

Challenges of Incorporating a Mobile Device Forensics Detectives Summer Camp with Critical Thinking Amongst K-12 Students

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Abstract— The researchers participated in a Mobile Device Forensics Detectives Summer Camp with intermediate students from the surrounding areas of Jackson, MS, who debated on critical thinking, deductive reasoning, problem-solving skills, defined the meaning of Mobile Device Forensics and what it entails in order for the students to achieve proficient or advanced levels on the students' state exams. The researchers had to overcome some barriers for the middle school students that subsequently had not occurred previously due to Covid-19, measure how effective this process progressed moving forward by the external evaluator, and discuss the challenges faced by the Leadership Team of the Mobile Device Forensics Group and how the researchers alleviated some of those issues.

Keywords— *mobile device forensics, electronic Crime Scene Investigation (eCSI), summer camp, critical thinking, problem-solving skills*

I. INTRODUCTION

There is a need to assist middle schools by starting a Mobile Device Forensics Detectives Camp (MDFDC) in an effort to increase performance on state exams and to increase underrepresented students' appeal to the STEM sciences. The Computer Science Department proposed the development of an electronic Crime Scene Investigation (eCSI) Program, patterning the popular television series CSI, which will educate students on their problem-solving, reasoning, and deduction skills while ascertaining mobile device forensics.

All education ceased in 2020 due to a novel pandemic, SARS CoV2. The epidemic began the year before which spread throughout Wuhan, China and transformed into a pandemic in March of last year affecting several countries and infecting people of many races [3].

At the start, K-12 education was rarely affected by SARS CoV2, yet students remained at their places of residence. The virus was only infecting those who had comorbidities, in nursing home settings, underlying conditions, and people older than 65. Eighteen months after the pandemic, most educational settings had begun with social distancing, air filtration improvements, mask suggestions, and hand hygiene in mostly every building, including public school environments [4]. There are several variants across the nation, but the fourth variant, Delta, has infected children or students Pre K-12, even in Mississippi. Of the number of infected patients in the US since July, there is a 240% increase in children under the age of 17 [6].

This study is designed of twenty-eight middle school students over the past three summers, omitting one summer due to COVID-19. The paper outlines the research as follows:

Methodology, Results, Acquired Knowledge, Conclusions, and Future Work.

II. METHODOLOGY

Coming from an area with needed improvement for the city and the school district, with the largest student population in the state of Mississippi with approximately 30,600 students with 99% of the population belonging to an underrepresented group as defined by National Science Foundation (NSF) [14]. There is a need for this university to reach out to all public schools in a defined area in order to enhance the middle school students' aspirations in attending a university to pursue a major in the STEM sciences resulting in an exciting and fruitful career.

Female students that are middle school aged have an opportunity that many past underrepresented females did not have when one was maturing. Being twice underrepresented as a woman and an African-American, it is vital that women play a role in computer science. Women today represent 18% of computer science graduates, where as in 1984, they represented 37%. Women make up half the workforce in the U.S., but they only hold 25% of jobs in the computing field [1]. There is also a gender inequality in the number of males versus females graduating with B.S., M.S., and PhDs in Science and Engineering (S&E), especially in computing. In 2011, women earned 57% of all undergraduate degrees, but only 18% of those degrees were in computer and information sciences. Since 2010, women have earned master's degrees at a steady pace of about 27% and for the past decade, the number of doctoral degrees earned by women in computing has stabilized at about 22%. Though these statistics may not seem as daunting at first glance, one must take into account the number of women planning to major in computing and information sciences as freshman. Since 1999, only 0.3% of incoming female freshmen intend to major in this discipline compared to 2% of incoming male freshmen [1].

Furthermore, Governor Tate Reeves signed into law "The Mississippi Computer Science and Cyber Education Equality Act" which every K-12 student has to be taught some form of Computer Science beginning in 2024 [15]. As a result, there needs to be a program developed to focus on underrepresented K-12 students who hold positions in computer science and instruction, especially women [19].

