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# Examining Participation and Outcomes Among Middle School Students in a Virtual Camp on Coding with Music

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**Abstract:** Attracting students to computing is crucial for advancing the development of new skills and fostering positive attitudes toward the field, especially among females and minoritized populations. One promising approach involves integrating computing with artistic activities, such as music. This study examines how learner's prior experiences influence their participation in a virtual summer camp on coding with music. The study also examines how participation in the camp influences participants' attitudes about computing, with an eye toward gender differences. Data were collected through participant surveys (*N*=73) and focus groups (*N*=48). Findings suggest that parents' and guardians' involvement is crucial for participation and integrating coding with artistic work holds promise for attracting students to the field. Findings can inform possible paths to engaging students in computing.

## Introduction

Our society recognizes the growing importance of teaching computing due to its impact on the job market and its capacity to develop skills such as problem-solving and creativity (Ching et al., 2018; Rao, 2017). Nonetheless, there are challenges in attracting student interest because learning computing can be perceived as difficult, unengaging, and a domain only suitable for the stereotypical vision of computer scientists (Robins, 2019). This is a critical challenge because student confidence is related to their motivation to achieve goals (Petrie, 2022), and positive attitudes toward computing are associated with better learning outcomes (Israel et al., 2015). Beyond that, the perceptions that students form from an early age influence their future and academic decisions, including their willingness to be part of the computing discipline (Tai et al., 2006). Those challenges are especially and largely faced by minoritized students who lack adequate access to resources needed to learn those skills and break down stereotypical images of who belongs in computing (Means & Stephens, 2021; Song et al., 2023).

A promising approach with potential to shift student attitudes toward computing is teaching programming through artistic endeavors (Freeman et al., 2014). This approach empowers learners to express themselves creatively, forming connections between their learning and their individual and cultural backgrounds, encompassing aspects like gender, race, and ethnicity (Freeman et al., 2014). Music has been proposed as a promising avenue because it shares similarities with programming--both rely on notation within a language and necessitate the development of concepts such as repetition and sequencing (Bell & Bell, 2018). Further, an emphasis on music can potentially shift focus away from jobs and toward intrinsic motivation for engaging with computing (Petrie, 2019). Nevertheless, further research is needed to explore the distinct advantages of teaching programming through music, particularly in relation to individual software affordances.

This paper examines one approach to teaching programming with music through an out-of-school program for middle-school students called *Code Beats*, which consisted of a 2-week summer camp conducted fully online during the COVID-19 pandemic. The program draws on culturally responsive computing (CRC) frameworks (Scott et al., 2015), which center computer science (CS) learning on students' experiences, identities, and cultures. CRC has the potential to promote authentic learning, increase relevance, and foster a sense of belonging by promoting identity development and positioning learners as creative users of technology (Madkins et al., 2020). In earlier work (Lusa Krug et al., 2021), we found that participating students exhibited positive changes in their attitudes and beliefs toward computing following their participation in camp activities. Nonetheless, prior work did not examine the motivation and experiences of students attending the camp and potential gender differences. Further, prior work demonstrated some technical challenges associated with Sonic Pi, the software used in the camp. Subsequently, we have modified camp activities for implementation using a software geared toward novice programmers, called *TunePad*, which allows users to interact with sounds and compose music using programming (Horn et al., 2022).

Building on our prior work, the aim of this research is twofold; first, we examine the motivation and prior experiences of students choosing to attend *Code Beats*. Second, we investigate the extent to which the camp influenced participants' perceptions about computing, with an eye toward gender differences. Specifically, three questions guide the work: (1) How did participants' prior experiences with coding and music motivate participation in the camp? (2) In what ways did participants engage with summer camp activities? and (3) How has participation in *Code Beats* influenced participants' attitudes about programming?

