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Self-Efficacy Development in Elementary-aged Learners through Dance as an Algorithmic Thinking Tool

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Self-Efficacy Development in Elementary-aged Learners through Dance as an Algorithmic Thinking Tool

by

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ABSTRACT

The purpose of this research is to demonstrate the effectiveness of a transdisciplinary approach in teaching computational thinking through dance to elementary-aged learners, with primary attention to females. With limited literature available on how pre-adolescents begin to construct conceptions of computer science and other engineering domains, including potential career pathways, the incentive of this project was to leverage a day camp for about 20 rising 3rd - 5th-grade learners to assess their identity development in computer science. Modules that teach computational thinking through dance paired with Unruly splats (block-based programmable electronic gadgets) were implemented. By conducting pre-and post-surveys and a 'draw a computer scientist' exercise at the beginning and at the end of the dance modules held on day 2 of the camp, the researcher was able to evaluate and determine the effect of the transdisciplinary approach on the elementary learners' perceptions and self-efficacy.

Keywords:self-efficacy, computer science, women, dance, algorithm, coding, computational thinking

DEDICATION

I would like to dedicate this work to my dad Rajesh Shrestha, my mom NarayanDevi Shrestha, my little sister Nitiva Shrestha, and my best friend Corbin J. Stovall for all their support and faith in me throughout my research. I would also like to dedicate this in memory of my brother, Siddhartha Raj Shrestha, and my cousin, Sarthak Malakar.

ACKNOWLEDGMENTS

Firstly, I am very grateful to have a supportive honors thesis advisor, Dr. Sarah B. Lee, who guided me throughout the process of my research and was very patient and understanding with me. I admire her passion for increasing women in computing which has inspired me to continue on this path. Secondly, I would also like to thank Ms. Litany Lineberry for sharing with me her research experience. This research was conducted during 2021 GenCyber Camp, so I express my gratitude towards them as well. Thirdly, I would like to acknowledge Honors College and staff for constantly supporting me to do better academically. Lastly, I would also like to give a vote of thanks to my family and friends for always believing in me.

TABLE OF CONTENTS

Keywords: ... iv

LIST OF TABLES ... viii

LIST OF ILLUSTRATIONS ... 1

CHAPTER I: DESCRIPTION ... 2

PREAMBLE ... 2

LITERATURE REVIEW ... 3

PROJECT GOALS AND ANTICIPATED OUTCOMES ... 6

CHAPTER II: METHODOLOGY ... 7

PARTICIPANTS ... 7

PROCEDURE ... 7

CHAPTER III: RESULTS ... 11

MALE PARTICIPANT’S RESPONSE ... 13

CHAPTER IV: DISCUSSION ... 16

LIMITATIONS ... 17

FUTURE WORKS ... 17

CHAPTER V: CONCLUSION ... 19

APPENDIX A: IRB Approval Letter ... 20

REFERENCES ... 21

LIST OF TABLES

Table 1: The number of students 11

Table 2: The number of positive change... 12

LIST OF ILLUSTRATIONS

Fig 2: Draw-A-Computer Scientist activity 10

Fig 3: The number of students changing 12

Fig 4: The number of positive changes 13

Fig 5: The percentage of subjects changing 14

Fig 6: Participant #4's Before-and-After drawing 14

Fig 7: Participant #8's Before-and-After drawing 15

Fig 8: Participant #14's Before-and-After drawing 15

CHAPTER I: DESCRIPTION

This research addresses the question, "Does the introduction of dance as a pathway to computational thinking skills enhance self-efficacy in computing among elementary school-age learners?" Self-efficacy in computing means a sense of belonging or confidence in computing. Computational thinking (Wing, 2006)by definition refers to the thought processes required in understanding problems and formulating solutions. The hypothesis is that there are a lot of womenwhomight choose to major in computer science and applycomputational thinking skills to a career path, but they are often demotivated or discouraged to get into the computing field because there is a misconception or stereotype that computing is difficult, not fun, or not at all for women. However, by integrating dance as an algorithmic process to link computer programming, the goal of this project is to engage youth with computational thinking, algorithm design, and the possibility of pursuing computing as an educational and career path. Incorporating dance as an algorithmic thinking tool involvesrelating a familiar activity to computational thinking. Designingdance choreography also requires thought processes with algorithms, and by definition, algorithms are basically steps in a process, and the combinations of these algorithms develop computational thinking used in computer programming.