A. Summer Camp 2019: Teaching Problem Solving and Critical Thinking Skills in an Effort to Enhance Performance on State Exams.

There were five middle school students from a certain middle school who were able to attend summer camp. The researchers had a vehicle rental agreement so that the students could be acquired from their residences. The details below have taken place during the summer camp of 2019, or before the pandemic.

When the middle school students were asked if they have ever completed picture puzzles or played the game of Twenty Questions before the answer was no. Rebus puzzles are little pictures that are puzzles often made with letters and words, which cryptically represent a word, phrase, or saying. When an inflexible problem seems to be unsolvable, K-twelve students have been hampered on this issue due to lack of direction or reasoning. This is where critical thinking and problem-solving skills come into play. There are eight main ways in which a rebus puzzles might be deciphered.

- Position – This is positioning the words, symbols, etc., relative to the rectangle containing the puzzle and the other words and symbols.
- Highlighting – Attention is drawn to some part of the picture by an arrow or underlining indicating where you should be looking.
- Direction – When a word is spelled in a direction other than left-to-right, it is relevant to the solution.
- Size – Larger or small words or symbols are used to convey concepts of size.
- Number – Numbers are exploited due to the closeness of sound.
- Color – If a word or symbol is not printed in black, the color is relevant to the solution.
- Style – The style of font is sometimes relevant. Tall, thin, slanted, fat, etc., might be concepts that may conclude to an answer.
- Sound – Phonologically cryptic; the sound may not always be the answer but it will be close enough to recognize [13].

Twenty Questions encourages deductive reasoning and creativity which started in the 1940s as a television show. In this game, one player, in this case the instructor, is chosen to be the answerer. The instructor chooses an object but does not reveal this to the class. All of the other players are questioners. They take turns asking a question which can be answered by a "Yes," "No," or "Maybe". The instructor answers each question. If the questioner guesses the correct answer, that questioner wins and the student becomes the answerer. If twenty questions are asked without a correct guess, then the instructor has stumped the class [18].

One student had answered the instructor's question and took their turn as the answerer. Everybody in the classroom, even the instructor was baffled and started asking questions too. The answer was "chalk". When the middle school students researched what chalk is made of, it was astounding.

The deductive reasoning and problem-solving skills played a major role in solving Twenty Questions. The questions were "Is it wooden?", "Is it plastic?", "Is it liquid?", etc. Based on the answers to those responses tells the questioner whether if it is or is not wooden, plastic, or liquid or infers that the answer is chalk.

The following critical thinking activities were designed to engage the students in application, analytical, synthesis, and evaluation skills. The cross-curricular activities present math, science, social studies and language arts content. The activities provided opportunities for students to connect their knowledge and opinions to the topic.

- Activity One: "Clocks and Calendars" allowed the students to solve time related riddles by solving and inferring [16].
- Activity Two: "Which Planet?" allowed the students to round diameters to the nearest thousands, answer space related questions, name and create their own solar system [16].
- Activity Three: The students were able to compare an older model mobile phone to newer models. A Motorola Bag Phone which was manufactured in the 1990s was analyzed and contrasted to Apple iPhone 10 and Samsung Galaxy 9e respectively. The students were amazed to see and learn about the older phone. The bag phones were designed to operate on AMPS and TDMA networks which have been extinct since 2008 [21].
- Activity Four: People often use cell phones to text message their friends, family, and/or acquaintances. The students were asked to match common and uncommon abbreviations and acronyms. Upon completion of this activity only one student solved all twenty-eight items, however, the remaining students had to infer and analyze to determine the correct answers.
- Activity Five: "Careers for Stem" was presented to encourage students to become interested in choosing a STEM Career. Upon completion of "Make a Budget" activity, the students determined their finances for a month. The budget was finalized based on careers chosen and monthly salaries in Mississippi. The students discovered that their lifestyles were not sustainable, so based on this information, some concluded that in the future they may need to choose another profession, and/or seek part-time employment to supplement their income.

