AFTER-SCHOOL STEM PROGRAMS AND THE IMPACT ON 21ST CENTURY SKILL DEVELOPMENT

by

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Dedication

This thesis is dedicated to my son, Jonah, for being the light that pushed me forward to continue pursuing my dreams and working to create a better life for our family.

Acknowledgements

There are many people that supported me throughout my time in graduate school at University of Houston–Clear Lake, including family members, coworkers, and fellow students. I am grateful for all the encouraging words and morale boosts when needed.

First, a special thank you to my husband Brandon. You have been my rock for almost 11 years now and never fail to build me up when I am feeling less than or uncertain about my abilities. Through late nights and tears, you stood by me and cheered me on. Even as we spent many months shut away from the world together social distancing and working from home throughout the COVID-19 pandemic, you continued to believe in me and love me all the same. I will never be able to thank you enough for how amazing you were throughout my pregnancy and welcoming our first child. I am blessed to have you and Jonah in my life. Our little family is the light of my life.

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Thank you to the owners and Center Directors of the Code Ninjas franchise that agreed to participate in this research study and who provided valuable feedback for this thesis. I am grateful for the opportunity to work with an amazing and talented community of people that are passionate about educating children and providing the skills to tackle new, unique challenges in the future.

I am also extremely grateful for the guidance from Dr. Jana Willis, my advisor on this project, for being available to answer my questions and always rapidly moving

forward to get each step approved as I submitted. I appreciate your support throughout my time at UHCL.

ABSTRACT

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This thesis used data collected from an online survey of 22 Code Ninjas employees in the United States to determine the impact of an after-school science, technology, engineering, and mathematics (STEM) program on students' development of 21st century skills. This study's findings indicated most owners and Center Directors agree social skills and creative thinking skills are improved through enrollment in an after-school program like Code Ninjas. More than half of the participants shared first-hand accounts of instances where students demonstrated 21st century skills while working in the Code Ninjas' program.

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CHAPTER I:

INTRODUCTION

With technology constantly and rapidly advancing, it is essential to engage K-12 students in science, technology, engineering, and mathematics (STEM) to build the foundational skills necessary to prepare them for the jobs of the future (Barcelona, 2014). Unfortunately, students in America are underperforming in STEM subjects and "dramatic changes [are] needed in the education system to truly fill the gap" (Burke & McNeill, 2011, p.2). While the skills learned through STEM can be acquired at any age, children can absorb these skills early on in their development to grow their interest in related fields later in life (McClure et al., 2017, p.14). Even though K-12 education has evolved over the last several decades to include more technology aspects, public schools have "simply fallen short in educating America's children in science, technology, engineering, and mathematics" (Burke & McNeill, 2011, p.6). The Century Foundation (TCF), a policy research institute founded in 1919, noted that the "United States is underfunding its K-12 public schools by nearly $150 billion annually" (2020). This is especially troubling seeing as students in the U.S. are being outperformed by their peers in other countries – a gap that can begin as early as age 4 or 5 (McClure et al., 2017, p.30).

To mitigate this issue, extracurricular programs can engage kids in STEM learning and grow their skill set. One such after-school resource is Code Ninjas, a kids' coding franchise that teaches STEM skills through the practice of building video games. Providing fun hands-on projects, gamification of learning, expansion of computer science curriculum, and wider access to kid-focused coding resources can inspire kids to pursue STEM subjects, while simultaneously encouraging the advancement of skills like critical thinking, creativity, collaboration, and communication (Nurlenasari et al., 2019, p.1).

This study aims to provide evidence that learning in after-school STEM environments can have a positive impact on students' 21st century skill development. The researcher believes it is just as important to evaluate the impact on the development of important life skills, including grit – or perseverance in the face of challenges, as it is to test how proficient students are in understanding programming concepts after participating in a coding program. This research topic is meaningful in its ability to provide first-hand experiences of how special STEM programs like Code Ninjas are to kids and their parents, not just for the skills they teach, but also the camaraderie and the sense of community that it provides.

The purpose of this study was to evaluate how the after-school program Code Ninjas contributes to students' skill development beyond the technical aptitudes normally associated with participation in STEM and computer science activities. Using responses to open-ended and closed-ended survey questions from Code Ninjas staff, the researcher examined how extracurricular STEM programs influence student growth in other non-technical skills, such as social interaction, motivation, creativity, and reasoning. The scope of the study was to determine which skills were positively impacted by participating in after-school STEM learning at Code Ninjas, as well as whether there were noticeable differences in the skills developed in off-campus versus on-campus programs. The research briefly summarizes the technical skills students can acquire and highlights the lesser-known interpersonal skills that can positively impact children's learning and development.

Much of the previous research either examined students in traditional school environments with teachers deploying STEM activities or focused on the impact of STEM activities on students' technical skills, proficiency in STEM topics, or the level of student interest in STEM careers. Evaluating the development of interpersonal skills,

sometimes called “soft skills,” gained from STEM learning and assessing off-campus after-school programs will expand existing research. Proposed research questions included the following: (1) Does participation in after-school STEM learning have a positive impact on students’ development of 21st century skills? (2) Besides technical skills, what interpersonal skills can students learn from participating in STEM activities in after-school learning environments? (3) Are there differences in the skills gained from participating in on-campus versus off-campus after-school STEM programs?

CHAPTER II:
LITERATURE REVIEW

A review of the literature involving STEM learning for children confirmed the need to study additional learning environments outside of traditional school curriculum to effectively grow interest in computer science education and related subjects. Much of the research recognized that coding, computer science and other STEM topics positively influence skill development, but it is less clear how and why these experiences are effective. The literature review concentrated on the necessity for new, more exciting learning experiences to engage K-12 students in STEM topics and encourage skills for their future.

Lacking Engagement in Traditional Learning Environments

Though school settings have previously been the typical environment for conducting research, unfortunately research agencies are missing opportunities for early STEM learning by prioritizing "investment in older children and in training undergraduates and graduate school students at a later stage of the STEM pipeline" (McClure et al., 2017, p. 42). Public schools lack the funding, administrative support, and professional development needed to quickly bring cutting-edge technology programs and tools into the educational experience for students (Becker, 2018, pp. 19-20). Han and Buchmann (2016) state that "proficiency in science and expectations to pursue a science career during adolescent years are especially important precursors to the subsequent likelihood of completing a STEM degree in college" (p.194). As McClure et al. mention, a "large percentage of students will have lost the confidence and motivation to engage in STEM subjects as adults" by the time they graduate from high school (2017, p. 38). It is crucial to address this education gap in science and technology as uninspired students are much less likely to pursue these topics later in their development.

Children are more technologically savvy than ever, so it makes sense that their learning experiences would become more integrated with computers, tablets, and other technologies over time to capture students' attention. However, without the administrative support necessary to purchase and implement more innovative instructional technologies, public schools have been slow in the adoption of these newer educational solutions (Becker, 2018, p. 85). Traditional school settings often miss out on the opportunity to provide captivating STEM learning experiences using practices that are familiar to students. For instance, Anderson's study in 2008 notes that "children play video games as much or more than they watch television" which could "provide opportunities for innovative approaches when applied to the classroom environment" (p.5).