PREAMBLE

This research idea was derived from thecuriosity to increase the number of women in computing. A question that was always on this author's mind,"Why are there fewer women in my computing classes?",in high school. Attending an all-girls junior high school, therewas not an issue; however, transition to co-ed senior high school, the reality struck the author. In the computing class, there was only one other female. In comparison to the state of computing field in the real world, the resemblance is notable. According to studies and statistics, women in computing were in high number in the past, but now, there is a very low number of women in computing (UCB-UMT, 2021). The objective of my research project is to encourage careers in computing and provide an alternative on how to engage femaleswith computing pathways. It is very important to cultivate the idea of computational thinking as a skill set that can be applied in any careercontentareaand not just in computer-related jobs.

Dance is often regarded as a field of Arts that is separated from the STEM field. However, there is an important presence of Arts in the STEM field. This project is supported by the idea of using a creative way of learning computational thinking, particularly, an artistic activity that is familiar to the learners to enhance self-efficacy, or sense of belongingness, in computing. For this project, Unruly Spats, a programmable device has been utilized that can be physically danced on. Using dance as an algorithmic thinking tool, this research will analyze its effect on elementary school-aged learners' inclination toward the computing field.

LITERATURE REVIEW

Vitores and Gil-Juarez (2015) deliver the rich history of involvement of women in computing and assess the reasons why there are fewer women in computing now. The first thing that is cleared out is the difference between 'women and computing' and 'women in computing.' Statistics show that there are good numbers in 'women and computing' which is the women using computers whereas there is a significant drop in ‘women in computing’ which is the presence of women in computing as a profession. The reason for this is the various stereotypes or misconceptions surrounding the idea of computer science as a profession. Their paper focuses on the misconceptions such as how computer scientists are only “nerdy, introverted males obsessed with technology”, inhuman and just work with ‘machines’. It also brings light to the “poor knowledge and awareness of computer science as a discipline or career” and just perceived as an “unattractive or boring” career. The authors claim that it is due to the ignorant education imparted before adolescence and the unconscious teaching biases that discourages the girls from taking an interest in computing careers. The paper discloses that not long ago ‘computers were women’ and women had a very important role in computing due to which it is even more important to bring back women into computing and for that, it is necessary to assess the hindrance faced by girls in computing from a very young age.

A. Wagh, B. Gravel, and E. Tucker-Raymond’s research (2017) explores how the youths incorporate computational thinking into their personal life and real-world applications. The authors study how the youths learn computational thinking and how they implement it in their projects. The purpose of their study is to conclude that computational thinking practices are helpful for everyone and not just computer scientists. In their study, it is also derived that unconventional computational practices such as music and personal experience can be used to relate or familiarize students with computing and introduce computational thinking. This discovery is important because identifying and accepting the overlap between computational thinking and other aspects of life will make the learning process more productive and innovative.

D. M. S. Corkin, A. Ekmekci, and A. Fisher (2020) research the struggles of underrepresented minoritized students and how unconventional computer science educational environments help these students to gain confidence in the CS field and develop computational thinking. It was found that the self-efficacy of the individuals was affected by the stereotypes related to computer scientists regarding "gender, race, ability, preferences, and values." This is important to my thesis because this helps in pointing out that there are stereotypes in the world that hamper the qualitative development of a sense of belonging in women in computing. The study showed that the majority of the underrepresented students did not go to the CS field because of "their lack of identification with the field." In this paper, the author provides the idea of alternative curriculum approaches to introduce computing among the students who have less sense of belonging to computing. The authors have used visual art as an unconventional teaching method to result in increased interest of students in CS. This made the students understand that CS may involve functioning in multiple environments and could also connect to an environment or culture that they are familiar with.

Lineberry et.al. (2018) claim that it is important to engage girls in computer science from an early age so that they develop self-efficacy before getting discouraged by external sources, providing detailed research on elementary girls' learning experiences of computer science through summer camp. The authors study the importance of introducing computing to young children and its impact on their interest in developing self-efficacy in computer science. The paper holds very common principles to A. Wagh (2017)'s paper about the role of computational thinking practices in youth. This paper is more focused on the urgency and importance of the inclusion of girls in computing and how introducing it at an early age is more effective.