B. Summer Camp 2019: Teaching the Middle School Students to Define Mobile Device Forensics and Show How Forensics is Manually and Automatically Examined.

The following mobile device forensics activities for middle school students were designed in order to introduce cellphones/smartphones to the students and show how to protect a mobile device:

- Activity One: The groups were given one smartphone which allowed the students to examine the smartphone in an effort to show the other students what contacts, call logs, texts, emails,

histories, usernames, passwords, operating system, name of the device, browser, pictures, etc., are. Each group had to match questions of smartphone functions to their definitions.

- Activity Two: The middle school students were given mobile device parameter identification activities. The students were told to identify the type of phone, operating system, encryption level, and pin code/passcode/pattern based on the smartphones given to them. The groups traded papers in order to see what the other middle school students had written and to check if their answers were correct with that smartphone.

- Activity Three: It was illuminated to the middle school students the methods users need in order to perform mobile forensics on a phone manually and introduced automated mobile device forensics and what it entails. It was articulated to the middle school students that automated mobile device tools are usually pricey. The group read "Tools Pricing" and the various categories in which tools are categorized. Using the Internet, the group had to identify the prices of a tool and present one fact about that tool based on what the students had learned.

- Activity Four: It was shown to the group how the mobile device forensics team is designated to handle extraction of digital evidence and perform extractions on a variety of devices. These extractions include logical, file system and physical extractions from mobile devices as well SIM cards, and external storage like an SD card. Cellebrite® Touch2, a mobile device forensics tool, was produced and shown what happens when a smartphone is connected to Cellebrite® Touch2. The group gained a basic understanding of how to open the extractions and conduct basic searches and how to create reports [7-9, 12, 22].

- Activity Five: The instructor told the students how to protect their mobile devices and the group researched additional ways that they could protect mobile devices in the future.

- Activity Six: The middle school students visited the lab, searched for their topic, and printed each topic. The team was provided the materials needed to construct the project boards such as glue, art, tools, pencils, magazines, and posters. The middle school students created posters based on what they had learned during that week of summer camp.

C. U.S. Marshal Service Visited JSU eCSI MDFDC

A Deputy United States Marshal came and spoke to the middle school students about Mobile Device Forensics and what role smartphones portray in catching the individual. He was born in Germany into a military family, and his family relocated several times thereafter. He ultimately went to this university where he majored in Criminal Justice. There was a program with the US Marshals Service where he went into the service expeditiously after he graduated. "There are 94 federal judicial districts, the District of Columbia, the Commonwealths of Puerto Rico and the Northern Mariana

Islands and the two territories of the United States. US Marshals Service offices are based on the organizational structure of the Federal District Court system. Mississippi is divided into two judicial districts that are referred to as the Northern and Southern Districts of Mississippi. For the Northern District, court is held in Oxford, Aberdeen, Ackerman, Corinth, Clarksdale and Greenville and in the Southern District, court is held in Jackson, Meridian, Natchez, Vicksburg, Biloxi, Gulfport and Hattiesburg." Mark B. Shepherd was appointed to serve as the United States Marshal by President Donald J. Trump and currently serves as the U. S. Marshal for the Southern District of Mississippi" [2].

D. Summer Camp 2021: Teaching Problem Solving and Critical Thinking Skills in an Effort to Enhance Performance on State Exams.

There were twenty-three middle school students across all municipalities who were able to attend summer camp with the aid of their parents. The distancing worked out better for the students rather than a bus taking them to and from summer camp. Also, there were policies and procedures of the Leadership Team, students, and parents had to adhere to due to COVID-19. It was suggested that the Leadership Team receive the COVID-19 vaccinations before the first day of summer camp. Even if the staff participants did not get the vaccine, they had to wear a mask at all times. When the students entered the building, two persons from the Leadership Team did temperature checks on the students every day. As soon as the students entered the classroom, they had an option: Either wear the mask that was provided to the students at home, or wear the face-shields given to the students by the Leadership Team. Every hour, the students had to go to the restroom to cleanse their hands thoroughly. As of yet, no student from summer camp in this group have been infected with COVID-19.