The Challenge of Merging Education and Entertainment

Unfortunately, the problem of merging leisure and educational games for learning observed in Anderson's study remains an issue even over 10 years later in 2021 – especially in the classroom (2008, p.7). Another obstacle for implementing new-age technologies in public school learning practices, such as interacting with educational video games, is due to schools being a place where students should "take learning seriously" with limited leisure time. While these are understandable measures to help focus student attention, it often means implementing more hands-on technology methods like educational video games could require a shift in the culture and philosophy of education in schools. Yet there is still a "lack of empirical research measuring how educational computer games" and other technology-based activities can enhance student learning to support such an undertaking (Anderson, 2008, p. 4).

This is where after-school environments, such as Code Ninjas, can fill in the gaps to engage students in STEM topics and educate them on the skills necessary to be

successful in a rapidly advancing and increasingly technical world. Code Ninjas teaches kids ages 5-14 how to code through the process of building video games, combining the practicalities of coding with the entertaining aspects of game learning. In a study investigating design thinking, an important facet of coding, Carroll notes the potential "to contribute to young people's metacognitive and social learning, as well as in specific subject areas" (2014, p. 16). Encouraging participation in design topics, especially those that are technology-based, is essential for children to begin building foundational knowledge and 21st century skills applicable for their future (Carroll, 2014, p.2).

While there may be a level of difficulty to learn more advanced skills like coding, these concerns can be mitigated by encouraging students with a fun and engaging learning experience that allows them to interact with the elements they are developing. Weintrop and Wilensky support this notion in their study proposing a strategy "to engage learners in programming that builds their interest and enjoyment of video games [by integrating] programming into the gameplay experience directly through the design of program-to-play games" (2016, p. 36).

Existing Research on After-School Learning

Reviewing existing research on after-school STEM learning environments helped determine the need to make a delineation between after-school STEM activities held on-campus at public schools and those offered in separate off-campus programs. Additionally, literature centered around the after-school component without specifically isolating STEM focused programs provided valuable insight into the range of skills that can be enhanced through supplemental learning in general. This information will help to tie together the advantages of STEM focused learning with the overall benefits of after-school programs.

One study sparked interest with its similar title *STEM Related After-School Program Activities and Associated Outcomes on Student Learning*. After reviewing the experiment, the researcher discovered that it examined after-school STEM activities within a charter-school setting, using only one location out of the 40 across the specified system (Adiguzel, Ayar, & Sahin, 2014, p. 312). Even though "student participation is voluntary and mostly driven by their interest and individual commitment," the activities were still being hosted on campus in the same school environment students experience every day (Adiguzel, Ayar, & Sahin, 2014, p. 312). While there was attention given to 21st century skills in this and other after-school program studies, the emphasis was on directly measuring the correlation between after-school STEM activities and students' achievement scores, competence of the topics, and their interest in pursuing related STEM careers (Adiguzel, Ayar, & Sahin, 2014, p. 312). This study will expand the research by focusing fully on the 21st century skills learned and evaluating off-campus STEM learning beyond one location.

Another study found 73 after-school programs in their meta-analysis of over 49 documents to determine the improvements experienced by student participation in extracurricular activities (Durlak & Weissberg, 2007). However, the research "only considered after-school programs that attempted to promote personal and social skills" to measure the effects on students (Durlak & Weissberg, 2007, p. 6). Focusing solely on STEM learning in an after-school environment will concentrate the results, which will provide an opportunity to make correlations among the technical proficiencies taught and the different 21st century skills they cultivate. This information is useful because after-school programs that "recognize the interdependence between youths' personal and social development and their academic development can be very effective" (Durlak & Weissberg, 2007, p. 27).

A study by Baran, Bilici, Mesutoglu and Ocak in 2016 investigated students' perceptions of an out-of-school STEM program based in Turkey. The researchers noted that access to STEM education in Turkey varies by school and that "only a very small percentage of students having education in specialized schools have access to STEM education" (Baran, Bilici, Mesutoglu, Ocak, 2016, p. 9). This aligns with what is experienced in schools in the United States as well. There are very few students that have adequate access to STEM education and most who do have access must do so through a specialized program outside of public school. Because the researchers determined that there was not much information on the students' perspectives of STEM activities, the study obtained data from 40 6th grade students' activity evaluation forms that were submitted after each STEM activity. The evaluation forms were used to review perceptions "on the content and skills gained, the challenges and limitations faced, and suggestions for improvement," which students listed as more comprehensive materials, attention and elements of fun, time, and more information at the beginning of the activity (Baran, Bilici, Mesutoglu, Ocak, 2016, pp. 14-15).

CHAPTER III:
METHODOLOGY

This study investigated how student interests and skills changed since the introduction of the Code Ninjas program using a mixed methods approach. Creswell and Guetterman define mixed methods research designs as "procedures for collecting, analyzing, and 'mixing' both quantitative and qualitative methods in a single study or a series to understand a research problem" (2019, p. 545). Qualitative data included documents, other written materials, and open-ended questionnaires with corporate staff and owners of the Code Ninjas franchise. Quantitative data included closed-ended survey responses from corporate staff and owners of the Code Ninjas franchise. Additionally, corporate-level data and reports were utilized to obtain metrics such as the number of total students, active locations, and student counts by program in the Code Ninjas system.

The frequency of certain responses were determined by compiling the results from the open-ended and closed-ended questions. Ascertaining the frequency of the categorical variables (skills) enabled the researcher to look for any patterns or relationships among variables, identify unique outliers, and draw conclusions. After making observations from the data, explanatory analysis was used to create graphs presenting the information in a visual manner. Because much of the information collected was qualitative data expressed in words, categorizations, and interpretations, it was important to present observations of the data using a combination of qualitative content analysis and quantitative statistical analysis.

Ethical Considerations

Prior to beginning the study, the researcher obtained consent from the Compliance team at Code Ninjas to include corporate data in the thesis and to survey franchise owners and Center Directors. Verbal consent was given as the research was intended to

be entirely separate from the corporate office, for the purpose of academic research, and consent and privacy notices would be detailed for all participants to agree. The U.S. Department of Health & Human Services defines minimal risk in a study as "the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests" (Protection of Human Subjects, 2021, 46.102). By this definition, minimal risk was perceived for participants because identities of all staff members, franchisees, children, and customers names would be protected and names would be omitted from the study. Therefore, caution was used to ensure no identifying information is included that would enable data to be linked to specific Code Ninjas locations or their customers. All participating staff members were provided with an informed consent form stating that their identities would be protected by omitting names and identifying information, and that they could withdraw from the study at any time without penalty.

Population, Sample and Participant Selection

Target population was defined as a "group of individuals with some common defining characteristic that the researcher can identify with a list or set of names" (Creswell & Guetterman, 2019). For this study, the target population was the owners and center directors of Code Ninjas franchises who worked directly with students in their programs.

From an email list that included 258 operational locations in the United States, 22 responded (8.43%) to the research survey (see Appendix B) for this thesis over a two-week period. Owners were encouraged to forward the email to their Center Directors if they felt comfortable doing so. As each Code Ninjas' location is individually owned, it was up to each owner's discretion whether they sent the information to their Center

Director. Because responses were based on willingness to participate, the owners and Center Directors were random in selection for the study.

