

Integrating Japanese Festival Traditions into Computational Thinking: A Culturally Responsive Approach to Micro:Bit-based Physical Computing

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Abstract—The current pre-tertiary educational landscape in Japan is defined by a significant paradox. While technological infrastructure has reached unprecedented levels of saturation through the Global and Innovation Gateway for All (GIGA) School initiative, student engagement and qualitative learning outcomes in computational disciplines have shown signs of stagnation. This research addresses this disparity by proposing a framework grounded in Culturally Responsive Teaching (CRT) and Culturally Responsive Computing (CRC), utilizing the traditional Japanese festival game of *Shateki* (target shooting) as a primary pedagogical vehicle. By leveraging the BBC micro:bit and a modular physical computing architecture, this study demonstrates how situating abstract programming concepts, such as sequential logic, conditional branching, and signal modulation, within familiar “vernacular” and “heritage” cultural contexts can foster intrinsic motivation and improve academic achievement among K-12 students. Through a pilot evaluation conducted during a community festival, this study provides quantitative evidence that CRT-based interventions not only enhance technical proficiency but also bolster a sense of student agency and cultural belonging. The results suggest that the success of modern educational technology initiatives depends less on hardware distribution and more on the pedagogical translation of technical content into culturally meaningful experiences.

Keywords—Culturally responsive teaching (CRT); Culturally Responsive Computing (CRC); computational thinking; micro:bit; K-12 education; physical computing; STEM education

I. INTRODUCTION

The Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the GIGA (Global and Innovation Gateway for All) School Program with the ambitious goal of providing a high-speed communication environment and a digital device for every student in primary and secondary schools across the nation [1]. This initiative was designed to eliminate educational gaps caused by socio-economic disparities and to prepare the next generation for Society 5.0, where cyber and physical spaces are highly integrated. Statistical indicators confirm the rapid success of the infrastructure rollout; student computer ratios have improved dramatically, and wireless LAN availability in classrooms has surged from roughly 40% to over 90% in just a few years [2]. Despite this technical achievement, the impact on learning remains contentious.

Recent data from the National Assessment of Academic Ability reveals a troubling trend. Between the 2024 and 2025 academic years, average correct response rates in core subjects like Japanese and Mathematics have declined across both elementary and junior high schools [2]. In mathematics, specifically, elementary school scores dropped from 63.6% to 58.2%, while junior high school scores fell from 53.0% to 48.8% [3]. These declines suggest that the mere presence of technology in the classroom does not guarantee improved cognition. In fact, many reports indicate that the GIGA School terminals are frequently used for non-educational entertainment, such as gaming or streaming services, which can detract from focused learning.

The root of this problem lies in the disconnect between “schooling” – the institutionalization of learning within a rigid, often Western-centric framework – and “education,” which should empower students to transform their environment [4],[5]. When programming is taught as a series of abstract, context-less syntax exercises, students often find the material boring or difficult. This is particularly evident in the K-12 sector, where students’ attention spans and motivation are deeply tied to the perceived relevance of the curriculum. The current failure to bridge the gap between high hardware accessibility and student interest necessitates a shift toward Culturally Responsive Teaching [6],[7].

In this respect, the primary contributions of this research are as follows.

- We developed a modular physical computing curriculum centered on the Japanese cultural heritage of *Shateki*, or target shooting game (Fig. 1), to teach the core principles of computational thinking.
- We implemented an asset-based pedagogical framework that validates students’ community knowledge as a foundation for technical mastery.
- With a pilot study at a community festival, we quantitatively evaluated the impact of culturally situated learning on student motivation and proficiency in programming logic.
- We performed a comparative analysis of educational hardware platforms to determine the suitability of micro:bit for CRT-based interventions.

The remainder of this study is organized as follows. Section II presents a brief literature review. Section III discusses the cultural significance of Japanese summer festivals (*Matsuri*) and the traditional game of *Shateki* as pedagogical tools. Section IV outlines the system architecture and hardware design, describing the use of the BBC micro:bit and modular sensors. Section V explains the pedagogical strategy employed, which centers on sequential execution, conditional branching, and debugging. Section VI presents the experimental evaluation and results from a pilot study conducted at a community festival. Section VII provides an impact analysis of the curriculum through the lenses of identity affirmation and student agency. Section VIII offers a comparative analysis of educational hardware platforms commonly used in Japanese schools. Section IX discusses the lessons learned in the *Shateki* project and outlines future research directions. Finally, Section X concludes the study.



