overall technology awareness when comparing students' feedback before and after the workshops. Moreover, students showed a good understanding of selecting technologies for various problems, with workshop 2 (digitalization and visualization) scoring the highest, followed by workshop 3 (data and programming). Overall, correct responses outweighed incorrect ones across all workshops. The study's significance lies in its potential to identify the effectiveness of these interventions, which can inform future support or enhancements ahead.

1 Introduction

In recent years, there has been a growing emphasis on the importance of digital skills in preparing youth for future employment opportunities. Educational programs play a crucial role in fostering student awareness and interest in these skills. This study evaluates the effectiveness of one such program, the TechSpark Immokalee program. The program's primary objective was to enhance students' digital skills, emphasizing technologies relevant to the construction industry in an underserved community. While digital skills are used in the construction industry, the same digital skills are also used in a wide range of other industries, so students not contemplating careers in construction can still benefit from the workshops as purposefully intended.

To assess the program's effectiveness, three research questions were formulated, aiming to gauge students' familiarity with technology, their problem-solving abilities, and their interest in the construction industry as a potential career path. The study uncovered several key insights regarding students' perceptions and experiences within the program.

Given the Construction Industry's ongoing challenges in talent retention and recruitment, initiatives like TechSpark have the potential to play a significant role in shaping early career development dynamics. Early exposure to educational programs focusing on digital skills during K-12 education may lead to positive outcomes in future talent acquisition. This study contributes to the broader discussion on educational programs fostering awareness and interest in digital skills and future job prospects.

2 Literature Review

According to the World Economic Forum (WEF), the workforce must adapt to the modernization of industries by upgrading their technological and digital skills in what they call a “fourth industrial revolution” [1]. As a result, the digital skills needed for the future will be in high demand; this will require the upskilling process to begin at a younger age to avoid scarcity and disruptive economic impact. The WEF highlights that architecture and engineering jobs are the second highest group with the most need for digital upskilling[1]. Despite this need, the Construction Industry comprises the highest percentage of workers with no digital skills (22%) and the highest with limited or no digital skills (50%) [2]. This puts construction workers, either trades and labor or office workers, at the greatest risk of being displaced by future technology or significantly affecting their industries if the gap in digital skills is not bridged [3]. The need for digital skills will only increase as technology becomes more ubiquitous in construction roles. For example, roles like Building Information Modeling (BIM) managers and Virtual Design and Construction (VDC) managers are becoming more common in construction projects. These roles have increased the demand for advanced digital skills that are often difficult to acquire and require higher education and more significant experience.

A holistic approach integrating digital skills education into the construction industry curriculum has yet to be established. Educational interventions at early ages have been of broad interest in addressing the digital skills gap, especially for youth in underserved communities [4]. It is also important to avoid jumping to conclusions that youth easily learn digital skills, which is not always the case [5]. In the specific case of digital upskilling for construction-related educational interventions, a few examples have included specific digital skills or general identification of digital skills [6, 7], but no studies has been found of educational interventions for youth in the early stages of their education, focused on the Construction industry. The TechSpark Immokalee initiative seeks to address such issues by developing educational interventions for youth at the middle school level and to raise awareness of digital skills specifically within the construction industry. Therefore, this project focuses on measuring the effectiveness of such interventions.

Measuring the effectiveness of similar interventions has followed standard survey procedures [8, 9]. As a result, our measuring approach relies on similar methods of handling surveys to the target audience to evaluate the proficiency and interest of the digital skills involved. We also measure students' interest in future construction jobs. The next section describes the major research questions and associated hypotheses, and subsequently the research methodology is further explained.

3 Major research questions with associated hypotheses

The research project seeks to answer the following research questions and associated hypotheses:

- RQ1 – Do educational workshops focused on technology, such as TechSpark, increase youth awareness in developing digital skills?

    - H1 – Youth digital skills awareness and interest will increase based on exposure to educational interventions, such as TechSpark.
- RQ2 – Do educational workshops focused on technology, such as TechSpark, increase youth awareness of job changes in the future?
    - H2 – Youth awareness of job changes based on technology advancements will increase based on their exposure to educational interventions, such as TechSpark.
- RQ3 – Do educational workshops focused on technology increase youth interest in prospective jobs in the construction industry?
    - H3 – Youth interest on jobs in the construction industry will increase based on educational interventions that highlight technology in Construction, such as TechSpark.

The outcomes measured to answer the RQs have been identified as follows:

Based on Research Questions:

- RQ1 – Students might present a higher level of comfortability and interest in applying digital skills to solve applied problems.
- RQ2 – Students might consider digital skills technologies to be ranked higher for a potential change to future jobs.
- RQ3 – Students might increase their interest in the construction industry based on the construction-related industries ranking higher in student preferences.

4 Brief Overview of the TechSpark Immokalee Initiative

TechSpark Immokalee is an initiative aimed at supporting the economic growth of the underrepresented community from Immokalee, Florida, United States. By providing youth access to educational resources, that allows them to explore opportunities and prospects for technology-oriented jobs, the exposure and excitement should entice them to continue future exploration and pursue advance digital skills. The initiative collaborates with organizations such as Microsoft Philanthropies, Florida Gulf Coast University, The Immokalee Foundation, and the Collier Industrial Development Authority.

The target population in this execution period, Spring 2024, are students at 6th, 7th, and 8th grades at Immokalee Middle School (approximately 45-60 students per section, totaling around 150 students), who are involved with The Immokalee Foundations' educational pathways. These students were selected to have an earlier-than-usual introduction to digital resources, given their limited access to such opportunities.

Immokalee, was the target population because of the low socio-economic status associated with the community, including many inhabitants being immigrants, the main industry being farming-oriented, and reported low digital equity within the region. Digital equity is calculated by i) the number of 25+ years old without graduating high school, ii) the number of households without a desktop or laptop, iii) the number of households without an internet broadband subscription of any type, iv) the percentage of people not using the internet at broadband speeds, and v) the percentage of annual median income spent of broadband. This aggregated data is provided by Microsoft AI for Good Lab [10].

Figure 1 shows a screenshot of the digital equity dashboard for the surrounding region of Immokalee, Florida, which highlights how Immokalee has the lowest digital equity within the city itself and how contrasting its digital equity is compared to the surrounding towns/cities.