L. Lineberry and S. Lee (2020) advocate the importance of the inclusion of arts in the STEM field. Through summer camps engaging with girls from grades 3 to 5, they have studied how art influences an individual's learning perception of computing. They have incorporated the modification of STEM to STEAM where A stands for Arts. By plotting this concept, this paper becomes very important for my discipline as it grows the idea of teaching computing through a component that an individual is already exposed to and is confident in. While experimenting with the "integration of learning dance moves with algorithmic thinking and computer programming", the young girls were able to connect the two activities which made it fun for them. This increased their confidence and sense of self-belonging in programming.

PROJECT GOALS AND ANTICIPATED OUTCOMES

The main goal of this project is to develop self-efficacy in girls incomputer science. To achieve this, the researcher used dance as a pathway to building self-confidence among girls toward computing. Through this research, the investigator seeks to provide a linkage to the participants between dance and computational thinking, along with an increase in their interest in computing.

CHAPTER II: METHODOLOGY

At the registration table on the first day of attendance, the parent/guardian was asked for permission for his/her child to participate in the research. This was presented by reviewing the parental consent script and related consent form with the parent/guardian. After the parent agreed, assent from the minor child was sought by reading the child recruiting script with the child. The child was asked to sign an assent form after he/she agreed to participate in the data collection.

PARTICIPANTS

Participants were recruited from those learners who attended the 2021 GenCyber Camp. There were 20 camp learners. 17 were girls and 3 were boys. They were rising 3rd-5th graders. The only participants in the survey were those who have consent and assent completed.

PROCEDURE

A presentation on Dance Algorithms was shown to the campers. Its main theme was learning to code by dancing. The young learners seemed very surprised and intrigued by the topic and showed interest in participation. They were then divided into three or four participants per group. They were asked to introduce themselves, brainstorm a group name, and pick a song for which they would like to design a dance routine. This process was linked back to the process of creating a computer algorithm. This is how they were introduced to the concept that everything around us as humans has an underlying algorithm with the possibility of conversion to computer code. The concept of a flowchart, widely used in computer programming design, was also introduced. They implemented a flowchart in their process of creating a dance routine. They were given 15 minutes to prepare the 30 seconds to a one minute dance routine using algorithms and flowcharts. They were given 10 minutes to practice. After they had completed the process, groups were paired together and they had to teach their dance routine to the other group using the algorithm they had just written. So they were teaching each other dance algorithms and flowcharts. They were again given 10 minutes to practice the dance routine. They had to make the decision to choose one song between the two, enforcing decision making. After they did so, they had to incorporate the dance routine using the Unruly Splats.

Unruly Splats are a cross-curricular STEM learning tool that combines coding games for kids with active play and social-emotional learning (SEL). The participants were asked to dance on the Unruly Splats. The website information for Unruly Splats was provided to them, they all had individual computers to work on, and everyone was able to login into their Unruly Splats account. At first, the participants were allowedto get comfortable and familiar with the system on their own and create simple fun drag-and-drop codes. Participants used beats, dance moves, and a lot of other elements in their dance that linked with computer coding and mathematics. They were given hints about numbers are used to count beats and incorporate them into dance steps, and how that is related to mathematics. The Unruly Splats had various elements that they could use to include in their dance routine, elements such as lights, sounds, music, instrument, timer, and step counts. They were given 15 minutes to code and then had five minutes to step up and showcase their dance performance using the Unruly Splats.

Before any major interaction between the researcher and the participants, campers with parental approval and assent were asked to complete an age-appropriate survey (B. M. Capobianco, B. French & H. Diefes-Dux, 2012) and Draw-a-Computer-Scientist activity to measure self-efficacy growth among participants. Each participant was assigned a random number, and a file that relates the number to the student was stored until the 2nd, the final survey and the drawing activity were administered. At that point, the file that connected the number to a participant's name was deleted. The survey is shown in Figure 1 and the Draw-a-Computer-Scientist form is shown in Figure 2.