All locations serve diverse student populations. Depending on the location, each center serves a range between 30-100 students who are enrolled in either the Code Ninjas JR, CREATE or After-School Program. With Code Ninjas camp offerings, there were some students that are one-time customers, but they still contributed to the culture within each facility. Information and observations of the students were based on location (participating centers), student age (5-14), current program level and the amount of time the customer/family had been with the center.

Data Collection – Quantitative

Code Ninjas corporate data was pulled from records and reports collected from metrics regarding student sessions. No identifying information was used, such as student or customer names. A survey was compiled via Microsoft Forms for owners and directors to complete anonymously regarding their perception of the skills students have gained through participation in Code Ninjas programs. The survey consisted of an estimated 20 items using a 0-5 **Likert scale** (see Appendix C) and took approximately 15 minutes to complete. Participants completed the survey online at a time of their choosing, with a deadline to submit their responses no later than 10 days after the Microsoft Forms link was shared.

Data Collection – Qualitative

At the end of the survey, all participating Code Ninjas staff completed an open-ended questionnaire with prompts to discuss their experiences working with the students at Code Ninjas. Topics included their observations regarding changes in student motivation, attention span, interest in learning and STEM topics, and demonstrations of 21st century skills such as critical thinking and problem solving.

Survey

A high priority email (see Appendix A) was sent to 258 of Code Ninjas franchisees currently open in the United States to ask for their participation in the study. The email outlined the purpose of the study, what degree and university the research is related to, and how long the survey would be open for responses (March 15, 2021 to March 26, 2021). Also included in the email was an informed consent document providing more details and a link to the survey itself. Two follow-up reminder emails were sent in the two-week period that the survey was open.

Once the survey was accessed, participants saw the following information: The purpose of this study is to evaluate whether Code Ninjas contributes to students' skill development beyond the technical aptitudes regularly associated with participation in STEM and computer science activities. INFORMED CONSENT: Your voluntary participation in this research project is indicated by completing the survey online, and you may cease your participation at any time by closing your browser. Such participation does not release the investigator(s), institution(s), sponsor(s) or granting agency(ies) from their professional and ethical responsibility to you. PRIVACY NOTICE: Please note that your name will be recorded for the sole purpose of potential follow-up questions pertaining to this research study. Your name, location, and any other identifying information will not be included in the research findings. Your individual responses will not be shared with the Home Office team outside of what findings are included in the published thesis.

The survey consisted of 12 questions – 8 open ended and 4 closed-ended. When participants first begin the survey, they must read the consent and privacy notices (listed in the previous paragraph) and select "Yes" to acknowledge them before moving on to the next question. Then they indicated their location and their role within Code Ninjas –

Owner, Director, or a dual role as Owner and Director. The question was open-ended for them to input their location name (or multiple locations for multi-owners) and then multiple choice to select their role.

The next question was required for participants to answer how likely the Code Ninjas program is to nurture several social skills – listening, sharing, communicating with others, following directions, teamwork, motivation, and commitment. They answered on a Likert scale for each skill with choices: very unlikely, somewhat unlikely, neutral, somewhat likely, or very likely. Next, the participating Code Ninjas staff members had the opportunity to expand on their responses to each skill, indicate if they've witnessed any additional social skills that were not included, and/or include an example of the social skills they've seen within their center.

Using the same format as the social skills section, the next part of the survey asked participants to rate the likelihood of students to improve different creative thinking skills by being part of the Code Ninjas program. Again, they could rate on a Likert scale of very unlikely, somewhat unlikely, neutral, somewhat likely, or very likely. The creative thinking skills were listed as follows: problem solving, analyzing information, organization, creativity, brainstorming, curiosity, and imagination. After rating each skill, there was an optional section for owners and directors to expand on their responses to each skill, include additional creative skills they've witnessed that weren't listed, and/or provide an example of creative skills demonstrated by students in the Code Ninjas center.

The last part of the survey provided an open-ended area to add any additional information for the purpose of the study or to supplement their survey responses. Additionally, a multiple-choice question – Yes or No answer – asked whether they would agree to be contacted for follow up questions if needed.

CHAPTER IV:

RESULTS

The online survey of 22 Code Ninjas owners and Center Directors in the United States found that:

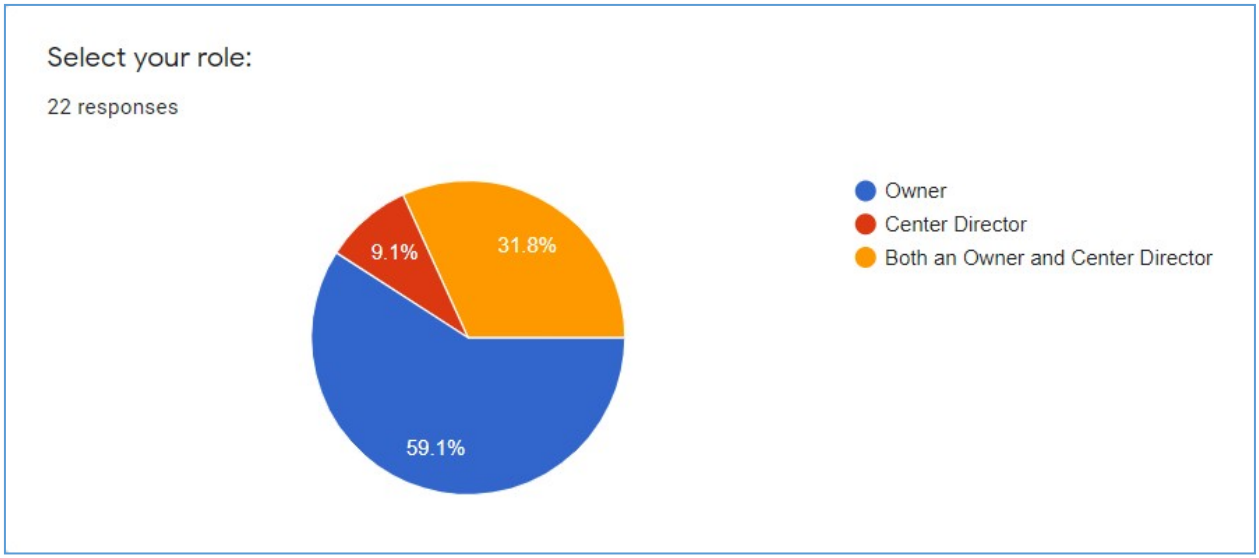
- Most agree that social skills are improved through enrollment at Code Ninjas
- Most agree that creative thinking skills are improved through enrollment at Code Ninjas
- More than half shared first-hand accounts of instances where students demonstrated 21st century skills while working in the Code Ninjas' program – e.g., displaying creativity when designing their own artwork for game backgrounds and characters
- Some soft skills, such as organization, are more difficult to teach than others but can be built upon with regular attendance at Code Ninjas – i.e., not missing sessions each week

Throughout the survey responses, there was one participant that consistently answered on the low end of the spectrum when rating whether Code Ninjas improved 21st century skills for enrolled children. Additionally, in the open response questions, the participant also reiterated their opinion that they "don't see any social skills improvement by being enrolled at Code Ninjas." Upon further investigation, it was determined that this participant's location was currently in the process of being sold. It is important to remember that survey responses are indicative of each individual's experiences with their business, as well as the students and families they have encountered. This is not to discount anyone's opinion, but to show the wide range of experiences that can occur across such a massive system.