Fig. 1. Photograph of a typical *Shateki* (Japanese shooting game) [Public domain] via <https://www.meijimura.com>.

II. LITERATURE REVIEW

To situate the proposed framework within the broader discourse of Computer Science Education (CSE), this section examines existing literature across three converging domains: Culturally Responsive Teaching (CRT), Culturally Responsive Computing (CRC), and Physical Computing. The synthesis of these fields suggests that while tangible interfaces improve the cognitive grasp of abstract concepts [8],[9], and cultural contextualization improves learner motivation [10],[11], there remains a scarcity of rigorous studies combining both methodologies within the specific cultural heritage contexts of East Asia.

A. Culturally Responsive Teaching (CRT) as a Pedagogical Foundation

Culturally Responsive Teaching (CRT) serves as the overarching pedagogical architecture for this study. Defined foundationally by Gay [12] and Ladson-Billings [13], CRT is a pedagogy that recognizes the importance of including students' cultural references in all aspects of learning. It posits that academic achievement improves when instruction is filtered

through the students' own cultural experiences and frames of reference.

In the context of STEM education, the disconnect between a student's home culture and the culture of the science classroom is often cited as a primary barrier to engagement. Research by Villegas and Lucas [14] emphasizes that sociocultural consciousness is a prerequisite for teachers to bridge this gap. However, traditional CRT literature has largely focused on the humanities and social sciences. Only recently has the scope expanded to technical disciplines, where the "culture-free" assumption of mathematics and logic is being challenged. By validating "vernacular" knowledge – such as the rules of a traditional festival game – educators can lower the affective filter, making rigorous academic content more accessible to young learners who might otherwise view themselves as outsiders to the domain of technology.

B. Culturally Responsive Computing (CRC) and Computational Thinking

Culturally Responsive Computing (CRC) represents the intersection of CRT and computer science education. Eglash et al. [15] have been instrumental in defining this space through "ethnocomputing," demonstrating that indigenous practices – such as cornrow braiding or Navajo weaving – contain inherent computational algorithms. By explicitly mapping these cultural artifacts to programming concepts, CRC transforms heritage from a passive backdrop into an active cognitive resource.

Scott et al. [16] further argue that CRC is essential for equitable participation in computing. Their work indicates that when curricula reflect the identities of underrepresented youth, there is a marked increase in both self-efficacy and the acquisition of Computational Thinking (CT) skills. CT, as defined by Wing [17] and elaborated by Brennan and Resnick [18], involves solving problems, designing systems, and understanding human behavior by drawing on the concepts fundamental to computer science.

However, a significant portion of CRC literature is situated within North American contexts, focusing on African American or Latino cultural matrices [19]. There is a distinct paucity of literature examining CRC frameworks within the Japanese educational system, particularly regarding how distinct cultural assets like *Matsuri* (festivals) can be leveraged to address the motivation crisis identified in the GIGA School era. This study aims to extend the CRC discourse by validating the *Shateki* game as a computational artifact capable of teaching conditional logic and algorithmic sequencing.

C. Physical Computing and Cognitive Load in Young Learners

The third dimension of this research is Physical Computing: the design of interactive physical systems by the use of software and hardware that can sense and respond to the analog world. This approach aligns with Papert's theory of Constructionism [20], which posits that learning is most effective when the learner is engaged in constructing a public entity. Recent studies strongly support the efficacy of physical computing tools, such as the BBC micro:bit, in fostering CT. Sentence et al. [21] found that physical computing devices provide immediate feedback loops that are crucial for novice

programmers. When a student programs a physical device to “shoot” a target, the abstract code becomes a tangible reality. This tangibility reduces cognitive load; the concept of a “variable” is no longer just a memory space but a score counter on a display; a “conditional statement” is no longer just syntax but the visible act of a point increment when the target is hit.