	No	Not Sure	Yes
1. I do my school work as well as my classmates.	1	2	3
2. I am good at solving problems in mathematics.	1	2	3
3. I am good at solving problems in science.	1	2	3
4. I use computers as well as my classmates.	1	2	3
5. I am good at working with others in small groups.	1	2	3
6. I like being a student at my school.	1	2	3
7. Being a student at my school is important to me.	1	2	3
8. I make friends easy at my school.	1	2	3
9. The teachers at my school want me to do well in my school work.	1	2	3
10. Engineers solve problems that help people.	1	2	3
11. Engineers work in teams.	1	2	3
12. Engineers design everything around us.	1	2	3
13. There is more than one type of engineer.	1	2	3
14. Engineers use mathematics.	1	2	3
15. Engineers use science.	1	2	3
16. Engineers are creative.	1	2	3
17. When I grow up I want to be an engineer.	1	2	3
18. When I grow up I want to solve problems that help people.	1	2	3
19. When I grow up I want to design different things.	1	2	3
20. When I grow up I want to work on a team with engineers.	1	2	3

Fig 1: Survey Statements to be rated by the participants

Draw-A-Computer Scientist

Close your eyes and imagine a computer scientist at work. In the space below, draw what you imagined.

Fig 2: Draw-A-Computer Scientist activity

CHAPTER III: RESULTS

Among the 20 campers, #1chose up front to not participate in the research, and #20chose to not participate after the activity, so there is data from only 18 participants. Table 1 demonstratesthatby the end of the study, 7 out of 18 subjects changed their answers on number 12, which states, “Engineers design everything around us.” 5 subjects were more sure that #11, “Engineers work in teams”. 3 subjects were more confident with statement #2 which says “I am good at solving problems in mathematics” as well as statement #16 which says “Engineers are creative” after the workshop.

Question #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
# of students positively changing response	*0*	*3*	*2*	*4*	*3*	*1*	*2*	*4*	*1*	*4*	*5*	*7*	*3*	*3*	*0*	*3*	*1*	*4*	*1*	*2*

Table 1: The number of studentschanging their responses to a higher number of agreement on the statements provided in the survey.

In accordance to Table 1, the Fig 3 shows that a lot of subjects had positive increase in their answer scale in survey number 12**.**

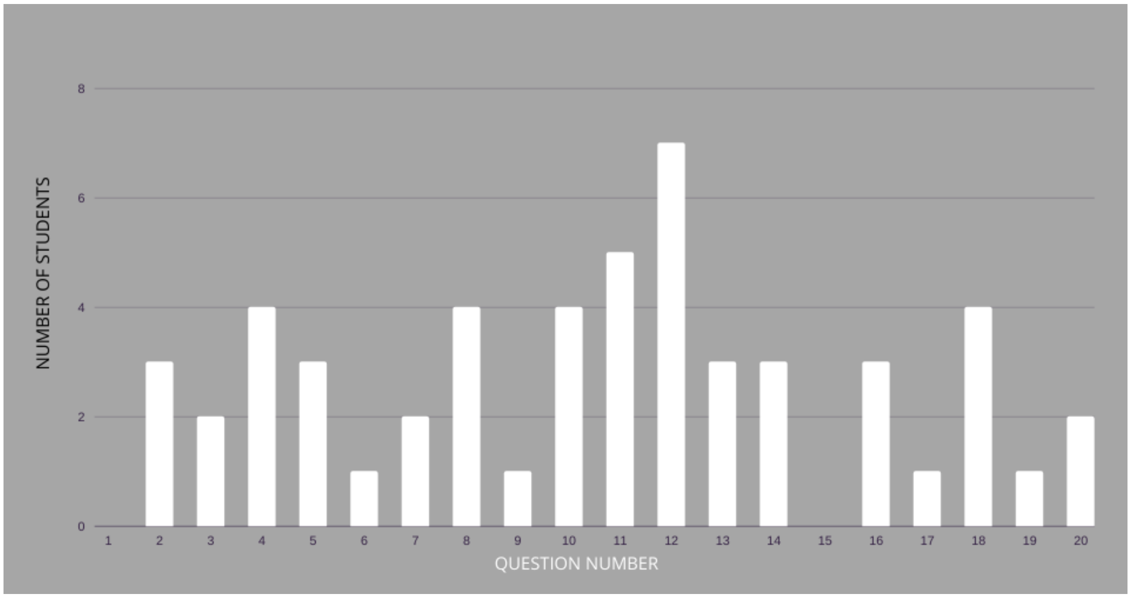

Fig 3: The number of students changingtheir responses to a higher number of agreements with the question number provided in the survey.

Subjects #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
# of statements that changed	*0*	*2*	*2*	*1*	*5*	*3*	*1*	*1*	*0*	*6*	*3*	*1*	*2*	*7*	*0*	*4*	*2*	*2*	*13*	*0*

Table 2: The number of positive changein from each student after taking the survey in the end.