Of the 22 responses, 13 (31.8%) were owners, 2 (9.1%) were Center Directors, and 7 (31.8%) were both an owner and center director (Figure 1). This information was collected to decipher the roles in Code Ninjas that played a part in their experiences and subsequently their responses to the survey.

Figure 1

Participants' Roles at Code Ninjas



Note. Owners are the franchisees within the Code Ninjas franchise who purchased a center. Center Directors are the staff members who are responsible for operations within the center. Some owners are also the center director, while others choose to hire for the position.

Social Skills

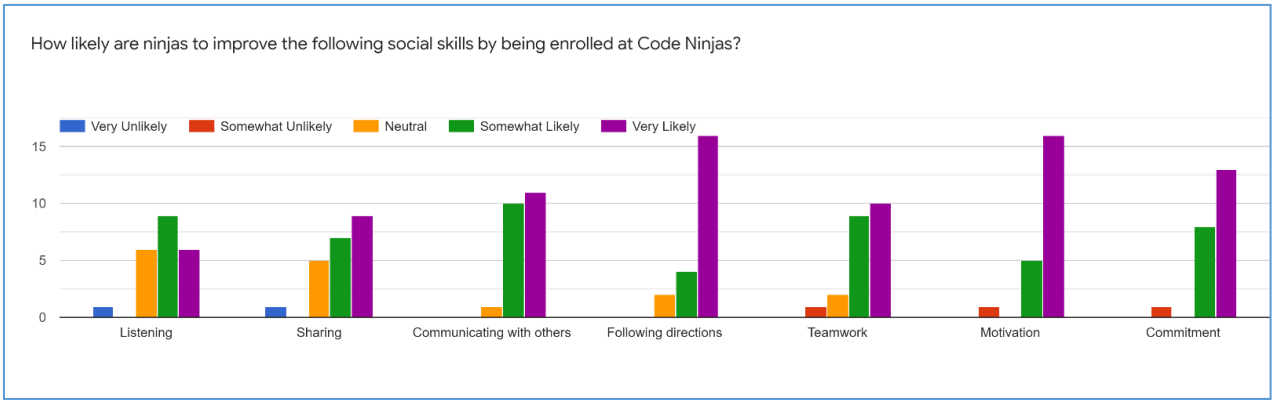
Pertaining to the question of how likely students are to improve certain social skills by being enrolled at Code Ninjas, participants were asked to rate listening, sharing, communicating with others, following directions, teamwork, motivation, and

commitment (Figure 2). The breakdown of the Likert scale ratings for each social skill are as follows:

- **Listening:** 1 Very Unlikely (4.5%), 6 Neutral (27.27%), 9 Somewhat Likely (40.9%), 6 Very Likely (27.27%)
- **Sharing:** 1 Very Unlikely (4.5%), 5 Neutral (22.72%), 9 Somewhat Likely (40.9%), 10 Very Likely (45.45%)
- **Motivation:** 1 Somewhat Unlikely (4.5%), 5 Somewhat Unlikely (22.72%), 16 Very Likely (72.72%)
- **Commitment:** 1 Somewhat Unlikely (4.5%), 8 Somewhat Likely (36.36%), 13 Very Likely (59.09%)

Figure 2

Social Skills



Note. Participants rated how likely seven different social skills are to improve for students enrolled at Code Ninjas.

Sixteen of the 22 participants (72.7%) responded to the prompt, "Use the space below to expand on your responses to any of the social skills included in the previous question." The key themes identified in the open-ended survey question to expand on the

social skills participants rated were: commitment, teamwork, and communication. However, 2 of the 16 responses (12.5%) provided more general statements – ironically, providing completely opposite opinions. One participant stated they "don't see any social skills improvement by being enrolled at Code Ninjas." The other voiced additional skills – critical thinking, problem solving, and collaboration – that they see within their center and that Code Ninjas is "teaching more than coding."

Commitment

Five of the 16 responses (31.25%) discussed their experiences with kids' commitment at Code Ninjas. One mentioned commitment to the program varies by age, and older kids were more committed than those who were younger. Another participant stated that they believe the students "already need to have a strong sense of motivation and commitment in order to excel at Code Ninjas." However, 2 of the 5 responses related to commitment discussed how they had seen kids stay committed to finishing projects even though it can be difficult, because they are interested in the curriculum. A fifth participant noted that the self-paced aspect of the curriculum helped kids to follow directions and "increases their commitment to the program by having them develop independent learning skills." Especially in coding, independent learning skills play a big part. Students must learn how there are different ways to solve a problem with code and continue to work at it until they find an answer. They need to learn to rely on their own knowledge and ability to explore and learn on their own.

Teamwork

The next theme in the open-ended response question to expand on the social skill ratings is teamwork or team activities. Five of the 16 responses (31.25%) mentioned teamwork, working in a group/with others, or team activities. In one participant's opinion, "teamwork and sharing skills are enhanced much more during camp season than

during regular attendance because there's more opportunity to apply those skills during camp." In essence, camp curriculum is meant to be more of a collaborative experience, while the regular curriculum focuses on self-guided materials.

On the other hand, two of the participants talk about how Code Ninjas itself provided a group for students to feel a part of – "a sense of pride and community" that kept them coming back. Having a community of like-minded peers to work with is great for students, and "reinforces their unique interests in technology [that] builds their confidence in the program." They had a feeling of belonging that made them excited to learn and share with others.

Unfortunately, COVID-19 in 2020 and 2021 impacted the ability to work together, at least in the traditional sense, for some locations. One participant mentioned how the pandemic has impacted sharing and teamwork for their location. Managing a business through COVID-19 is a unique challenge to navigate in general, but especially in a small business that thrives on interaction and building a sense of community.

Communication

Communication also played a big role in the social aspect of Code Ninjas. Four of 16 participants (25%) who responded to the question included communication in their answer. Half of them said communicating with Code Senseis, Code Ninjas' specialized tutors, is a potential strength and allowed them to get help when they need it. One participant noticed "great communication amongst the children when there are at least three" working on the curriculum at the same time. They can talk about the lessons together and "interact with one another about how they completed the program and what they saw when they were working through it."