## The importance of teaching programming

While a considerable amount of literature has been published on the importance of teaching programming for the workplace, a growing body of literature provides evidence on the benefits of learning programming for developing cognitive abilities (Ching et al., 2018). Ching et al. (2018) argue that working on computing tasks enhances cognitive skills related to problem-solving, creativity, and reflection, while also improving domain knowledge in other subjects (e.g., math). Further, Melro et al. (2023) identified additional skills gained through programming, such as collaboration, participation, and communication. As a result, world-wide efforts are under way to include programming in official school curricula starting from the early grades (Tikva & Tambouris, 2021). A focus on early grades is critical since it is during the adolescent years that students begin to form opinions and ideas that will later impact their decisions to pursue computing in high school and tertiary education (Petrie, 2022). Beyond exposure, student beliefs are also critical in their decision to further pursue interests in computing. Students' perceived usefulness and difficulty as well as confidence in their own abilities, is likely to determine their motivation to achieve goals while learning (Lavy, 2021; Petrie, 2022). Consequently, exposing students to CS from early age can influence their identities, beliefs, and attitudes toward the discipline (Song et al., 2023).

While efforts to integrate programming in school curricula are critical, it is important to also recognize the potential of informal out-of-school programs (Means & Stephens, 2021). Informal programs can connect learners with role models in STEM areas, involve them in communities of practice, and foster a sense of belonging (Means & Stephens, 2021). However, out-of-school programs promoted by community-based organizations, libraries, and museums are just beginning to shift their focus toward CS (e.g., Means & Stephens, 2021). The limited availability of out-of-school programs can present an even greater challenge for minoritized communities. Means and Stephens (2021) argue that affluent families tend to invest more in out-of-school learning opportunities than those from more vulnerable socioeconomic backgrounds. Even when organizations aim to provide inclusive programs, they encounter different challenges during the implementation. Those include scheduling difficulties due to the work schedules of parents or guardians, transportation, need for cultural adaptations, and availability of technology resources (Means & Stephens, 2021).

### Programming with music

To address challenges related to students' beliefs, attitudes, and perceptions around computing, the literature has proposed incorporating computing into other domains (e.g., music), as a way of attracting new learners (Lusa Krug et al., 2021). Bringing creative and artistic work into computing can engage students by allowing them to express themselves and generate learning experiences that are appealing to their ethnic background, including race, gender, as well as cultural and economic background (Freeman et al., 2014). This approach has the potential to foster engagement, and therefore, help overcome barriers associated with negative attitudes and perceptions around computing.

Among artistic disciplines, music has received special attention because of its similarities with programming. Bell and Bell (2018) noted that both music and programming use notation within a language and are based upon fundamental CS concepts (e.g., repetition). Moreover, music is widely enjoyed across different ages and plays a significant role in social interactions, which could be highly beneficial for learning introductory programming concepts (Song et al., 2023). Therefore, various initiatives have proposed teaching music with programming, often utilizing software such as Jython Music (Bill et al., 2016), EarSketch (Magerko et al., 2016), TunePad (Horn et al., 2022), and Sonic Pi (Aaron et al., 2016) with growing evidence that this approach can improve attitudes and perceptions toward computing (e.g., Lusa Krug et al., 2021).

## Code beats virtual camp

Previously, we piloted the camp curriculum using the professional software Sonic Pi (Lusa Krug et al., 2021). Results from this work indicated positive outcomes in participants' attitudes toward computing, but also demonstrated some technical challenges associated with the choice of software. Following this effort, we have redesigned camp activities shifting from Sonic Pi to TunePad. From a technical perspective, TunePad shares similarities with Sonic Pi, but is browser-based. Since it doesn't require installation, it is accessible to different types of devices used in school and out-of-school settings (Horn et al., 2022). Additionally, there are important differences in how code is organized and synchronized across the two software. Sonic Pi has a code editor for all codes stacking line by line, decomposing into threads, and playing at once. TunePad uses multiple blocks that each consist of an interactive graphical instrument and a code editor. These blocks can be played individually or together, mimicking different music tracks. This block style has advantages compared to the traditional all-together code editor in Sonic Pi (Horn et al., 2022). First, it organizes code segments around instruments and keeps code short and manageable, which is appropriate for students new to programming. Second, it creates a natural form of parallel execution with code segments, while Sonic Pi executes each line of code simultaneously and is counterintuitive to traditional programming (Petrie, 2019). Parallelism is a CS concept primarily introduced to non-novice learners in a later study due to its complexity (Aaron & Blackwell, 2013). Exposing learners through music tracks in the early stage could introduce this concept more naturally.