Furthermore, research by Hodges et al. [22] suggests that physical computing is particularly effective in collaborative settings, fostering “computational participator” behaviors. The tangible nature of devices allows for shared attention and collaborative debugging, which are critical components of the social learning environment found in festival preparations.

D. Synthesis: The Intersection of Culture and Tangibility

While the individual benefits of CRC and Physical Computing are well-documented, the synergy between them remains underexplored in current literature. Most CRC interventions rely on screen-based simulations (e.g., culturally relevant Scratch projects), while most physical computing interventions utilize generic projects (e.g., traffic lights, weather stations) that lack deep cultural resonance.

This research posits that the intersection of these domains offers a unique force multiplier for educational outcomes. By combining the tangible scaffolding of physical computing with the motivational scaffolding of CRC, we propose a holistic framework. The *Shateki* project utilizes the micro:bit not merely as a generic controller, but as a modern instrument to re-enact a centuries-old tradition, thereby validating the students’ past while equipping them for the future.

III. THE CULTURAL SIGNIFICANCE OF MATSURI AND SHATEKI IN JAPAN

Japanese summer festivals, or *Matsuri*, are pivotal community events that combine traditional religious elements with modern social celebration [23]. Originally rooted in agrarian prayers for harvest and protection from pestilence, they have transitioned into vibrant spaces where residents participate with fervor and actively engage in community bonding [24]. Central to the *Matsuri* experience are the *Yatai* (stalls) that offer a variety of foods and traditional games. These games are not merely recreational; they are cultural resources that teach focus, patience, and skill while fostering a sense of shared belonging.

Among these activities, *Shateki* (target shooting) is particularly iconic. In a traditional *Shateki* stall, a player uses an air rifle, typically firing cork bullets, to attempt to knock prizes off a tiered display (Fig. 1). The prizes range from inexpensive snacks and candies to high-value toys or character goods [25]. The cultural significance of *Shateki* is deep; for adults, it represents a nostalgic link to their childhood, and for children, it is a thrilling test of aim and nerve. The mechanics of the game are intuitively understood by Japanese citizens of all ages, making it an ideal low-floor entry point for teaching computational logic.

By framing a programming lesson around building a *Shateki* game, educators can tap into “funds of knowledge” that students already possess [4]. Instead of learning about sensors and infrared light in a vacuum, students learn how to

“build a festival” using digital tools. This approach aligns with the CRC tenet of “asset building,” where students’ existing cultural expertise is validated and used as a bridge to new technical knowledge [26].

IV. SYSTEM ARCHITECTURE AND HARDWARE DESIGN

To implement the digital *Shateki* experience, this research utilizes the BBC micro:bit platform. The micro:bit is a microcontroller designed specifically for education, featuring integrated sensors, an LED matrix, and physical input-output pins [27]. To program the BBC micro:bit, Microsoft MakeCode [28] – a free, open-source web-based platform – is used. The platform supports block-based programming, similar to Scratch. Such block-based programming has been proven to be useful for early-stage learners [29]. For this study, a modular system was designed to simulate the physical interactions of a shooting gallery. As shown in Fig. 2, the hardware components include the micro:bit unit, a workshop module, vibration sensors, and infrared (IR) LED/receiver modules.

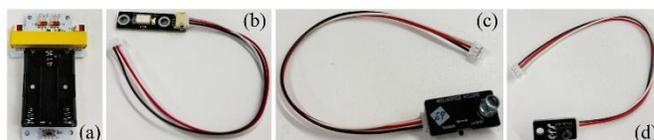


Fig. 2. Hardware components: (a) Workshop module for micro:bit, (b) Vibration sensor for micro:bit, (c) Infrared LED module for micro:bit, (d) Infrared receiver module for micro:bit.

A. Physical Computing Modules

The system is designed to be modular, allowing students to understand the relationship between different hardware units and their specific roles in a distributed computing environment. Table I provides a breakdown of the hardware components used in the *Shateki* system. The role and purpose of each component are also summarized in Table I.