Nine participants identified additional social skills (Figure 3) at their location that were not included in the previous question. Their answers were as follows:

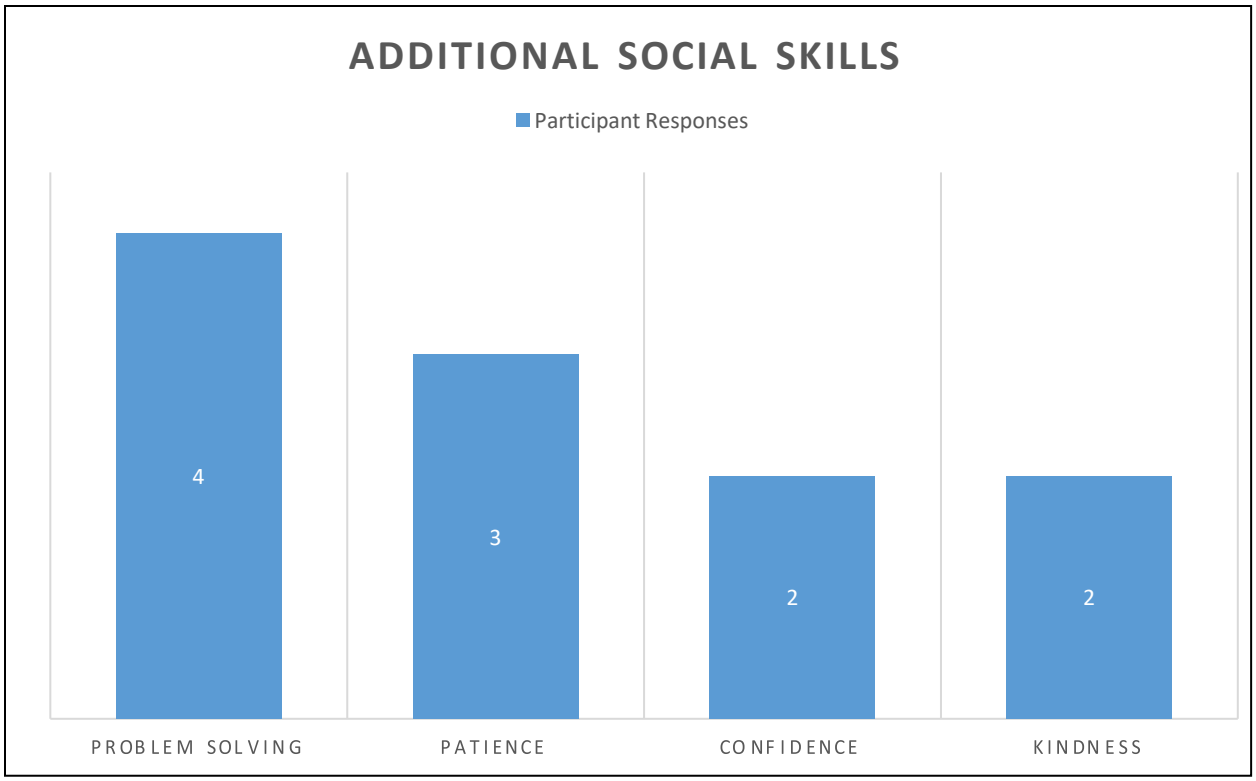
- Problem solving, challenging by coming up with their own code, competitiveness among other students
- Persistence and problem solving
- Kindness
- Perseverance and grit
- Confidence and problem solving
- Respect for property and other people, problem solving, patience, helping others, self confidence
- Leadership and advocating for themselves

Of the nine participants who answered the open-ended question for additional social skills, four mentioned problem-solving; three mentioned persistence, perseverance, or patience; two mentioned confidence; and two mentioned kindness or helping others.

Another important response indicated learning at Code Ninjas has made a "great impact on a student on the spectrum in regard to their social skills." In the literature review *The Impact of Technology on People with Autism Spectrum Disorder*, the authors found that "people with autism spectrum disorder (ASD) tend to enjoy themselves and be engaged when interacting with computers, as these interactions occur in a safe and trustworthy environment" (Valencia, Rusu, Quiñones, & Jamet, 2019, p.1). As students learn together, they can socialize and develop friendships with others. This interaction is important for children's development, especially those with autism who may struggle with social skills. Code Ninjas provides a safe environment for all kids to learn programming while also connecting with peers who share their interests.

Figure 3

Additional Social Skills Identified



In the open-ended question asking participants to provide an example of meaningful social interaction at their Code Ninjas location, 16 of 22 participants submitted responses (72.72%).

Five of the 16 responses (31.25%) discussed instances where they had seen quiet, shy, or introverted children begin to come out of their shell, gain confidence in themselves, and make new friends within the program. A few students who felt like outcasts in school could come to Code Ninjas and be themselves with other like-minded kids. For example, one survey stated that a student was being bullied at school and asked his parents "if he could come every day so he could be with other kids like him." Another response mentioned a very quiet and shy boy who "gained a

tremendous amount of self-confidence while attending and progressing through the belt program… He even started helping other[s] when they needed it." Other examples discussed how parents exchange information to schedule play dates outside of the program. A common theme in the anecdotes was the experience of witnessing students become friends and feel like part of a community.

Helping Others

The next theme found in the examples of meaningful social interaction at Code Ninjas was helping others. Four of the 16 responses (25%) to this open-ended survey question included helping others as part of their example of meaningful social interaction at their location. One stated, "all of our students have the ability to experience what it feels like to be the teacher and the student" because they can explain a concept to another child that they just learned while continuing to practice their skills.

The helpfulness and interaction between students did not appear to be isolated to new friends or peers either. As one response stated, one of the best and most unexpected things they've seen is "siblings supporting each other and encouraging each other." At their Code Ninjas locations, they have "several sets of siblings and it seems to impact all of them."

Another example discussed a 9-year-old girl's interaction with an older student in the program who was newer and earlier in the curriculum. When the older student became stumped on a particular part, the younger girl "volunteered to go on the white board to have a while board session about code and what the code should be." Soon the older girl was able to come to her own conclusions but continued listening to the other's explanations and eventually steered the discussion to the

answer/conclusion she had come to. The survey respondent indicated that this interaction was a "boost in confidence for the both of them."

Increase in Confidence

Five of the 16 participants (31.25%) also witnessed an increase in confidence in their students. One person stated that "parents see the transformation in their kids after they are part of a coding competition and other STEM projects. [Participation in these activities] brings a lot of confidence and they can implement these skills in other parts of their life."

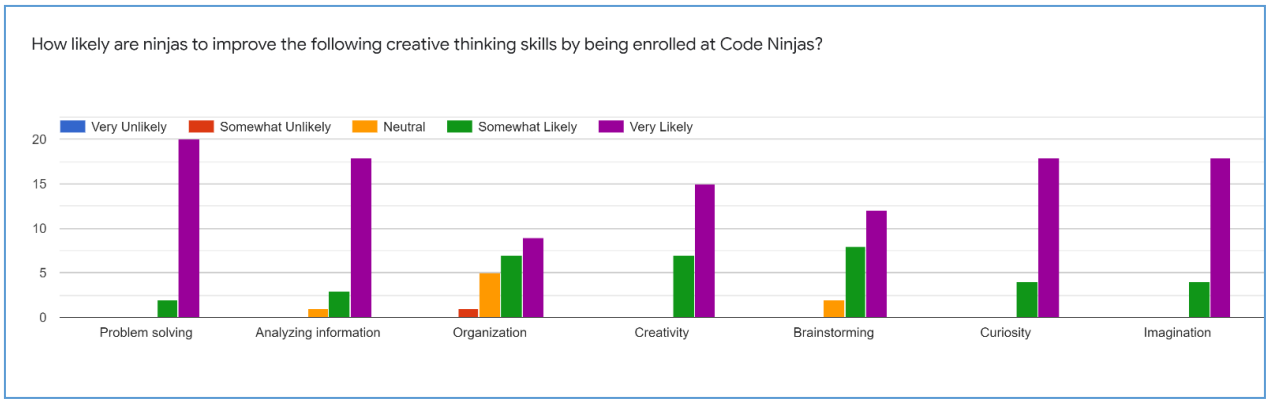
Creative Thinking Skills

Participants were asked to rate how likely students were to improve certain creative thinking skills by being enrolled at Code Ninjas. These skills included: Problem solving, analyzing information, organization, creativity, brainstorming, curiosity, and imagination (Figure 4).

