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BOARD # 382: Integrating Music and Flow-Based Programming Builds Teachers' Confidence in Computer Science. An ITEST program.

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A NSF ITEST Program: Integrating Music and Flow-Based Programming Builds Teachers' Confidence in Computer Science

1 Introduction

In recent years, computer science (CS) education has become a critical component of K-12 curricula, aimed at equipping students with essential 21st-century skills such as problem-solving, critical thinking, and creativity [1]. As this field evolves, educators are increasingly exploring approaches to make CS education more engaging and relevant by incorporating the arts [2]. Among these approaches, integrating music into programming has gained significant attention for its potential to foster creativity and engagement. Music not only enhances the appeal of coding for students but also enables them to express their musical ideas in transformative ways that go beyond traditional performances [3]. Flow-based programming offers a particularly accessible and intuitive entry point for integrating programming with music [4]. Its user-friendly design aligns seamlessly with the structure of music, allowing students to compose, organize, and manipulate sounds in an interactive environment [5]. However, the success of such interdisciplinary approaches hinges on teachers, who serve as the primary facilitators of these innovative practices in the classroom. Teachers' confidence, attitudes, and willingness to adopt new CS tools significantly impact the effectiveness of these methods and, ultimately, student outcomes [6]. For educators with limited or no prior experience in CS, professional development is crucial to building the necessary skills and confidence to integrate such tools effectively [7]. Recognizing this need, our study explored how flow-based music programming environments influence teachers' confidence and attitudes toward CS education.

The study involved ten elementary school teachers participating in a six-hour, in-person workshop focused on M-flow, a flow-based programming platform designed for creating music and organizing sounds. The workshop provided a hands-on curriculum that combined practical programming exercises with strategies for classroom integration. Our findings revealed significant growth across three key dimensions: self-efficacy, interest, and attitudes. These findings underscore the transformative potential of flow-based music programming in empowering teachers to embrace CS education. By enhancing their confidence, interest, and attitudes, this approach supports the integration of CS into classrooms, broadening students' exposure to creative and technical opportunities. This work, funded by the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST) program, contributes to the growing body of research on interdisciplinary CS education and highlights the critical role of teacher development in driving educational innovation.

2 Methods

2.1 Mflow and aligned curriculum

M-flow is a flow-based music programming environment that allows users to create sounds by dragging blocks onto a canvas. For example, users can record sounds, trigger drum blocks, create loops, use keyboard strokes, introduce randomness, set alarms, and share their creations. M-flow is free and publicly available[1]. Other platforms like EarSketch [8] and TunePad [9] can also effectively engage children in music programming. However, these platforms have primarily been used with older students and often require educators with expertise in both music and programming [10]. Flow-based programming presents an alternative that overcomes these limitations. It is designed to be accessible to younger learners and feasible for implementation by teachers without specialized training. For a more thorough description of Mflow and its curriculum, see Mflow website[2].

2.2 Workshop design and implementation

The workshop was six hours long, and was guided by an expert, Dr. Victor Minces. There were 10 teacher participants, with an average class size of 25 students, plus the district's science coordinator. Generally, the teachers had little or no experience teaching programming. The curriculum consists of 10 lessons, in which students learn Mflow in consecutive rounds of free exploration, guided exploration, and discussion. In the workshop, teachers experienced the curriculum as students, after which they discussed their thoughts and how they would implement it in their classrooms.

2.3 Measurements and data collection

Pre- and post-workshop surveys were conducted to investigate the impact of flow-based music programming environments on teachers' self-efficacy, interest, and attitudes toward teaching programming. Table 1 outlines the specific survey questions, all rated on a five-point Likert scale. For example, the post-survey #1 has "Much more confident/more Confident/Equally confident/Less confident/Much less confident". The pre-workshop survey established a baseline of participants' confidence, interest in programming, and perspectives on teaching programming, while the post-workshop survey assessed changes in these areas, focusing on shifts in confidence, interest, and perceptions following the workshop.

3 Results

As shown in Table 2, the pre-survey results indicate that for question #1, the mean score is significantly lower than the neutral midpoint value of 3 on a five-point Likert scale ($p < 0.01$). In contrast, for question #2, the mean score showed no significant difference compared to the neutral value. Post-workshop, the results for the corresponding post-survey questions revealed a notable increase in confidence. For post-survey questions #1, #2, and #3, the mean scores were all above

[1] https://mflow.sciencemusic.org/
[2] https://listeningtowaves.com/mflow

Table 1: Survey questions

Phase	No.	Category	Question Item
Pre	1	Self-efficacy	How confident do you feel about teaching programming?
	2		How confident do you feel about addressing the issues you might encounter while learning programming?
	3		How effective do you think your teaching of programming has been?
	4		How confident do you feel about solving the problems students encounter while learning programming?
	5	Interest	Are you interested in learning and understanding programming?
	6		Are you interested in improving and innovating programming teaching methods?
	7	Attitude	How important do you think computer science or programming education is for yourself as a teacher?
	8		How much do you agree with the following statement: "Learning computer science or programming can benefit my professional development?"
Post	1	Self-efficacy	After this workshop, do you feel more confident in teaching programming courses?
	2		After this workshop, do you feel more confident in addressing the issues students might encounter while learning programming?
	3		After this workshop, do you feel more confident in learning new programming concepts on your own?
	4	Interest	After this workshop, has your interest in learning more about programming increased?
	5		After this workshop, are you more interested in integrating programming into your teaching practices?
	6		After this workshop, are you more willing to participate in further training or workshops on computer science or programming?
	7	Attitude	After this workshop, I view programming education as more important for my role as a teacher.
	8		After this workshop, I believe more strongly that learning programming can benefit my professional development.
	9		After this workshop, I am more convinced of the value of incorporating programming into my curriculum.
	10		I recommend this workshop and M-flow curriculum to other teachers.