TABLE I. COMPONENTS USED IN SHATEKI GAME

Module Name	Technical Role	Purpose in <i>Shateki</i> Game
micro:bit v2.2	Central procession unit	Manages logic, variables and display
Workshop module	Power and I/O distribution	Facilitates remote sensor connectivity
Vibration sensor	Analog input (Piezoelectric)	Detects projectile impact on the target
Infrared LED	Signal output (38.5 kHz)	Creates a digital tripwire for boundaries
Infrared receiver	Signal detection	Monitors for interruptions in the IR beam

As shown in Fig. 3, the system architecture is bifurcated into two primary subsystems: the Target Function and the Boundary Function. In a traditional *Shateki* gallery, the player must stay behind a line; if they cross it, the attempt is void. By digitizing this rule, students learn about sensor-based automation. The Target Function uses a vibration sensor to detect when the target has been struck, while the Boundary

Function uses an IR beam to detect if the player's foot has crossed the designated firing line.

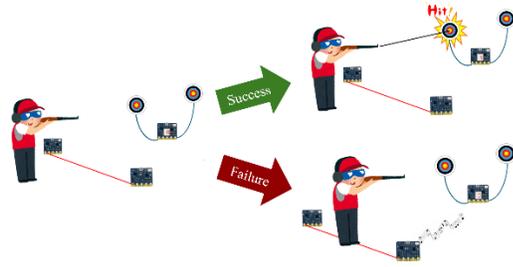


Fig. 3. Overview of the Shateki game with success and failure cases.

B. Hardware Connectivity and Constraints

As shown in Fig. 4, the completed hardware assembly integrates these modules into a cohesive playset. The target function is physically separated from the infrared boundary units, necessitating a multi-micro:bit setup. In this configuration, one micro:bit acts as the target scorekeeper, while two others manage the infrared transmission and reception. This setup is intentional, as it introduces students to the concept of hardware independent of a single "brain," mirroring real-world IoT (Internet of Things) architectures.

The technical challenge for students lies in the analog-to-digital conversion (ADC) process. For the vibration sensor, an analog value of 0 indicates an impact, whereas 1 indicates a steady state. For the IR receiver, the logic is similar: a detected beam returns 1, while an interruption (a broken beam) returns 0. Navigating these inverted logic states provides a fertile ground for developing critical thinking and problem-solving skills, as students must often debug their assumptions about how "on" and "off" signals should behave.

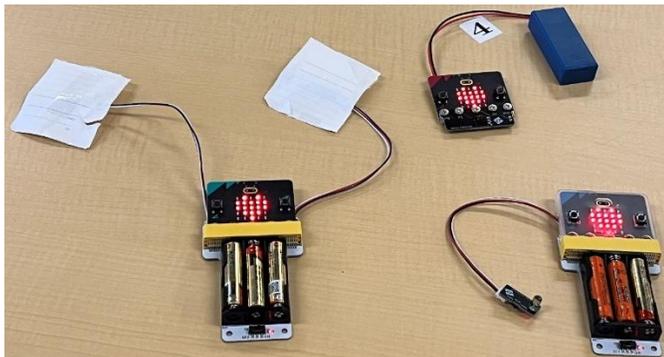


Fig. 4. Hardware setup of the Shateki game.

V. PEDAGOGICAL STRATEGY

The instructional design of the Shateki project is centered on the three fundamental principles of programming: sequential execution, conditional branching, and iteration. The pedagogical innovation here is the use of debugging as a primary learning activity. Research suggests that providing students with broken but mostly functional code encourages deeper analysis than starting from a blank screen [30].

A. Programming the Target Logic

Students are provided with an initial code block for the Target Function that contains a logical bug. As shown in Fig. 5, the initial code incorrectly maps the sensor input to a pin that is not physically connected to the workshop module. Students must trace the physical jumper wires to the correct pin (typically P0) and update the code accordingly. As shown in Fig. 6, the correct logic involves an "if-then" statement: if the vibration sensor detects a hit (analog_value=0), then increment the score variable by 1. This exercise teaches conditional branching in a way that is immediately visible through the 5x5 LED display, which shows the score increasing in real-time. Such instant feedback improves program comprehension [31].