- **Problem solving:** 2 Somewhat Likely (9%), 20 Very Likely (91%)
- **Analyzing information:** 1 Neutral (4.5%), 3 Somewhat Likely (13.6%), 18 Very Likely (81.8%)
- **Organization:** 1 Somewhat Unlikely (4.5%), 5 Neutral (22.7%), 7 Somewhat Likely (31.8%), 9 Very Likely (40.9%)
- **Creativity:** 7 Somewhat Likely (31.8%), 15 Very Likely (68.1%)
- **Brainstorming:** 2 Neutral (9%), 8 Somewhat Likely (36.4%), 12 Very Likely (54.5%)
- **Curiosity:** 4 Somewhat Likely (18.2%), 18 Very Likely (81.8%)
- **Imagination:** 4 Somewhat Likely (18.2%), 18 Very Likely (81.8%)

Figure 4

Creative Thinking Skills



Note. Participants rated how likely seven different creative thinking skills are to improve for students enrolled at Code Ninjas.

In the optional question to expand on their responses to any of the creative thinking skills that were rated, 11 of 22 (50%) participants submitted responses.

Seven of 11 responses (63.6%) discussed how creativity was used when problem solving or creating new things in the program. One Code Ninjas location stated it is "really amazing when we see kids come up with a totally new way of accomplishing the given task." Another had a similar sentiment with "we are constantly amazed by all the different, creative solutions our ninjas provide." Not only do students need to use creativity when following the curriculum, but they also have the opportunity to use their imagination and flex creative skills as they "customize their games," "put their own spin on the video games," or put "their own stamp on the games they build." Some examples include students creating their own unique video game **sprites** and **backgrounds** (see Appendix C).

Two of 11 responses (9%) mentioned regular attendance contributed to Code Ninjas' ability to improve creative thinking skills. However, another participant discussed that creativity was also seen in the initial game building session that provides a preview of Code Ninjas for newcomers. They saw a peak in interest in the program when kids realized they were able to make their own creations, so the center teaches a few concepts and ensures there is time for customization to be completed on the game.

A common theme in the survey responses was that the self-directed curriculum provided students with the freedom to create and build new things as they meet the minimum expectations for each activity. Because they could make their games as unique as they want, kids were able to practice skills like brainstorming, imagination, and curiosity. They had the freedom to explore different aspects of their games and bring their ideas to life. While Code Senseis (teachers) were available for guidance when students got stuck or needed extra help understanding concepts, having self-directed curriculum helped kids to be self-reliant and more confident in their abilities. They also had the option to discuss the activities with their fellow students, creating their own community within each Code Ninjas center.

Creative Problem Solving

Three of the 22 respondents discussed how students demonstrate creative problem solving in Code Ninjas' "Prove Yourself" activities, which were included at the end of each lesson for students to demonstrate what they learned. Instead of providing step-by-step instructions, students were given a prompt to complete to show the new skills gained from the last lesson. One person said they were "constantly amazed by all the different, creative solutions our ninjas provide" and another stated, "kids are able to explore their own creativity… and [put] their own

stamp on the games they build." The third survey participant discussed how each kid was different, so it was natural that their approach to each problem was unique as well. They too were amazed to see when "kids come up with a totally new way of accomplishing the given task."

An important observation from one survey response was that all of the creative thinking skills rated in the survey – problem solving, analyzing information, organization, creativity, brainstorming, curiosity, and imagination – could be greatly improved upon at Code Ninjas, however, regular attendance in the program played a large role in students' progress. Different belts (or levels) in the base program taught different skills that built upon what students learned. As they created new things, they could expand upon what they learned in previous lessons. Regular attendance allowed students to revisit the curriculum regularly, so their skills stayed sharp, and knowledge didn't get lost.

One owner shared a PDF (Figure 5) that they created for their parents and students to identify what the profile of a Black Belt Ninja, the highest level a student can reach in the program. The traits that the owner identified are that a student must be consistent, regression-free, curious, practice regularly, participate in the Code Ninjas community, receive support from their parents, and apply what they learn to their schoolwork. Another survey response pointed out that they tell parents that it does not matter whether the child becomes a programmer or not. Code Ninjas aims to develop creative problem-solving skills to prepare kids for the future regardless of their career path. Learning how to code helps to develop those important life skills that will benefit them in all aspects of their life.

Figure 5

Profile of a Black Belt Ninja – Owner-Provided Resource

Note: Created by Code Ninjas' center owner, PDF.

In addition to the regular Code Ninjas' program and the prove yourself assignments, kids could also showcase creativity before they joined Code Ninjas by participating in a Game Building Session. These sessions allowed kids to test out the program by creating a simple game on one of the center's laptops. One of the survey

participants noted that kids "want to create their own sprites or backgrounds and when they see that they are allowed to, their interest really peaks in the initial program." This center stated that they focus on teaching small, easy-to-grasp concepts that the child can explain to their parents after, while allowing ample time to customize their game in the 30-minute Game Building Session.

To effectively improve brainstorming skills at Code Ninjas, students may need to work together with a Code Sensei for some time to completely map out a project or activity, but as they progress further in the curriculum, the process becomes easier. They are also able to use their imagination as they talk the project through with a Code Sensei and come up with their own ideas for stories, characters, backgrounds, and other creative elements in their games. However, creativity does not just stop with the kids enrolled in Code Ninjas. As owners and Center Directors constantly point out, the staff are instrumental in coming up with new ideas for activities, camps, and designs.

Organization is another skills that is not simple skill to teach, but students can exercise their proficiency by arranging their code more clearly. They are also able to be creative with their code in order to reach a solution – problem solving in their own way to get to the same result. Debugging games in different ways can also contribute to problem solving skills, because just like coding, there are different routes to debugging as well.

Six participants identified additional creative thinking skills that were not listed in the previous survey question. The responses were as follows:

- Accepting failure and not seeing failure as a negative but as an opportunity to learn
- Teaching or mentoring
- Originality and inventiveness
- Real-world connection with everyday things

- Logical thinking
- Spatial conceptualization with X, Y, and Z axis and building/positioning objects

All twelve of the examples of creative thinking that owners and Center Directors submitted mentioned how inventive students were in their designs, creative approaches to problem-solving, and their ability to think outside the box. As one person stated, kids are relieved to have flexibility in their learning at Code Ninjas, whereas schools require "standardized, one-size-fits-all answers." With this creative freedom, students frequently come up with new methods to find a solution, work harder to improve their games, and are excited about making their own designs. It is easy for the staff to see the students are proud of their work because they can explore the curriculum on their own and decide how they want to approach each activity.