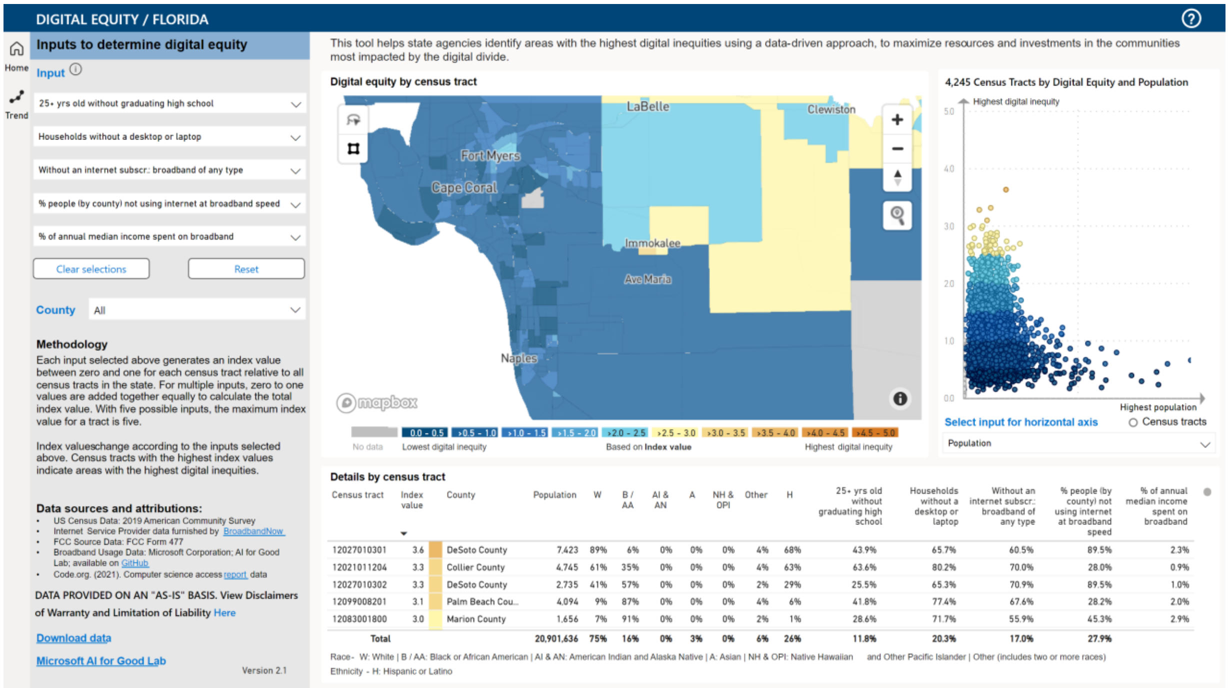

Figure 1. Digital Equity Dashboard of the surrounding Immokalee Region. Immokalee is shown as a town with lower digital equity [10].

The educational workshop consists of a 4-week program, for each grade, where each week they learn about a new topic: 1) digital skills on reality capture, 2) digitalization and visualization, 3) working with and programming data, 4) AI and Robotics. The TechSpark initiative runs for 12 weeks, where a new grade comes in every four weeks. Furthermore, the educational workshops were developed simultaneously with the assessments, and both evolved as needed based on the instrument development and testing (see sections 5.1 and 5.2 for further details). However, this article focuses on the challenges within the assessment portion and does not delve into the development of the workshops.

5 Research Methodology

The research methodology for the study is presented in Figure 2. The study includes four main stages to measure the effectiveness of the TechSpark Immokalee program. The development of the workshops themselves is not part of this study, given that this study's scope is to understand the challenges and best practices for measuring the effectiveness of educational interventions on digital skills aimed at youth in underrepresented communities.

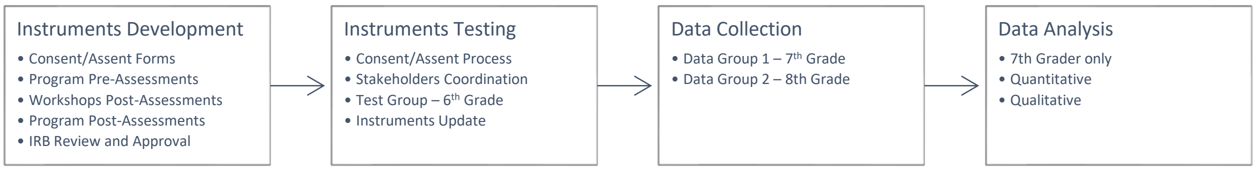

Figure 2. Study Research Methodology

The target population of this study is only the middle schoolers involved with the TechSpark Immokalee initiative during January and April 2024. The rest of this section focuses on the main stages of developing the assessments for education interventions, as indicated in Figure 2.

5.1 Instruments Development

Data collection instruments were developed based on RQ1, RQ2, and RQ3. Thus, *digital skill awareness* and *interest in a future construction career* were selected as dependent variables. For this study, digital skill awareness was defined as the skills needed for students to interact effectively with data-driven physical and digital elements [11]. ***Awareness of future job changes*** was defined as the student's understanding of the revolutionary potential that technology can have on future jobs, and it is considered a dependent variable. These were defined based on the current understanding of technology's impact on the future. ***Interest in a future construction career*** was defined as the student’s motivation to pursue a construction-related career in the future. We relied on expectancy-value theory [12] to operationalize such motivation as the product of two measures: i) The subject's perceived likelihood of following a construction-related job path (i.e., the expectancy), and ii) the degree of preference for a construction-related job path when presented with a pool of alternatives (i.e., the value).

We defined ***stimulation to action*** as the students’ interest in continuing to develop digital skills. This was measured as the student’s choice to access additional resources related to the four digital skills (i.e., reality capture, digitalization & visualization, working with and programming data, AI & Robotics) and/or register for upcoming workshops.

To take a holistic approach and through consideration of the target audience needs and the environment that the workshops were done, these instruments were developed in collaboration with researchers from Florida Gulf Coast University (FGCU), the University of Virginia (UVA), The Immokalee Foundation (TIF), and the Collier County School District (CCSD).

5.1.1 Consent/Assent forms

Consent and Assent forms followed the standard format provided by the Institutional Review Board (IRB) at FGCU. This includes having a consent form completed by the parents or guardian of the minor in the study, as well as an assent provided by the minor after the parent/guardian has provided consent.

5.1.2 Program pre-assessment

The program pre-assessment serves as the baseline measurement to gauge participants' existing levels of digital skill awareness and their interest in pursuing a construction-related career in the future. This instrument establishes a starting point or control for the subsequent workshop and program post-assessment by assessing familiarity with construction-related concepts and overall awareness of technological advancements. The pre-assessment provides valuable insights into participants' demographics, current knowledge, and perceptions. The program pre-assessment was initially administered digitally but was then switched to paper after the instrument testing.

Workshop Assessment

To evaluate ***digital skill awareness,*** for each workshop, we created two different scenarios that mirror the challenges they might encounter in real construction industry scenarios. We were interested in evaluating the students' ability to translate their understanding into practical decision-making rather than assessing theoretical knowledge alone. By prompting students to choose the most suitable tool for a given scenario, the questions assess their ability to apply digital skills in practical situations. The questions indirectly gauge students' familiarity with a variety of digital tools. Their choices reflect their degree of awareness and understanding of available tools, showcasing whether they are acquainted with a diverse range of technologies relevant to the construction industry. On the other hand, assessing students' comfort levels in using a specific digital tool provides insights into their confidence and self-perceived competence. This subjective measure complements the objective evaluation of their tool selection, offering a holistic view of their digital skill awareness, confidence, and readiness to apply their knowledge.

These scenarios were crafted to assess participants' knowledge of digital technologies and their readiness to apply them in practical construction scenarios. By presenting authentic challenges and contrasting traditional methods with modern technologies, the scenarios prompt participants to critically evaluate their skills and comfort level, contributing to a comprehensive assessment of their digital literacy and preparedness for the evolving demands of the construction industry.