B. Signal Modulation and Boundary Function

The Boundary Function introduces more sophisticated concepts. The IR LED must be modulated to a specific frequency (approximately 38.5 kHz) for the receiver to detect it reliably. On the micro:bit, this is achieved by simulating a frequency through rapid pulse repetitions. As shown in Fig. 7(a), the sample code provided to students has the "repeat" value set to 0, meaning no signal is sent. Students learn that for communication to occur, the transmitter and receiver must agree on a "signal" presence. As shown in Fig. 7(b), setting the loop to 100 repetitions creates a stable enough frequency for detection.



Fig. 5. Initial incorrect program (target logic).



Fig. 6. Program with corrected if-then logic.

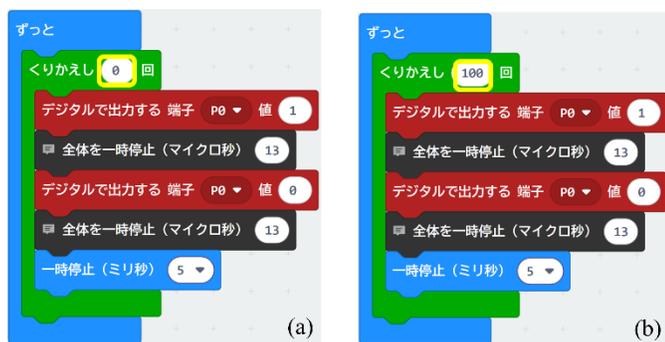


Fig. 7. Program for sending signal: (a) Incorrect, (b) Correct.

On the receiving side, students must manage the inverted logic of infrared detection. As shown in Fig. 8, the initial code might have a threshold value (e.g., 5) that does not match the binary nature of the IR receiver output. By testing the system and viewing the data on their screens, students identify that they must check for a value of 0 to detect a “broken” beam. As shown in Fig. 9, the corrected code triggers a warning sound and displays a danger icon on the LED matrix when the line is crossed. This creates an immediate cause-and-effect relationship between code and physical action, which is a key driver of engagement in physical computing [32].



Fig. 8. Incorrect receiver program.

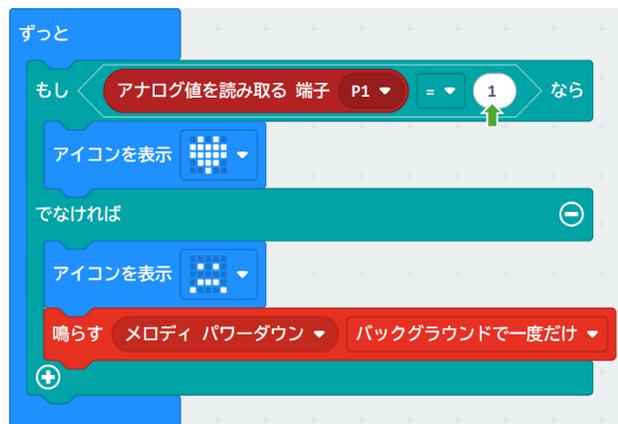


Fig. 9. Corrected receiver program.

VI. EXPERIMENTAL EVALUATION AND RESULTS

The efficacy of this culturally responsive Shateki curriculum was evaluated during the Akabanedai Festival in Tokyo, a community event that provided a naturalistic environment for testing. The participants included 31 students, primarily in the elementary and junior high school demographics, who engaged in the programming and gaming activities. Evaluation was conducted through digital questionnaires and a confirmation test (a quiz to check comprehension of basic programming concepts) administered after the experience.

A. Participant Profile and Prior Experience

The majority of the participants were within the K-12 target group. Interestingly, the survey data revealed that many students had very little prior exposure to programming. Over 60% of respondents indicated they had “never” or “hardly ever” received programming education. Furthermore, usage of the micro:bit was almost zero before the festival, with nearly all participants being first-time users.

This data underscores the importance of the CRT approach. When students are blank slates with regard to technical skills, the cultural familiarity of the Shateki game acts as a critical scaffolding tool, preventing the technological intimidation that can occur with abstract coding tasks [33].