To encourage creative thinking skills, one Code Ninjas location allowed students to be a "Sensei for a Day" where they were able to assist the Code Senseis as they worked with other students. This allowed the students to not only work through different code issues with their peers, but also to have the opportunity to experience how other kids think in ways that may differ from their own. Getting to be on the mentoring side of learning also helps students gain a deeper understanding of the material, which in turn enables them to make real life connections with what they have learned. One survey participant said they love receiving messages from parents whose child made a correlation with something they learned and were able to explain it to them.

A response that goes hand in hand with the "Sensei for a Day" mentorship opportunity is one that discussed how a student created their own website to teach basic JavaScript to students who were new to coding. It was exciting for the staff to see how the child not only learned how to code but had a deep enough understanding to create a resource for others to learn too. Another participant who discussed teaching and

mentoring included students love to “share skills and teach [those] who are younger or in lower belts than them… They come up with their own technique to convey ideas on projects they have created.”

With all of these examples, it become clear that “critical thinking is a pillar of [Code Ninjas’] programs.” The students learned from each other and applied artistic skills to the code, game, characters, and background. When kids were given the opportunity to create without fear of being wrong, the sky was the limit. They were able to drive their own learning and dive deeper into the subjects that most interested them. Especially when camp season comes around, students have the opportunity to learn more about certain topics in a fun, hands-on group setting. No matter what the students were working on, whether it was through whiteboard sessions, TinkerCAD, Artec blocks, Scratch, robotics, or website building, “Code Ninjas exudes creativity” and teaches kids about refinement and perseverance to make their projects their own.

Additional Information Provided

Seven participants out of 22 (31.81%) wanted to provide additional information at the end of the survey. Two of the seven responses (28.57%) were to convey excitement about the thesis and that they were looking forward to seeing the final results.

One of the seven responses (14.28%) expanded on a popular tool called TinkerCad that was used at Code Ninjas. TinkerCad is a creative tool that allows students to make original creations that can be 3D printed and shared. This participant said, “they are amazed by their designs” and believes they are “definitely some future engineers and architects in the making.” Especially when you consider that Code Ninjas is for kids ages 5-14, that is an impressive age for making their own 3D designs. This was also an example of some of the hands-on projects that gave students a tangible product to take home at the end.

Three of the seven responses (42.85%) discussed the need that Code Ninjas fulfills for the community by providing coding and STEM education. Those responses included:

- "I believe what we do here at Code Ninjas is pivotal to our young people's development and cognitive growth."
- "STEM programs like Code Ninjas are excellent because they provide a safe place for kids to learn and grow at their own pace without pressure."
- "Schools aren't able to provide the level of expertise that outside programs can provide… When we get down to specific skill sets like computer science, that education is completely lacking."

One of the seven responses (14.28%) brought up an important conversation about the need for more inclusion in coding – specifically more Black, African American students, and especially girls. The participant stated, "as a Black, African American woman, many of these skills are not always taught to us or valued due to fear of being curious or failing at something the first time because we may not get another chance to prove ourselves." She provided an example of parents bringing in their sons for a free game building session while their sisters sat in the lobby. After encouraging parents to have their daughter participate too, "the girls enjoy it and want to sign up each time too!"

Programming is like its own language, and just like Language Arts, the availability of these skills should be open for everyone to learn. Advertising and accessibility should not be limited by ethnicity, gender, or any other self-identifier, especially when these programs are meant to create future leaders. As one owner says, "we are creating ethical coders for the future" and enabling younger generations to create solutions for others.

CHAPTER V:

DISCUSSION

Summary

Through this study, potential explanations were proposed for the multitude of skills and positive impacts that after-school STEM learning has on students' development and, subsequently, their preparation for the future. The results indicate that participation in after-school STEM learning does have a positive impact on students' development of 21st century skills. Most participants agreed that after-school programs like Code Ninjas improved social and creative thinking skills for students, and that these 21st century skills are beneficial to students' development and overall education. This follows the findings by Durlak and Weissberg that students in after-school programs had "multiple benefits that pertain to youths' personal, social, and academic life" (2007, p.7).

Based on the survey results, interpersonal skills that students can learn from participating in STEM activities in after-school learning environments include social skills: listening, sharing, communicating with others, following directions, teamwork, motivation, commitment; and creative thinking skills: problem solving, analyzing information, organization, brainstorming, curiosity, and imagination. Additional 21st century skills identified by the survey respondents included collaboration, persistence, perseverance and grit, patience, confidence, leadership, and respect for other people and property.

As far as differences in the skills gained from participating in on-campus versus off-campus after school STEM programs, it depends on the number of students within the program. With learning environments like Code Ninjas, there are several tutors available to assist students, in addition to the Center Director, who oftentimes has a background in education. If there is a small group of students in an on-campus program with a low

student to teacher ratio, the benefits may be comparable to an off-campus after-school STEM program. However, the curriculum would need to be built or taught in such a way that it is educational while also being fun for the students. As stated in Anderson's study, game-based learning creates "engaging and immersive experiences for learning that focus on delivering specific learning goals, outcomes, and experiences" (2008, p. 7). The video game aspect of learning at Code Ninjas makes the curriculum entertaining for students, along with the camaraderie they experience working together with their peers.

There was a recurring theme in all the open-ended survey responses – that there are consequences of children not being adequately prepared in science, technology, engineering, or mathematics subjects, and how extracurricular STEM education can fill that void. Durlak and Weissberg's 2007 study found evidence that where and how students spend their time outside of school "has important implications for their development" (p. 10). Formal after-school programs like Code Ninjas provide a safe and supportive environment for students to engage in activities that are beneficial to their skill development. This aligns with Baran et al.'s out-of-school STEM education study based in Turkey that stated after school STEM clubs are designed "to increase students' interest and attitudes… towards STEM" subjects (2016, p. 9).

Even though this study's purpose was to investigate the positive impact that these learning topics and environments could have on educational and personal development, it was expected that the results could also discover perceived negatives of increased technology use as well. However, most of the participants were optimistic about the use of technology to prepare kids for the future and provide access to curriculum. Anderson's 2008 study supports this notion by acknowledging that technology could "provide opportunities for innovative approaches when applied to the classroom environment" (p. 5).

Limitations

Limitations of this study include a lower-than-expected response rate resulting in a small sample size. For future studies, responses to the survey could be analyzed based on the phase of development each franchise location is in. This could be accomplished by adding an additional question to the survey asking how long the location has been open.

For this thesis, the focus was on the gap in available STEM education in American public schools, so locations in the United Kingdom and Canada were excluded from the study due to differences in education systems. It would be beneficial to conduct similar studies in other countries to determine if this problem is isolated to the U.S. and if other countries place more importance on providing science, technology, engineering, and mathematics resources for children.

Though the intent of this research study was separate from the corporate office for Code Ninjas, some owners may have been less inclined to answer because the researcher was employed by the corporate office at the time the survey was distributed. In an attempt to mitigate this concern, it was conveyed in the email asking for participation, the informed consent document, and in disclaimers on the survey itself that their privacy was of utmost importance. However, the number of responses to the survey may have increased had an external person asked for franchisee participation.