For instance, in Workshop 1, Scenario 1 focused on technology selection, simulating the challenge of capturing precise site details for planning and design. Participants were prompted to consider the most appropriate technology for the task, encouraging critical evaluation of each technology’s suitability based on scenario requirements.

In Workshop 1, Scenario 2 immersed participants in a real-world problem faced by design engineers: capturing accurate building dimensions for construction drawings. The scenario contrasted traditional methods (tape measure and notes) with newer technology (laser scanner), prompting participants to assess their comfort levels with adopting digital technologies.

Another goal is to encourage participants to actively pursue further learning opportunities of each technology discussed during the program. We included additional resources tailored to each technology to measure the stimulation to action variable, like online courses, articles, and access to platforms and services that delve deeper into the applications, functionalities, and practical use of the technologies introduced. Participants were then asked to express their interest in pursuing further learning opportunities for each technology. By asking participants about their interest in pursuing further learning opportunities, the instrument directly measures the extent to which the program has stimulated them to take action. It evaluates their motivation to delve deeper into the technologies covered, showcasing the program's impact in sparking an ongoing curiosity and commitment to learning.

Post-Program Assessment

The post-assessment was administered on paper at the end of each workshop. The post-assessment program served as a comprehensive evaluation tool to measure the initiative's overall success. It assesses the sustained impact on participants' perspectives on developing digital skills, future job prospects in Construction, enduring interest in the industry, and continued motivation to take action. This evaluation mainly focuses on discerning any shifts or changes in participants' interest in pursuing a career in Construction compared to the responses gathered during the pre-program assessment. This comparative approach allows for a nuanced understanding of how the program has influenced participants over the four-week duration.

The ***evaluation of awareness of future job changes was done during the post-program assessment, and it was evaluated post-facto based on students'*** understanding of the potential impact on future jobs. In this context, students ranked the digital skills categories, identified as the workshop weekly topic (reality capture, digitalization, and visualization, working with data and programming, and AI and robotics), from potentially no change to revolutionary change, on a 5-point Likert scale.

5.1.3 IRB Review and Approval

The instruments mentioned in this subsection, including consent/assent forms, program pre-assessment surveys, workshop post-assessment surveys, and program post-assessment surveys, were reviewed and approved by FGCU's IRB office. The IRB process includes initial submission and an update based on the IRB board review and findings during the instrument testing stage.

5.2 Instruments Testing

As the workshops progressed, the instruments were tested for their effectiveness, practicality for the students, and reliability of the data.

5.2.1 Consent/Assent Process

Minors' data is highly protected in the state of Florida. As a result, paper consent/assent forms were provided by FGCU/UVA to the TIF/CCSD to be completed by the parents/guardians and the students. TIF/CCSD retained consent/assent forms for verification and storage.

To de-identify data from students to be collected during the instruments testing and data collection stages, students had unique Individual Identifiers (IDs) to be used in the surveys instead of their personal information. FGCU/UVA then collected this de-identified data for data analysis. This process was reviewed by FGCU's IRB board and was considered appropriate.

5.2.2 Stakeholders Coordination

As indicated previously, access to information from the students was a concern among the TIF/CCSD. As a result, FGCU/UVA channeled forms and surveys that required additional coordination through them. Initially, only consent/assent forms would be handled on paper, while all other surveys would be handled digitally during the workshops. However, access to a reliable internet connection and computers at Immokalee Middle Schools proved unreliable, so survey completion was switched from digital to paper during the testing phase. However, QR codes or links were kept on the worksheets provided during the workshops so that students could continue accessing the resources throughout the TechSpark program.

5.2.3 Test Group – 6th Grade

The initial instruments were tested with the first cohort of students belonging to the 6th grade. For this cohort, 45 students participated in the workshops.

5.2.4 Instruments Update

Instruments were updated based on the following considerations:

- Provided Spanish and Haitian-Creole translations for the consent forms so guardians/parents and students who do not speak English could understand what was stated in the forms.
- Kept survey language suitable for 6th graders.
- Switched surveys from a digital to paper-based medium.
- Added links and QR codes to the end of the paper surveys as additional resources provided throughout the workshops.

5.3 Instrument's purpose

The surveys sought to identify different aspects of the effectiveness of the TechSpark program. As a result, six surveys were administered to the students to identify the overall effectiveness of the educational program and the students' understanding of each of the four workshops throughout the program.

To elucidate the effectiveness of the educational program, surveys 0 and 5 were developed to be compared. These surveys asked students about their level of interest across industries, degree of interest in different technologies, and familiarity with those technologies. Student's understanding of each workshop was evaluated based on their responses to surveys 1, 2, 3, and 4, which focused on the student's technology selection, confidence in problem-solving, and concerns about problem-solving.

5.4 Data Collection

Data for the 7th and 8th grade students was collected at Immokalee Middle School. The instruments used were updated after the instruments testing phase. Table 1 shows the detailed timeline with major activities and milestones for the instrument testing and data collection stages.

5.4.1 Data Group 1 – 7th Grade

Data group 1 consists of 7th grade students at Immokalee Middle School. These students completed the TechSpark workshops between February and March 2024. Their data was collected to measure the effectiveness of the TechSpark Workshops, and their data was used in this article for analysis and interpretation. For this cohort, 56 students participated in the workshops.

Table 1. Data Collection detailed timeline with major activities and milestones.

Study Phase	**Activities and Milestones**
Recruitment	1. This is for all grades. No recruitment done, given that only students participating in TechSpark Immokalee could participate in this study.
Test Group - 6th Graders	3. Consent and Assent a. The Immokalee Foundation coordinated with Immokalee Middle Schools to distribute and record consent forms through a digital survey or paper. b. Consent was done before the first TechSpark Immokalee Session, approximately 1 week prior to the first TechSpark Workshop. 4. Pre-Assessment a. Survey 0 – Pre-Assessment – Before TechSpark Program to Start b. Done by The Immokalee Foundation in-person at the Immokalee Middle School. 5. Workshop 1 a. Survey 1 – Post-Assessment 1 – Workshop 1 – A Day after workshop 1. In-person. 6. Workshop 2 a. Survey 2 – Post-Assessment 2 – Workshop 2 – A Day after workshop 2. In-person. 7. Workshop 3 a. Survey 1 – Post-Assessment 3 – Workshop 3 – A Day after workshop 3. In-person. 8. Workshop 4 – last workshop for 6th grade a. Survey 4 – Post-Assessment 4 – Workshop 4 – A Day after workshop 4. In-person. 9. Program Post-Assessment – Survey 5 a. This was done at the same time survey 4 is done. In-person. 10. Instruments evaluation. a. Challenges and considerations regarding completion of surveys were discuss to incorporate in the Instruments update. See section 5.2.
Instruments Update	11. Survey material update based on lessons learned from Test group.
Data Group 1 – 7th Grade	12. Consent and Assent a. The Immokalee Foundation coordinated with Immokalee Middle Schools to distribute and record consent forms either through a digital survey or paper. b. Consent was done before the first TechSpark Immokalee Session, approximately 1 week prior to the first TechSpark Workshop. 13. Pre-Assessment a. Survey 0 – Pre-Assessment – Before TechSpark Program to Start b. Done by The Immokalee Foundation in-person at the Immokalee Middle School. 14. Workshop 1 a. Survey 1 – Post-Assessment 1 – Workshop 1 – A Day after workshop 1. In-person. 15. Workshop 2 a. Survey 2 – Post-Assessment 2 – Workshop 2 – A Day after workshop 2. In-person. 16. Workshop 3 a. Survey 1 – Post-Assessment 3 – Workshop 3 – A Day after workshop 3. In-person. 17. Workshop 4 – last workshop for 6th grade a. Survey 4 – Post-Assessment 4 – Workshop 4 – A Day after workshop 4. In-person. 18. Program Post-Assessment – Survey 5 a. This was done at the same time survey 4 is done. In-person. b. Surveys were collected by TIF/CCSD and the returned to FGCU/UVA for analysis
Data Group 2 – 8th Grade	19. Same as Data Group 1 – 7th Grade.
End of TechSpark Immokalee	