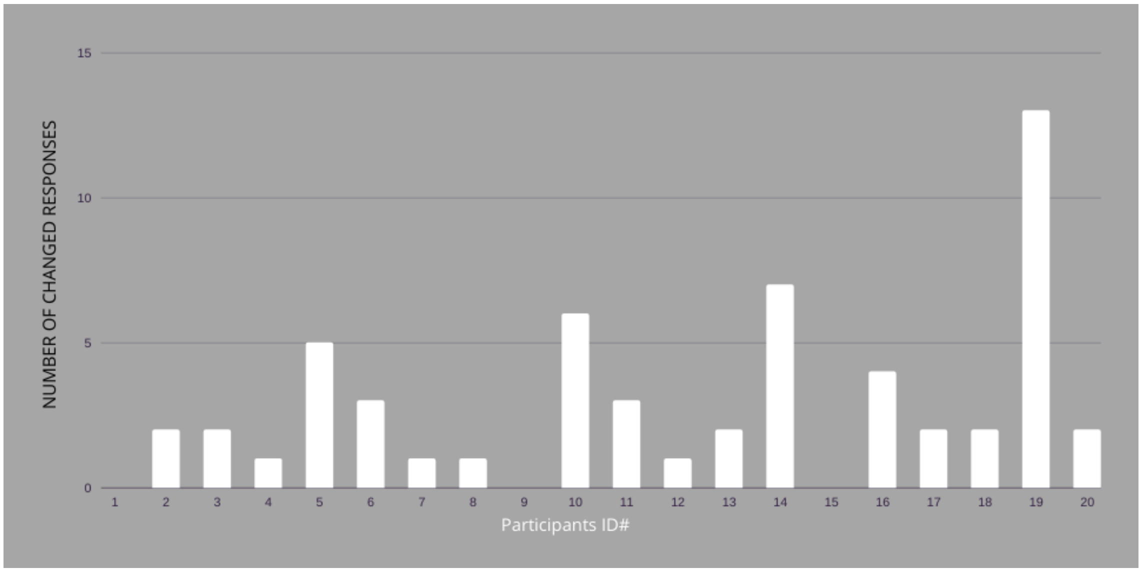

Fig 4: The number of positive changesin responses from each student after taking the survey in the end.

MALE PARTICIPANT'S RESPONSE

#3, #13, and #19 were male camp learners. Looking at the statistics, #19 has the highest positive change in their response.

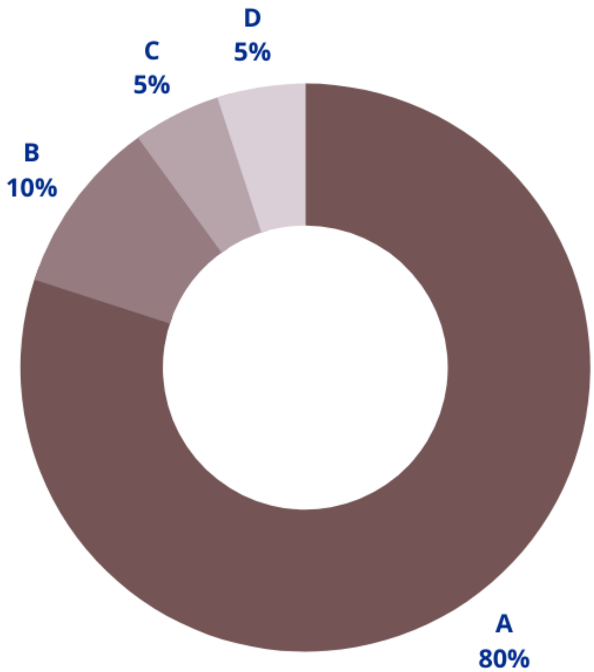

Fig 5: The percentage of subjects changing their responses to the survey in the end. A: 80% of the participants had a positive change in their responses. B: 10% had no changes. C: 5 % did not take the survey. D: 5% refused to take the final survey.

16 of the 18 active participants positively changed their responses to the statements in the survey.