**Table 1**
*Programming and Musical Concepts during the Camp*

| Class | Programming Concepts | Musical Concepts | TunePad command examples |
|---|---|---|---|
| Class 1 | Sequencing | Melody | playNote(60) |
| Class 2 | Constant<br>Variable | Melody | C = 60<br>playNote(C) |
| Class 3 | Functions (single parameter) | Rhythm | #parameter beats<br>playNote(C)<br>#parameter length<br>rest(1) |
| Class 4 | Functions (multiple parameters) | Rhythm and Melody | #parameter (beats, velocity, sustain)<br>playNote(C, velocity = 20, sustain = 2) |
| Class 5 | Lists | Chords | D_maj7 = [38, 42, 45, 49]<br>playNote(D_maj7) |
| Class 6 | Repetitions (numeric control) | Rhythm | for i in range(4):<br>    playNote(C) |
| Class 7 | Repetitions (list iteration) | Harmony | for note in chord:<br>    playNote(note) |
| Class 8 | Repetitions (nested lists) | Chord progression | D_maj7 = [38, 42, 45, 49]<br>G_maj7 = [43, 47, 50, 54]<br>chords = [D_maj7, G_maj7]<br>for ch in chords:<br>    for i in range(4):<br>        playNote(ch, 2) |
| Class 9 | Modularization;<br>Parallelization | Orchestration | using multiple tracks |
| Class 10 | Modularization;<br>Parallelization | Orchestration | using multiple tracks |

Our team designed the curriculum for the 2-week summer camp, but in response to COVID-19, we formulated it for online delivery. Each day of the camp consisted of a 1-hour online streamed learning session utilizing the YouTube platform. The live-streamed learning session included several activities, including an introduction to computing concepts delivered by computer scientists, music theory concepts delivered by a music education expert, a worked music coding example in TunePad with live coding, highly scaffolded in-class coding activities, and a quiz competition (see Table 1). Our scaffolded in-class coding activities included three different forms: (a) complete the code, (b) debug buggy code, and (c) Parsons Problems. After each live session, we provided an after-class music programming assignment to reinforce the music and coding concepts introduced on that day. The assignment provided initial code sequences and task instructions. All assignments were open-ended, allowing participants to create and express their own ideas. On Class 9 and Class 10, the after-class assignments were capstone project competitions, where we provided three sketches for participants to choose from as their initial code. Participants needed to add at least one original music track to create their own music project.

In addition to the structured live session, we also held office hours (1-hour) after each live streaming session which provided individual help toward assignment completion. The office hour was delivered by computer scientists as well as high school interns trained by our team. The participants were also strongly encouraged to upload their music coding products each day for review. A culminating event, the *Battle of the Beats* competition, was held in person with over 200 people in attendance. An album was created with the top ten student beats (selected through audience participation), in collaboration with a Grammy award-winning artist.

## Participants

We utilized a flier, which we distributed to school districts in the investigators' states, as well as various community organizations. In total, 314 students completed the registration form. Of those, 132 students agreed to participate in the research. We refer to the 132 students who signed the consent form as the participants. Due to the number of participants, we offered two instantiations of the 2-week camp, one in the morning (Camp A) and one in the afternoon (Camp B). Participants chose their preferred time slots based on their availability.

The population for Camp A (N=82) was, on average, 11.7 years old (min: 9 - max: 14), and was 43.8% female, 50.7% male, and 5.5% prefer not to say. The self-declared race distribution was 28.8% African-American; 19.2% Asian; 2.7% Hispanic; 6.8% Multiracial, not Hispanic; 2.7% Other; 4.1% Prefer not to say; and 35.6% White. The population for Camp B (N=50) was, on average, 11.9 years old (min: 7 - max: 15), and was 34% female, 64% male, and 2% prefer not to say. The self-declared race distribution was 24% African-American; 14% Asian; 8% Hispanic; 6% Multiracial, not Hispanic; 10% Other; 6% Prefer not to say; and 32% White.

## Methods

A mixed methods approach which combined pre- and post-surveys and focus groups was utilized.