5.4.2 Data Group 2 – 8th Grade

Data group 2 consists of 8th grade students at Immokalee Middle School. These students completed the TechSpark workshops between March and April 2024. Their data was collected to measure the effectiveness of the TechSpark Workshops, but their data was not used for the data analysis in this study and will be used in future analysis.

5.5 Data Analysis

A mixed methods approach was used to collect and analyze data obtained from TechSpark Immokalee. Data collected consists of a series of surveys that capture students' understanding of digital skills in the context of the TechSpark initiative. The survey questions are designed to assess students' problem-solving confidence through practical scenarios rather than relying on self-assessment.

5.5.1 Quantitative

Quantitative data will be collected through closed-ended or multiple-choice questions that seek to capture students' understanding, preferences, and perceptions numerically. Data will be tested for statistical significance for pre- and post-assessment. For problem-solving questions, the correctness of the alternatives will be evaluated.

5.5.2 Qualitative

Surveys also include open-ended questions where students can express their understanding, preferences, and perceptions, in their own words, about the topics taught in the educational intervention .

6 Results

This section presents the results obtained from the data collection and analysis. The results will be presented based on the metrics identified and their effect on the hypotheses mentioned earlier.

6.1 Sample Population Demographics

At the time of writing, the TechSpark program just finished, therefore, the results presented here are only based on the data collected from the 7th-grade group, where data collection and analysis has been completed. The data from the 6th-grade test group was not used because the survey were used as a dry run to be modified and enhanced based on feedback from the group. Data collection from the 8th graders was collected, but because of timing, its data analysis is not completed. However, the data collected with the 8th graders will be used in a future comparative evaluation. Table 2 presents the demographic data from the sample population.

The demographic data presented here was obtained from survey 0, which was done before the educational program started. The questions that formulated the demographic data are presented in Table 2, with their respective statistics. It can be observed that a vast majority of participants identified themselves as being non-white (~91%) and from a Hispanic or Latino origin (~95%).

Table 2. Demographic data for the study's data sample group (7th grade only)

Question	Answer	Frequency (N = 56)	Percent
How do you identify yourself?	Male	18	32.14%
	Female	37	66.07%
	Other	0	0.00%
	Prefer not to say	1	1.79%
Choose one or more races that you consider yourself to be	White or Caucasian	5	8.93%
	Black or African American	4	7.14%
	American Indian/Native American or Alaska Native	3	5.36%
	Asian	0	0.00%
	Native Hawaiian or Other Pacific Islander	0	0.00%
	Other	41	73.21%
	Prefer not to say	3	5.36%
Are you of Spanish, Hispanic, or Latino origin?	Yes	53	94.64%
	No	3	5.36%

6.2 Post-Workshops Assessment

After each workshop, students responded to questionnaires that challenged them to think about a given problem related to the workshop topic and analyze possible solutions to the problem given. This section presents the results of the three main questions posed to the students to measure their understanding of each workshop topic.

6.2.1 Students' Technology Selection Assessment

The first question asked to the students was to identify the most appropriate technology to solve a given problem related to the workshop topic. The assessment for students' understanding of proper technology selection was done by providing them with a problem with some context and asking them to select the most appropriate technology to solve the problem. Table 3 presents the questions that were provided along with descriptive statistic of the results.

For each workshop question, two correct and incorrect answers were provided as answer choices. Correct answers were graded with a +1 score whereas incorrect answers were graded with a -1 score. All other answers were considered neither correct nor incorrect and graded as a 0 value in analysis (see Table 3).

A total score was obtained for each student by getting the sum of their responses. Table 3 also presents the statistical data for the answers provided and the students' average scores across the workshops. Figure 3 shows the comparison of scores visually based on box and whisker plots for the 7th graders.

Table 3. Provided Questions and Assessment of Answers for Technology Selection Assessment. Statistical Data is included.

	Workshop 1	**Workshop 2**	**Workshop 3**	**Workshop 4**
Workshop Topic	Reality Capture	Digitalization and Visualization	Data and Programming	AI and Robotics
Technology Selection Assessment. Question	Imagine you are working on a construction project, and you need to capture precise details of the site for planning and design purposes. Which of the following tools is more appropriate for this task?	Imagine you have to create a visualization of an architectural design. Which of the following technologies are the more appropriate for this task?	Imagine you have collected data about different construction projects. Now, you need to analyze the data and identify insights or problems present based on the data so others can understand what is working well or not in the project. Which of the following tools are more appropriate for this problem?	Imagine leading a construction project with a focus on introducing innovative AI solutions to enhance efficiency and safety. Which of the following tools are more appropriate for this task?
Expected Correct Answers (+1)	Drones Point Clouds	Virtual Reality 3D Models	Programming Virtual Reality	ChatGPT Programming
Expected Incorrect Answers (-1)	3D printing ChatGPT	Sphero ChatGPT	3D printing Robot Dog	Sphero Virtual Reality
N (students)	55	53	53	49
N (Responses)	213	232	229	235
Incorrect Responses	32(15.02%)	19(8.19%)	43(18.78%)	45(19.15%)
Neither Correct/Incorrect	123(57.75%)	127(54.74%)	118(51.53%)	133(56.60%)
Correct Responses	58(27.23%)	86(37.07%)	68(29.69%)	57(24.26%)
Average Score	0.473	1.264	0.472	0.245
Std. Dev.	0.742	0.812	1.203	0.902

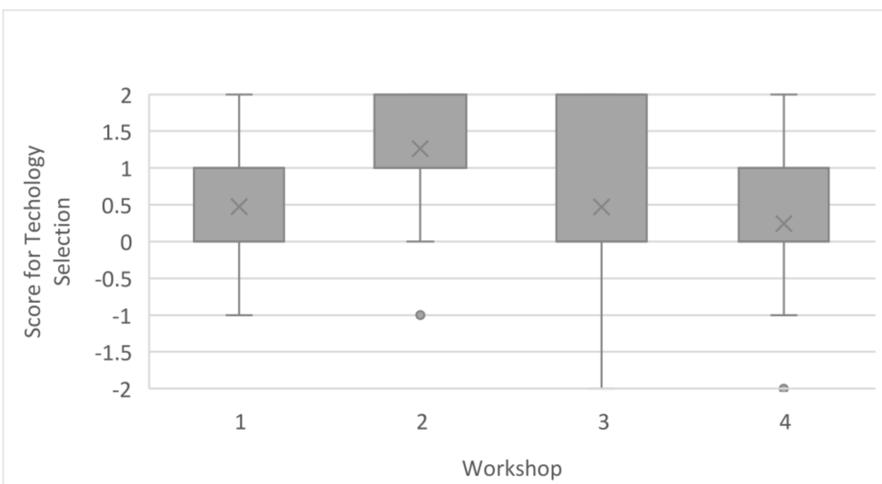

Figure 3. Box Plot Diagram for the Technology Selection Assessment Scores

To corroborate if the scores obtained were significantly different between workshops, a One-Way ANOVA analysis was conducted, indicating statistical significance between groups. See Table 3.