B. Quantitative Analysis of Motivation and Satisfaction

The post-experience survey utilized a 5-point Likert scale to measure various aspects of student engagement and understanding. The results are summarized in Table II.

TABLE II. RESULT OF QUESTIONNAIRE SURVEY

Metric	Avg. score	SD
Enjoyment of the experience	4.77	0.57
Overall satisfaction	4.70	0.60
Desire to try again	4.57	0.77
Increase in programming motivation	4.30	0.84
Desire to recommend to others	4.27	1.01
Sense of achievement/completion	4.03	1.00
Understanding of programming logic	3.87	1.01

The exceptionally high score for Enjoyment (4.77) and Overall Satisfaction (4.70) indicates that the festival context was highly effective at creating a positive learning environment. More importantly, the score for Programming Motivation (4.30) confirms that the CRT framework successfully transformed a difficult technical subject into an appealing one. Fig. 10 shows a collage of students programming and trying the game.

The quiz results, as shown in Fig. 11, provide evidence of academic achievement. Among the 25 test takers, the score distribution was heavily weighted toward the high end, with many students demonstrating mastery of the three principles of programming and sensor logic. This result directly contradicts the national trend of declining academic scores in mathematics and science, suggesting that when content is “culturally situated,” students can achieve high levels of mastery even in short-duration interventions.



Fig. 10. Students programming and testing the Shateki game.

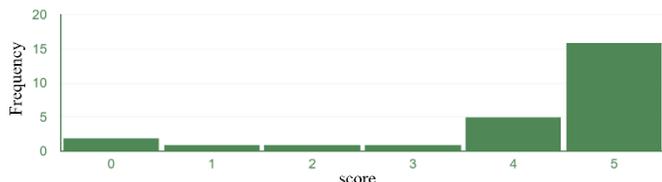


Fig. 11. Distribution of quiz scores.

VII. IMPACT ANALYSIS

The success of the Shateki project can be explained through several key CRT mechanisms: identity affirmation, immediate feedback, and student agency.

A. Identity Affirmation and Cultural Capital

By using a festival game, the curriculum validates students' cultural capital – the knowledge and skills they have gained from their families and communities [26],[34]. Instead of the classroom being a place where their external life is ignored, it becomes a place where their cultural heritage is digitized and celebrated [35]. This reduces cultural alienation and increases a sense of belonging, which is a prerequisite for sustained academic engagement in STEM fields [33].

In Japan, where the GIGA school initiative has standardized the digital experience, there is a risk of cultural blindness, where the unique local and national traditions of students are overlooked in favor of generic globalized content [36],[37]. The Shateki game re-injects “Japaneseness” into the computer science curriculum, allowing students to see computing as a tool for cultural sustainability – preserving the old through the new [38].

B. Immediate Feedback and Physicality

The micro:bit's physical nature provides immediate feedback that is qualitatively different from screen-based programming. When a student fixes a line of code and a physical target starts counting scores, or an infrared beam starts sounding an alarm, the abstraction of the computer becomes

concrete [33]. Students were highly motivated to use the micro:bit for other activities after the session, suggesting that the “physicality” of the experience created a lasting interest in hardware-software integration.

This immediacy is particularly important for younger learners who may find traditional GIGA-school terminals boring or distracting. The tactile nature of the workshop modules and sensors keeps students on-task and focused on the problem-solving process.

C. Empowering Student Agency

The debugging approach used in this research promotes student agency, i.e., the feeling that the learner is a producer of knowledge rather than a passive consumer [38]. When students fixed the bugs in the Shateki code, they were not just following a tutorial; they were, in essence, reclaiming the system and making it work according to their understanding of the game's rules. This aligns with the CRT principle of critical consciousness, where students learn to manipulate and control the technology in their environment [38].

VIII. COMPARATIVE ANALYSIS OF EDUCATIONAL HARDWARE

To understand why the micro:bit was chosen for this culturally responsive intervention, it is necessary to compare it with other prevalent hardware platforms in Japanese education. A comparative evaluation of such educational hardware is presented in Table III.