### Data collection

A pre-post survey was distributed to all participants using Qualtrics. If participants submitted at least one in-class activity, we could match their usernames with the pre-camp survey, which collected demographic information. The pre-camp survey included 6 demographic items and 7 items about participants' backgrounds and interests. It also included 26 items related to (a) participants' confidence, interests, and sense of belonging in computing; (b) attitudes toward gender equity in computing; and (c) future intentions to engage in computing. These items were adapted from prior instruments (Bruckman et al., 2009) and each was rated on a 5-point likert-scale. Likert-scale items appeared again on the post-camp student survey. Cronbach's alpha was calculated for each scale and for the whole survey. Both the pre and post survey demonstrated acceptable alpha levels indicating internal consistency. Only data from students with active parent/guardian consent are included in this report. We matched pre-post surveys based on participants' unique usernames. A total of 163 students completed the pre-survey and a total of 81 students completed the post-survey. When matched, we recorded a complete set of 73 pre-post surveys.

Data were also collected through focus groups with a subset of participants. All focus groups were held on Zoom immediately following the last session of each camp. Participants were invited to participate if they (a) had parent/guardian consent, (b) had submitted a pre-camp survey, (c) could be reached by email, and (d) had submitted an exit ticket on Day 3 of the camp. Exit tickets were used as a measure of attendance. For camp A, 51 invitations were sent, and 28 students attended the focus group (54.9% response rate). For camp B, 34 invitations were sent, and 20 students attended the focus group (58.8% response rate). The focus group protocol included 11 questions that probed students' reasons for attending the camp and prior experiences with music and/or coding, their response to the camp and the music used within it, what they liked most about *Code Beats,* and suggestions for improvement. Participants were also asked to describe their interactions with camp staff and peers and share anything that surprised them or that they felt proud of regarding *Code Beats*. All focus groups were recorded and transcribed for analysis.

### Data analysis

Descriptive statistics were generated for all the questions of the pre and post-test survey. Those include means, standard deviation, media, minimum, maximum, range, skew, and kurtosis. Each of the questions were later grouped by categories related to attitudes and perceptions. These categories and the number of questions associated with them included: computing confidence (4), computer enjoyment (5), perceived usefulness (4), motivation to succeed (3), identity and belonging (3), intent to persist (4), and (5) attitudes toward gender equity. Once grouped, descriptive statistics such as mean and standard deviation were calculated for each category. After that, a paired t-test was conducted to determine if there was a significant difference between both measurements, before and after participation in the camp. This test assumes an $\alpha$ of 0.05.

Analysis of the focus group data included several steps. First, data were cleaned and organized into a matrix, including 45 participants who could be identified and their answers to each focus group question, if applicable. (Not all students addressed all questions). Second, responses to each question were reviewed and thematic codes were developed using structural coding aligned with the research questions (Saldaña, 2021). For selected questions, coded data were then quantified to determine the "weight" of each theme within the overall data pool. Finally, focus group data were used to expand upon key findings from the survey data.

## Findings

### Prior experiences and motivation for participation in the camp

Survey and interview data indicated that prior experience in music and coding, coupled with encouragement from guardians and parents were decisive factors for participation. The pre-test survey asked participants to indicate the reason they joined the camp. The three most noted reasons included: "My parent or guardian recommended it" (69.9%), "I am interested in computing" (51.5%), and "I am interested in music" (44.2%) (see Table 2).

The focus groups contained questions related to participants prior experiences with music and coding. Since some of them joined the focus groups late or did not address these questions, 37 out of 45 participants are included here. Of those, 91.9% (34 out of 37) noted having previous experience with music by hearing it, taking lessons, participating in orchestra, etc. Those experiences were formal and informal, as one participant noted "*Well, for starters, I'm a break dancer, so I had to dance to a lot of music and then I write a lot of song lyrics, mostly rap music. And I guess, my mom has gone over some piano lessons with me. And I also made beats from other websites before.*" Another participant indicated how their previous knowledge of some instruments led them to learn music from another approach: *"I also wanted to join because I played the drums, and I sang, and I do a little bit of piano. I thought it'd be good to learn about music, but not just with an instrument, with computers".*

Of the 37 participants, 29 (78.4%) indicated having prior experience with coding through structured classes, camps, or projects as highlighted by this participant "*I've done a lot of coding in the past. At school…during lunch times, we would get to go into the computer lab and do different coding projects…*". Other participants, shared prior experiences of learning coding independently, as noted by one participant: *"My Dad is a computer scientist. He teaches and he found a site that I've really liked to use ever since I was seven years old and it's called Code.org. And that's my experience with coding. I love making code in that site."*