Table 4. One-Way ANOVA Results for the Technology Selection across Workshops Question

	Sum of Squares	df	Mean Square	F	Significance
Between Groups	31.24406016	3	10.415	12.034	***0.000
Within Groups	178.2797494	206	0.865		
Total	209.5238095	209			

****Indicates significance at p<0.05*

Table 5. Provided Case Study for Student Analysis of their Confidence to solve given problem. Statistical Data is Included

Workshop	Question: Confidence in Problem Solving	N (Total)	[a]Mean	Std. Dev.	Std. Error Mean	Shapiro-Wilk Test
1	Place yourself in the position of a design engineer and you have to develop the construction drawings for a big warehouse project, such as a Walmart supermarket. However, as part of the design process you need to understand the current conditions in the warehouse, so you have to take measurements and capture the building dimensions and characteristics. Traditionally, you could have used a tape measure and take notes to obtain the warehouse dimensions. However, you recently learned how to use a laser scanner, so you will get the dimensions of the warehouse with the laser scanner. In this hypothetical scenario, how comfortable you would feel solving this problem?	55	3.836	1.475	0.199	***0.002
2	Place yourself in a position of the steel company in a medical hospital project. You need to show the other professionals and workers how to do the steel installation. You can develop a document that explains the construction sequence with some pictures that show the process. However, you have developed 3D models in the past for small projects. So you think you can develop a 3D model animation that shows the construction process to the rest of the project team. In this hypothetical scenario, how comfortable you would feel solving this problem?	53	3.472	1.395	0.192	***0.005
3	Place yourself in the position of a project designer. You have to add a room ID to all rooms in a building. Typically, that is manually done by adding the Building Level + a number. For example, a Room located on the third floor will start with a 3 and be followed by a number, such as room 311. However, you recently learned to program and plan to develop a program to automate this process. How comfortable would you feel solving this problem with technology in this hypothetical scenario?	53	3.604	1.335	0.183	***0.001
4	Place yourself in the position of a project manager who is trying to predict based on similar previous projects, how will be the performance of the next project. Typically, data from similar projects is good enough for predicting project cost and performance. However, this project, although similar, it has conditions that have not been seen before. Nevertheless, you have learned how to predict with Artificial Intelligence based on data and this project has enough data for doing this. In this hypothetical scenario, how comfortable you would feel solving this problem with Artificial Intelligence?	49	3.429	1.258	0.180	***0.000

*[a]6-points Likert Scale. ***Indicates significance at p<0.05.*

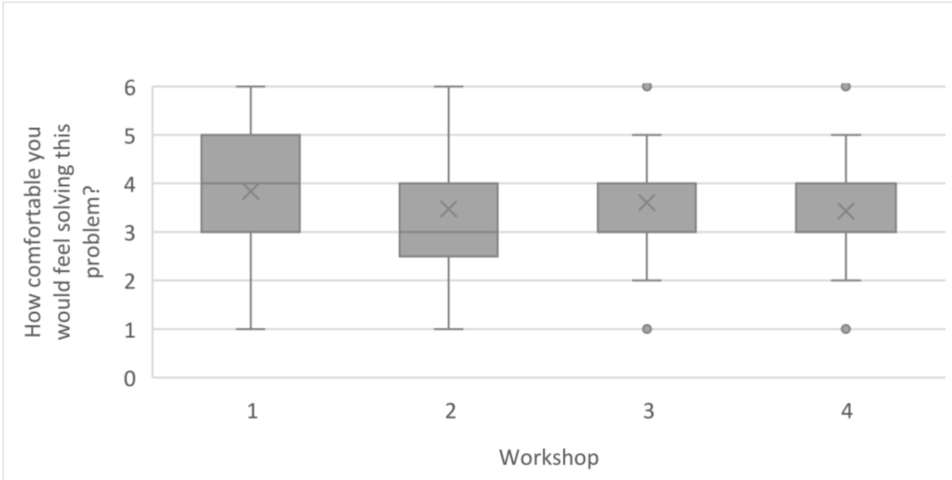

Figure 4. Box Plot Diagram that showcases the Student's Confidence in Problem Solving

6.2.2 Confidence in Problem Solving

The second question posed to the students was to analyze a case related to the workshop topic and indicate their confidence in solving the problem, while mentally considering using a technology, that indicates their own digital skills confidence (see Table 5). This was based on their previous experiences during the workshops including interacting with the technology, learning similar to a classroom lecture, or seeing use case examples.

The differences between the student's confidence to solve given problems across workshop topics was then measured by doing a One-Way ANOVA. The difference in scores were not statistically significant.

Table 6. One-Way ANOVA results for the Confidence in Problem Solving Question

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.366887	3	1.788962	0.951246	0.416793
Within Groups	387.4141	206	1.880651		
Total	392.781	209			

6.2.3 Concerns Towards Problem-Solving

As a follow-up to the case study, previously mentioned, students were also asked about their concerns in solving the given problem with a novel technology.

Three generic responses were provided to the students to express their concern about either:

- Answer 1: More concerned about uncertainty of using novel technology, despite its benefits
- Answer 2: More concerned that technical knowledge is more important than method used
- Answer 3: More concerned that novel technology complicates things, and traditional methods work fine despite more effort

More specific answers were provided to the responses at each workshop to more clearly identify the concern with the technology in the case study provided, as shown in Table 7.

Table 7. Provided Questions and Answers for Student Concerns Toward Problem Solving. Statistical Data is Included

	Workshop 1	Workshop 2	Workshop 3	Workshop 4
Workshop Topic	Reality Capture	Digitalization and Visualization	Data and Programming	AI and Robotics
Question: Concerns Toward Problem Solving	In the scenario described above, what option, among the ones below, better describes your concern towards solving the problem described?			
Answer 1: More concerned about uncertainty of using novel technology, despite its benefits	I am more concerned that using the laser scanner feels less certain, despite the benefits in making things faster	I am more concerned that using 3D models will take time despite the end result could be more practical	I am more concerned that automating this task with code will take time despite the end result to be more practical	I am more concerned that forecasting with Artificial Intelligence feels less reliable than relying on previous known practices
Answer 2: More concerned that technical knowledge is more important than method used	I am more concerned that my technical knowledge in engineering is more important than the method to get the measurements	I am more concerned that my technical knowledge is more important to explain the construction process to other professionals and workers	I am more concerned that my technical knowledge is more important to solve the problem than automate the task	I am more concerned that my technical knowledge is more important to solve the problem than predicting with any Artificial Intelligence method
Answer 3: More concerned that novel technology complicates things, and traditional methods work fine despite more effort	I am more concerned that the laser scanner might make things more complicated, and the tape measure will work fine but will take more time	I am more concerned that using 3D models will not be a great benefit for the purpose of showing of the construction process and explaining and the report might be enough	I am more concern that automating the task with code will not be a great benefit for the purpose of number the rooms and doing manual is good enough	I am more concerned that forecasting with Artificial Intelligence will not be of great benefit for the purpose of defining project management practices and previous practices are good enough
N (students)	54	53	53	49
Answer 1 Selected	17 (31%)	23 (43%)	18 (34%)	18(37%)
Answer 2 Selected	18 (33%)	23 (43%)	25(47%)	25(51%)
Answer 3 Selected	19 (35%)	7 (13%)	10(19%)	6(12%)