The details below have taken place the summer camp of 2021, or after the pandemic. All of the activities are similar except the following activities.

- Activity one: "Critical Thinking about Technology" From Here to There: Students were asked questions such as "How would flying automobiles affect manufacturing thirty years from now? Industry? What happens to gas pumps in your local neighborhoods? Are gas pumps going to be off-grid?" Name some advantages and disadvantages of flying automobiles.

- Activity two: "STEM Star" was presented to the students in order to show the underrepresented scientists, what their job entails, and what they have done for society thus far. The students had to investigate the STEM Star and use that research to create a STEM Star Poster.

- Activity three "Mentoring for middle school students" Mentoring for middle school students is a novel approach. The researcher told her story of never having a mentor until graduate school, but nevertheless, the need to acquire a mentor academically is needed, especially in urban cities like Jackson, MS. The researcher asked the twenty-three students which one of them had a mentor. Less than 10% raised their hands. The researcher

presented examples of an academic mentor including the counselor, principal, co-principal, etc., from their school as someone that the middle school students can contact to achieve their academic needs [23].

- Activity four: “Building a Robot” In groups of four, (one group had three), middle school students built robots and told how each functioned. The students were grouped in teams so they could understand the meaning of teamwork and listening to others instead of individually. They also built several robots including the “Piglet,” which the Leadership Team and the students did together, and the “F 15 Fighter,” which the students did on their own [20].

E. Summer Camp 2021: Teaching the Middle School Students to Define Mobile Device Forensics and Show How Forensics is Manually and Automatically Examined.

The following mobile device forensics activities for middle school students were developed along with the previous year in order to introduce cellphones/smartphones to the students and show how to protect a mobile device:

- Activity One: There was a twenty-minute lecture of what a mobile device entails followed by “How Secure Is My Password”. This tells the students a password that a computer could guess in an instant. For example, if the user typed “abcd” into the textbox, the password would be cracked instantly because it is a common password and it is also one of the top 820 passwords most used. Now say if the user typed “tIger1877” it would take a computer about three days to crack. The students had to come up with a password that would take a computer at least a year to crack [17].
- Activity Two: The students had to complete an activity named “Techno Matching”, where the students place a capital letter on the line to match that word with that picture [11]

III. RESULTS

A. Recruitment and Selection of Participants

For the first year, the researchers went to the regional office to discuss placing one or more of their middle school students in this program, leading the Leadership Team to two middle schools where the investigators spoke to both principals about placing their students in the summer activities. As a result, ten middle school students and their parents were expected to participate in summer camp, but due to necessary modifications, only 16.6% middle school students attended. 40% were transported by guardians, and 60% were transported by the university. Of the total number of middle school students, 80% of them were females. There were no COVID-19 restrictions in place, so the capacity of students should have been at the maximum level. There were also three undergraduate computer science students under the researcher’s tutelage who assisted the students and researched topics in STEM.

This year, the Leadership Team employed a different recruitment strategy in an effort to have more camp participants. There were intentional efforts to recruit students

of the university’s employees first. According to fall 2020 data, this university has well over one thousand faculty and staff. Other recruitment efforts were through networking at various functions. Twenty-five summer campers were recruited by the principal investigator and staff personnel to participate in the Mobile Device Forensics Detectives Camp. The capacity was held at fifty percent of the total slots available to comply with COVID-19 safety protocols. Twenty-three students participated from six school districts, one charter school, and three private schools, which made for a more robust project. The students were from diverse backgrounds and brought different experiences to the summer camp with one undergraduate computer science student under the researchers’ tutelage who assisted the students and researched topics in STEM.

B. Data Analysis

The middle school students were administered a survey to assess their career interest that was developed by [5]. The students were also asked to complete a survey adapted from [10] to assess their perceptions about scientific disciplines. After analyzing the raw data from both the pre- and post-questionnaires, there was minimal impact in the science, technology, engineering, and math at the conclusion of the camp. Similarly, there were minimal gains in a STEM career and education following the camp activities.