Arduino [39] and Raspberry Pi [40] offer high extensibility but have a steep learning curve involving complex wiring and OS management, which can become a barrier for beginner students. LEGO Education [41] is highly refined but prohibitively expensive for widespread GIGA school implementation, potentially widening the socio-economic gap CRT seeks to close. Robot-based toys like Sphero [42] and Ozobot [43] are engaging but often act as black boxes where the internal sensor logic is hidden from the student.

The micro:bit strikes the ideal balance. Its low cost and built-in features make it accessible to underserved schools, and its open pin architecture allows for the modular Shateki design. Furthermore, the total cost for the Shateki set used in this study was around 26,800 JPY (around 170 USD) per complete set. While this may seem high, the micro:bit itself is the only component needed for each student (approximately 3,400 JPY or around 20 USD), with sensors shared in a station-based learning model. This ensures that the technology is accessible and relevant for all learners, a core requirement of the CRT Areas of Opportunity framework [44].

TABLE III. COMPARISON OF HARDWARE TYPICALLY USED IN PHYSICAL COMPUTING EDUCATION

Platform	Operability	Safety	Approx. Cost (in JPY as of Dec. 2025)	Cultural Adaptability	Feedback Immediacy
BBC micro:bit	High	High	3,400	High	Excellent
Arduino	Low	Medium	3,000	Medium	Medium
Raspberry Pi	Low	High	6,000	Low	Low
LEGO Education	High	High	25,000	Medium	High
Sphero / Ozobot	High	High	15,000	Low	High

IX. LESSONS LEARNED AND FUTURE WORK

Despite the success of the Shateki project, several challenges remain for broader implementation in Japanese schools.

A. Language and Technical Jargon

Feedback from the Akabanedai Festival indicated that for some elementary school students, the technical language used in the coding blocks was too difficult. This highlights a critical need for linguistic responsiveness in CRT. A culturally responsive teacher must be a pedagogical translator, converting abstract terms like variable, analog threshold, and signal modulation into metaphors that resonate with the students' everyday language and festival experiences [33].

B. Calibration and Differentiation

The survey results showed a spread in the "Sense of achievement" and "Understanding of programming logic" scores, with standard deviations around 1.0. This suggests that one-size-fits-all instruction is ineffective even within a culturally responsive framework. Some students found the tasks too easy, while others struggled with the logic of the infrared receiver. To address this, future curricula should offer tiered challenges, for example, allowing advanced students to add sound effects or timers to their Shateki games, while ensuring beginners can complete the core vibration and boundary logic.

C. Sustaining Interest Beyond the Novelty Effect

While the fun of the festival game provides an initial hook (a phenomenon known as the novelty effect [45]), the ultimate goal of CRT is to build long-term computational identity [26]. This requires moving from single-experience workshops to a spiral curriculum where the micro:bit is used across different subjects, such as using the vibration sensor in a science class to measure tectonic movements or using the LED matrix in a math class to visualize data. The Shateki project should be seen as the gateway that proves to students they belong in the world of computing.

X. CONCLUSION

This research has demonstrated that the pervasive disengagement and declining academic outcomes observed in the wake of the GIGA School initiative can be mitigated by adopting a Culturally Responsive Teaching framework. The micro:bit-based Shateki shooting game serves as a powerful evidence-based model for this approach. By situating the abstract principles of programming within the joyous and familiar context of a Japanese summer festival, the project achieved high levels of student satisfaction, increased learning motivation, and measurable cognitive gains in programming logic.

The success of the Shateki project highlights that effective technology integration is not a function of the number of devices in a classroom, but the degree to which those devices are used to celebrate and extend students' cultural identities. When students are empowered to "build their own festival" using sensors and code, they move from being passive

consumers of Western-centric software to being creative innovators with their own cultural voice.

For Japanese education to fulfill the promise of the GIGA School era, it must move beyond hardware distribution toward a pedagogy that values vernacular and heritage culture as essential components of STEM success. By making Culturally Responsive Computing the central theme of computer science education, we can ensure that every student – regardless of their socio-economic background – can see themselves as a capable and innovative citizen of the digital future. The Shateki experience proves that the path to high-tech mastery often begins with a very traditional, very human connection.

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