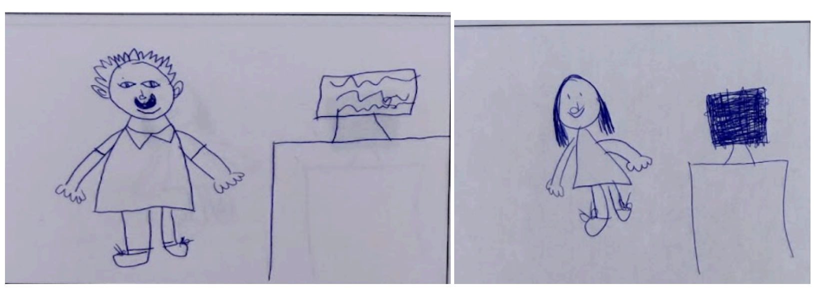

Fig 6: Participant #4's Before-and-After drawingof a Computer Scientist. The right side shows the before and the left side shows the after.

Participant #4 drew a Computer Scientist in the form of a male, whereas at the end of the workshop, this participant drew a female Computer Scientist.

Fig 7: Participant #8's Before-and-After drawingof a Computer Scientist.

Participant #8 drew a Computer Scientist in the form of a male, whereas at the end of the workshop, they drew a group of female Computer Scientists.

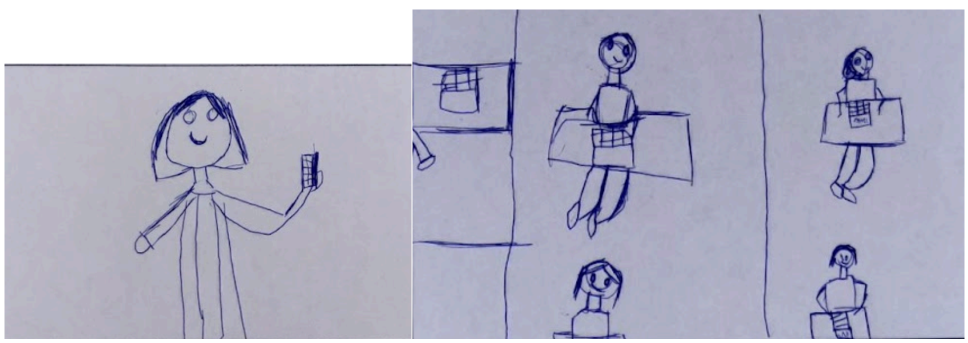

Fig 8: Participant #14's Before-and-After drawingof a Computer Scientist.

Participant #14 drew a Computer Scientist in the form of a female, whereas at the end of the workshop, they drew a group of female and male Computer Scientists.

CHAPTER IV: DISCUSSION

With a significant change in responses from the survey and drawing activity, this study was successful in determining the effects of introducing computing through an unconventional method such as designing and implementing a dance. From the figures and tables in the results, many participants were more confident in their coding after relating coding with everything around them. Many participants were postively influenced to learn computational and algorithmic thinking through dance. The young learners became more interested in coding and understanding the link between two opposing concepts, computing and dance, coming together to exist in harmony. It is seen that the young female learners developed confidence in responding to their survey statements regarding their understanding of computing concepts as well as their ability to do work in this field. It is notable that this activity impacted young male learners as well to have a better understanding of the concept of computer science and enhanced their identity development.

Introducing computing to the young learners this way helped clear misconceptions about computing such as it being an introverted/one-person work, it lacking creativity, or it is only for males. Seeing distinct changes in some of their drawings, where they have drawn male Computer Scientists in the beginning when they were given no context and only were to use their unconditioned raw imagination, and then when they completed the module they drew a female Computer Scientist or a group of persons. This shows that they felt a sense of belonging in the field of computing. 3 out of the 18 subjects who participated, were open to the idea of a female as Computer

Scientist. This shows that the majority still can't envision that concept, which is also the same case in the real world, however, being able to change the minds of even just 3 participants is a victory towards helping represent women in computing.

Assessment demonstrated that the workshop increased the participants' self-efficacy in computing. The change in responses to the survey questions demonstrates that this creative approach to coding was indeed helpful. An interdisciplinary approach and unconventional method of introducing coding through dancing was an effective way of sparking interest among the students at a young age.

LIMITATIONS

While this research revealed positive outcomes, there were limitations. Firstly, this study was based on the performance of the participants during the short amount of time in a summer camp which cannot determine the long term effects. There were only 18 datasets to analyze, and 15 were females. The study could not include different races, ethnic groups, and genders. This may have caused saturated or similar results and also is inconclusive to larger population. Along with that, the summer camp was a Cyber-camp so the participants may have had some prior interest or knowledge in computing. This could have influenced some of their answers in the survey questions.