In the summer of 2019, out of the five students that participated, all but one said that they wanted to attend this university and 50% of the 100% wanted to major in Computer Science. For year three, out of the twenty-three students that participated in summer camp, it was stated on the pretest that 34.7% of them said that they were not interested in STEM, 34.7% of them said that they were unsure, and 30.4% of them want to major in Computer Science or another STEM discipline. But, in the post-test, the researcher received the same answer.

Although the questionnaires indicated minimal impact, camp personnel provided qualitative data that suggested otherwise. According to camp personnel, most of the campers demonstrated interest during the one-week camp. Many of them asked questions of each presenter and was able to state three to five things that they learned during the camp on the final day. The questionnaire responses could have been due to the lack of understanding of the questions and the time that the post-questionnaire was administered to the campers for completion. The post-questionnaire was administered at the very end of the last day after all of the activities concluded.

C. Camp Personnel

The personnel for the summer camp shared their experiences regarding the summer camp and stated that the Mobile Device Forensics Detectives Summer Camp was a success overall. It was a great opportunity for those campers who had a genuine interest in STEM to dive deeper into those disciplines. The camp was well organized and about 90% of the campers seemed generally interested in mobile forensics and STEM. Senior personnel indicated that these campers showed enthusiasm in mobile forensics by the questions they asked of the presenters.

IV. ACQUIRED KNOWLEDGE

For next summer, the Leadership Team will do further research for the middle school students pre and post-test and produce a survey that is easier and not so lengthy and revisions should be made to the post-questionnaire to provide

an opportunity for the camp participants to actually share their experiences about the Mobile Device Forensics Detectives Camp. The researchers should consider revising the agenda for the summer camp to include more time for hands-on activities and shortening breaks as to not lose the middle school students' interest. The camp personnel may want to consider revising the application to screen the students for their interest in the STEM area. This strategy may ensure that the camp participants are really interested in STEM. Additionally, the Leadership Team wants to purchase a substantially tall robot to let students know how it functions, but only if funds are available.

V. CONCLUSION

Middle school students took part in an eCSI-MDFDC, a summer camp, centered on critical thinking and deductive skills while learning about mobile device forensics. 6th - 8th graders involved themselves in the critical thinking, deductive reasoning, and problem-solving skills for the summers of 2019 and 2021, respectively. Students were told about the meaning of mobile device forensics and the uses of it (collecting, analyzing, preserving and reporting). A US Marshal visited our summer camp and told the students how you seize a criminal using a mobile device for both years.

The program has the potential to bridge the gap for the K-12 community and its students struggling in the STEM sciences and provide a positive impact on students at the undergraduate and graduate levels by developing their complex problem-solving skills and mobile device forensics. eCSI will serve as a rigorous recruitment tool to STEM, especially computer science and computer engineering because the number one fixation that deters students from majoring in computing is programming. eCSI gives these students a way to be involved in the computing sciences in a fashion that does not center around programming, especially female students. Providing underrepresented successful role models who are also subsumed as underrepresented minorities will establish a foundation for their further interest in STEM education and validate the importance of this research.

VI. FUTURE WORK

Due to unforeseen circumstances, mentoring is the main priority next year. There are four college students, three undergraduate and one graduate, to be joining the group this year. The Leadership Team will have to change the format of scheduling to allow the mentors to take part in the summer camp process since the graduate and undergraduate students remained at their homes the first part of the pandemic.

The researchers plan to have a Cyberbullying Criminal Investigator Activity next summer where students and the faculty will discuss fingerprints, footprints, signatures, DNA, and mobile device evidence. Based on what was discussed, the students will participate in groups of four and examine their own fingerprint and take a mold of their footprint. The students then will take part in four resource centers to match a footprint with other footprints, fingerprints with other fingerprints, etc. based on that criminal investigator's story.

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