6.3 Comparison of Pre- and Post-Education Program Student Perceptions

Surveys 0 and 5 were administered to identify if the TechSpark educational program can stimulated students' interest in the construction industry and also stimulated their interest and familiarity with the different emerging technologies mentioned in these workshops. By comparing the pre- and post-educational perceptions, nuances in the assessment at these different times were expected to be significant. This section delves into the specifics of these questions and their effect on the educational program's effectiveness.

6.3.1 Degree of Interest across industries

The students were asked about their level of interest across industries to indirectly obtain a perception of the students' level of interest in the construction industry and other industries. Table 8 presents the students' indicated level of interest across key industries for a comparison before and after TechSpark. These industries were obtained from the Bureau of Labor Statistics (BLS); however, only a few were selected among all available. The responses by the students were based on a 5-point Likert scale.

Before TechSpark, the Healthcare industry ranked first, while the Construction Industry ranked third, and Transportation ranked last, in 7th place. However, after TechSpark, healthcare ranked first despite having a lower mean, and the construction industry ranked 4 despite a slight increase in its mean, with the information industry stepping one place in the rank. See Table 8.

Table 8. Statistics for Student's Selection of Interest Across Industries

Please indicate the level of INTEREST for the following careers	**Program Comparison**	**N (Total)**	**Mean**	**Rank**	**Std. Dev.**	**Std. Error Mean**	**Shapiro-Wilk Test**	**Lavene's Test**	**Paired Sample T-Test**
Agriculture, Forestry, and Fishing	Before TechSpark	56	2.25	6	1.19	0.16	*0.000	0.290	0.213
	After TechSpark	49	2.53	6	1.08	0.15	*0.001		
Accommodation and Food Services	Before TechSpark	56	2.80	2	1.26	0.17	*0.000	0.121	0.557
	After TechSpark	49	2.94	2	1.07	0.15	*0.002		
Transportation and Warehousing	Before TechSpark	56	2.22	7	1.17	0.16	*0.000	0.511	0.203
	After TechSpark	49	2.50	7	1.05	0.15	*0.000		
Construction	Before TechSpark	56	2.54	3	1.31	0.17	*0.000	0.471	0.521
	After TechSpark	49	2.69	4	1.19	0.17	*0.002		
Information	Before TechSpark	56	2.52	4	1.33	0.18	*0.000	0.572	0.398
	After TechSpark	49	2.74	3	1.25	0.19	*0.003		
Healthcare and Social Assistance	Before TechSpark	56	3.18	1	1.49	0.20	*0.000	0.392	0.785
	After TechSpark	49	3.10	1	1.37	0.20	*0.002		
Manufacturing (such as fabrication of cars, products, or tools)	Before TechSpark	56	2.50	5	1.32	0.18	*0.000	0.594	0.773
	After TechSpark	49	2.57	5	1.28	0.19	*0.000		

Significance in the Shapiro-Wilk Test denotes distribution is not normal. **Significance in Lavene's Test indicates variances are significantly different. Thus, Equal Variances not Assumed in T-Test* Significance in Independent Sample T-Test (T-Test) indicates results are significant. All significance is measured at p<0.05.*

Table 8 also shows statistics obtained from the data, including the verification of normality distribution with the Shapiro-Wilk Test, the test of variances with Lavene's Test, and the significance of paired sample T-Test. Our analysis shows that any of the comparisons between students' level of interest across careers before and after TechSpark is significant.

More specifically, a follow-up question asked the students if they had considered a career in Construction. Students' responses were given on the following responses:

- Yes. Analyzed with a value of 2.
- Maybe. Analyzed with a value of 1.
- No. Analyzed with a value of 0.

An analysis was made among their answers, as presented in Table 9. However, no significant difference was identified in these comparisons despite indicating a higher mean in the students' responses.

Table 9. Statistics for Question: Have you considered a career in Construction?

	Program Comparison	N (Total)	Mean	Std. Dev.	Std. Error Mean	Shapiro-Wilk Test	Lavene's Test	Independent T-Test
Have you considered a career in Construction?	Before TechSpark	56	0.6964	0.76085	0.10167	*0.000	0.543	0.438
	After TechSpark	**48	0.5833	0.70961	0.10242	*0.000		

Significance in the Shapiro-Wilk Test denotes distribution is not normal. **Significance in Lavene's Test indicates variances are significantly different. Thus, Equal Variances not Assumed in T-Test* Significance in Independent Sample T-Test (T-Test) indicates results are significant. All significance is measured at p<0.05.*
***Not the same number of students responded the survey after TechSpark.*

Figure 5 shows a bar graph for the students' answers to the questions above.

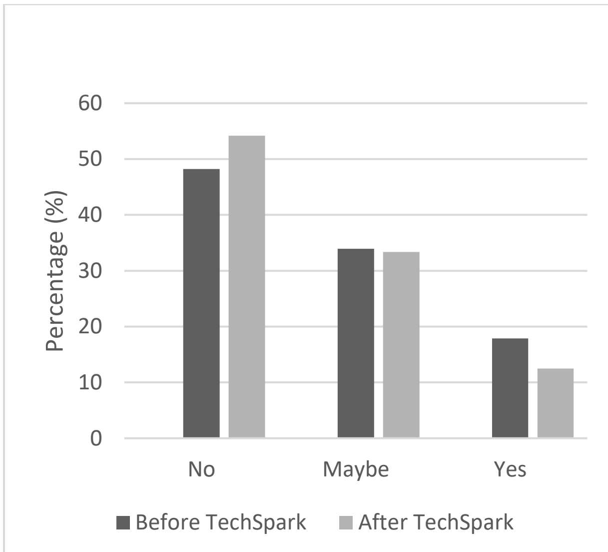

Figure 5. Bar chart for Question: Have you considered a career in Construction? Shown Before and After TechSpark.

As a follow-up to the question about students' consideration of the construction industry, the students were asked for reasons why they might not consider it. Five options were provided as a multiple answer option, including one option for the other, allowing them to select more than one reason. Figure 6 presents a bar graph for the responses to this question.

6.3.2 Degree of Interest in Technologies

The degree of students' interest in technology was another question that was posed to them. Students expressed their interest in 10 technologies discussed across all the educational workshops. Table 10 presents the comparison of students' level of interest before and after TechSpark. The responses by the students were based on a 5-point Likert scale.