Recommendations for Future Research

From the section of the survey that allowed Code Ninjas staff to provide any additional information for the study, one Owner brought up an important point about the need to include more Black students in coding or STEM programs. The research on STEM programs could greatly benefit from future studies focused in this area. It would be interesting to determine the causal relationship behind why more Black students are not involved in STEM learning. Is there a lack of after-school programs available in

communities? Are programs targeting other ethnicities as their customer base? Can Black-owned after-school programs positively influence the enrollment numbers for Black students? Or is there simply less representation of Black students in STEM and coding? And lastly, what would drive more enrollments or what is the best solution for spreading the word about after-school STEM learning?

Another area that would benefit from focus in future studies is the impact of STEM learning for skill development in neurodivergent individuals. In the additional information section of the survey, a participant noted the improvement of social skills through Code Ninjas for students on the autism spectrum. Valencia et al. state that "most people with autism show a natural affinity for technology and a good disposition for using technology and learning through the use of computers" (2019, p7). In general, more inclusion is necessary to equip young people with important life skills for their future; however, the social aspect of programs like Code Ninjas can be life changing for students on the autism spectrum. After-school STEM learning can provide an opportunity to practice socialization and connect with peers about topics they enjoy in a safe, encouraging, and structured environment.

Conclusion

In some ways, the coding skills students learn at Code Ninjas are secondary to other life skills, such as communication and collaboration, that they gain through the program. That is why the Code Ninjas' framework is important – business owners and their staff are encouraged to promote the social aspects of their programs, not just STEM and coding skills. Parents bring their children to programs like Code Ninjas because it is more fun to learn with peers than to complete assignments on their own at home. Students want to continue with the Code Ninjas curriculum because of the sense of

community they experience within the center, and the generalization of other skills besides coding is a plus.

Hopefully, this study can help to extend existing knowledge about STEM for K-12 students – in general and in after-school settings – and influence the development of more kid-focused STEM activities. Additionally, this study may add to the subject of after-school program effectiveness for future research regarding student development and increase the percentage of families who enroll their children in after-school STEM learning.

As one participant stated, "coding is the literacy of now" and the American school system is not providing that push for knowledge as has been the case for English and Mathematics in the past. By evaluating all of the benefits for children's development with participation in STEM learning- including 21st century skills like grit, determination, critical thinking, and teamwork - the U.S. can hopefully begin to bridge the gap between the number of students interested in these subjects and the increasing number of technology-focused jobs available for the future.

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APPENDIX A:

SURVEY PARTICIPATION EMAIL

Hi All,

I am reaching out to ask for your participation in a research study to obtain my Master of Science in Instructional Design and Technology at the University of Houston – Clear Lake.

The title of my thesis is *After-School STEM Programs and the Impact on 21st Century Skill Development*. In this study, I will be exploring how Code Ninjas contributes to students' skill development beyond the technical aptitudes regularly associated with participation in STEM and computer science activities.

I assure you that my research is entirely separate from Home Office, and your privacy is of utmost importance to me. If you are interested in participating, please see this **Informed Informational Document About Research** to read the consent statements and learn more about this study.

After reading the Informed Informational Document, you can access the research survey here: Code Ninjas' Impact on 21st Century Skill Development (linked). This survey will be open for your responses for two weeks until Friday, March 26, 2021.

Note that your responses are not limited to this survey. You are more than welcome to reach out to me directly with additional information you wish to provide. I am also happy to answer any questions you may have about this study.

Thank you for your time and consideration.

Best regards,

Sara Katherine Dees

APPENDIX B:

CODE NINJAS' IMPACT ON 21ST CENTURY SKILL DEVELOPMENT SURVEY

The purpose of this study is to evaluate whether Code Ninjas contributes to students' skill development beyond the technical aptitudes regularly associated with participation in STEM and computer science activities.

INFORMED CONSENT: Your voluntary participation in this research project is indicated by completing the survey online, and you may cease your participation at any time by closing your browser. Such participation does not release the investigator(s), institution(s), sponsor(s) or granting agency(ies) from their professional and ethical responsibility to you.

PRIVACY NOTICE: Please note that your email and location name will be recorded for the sole purpose of potential follow-up questions pertaining to this research study. Your name, student names, and any other identifying information will not be included in the research findings. Your individual responses will not be shared with the Home Office team outside of what findings are included in the published thesis.

Consent and Privacy Notices

Q1 I have read and agree to the informed consent and privacy notices. (Required)

Δ Yes

Δ No

Location and Role

Q2 Please enter your Code Ninjas location name. (Required)

Q3 Select your role: (Required)

Δ Owner

Δ Center Director

Δ Both an Owner and Center Director

Social Skills

Q4 How likely are ninjas to improve the following social skills by being enrolled at Code Ninjas? (Required)

	Very Unlikely	Somewhat Unlikely	Neutral	Somewhat Likely	Very Likely
Listening	Δ	Δ	Δ	Δ	Δ
Sharing	Δ	Δ	Δ	Δ	Δ
Communicating with others	Δ	Δ	Δ	Δ	Δ
Following directions	Δ	Δ	Δ	Δ	Δ
Teamwork	Δ	Δ	Δ	Δ	Δ
Motivation	Δ	Δ	Δ	Δ	Δ
Commitment	Δ	Δ	Δ	Δ	Δ

Q5 Use the space below to expand on your responses to any of the social skills included in the previous question. (Optional)

Q6 Have you observed additional social skills at your location that were not included above? If so, please elaborate below. (Optional)

Q7 Please provide an example of meaningful social interaction within your Code Ninjas location. (Optional)

Creative Thinking Skills

Q8 How likely are ninjas to improve the following creative thinking skills by being enrolled at Code Ninjas? (Required)

	Very Unlikely	Somewhat Unlikely	Neutral	Somewhat Likely	Very Likely
Problem solving	Δ	Δ	Δ	Δ	Δ
Analyzing information	Δ	Δ	Δ	Δ	Δ
Organization	Δ	Δ	Δ	Δ	Δ
Creativity	Δ	Δ	Δ	Δ	Δ
Brainstorming	Δ	Δ	Δ	Δ	Δ
Curiosity	Δ	Δ	Δ	Δ	Δ
Imagination	Δ	Δ	Δ	Δ	Δ

Q9 Use the space below to expand on your responses to any of the creative thinking skills included in the previous question. (Optional)

Q10 Have you observed additional creative thinking skills at your location that are not included above? If so, please elaborate below. (Optional)

Q11 Please provide an example of significant creative thinking within your Code Ninjas location. (Optional)

Other Information

Q12 Any other information you would like to provide? (Optional)

Q13 If needed, are you open to answering potential follow-up questions? (Required)

- Δ Yes
- Δ No

APPENDIX C:

DEFINITION OF TERMS

Backgrounds: The part of a video game that lies behind objects in the foreground, often designed by the game builder themselves using digital art tools.

Coding: Also known as computer programing, coding is the process of designing and building step-by-step instructions for a computer program to perform a task.

Game Building: Also known as video game development, game building is the process of designing an interactive simulation for players to engage in a story to solve a perceived problem. Art and audio are used to enhance the experience for users.

Likert Scale: Research scale used to rate responses to a statement in a questionnaire. Typically on a 5-point scale, the responses are: Strongly Disagree, Disagree, Neutral, Agree, or Strongly Agree.

Sprites: A sprite is a computer graphic that is used in a video game's scene, often synonymous with the player in the game.