FUTURE WORK

The results shown by the small group of young learners in this study are applaudible, but it could be more beneficial to have a bigger and diverse group of participants in the future. There should also be consideration of more detailed questions relating to computing in the survey to help further determine the self-eficacy of the young learners. Conducting this research in a longer period of time may be of importance if considered. Furthermore, it might be beneficial to have bi-weekly survey check-points for a few months to keep track of how much and how long the introducing of computing through dance impacted their perception of computing.

CHAPTER V: CONCLUSION

This study proposes the idea of using unconventional and creative ways of introducing the concepts of computing among elementary-aged learners in the hopes to recruit young learners into the world of Computing. Originating from the usual question of "Why are few women in Computing?" this research has served to embark on the journey of expanding computing from a young age. By analyzing the dataset, this study was able to conclude that introducing dance as an algorithmic thinking tool helped in developing the self-efficacy and self-confidence of the young learners in computing and also help clear out their misconceptions and doubts regarding the field of computing. By educating and bringing awareness to the young learners about the possibility of computing as a career, this research supports the values of incorporating computational thinking into our personal lives and familiarizing the concept of computing being involved in various disciplines. This research imparts the message that to increase the representation in computing careers and self-efficacy in it, it is necessary to cultivate logical thinking through correlating familiar activities such as dance in young learners with an unbiased educational system.

APPENDIX A: IRB APPROVAL LETTER

Office *of*
Research Integrity

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NOTICE OF INSTITUTIONAL REVIEW BOARD ACTION

The project below has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services regulations (45 CFR Part 46), and University Policy to ensure:

- The risks to subjects are minimized and reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered involving risks to subjects must be reported immediately. Problems should be reported to ORI via the Incident template on Cayuse IRB.
- The period of approval is twelve months. An application for renewal must be submitted for projects exceeding twelve months.

PROTOCOL NUMBER: IRB-21-213
PROJECT TITLE: Self-Efficacy Development in elementary aged learners through Dance as an Algorithmic Thinking Tool
SCHOOL/PROGRAM: School of CSCE, Computing Sciences & Computer
RESEARCHER(S): Sarah Lee, Niva Shrestha

IRB COMMITTEE ACTION: Approved
CATEGORY: Expedited
7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

PERIOD OF APPROVAL: June 7, 2021

Donald Sacco, Jr.

Donald Sacco, Ph.D.
Institutional Review Board Chairperson

REFERENCES

A. Vitores and A. Gil-Juárez, "The trouble with 'women in computing: a critical examination of the deployment of research on the gender gap in computer science," *Journal of Gender Studies*, vol. 25, no. 6, pp. 666–680, 2015.

A. Wagh, B. Gravel, and E. Tucker-Raymond, "The Role of Computational Thinking Practices in Making," *Proceedings of the 7th Annual Conference on Creativity and Fabrication in Education*, 2017.

B. M. Capobianco, B. French and H. Diefes-Dux, "Engineering Identity Development Among Pre-Adolescent Learns", *Journal of Engineering Education,* 2012

D. M. S. Corkin, A. Ekmekci, and A. Fisher, "Integrating Culture, Art, Geometry, and Coding to Enhance Computer Science Motivation Among Underrepresented Minoritized High School Students," *The Urban Review*, vol. 52, no. 5, pp. 950–969, 2020.

F. Sagasti, "Information Technology and the Arts: The Evolution of Computer Choreography during the Last Half Century," *Dance Chronicle*, vol. 42, no. 1, pp. 1–52, 2019.

F. Heintz and L. Mannila, "Computational Thinking for All," *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, 2018.

L. Lineberry, S.B. Lee, J. Ivy, H. Bostick, "Bulldog Bytes: Engaging Elementary Girls with Computer Science and Cybersecurity". *ASEE Southeastern Section Conference, Daytona Beach, FL*, 2018.

L. Lineberry and S. Lee, “Dance-a-Bit: Integrating Dance with Teaching Algorithmic Thinking,” *2020 ASEE Virtual Annual Conference Content Access Proceedings*, 2020.

National Girls Collaborative, Retrieved November 7, 2017, from https:// ngcproject.org/