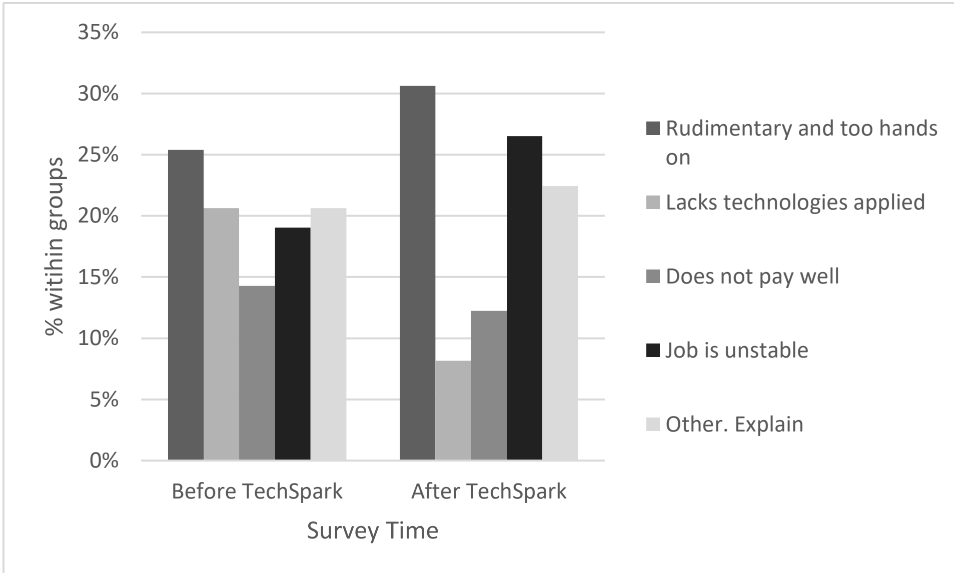

Figure 6. Bar Chart for Students' Responses to the Question: What might be some reasons for not considering Construction as a career?

Table 10 shows the data resulting from the analysis of the students' degree of interest in technologies. Results show inconsistency in the effectiveness of the educational program based on the means. Some technologies indicate a higher degree of interest (e.g., AI/ML, AR/VR), but others show a decrease of interest (e.g., Drones, 3D models). However, no significant difference was identified in these comparisons.

6.3.3 Degree of Familiarity with Technologies

Likewise, a comparison of the degree of Familiarity with Technologies was made similarly to the Degree of Interest in Technologies. Table 11 presents the data for this comparison.

The analysis presented in Table 11 indicates an overall increase in familiarity after TechSpark (e.g., 3D visualizations and models, AI/ML, 3D printing, Lidar/Laser Scanners, and others). Notable exceptions include drones. The significance of this increased familiarity was found only in the LIDAR/Laser Scanner.

Table 10. Statistics for Students' Interests in Technologies

Please rank the level of INTEREST you have with the following technologies	Program Comparison	N (Total)	Mean	Std. Dev.	Std. Error Mean	Shapiro-Wilk Test	Lavene's Test	Independent T-Test
Drones	Before TechSpark	53	3.4717	1.11982	0.15382	*0.001	0.143	0.641
	After TechSpark	48	3.375	0.93683	0.13522	*0.000		
3D Visualization and models	Before TechSpark	54	3.2407	1.08045	0.14703	*0.000	0.076	0.437
	After TechSpark	48	3.0833	0.94155	0.1359	*0.000		
AI/ML	Before TechSpark	54	2.5556	1.14376	0.15565	*0.000	0.065	0.311
	After TechSpark	48	2.7708	0.97281	0.14041	*0.000		
3D printing	Before TechSpark	54	3.5	1.25518	0.17081	*0.000	**0.041	
	After TechSpark	48	3.2708	1.00508	0.14507	*0.000		0.309
LIDAR/Laser Scanner	Before TechSpark	53	2.7547	1.15867	0.15916	*0.000	0.331	0.983
	After TechSpark	48	2.75	1	0.14434	*0.000		
AR/VR	Before TechSpark	52	2.8077	1.40082	0.19426	*0.000	**0.004	
	After TechSpark	48	3.0417	1.09074	0.15743	*0.000		0.352
Programming	Before TechSpark	54	2.537	1.25462	0.17073	*0.000	0.091	0.705
	After TechSpark	48	2.625	1.06441	0.15364	*0.001		
Robotics	Before TechSpark	54	2.8704	1.21386	0.16518	*0.001	0.522	0.42
	After TechSpark	48	3.0625	1.1743	0.1695	*0.002		
Cloud Data and Computing	Before TechSpark	54	2.4074	1.25169	0.17033	*0.000	0.895	0.99
	After TechSpark	47	2.4043	1.20974	0.17646	*0.000		
Digitalization	Before TechSpark	54	2.5	1.17762	0.16025	*0.000	0.599	0.329
	After TechSpark	48	2.7292	1.18033	0.17037	*0.000		

Significance in the Shapiro-Wilk Test denotes distribution is not normal. **Significance in Lavene's Test indicates variances are significantly different. Thus, Equal Variances not Assumed in T-Test* Significance in Independent Sample T-Test (T-Test) indicates results are significant. All significance is measured at p<0.05.*

7 Findings

The findings in this study are divided based on the expected outcome for each research question.

7.1 Expected Outcome from RQ1: Students might present a higher level of comfortability and interest in applying digital skills to solve applied problems.

This question was sought to be addressed through multiple survey questions. To begin with, based on surveys 0 (pre-assessment) and 5 (post-assessment) we found an increased level of interest and familiarity with emerging technologies. Sections 0 and 6.3.3 delved into these aspects, indicating inconsistent results regarding the students' degree of interest in the technologies but a consistent increase in the degree of familiarity with technologies. Nevertheless, with only the increase in familiarity with the Laser/LIDAR scanner as the only significant increase, more evidence is needed to validate the increase in familiarity with other technologies.

Table 11. Statistics for Students' Familiarity with Technologies

Please rank the level of FAMILIARITY you have with the following technologies	Program Comparison	N (Total)	Mean	Std. Dev.	Std. Error Mean	Shapiro-Wilk Test	Lavene's Test	Independent T-Test
Drones	Before TechSpark	54	3.7037	1.10964	0.151	*0.000	0.102	0.585
	After TechSpark	47	3.5957	0.82514	0.12036	*0.000		
3D Visualization and models	Before TechSpark	54	3.1852	1.24498	0.16942	*0.000	0.052	0.521
	After TechSpark	46	3.3261	0.87062	0.12837	*0.000		
AI/ML	Before TechSpark	53	2.5849	1.27753	0.17548	*0.000	**0.018	
	After TechSpark	46	3.0217	0.99976	0.14741	*0.001		0.06
3D printing	Before TechSpark	54	3.2593	1.23143	0.16758	*0.000	**0.034	
	After TechSpark	47	3.1915	0.96995	0.14148	*0.001		0.758
LIDAR/Laser Scanner	Before TechSpark	53	2.1509	0.92811	0.12749	*0.000	0.842	***0.004
	After TechSpark	47	2.7021	0.95359	0.1391	*0.000		
AR/VR	Before TechSpark	54	2.7778	1.28367	0.17468	*0.000	0.055	0.134
	After TechSpark	46	3.1304	1.00241	0.1478	*0.003		
Programming	Before TechSpark	53	2.717	1.24618	0.17118	*0.000	0.055	0.332
	After TechSpark	47	2.9362	0.96469	0.14071	*0.001		
Robotics	Before TechSpark	54	3.037	1.24329	0.16919	*0.001	0.368	0.911
	After TechSpark	47	3.0638	1.13068	0.16493	*0.005		
Cloud Data and Computing	Before TechSpark	53	2.3396	1.20804	0.16594	*0.000	0.399	0.184
	After TechSpark	46	2.6522	1.09985	0.16216	*0.001		
Digitalization	Before TechSpark	54	2.3333	1.22859	0.16719	*0.000	**0.046	
	After TechSpark	46	2.7609	0.94715	0.13965	*0.000		0.053