**Table 2**
*Reasons for Attending the Camp*

| Reason | Frequency | Percentage |
|---|---|---|
| My parent or guardian recommended it | 114 | 69.9 |
| I am interested in computing | 84 | 51.5 |
| I am interested in music | 72 | 44.2 |
| The camp sounded fun | 60 | 36.8 |
| I am interested in performing | 30 | 18.4 |
| An adult at school recommended it | 5 | 3.1 |
| My friends at school were doing it | 3 | 1.8 |
| Other reasons | 14 | 8.6 |

### Engagement with camp activities

As noted, the camp featured several components, including a daily live session streamed on YouTube Live, independent activities, an optional hour-long Zoom help session, and the opportunity to independently create beats. On the post-camp survey, participants were asked how many of the live and help sessions they had attended and how much time they spent on independent work. Responses are in Tables 3 and 4.

**Table 3**
*Live and Help Sessions Attended*

| | Live sessions | | Help sessions | |
|---|---|---|---|---|
| | Number | Percentage | Number | Percentage |
| 0-2 | 6 | 7.4 | 73 | 90.1 |
| 3-5 | 2 | 2.5 | 2 | 2.5 |
| 6-8 | 10 | 12.3 | 1 | 1.2 |
| 9-10 | 63 | 77.8 | 5 | 6.2 |

In focus groups, some participants elaborated on how much time they spent on camp activities outside of the live sessions, and why. One student noted: *"[I] did the assignments right after class and it took about five* *minutes… it was easy because of [my] experience.”* Another student, however, noted: *“No [I never attended the Zoom sessions], because I never really desired to get deep into it. Like I said, this was an interesting concept, I enjoyed the idea. Just, it never went too deep…. And at the end it was like, ‘You don't have to participate if you don't want to.’ I don't want this to be like school.”*

**Table 4**
*Self-reported After-class Time Spent Daily*

| Amount of independent work time daily | Number | Percentage |
|---|---|---|
| Almost none | 5 | 6.2 |
| Less than 15 minutes | 16 | 19.8 |
| 15 – 30 minutes | 36 | 44.4 |
| 30 – 45 minutes | 10 | 12.3 |
| 45 – 60 minutes | 5 | 6.2 |
| More than 60 minutes | 9 | 11.1 |

## Attitudes toward computing

Based on the t-test statistics and p-value of the analysis conducted on pre and post-test questions related to attitudes toward computing, the findings do not indicate any significant changes in attitudes after the program (see Table 5). Only the computing confidence category shows a marginal effect with a moderately substantial difference with a p-value below 0.10 and close to 0.05.

**Table 5**
*Values of Pre-test, Post-test, T-statistics, and P-values for Each Category*

| Category | Pre-test Mean | Post-test Mean | t | p |
|---|---|---|---|---|
| Computing confidence | 3.48 | 3.80 | -1.82 | 0.07 |
| Computer enjoyment | 4.41 | 4.41 | -0.05 | 0.96 |
| Perceived usefulness | 4.51 | 4.46 | 0.43 | 0.66 |
| Motivation to succeed | 3.72 | 3.85 | -0.88 | 0.37 |
| Identity and belonging | 3.61 | 3.80 | -0.49 | 0.23 |
| Intent to persist | 3.43 | 3.52 | -0.41 | 0.69 |
| Attitudes Toward Gender Equity | 4.78 | 4.75 | 0.21 | 0.84 |

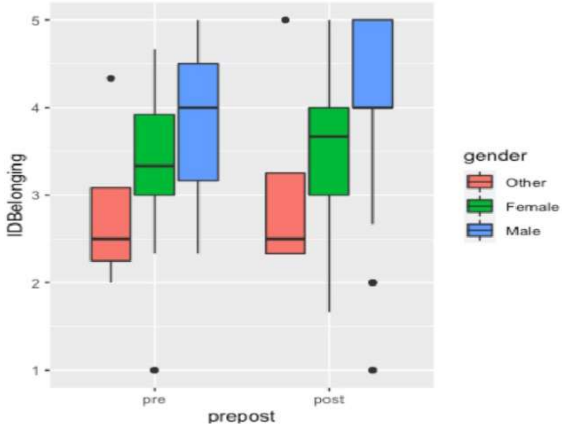
We observed that there are no significant differences in gender between pre/post-test, indicating that gender remains stable before and after the camp. We consequently ran a two-way analysis of variance (ANOVA) tests between gender and other scales to explore their relationships. We found that the Identity and belonging scale had a main effect on gender ($F = 7.86$, $p < 0.05$), but no main effect on pre/post-test. A post-hoc test, Tukey’s test, revealed that the male participants scored higher on the Identity and belonging test than female participants ($diff = 0.48$, $p < 0.05$). The difference can be seen in Figure 1.