4.4, significantly exceeding the neutral midpoint ($p < 0.001$). For teachers' interest, the pre-survey results for question #5 showed a significant difference compared to the neutral midpoint value of 3.0 ($p = 0.001$), indicating that teachers were already interested in programming prior to the workshop. For pre-survey question #6, no responses were recorded, likely due to participants' lack of prior experience in teaching programming. Post-workshop, question #4 continued to demonstrate a significant difference from the neutral value ($p = 0.001$), reflecting sustained interest. For the post-only questions (#5 and #6), the mean scores were both significantly higher than the neutral midpoint of 3.0 ($p < 0.001$ for both). For teachers' attitudes, the pre-survey results indicate a significant difference from a neutral attitude for question #7 ($p < 0.05$). However, for question #8, there was no significant difference, suggesting teachers did not initially hold a more positive attitude toward this belief ($p = 0.54$). Post-workshop, teachers showed significantly improved attitudes, and all these post-survey responses showed significant differences compared to a neutral attitude ($p < 0.001$).

4 Discussion

This study underscores the transformative potential of M-flow, a flow-based music programming environment, in enhancing elementary teachers' confidence, interests, and attitudes toward CS. After a six-hour workshop, teachers reported significant gains in their ability to teach and troubleshoot programming, highlighting the value of integrating hands-on practice with engaging content. This approach aligns with prior research suggesting that accessible, user-friendly programming tools help reduce anxiety and foster a sense of accomplishment [11]. Additionally, employing creative mediums such as music can bolster user's sense of agency, further increasing their motivation to explore computational concepts [5]. Moreover, these findings align with the qualitative reports of teachers' growing appreciation for programming as a powerful medium for creativity, problem-solving, and collaboration. By linking coding with music, the workshop grounded an often abstract technical skill in a more tangible and engaging context, thereby supporting teachers' recognition of programming's interdisciplinary utility [5]. Such contextualization has been shown to support shifts from situational interest to more enduring personal interest, as teachers begin to see programming as both meaningful and compatible with their pedagogical practices [12]. The high post-survey scores and reduced variability point to a

Table 2: Survey Results. *Note: For all question items, the t-test compares the scores with a neutral valence (e.g., 3.0 for a five-point scale). "/" means no responses were collected from the teachers.*

	Pre-survey			Post-survey		
Category	Item No.	Mean (SD)	T-test results	Item No.	Mean (SD)	T-test results
Self-efficacy	1	2.30 (0.67)	t = 8.82, p <0.01** Cohen's D = -1.04	1	4.50 (0.53)	t = 9.00, p <0.001*** Cohen's D = 2.85
	2	3.20 (0.79)	t = 0.80, p = 0.44	2	5.00 (0.00)	t = 8.51, p <0.001*** Cohen's D = 2.69
	3	/	/	3	4.40 (0.52)	t = 8.57, p <0.001*** Cohen's D = 2.71
	4	2.80 (0.79)	t = 0.80, p = 0.44	/	/	/
Interest	5	4.40 (0.70)	t = 6.33, p = 0.001*** Cohen's D = 2.00	4	4.40 (0.52)	t = 8.57, p <0.001*** Cohen's D = 2.71
	6	/	/	5	4.60 (0.52)	t = 9.80, p <0.001*** Cohen's D = 3.10
	/	/	/	6	4.50 (0.85)	t = 5.58, p <0.001*** Cohen's D = 1.77
Attitude	7	4.30 (0.67)	t = 6.09, p <0.001*** Cohen's D = 1.93	7	4.60 (0.52)	t = 9.80, p <0.001*** Cohen's D = 3.10
	8	3.30 (1.49)	t = 0.63, p = 0.54	8	4.80 (0.42)	t = 13.50, p <0.001*** Cohen's D = 4.27
	/	/	/	9	4.80 (0.42)	t = 13.50, p <0.001*** Cohen's D = 4.27
	/	/	/	10	4.90 (0.32)	t = 19.00, p <0.001*** Cohen's D = 6.01

growing consensus that programming is relevant and accessible—an essential step in sustaining long-term engagement and motivating teachers to seek further professional development opportunities. Lastly, the workshop reshaped teachers' attitudes about the significance of CS education and its alignment with their professional growth. The majority of participants left with a stronger conviction about the importance of integrating computer science, recognizing it as a critical 21st-century skill set for their students' future [13]. This attitudinal change is vital, as teachers who see clear benefits in adopting new pedagogical methods are more likely to remain resilient in the face of challenges and incorporate technology long-term [14]. By experiencing firsthand how programming and music reinforcement can yield both technical and creative skill development, teachers discovered new ways to enrich their classrooms and elevate student engagement. Together, these positive shifts in self-efficacy, interest, and attitudes show the importance of well-designed, interdisciplinary professional development initiatives like M-flow, setting the stage for broader and more sustained adoption and integration of CS in elementary education. Future research with a larger cohort and longitudinal design is needed to examine the persistence of these effects over time. Future work will extend the research to include classroom implementation of the M-flow curriculum. With approximately 200–300 students taught by these ten teachers, future studies can evaluate how flow-based music programming influences student engagement, learning outcomes, and attitudes toward programming. Additionally, longitudinal studies could explore how sustained teacher training and curriculum use further impact both teacher proficiency and student success in computer science education.

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