Significance in the Shapiro-Wilk Test denotes distribution is not normal. **Significance in Lavene's Test indicates variances are significantly different. Thus, Equal Variances not Assumed in T-Test* Significance in Independent Sample T-Test (T-Test) indicates results are significant. All significance is measured at p<0.05.*

Surveys 1 through 4, relating to the technology selection assessment, sought to measure the students' comprehension to identify which technologies to use for a problem given, see section 6.2.1. Based on the statistical data obtained in Table 3 and Figure 3, it can be observed that the assessment scores were highest for workshop 2 (digitalization and visualization) and second highest for workshop 3 (data and programming). Both workshop 1 (reality capture) and workshop 4 (AI and robotics) seemed to have similar scores. Overall, all scores averaged above 0, denoting an overall higher frequency of correct responses in contrast with a lower frequency of incorrect responses. We found significant differences across the workshops based on our One-Way ANOVA, but we would like to pose the question of whether we can render an overall understanding of digital technologies while considering all assessment scores. This seems to imply an exploratory factor analysis, which will be considered as part of the follow-up research study.

Lastly, this question was further explored by considering students' level of comfort, or confidence, for problem-solving, as presented in section 0. The results presented in Table 5 and Figure 4 indicate that students were the most comfortable solving the given problem for the problem related to workshop 1 (reality capture). For the other workshops, they seemed more neutral, meaning less confident. A one-way ANOVA was constructed to explore if there were any differences between workshops, but no significant differences were found.

Based on our findings, the evidence is considered inconclusive in confirming RQ1.

7.2 Expected Outcome from RQ2: Students might consider digital skills technologies to be ranked higher for a potential change to future jobs.

Two survey questions sought to address RQ2. First, this question was explored by considering the level of comfort, or confidence; students have for problem solving as presented in section 0. It is thought that if students feel confident in solving problems with technologies, they might consider taking job roles that utilize these technologies.

Another survey question that explored RQ2 was the concerns toward problem solving, as shown in section 6.2.3. This question was a follow-up to the confidence in problem-solving questions, and students were asked to select the most significant concern in solving the problem among three options. However, the responses intrinsically compared a novel technology and a traditional method related to the workshop topic (see Table 7). Answer 1 was posing that novel technology has uncertainties that outweigh its benefits. Answer 2 was posing that technical knowledge was, above all, more important than whatever novel technology or method was used.

Furthermore, answer 3 posed that novel technologies complicate things, and traditional methods were already good enough. presents a graphical representation of the answers selected by the students. As noted, any of the responses are positive from the technological perspective, but if a concern arises, concerns are being identified. For workshop 1 (reality capture), all three options have similar frequencies. For workshop 2 (digitalization and visualization), concerns about technology uncertainty and technical knowledge seem more frequent than the concern that technology is no better than traditional methods. For workshop 3 (data and programming), technical knowledge is predominant, followed by uncertainty about technology being no better than traditional methods. Lastly, workshop 4 (AI and Programming), is very similar to the results found in workshop 3.

Based on our findings, the evidence is considered inconclusive in confirming RQ2.

7.3 Expected Outcome from RQ3: Students might increase their interest in the construction industry based on the construction-related industries ranking higher in student preferences.

The pre and post-program assessments (surveys 0 and 5), delved into elucidating RQ3. First, the students were asked about their level of interest across a selected number of industries including the construction industry, then a follow-up question was made about whether they would consider the construction industry was considered as a future career prospect. See section 6.3.1. Although the degree of interest, based on mean, increased after TechSpark, its rank compared to the mean interest scores of other industries decreased. After TechSpark, the Information industry increased in interest, which placed it at a higher rank than Construction. This tells about the nature of TechSpark's technology focus, which students might relate to jobs in the information industry. However, these assertions were not able to be confirmed given that no significance was found.

When students were asked if they were considering Construction as a prospective career, approximately 50% said no. This assessment slightly increased after TechSpark. Following up on why students did not consider the construction industry more, students indicated that the Construction industry is rudimentary and too hands-on (presented in Figure 7). The next greatest reason was because construction industry jobs were unstable. Interestingly, the reason for the lack of technology being a deciding factor was decreased substantially after TechSpark, indicating some improvements in this regard. The construction industry not paying well was another factor that improved.

Based on our findings, the evidence is considered inconclusive in confirming RQ3.

8 Discussion

This study aimed to assess the effectiveness of educational programs seeking to increase awareness and interest in digital skills relevant to future technology-driven job opportunities. Specifically, this study evaluated the TechSpark Immokalee program, a collaborative effort involving Microsoft, The Immokalee Foundation, and Florida Gulf Coast University. The program focused on enhancing middle school students' digital skills overall, particularly in construction industry-related technologies.

Three research questions were formulated to evaluate the program's effectiveness. Several key insights emerged from the study. Firstly, working with the targeted student demographic posed challenges related to assessment, instrument development, and program execution. Additionally, the workshops within the educational program faced challenges beyond this article's scope.

None of the three research questions yielded conclusive findings based on the available data. Therefore, ongoing efforts are needed to explore alternative measures and adjustments for assessing the program's effectiveness. Evidence might come from reconsidering the data instruments used or the TechSpark workshop itself.

Higher workshop scores for digitalization and visualization compared to other workshops.

- Neutral sentiments regarding problem-solving comfort.
- Varied levels of concern regarding problem-solving with technology.
- Approximately half of the students do not consider the construction industry as a career option.
- Reduced concerns about technology as a deterrent to considering the construction industry as a career.
- Growing interest in the Information industry as a potential career path.

The Construction industry faces persistent challenges in retaining and recruiting talent. Initiatives such as TechSpark have the potential to illuminate early career development dynamics. Early exposure to educational programs like TechSpark during K-12 education may lead to positive outcomes in future talent acquisition and bring more digitally skilled professionals to these industries identified as requiring a modernized workforce. Therefore, this study supports research endeavors aimed at shrinking the workforce gap and helping to mitigate challenges in the Construction industry by examining the effectiveness of educational programs and identifying reasons for lack of interest. However, while this study provides valuable insights, it could not validate the program's effectiveness.

As a result, future research endeavors will focus on methodologies for developing educational workshops, an aspect not addressed in this study, and exploring methods for measuring their effectiveness. Moreover, we will employ an enhanced participatory design method to get better student feedback on their understanding and design of our survey questions. Consequently, this research contributes to the body of knowledge on educational programs to foster awareness and interest in future job prospects fueled by technology.

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