Findings from focus groups indicated that participants found coding with beats enjoyable and meaningful (46.5%). As one participant characteristically noted, *“I thought it was really cool getting a problem and it would be hard to solve it. And then after a little bit of struggling, you finally accomplished it. You…feel really good..”* Other participants described specific coding skills they enjoyed, such as chords, variables, and debugging: *“…having to stay on one code for a couple of hours because I messed up, because I spelled something wrong during the code. So I kept changing everything and I realized, oh, I spelled this wrong...it brought me joy when I realized that I spelled that wrong.”* Similarly, other participants expressed the satisfaction they experienced from learning new skills as well as pride in their learning and the work they completed during the camp. One participant noted, *“I definitely feel like I learned a lot about coding with TunePad, and I definitely think I’ll use it in the future cause it’s fun.” Finally,* one participant described her joy in sharing work with others: *“I like showing the beats that I just made for fun to my friends... I would let them listen, like the one I entered into the competition. They helped me name it.”*

Discussing their future plans, the majority of participants indicated their intention to persist with some aspect of the camp (i.e., coding and/or music). Participants noted a variety of alternatives to continuing with computing such as taking classes in school, learning by themselves, or participating again in *Code Beats*. One participant noted: *“I’m taking computer science for seventh grade.”* while another participant noted, *“Probably going to do more coding by [my]self...”.* Finally, a third participant explained their interest in specifically combining programming with music: *“So mostly coding, but also along the lines of more instruments. Like* *lessons... I think I want to be better at guitar and play some piano... it seemed like there's so much to learn about coding and also music, there's different types. You can get better and it looks cool."*

**Figure 1**

*Results for Tukey's test on gender and Identity and Belonging*




## Discussion and conclusion

Findings indicated that parents and guardians played an important role in motivating participation in the camp. Most participants indicated that their parents or guardians recommended it or signed them up. This finding is consistent with prior literature identifying the critical role of parents in choosing informal computing activities for their children and their willingness to support CS education (Crowley & Jacobs, 2002). It also points to the need for cultivating strong relations with parents. Toward this end, the live competition held to celebrate students' work, was open to both students and families. Further, findings indicated that prior experiences with either music or coding also played a role in student motivation to attend. While existing literature already indicates that prior computing experiences may motivate students to learn more programming (e.g., Witherspoon et al., 2016), findings indicate that the integration of computing in creative arts has the potential to attract students with interests outside of programming alone. Findings also indicated that overall students engaged with camp activities. The majority of participants attended all live sessions and spent at least 15-45 minutes completing independent work. Most participants, however, did not attend the individual help sessions. One potential explanation is that students may have perceived these sessions as necessary only if they required support. Another explanation is that given the informal nature of the camp, there was no accountability or grades and students did not feel pressure to attend.

Finally, findings indicated mixed results when considering shifts in participants' attitudes toward computing. Specifically, quantitative data suggest that participants' perceptions remained largely unchanged with no statistically significant variations observed. However, qualitative data provide evidence of positive attitudes experienced during the camp and future intentions of continuing with related activities. Findings indicated that students entered the camp with strong attitudes toward enjoyment and perceived usefulness leaving little room for growth. Other areas scored lower, yet the online delivery of the camp may have impacted outcomes. For instance, limited opportunities to work with peers and interact with instructors in person may have contributed to limited shifts in participants' motivation and identity development. The focus groups revealed positive attitudes and learning gains among participants after completing the camp, demonstrating how the experience influenced future decisions to get involved in computing activities. We recognize, however, that since participants volunteered to attend the focus groups, they were potentially more likely to have stronger positive feelings about the camp. Importantly, with the exception of Identity and belonging, findings did not reveal gender differences before or after the camp. This finding is important because gender gaps in programming involvement tend to persist (Witherspoon et al., 2016). This finding indicates the potential of *Code Beats* to support continuous interest and involvement among all students, independent of gender.

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