

# **Evaluating the Psychological Impact of International STEAM Education: Pre–Post Evidence from the 2025 STEAM International Collaboration**

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## **Abstract**

This study designed and implemented a digitally mediated international STEAM collaboration and examined its educational and psychological impact. Secondary school students from seven schools across four countries participated in projects aligned with Sustainable Development Goals (SDGs), developing and presenting solutions using a shared technological toolkit. A pre–post survey design was employed to assess changes in learners' confidence in technology, English communication confidence, leadership-related dispositions, and communication-related psychological characteristics. The results revealed no statistically significant changes in technical confidence, English self-assessment, or leadership-related characteristics during the intervention period. In contrast, statistically significant reductions were observed in interpersonal anxiety and communicative tension. Participants reported decreased nervousness in social situations, reduced general tension, and lower physical and vocal signs of nervousness during interaction. These findings indicate that short-term participation in international STEAM collaboration was associated with changes in communication-related psychological conditions rather than measurable increases in technical or leadership confidence. Because students worked toward common SDG goals using the same standardized toolkit, interaction was grounded in shared objectives and tools. This structured collaborative framework may have reduced uncertainty during intercultural communication. Overall, the study provides empirical evidence that international STEAM collaboration can support communication-related psychological adjustment within digitally mediated, cross-cultural learning environments.

**Keywords:** STEAM education, international exchange, international collaborative learning, psychological safety

## **1. Background/ Objectives and Goals**

In recent decades, STEM education has been widely recognized as essential in response to rapid technological advancement and socio-economic transformation (UNESCO, 2017). Within this movement, STEAM education—integrating the arts into STEM—has gained increasing attention as a framework for fostering creative thinking and socially responsible innovation (Belbase et al., 2022). Contemporary educational discourse further emphasizes the importance of global competence and intercultural engagement as central competencies for the 21st century (UNESCO, 2021). In this context, cross-cultural learning experiences are considered critical for shaping learners’ cognitive and socio-emotional development.

Prior research in intercultural communication suggests that engagement across cultural boundaries can significantly influence learners’ psychological states. In particular, higher levels of intercultural mindfulness have been associated with reduced anxiety in intercultural interactions, as well as increased flexibility and empathy toward others (Khukhlaev & Bratkina, 2021; Khukhlaev et al., 2022). These findings imply that structured international learning environments may contribute to important shifts in learners’ socio-emotional dispositions.

However, within the context of STEAM education, the psychological impact of sustained international collaborative learning remains insufficiently clarified. Although interdisciplinary STEAM initiatives have expanded globally, many implementations remain confined to individual schools or regional educational systems. Opportunities for structured, long-term intercultural collaboration are still limited. Empirical studies indicate that STEAM practices tend to emphasize cross-curricular integration within a single institutional context rather than international, cross-cultural engagement (Kobayashi & Hitomi, 2024; Kowatari, 2025). Consequently, there is a lack of systematic evidence regarding how international STEAM collaboration influences learners’ psychological processes.

To address this gap, the present research investigates the psychological effects of participation in an international STEAM collaboration project. And, this research aims to examine the impact of international STEAM participation on learners’ technical and English confidence, leadership characteristics, and communication-related dispositions in order to provide empirical support for the value and advancement of international STEAM initiatives.

## **2. Methods**

### **2.1 Research Design**

This study employed a pre–post survey design to compare participants’ responses before and after engagement in the 2025 STEAM International Collaboration. Specifically, the study

aimed to clarify the psychological effects of participation in a digitally mediated, cross-cultural STEAM learning environment by examining its impact on learners' confidence in technical skills and English communication, leadership characteristics, and communication-related dispositions. A quantitative survey approach was adopted to analyze changes between pre- and post-intervention measures.

The study was approved by the Ethics Committee of the Center for Computational Sciences, University of Tsukuba (Approval No. 23-004). All data were anonymized to prevent third-party identification of personal information. Participants were informed of the study's purpose, that participation was voluntary, and that refusal would result in no disadvantage. Oral and written informed consent were obtained prior to participation.

## **2.2 Project Overview: 2025 STEAM International Collaboration**

The 2025 STEAM International Collaboration involved secondary school students from four countries—Malaysia, the Philippines, Indonesia, and Japan—across seven participating schools. The project was designed as an international collaborative learning experience centered on Sustainable Development Goals (SDGs), specifically Goal 4 (Quality Education) and Goal 13 (Climate Action). Students were instructed to develop a project that addressed one of these goals and to present their solution at a final international showcase.

Students in each country formed teams within their respective schools and began developing technology-based solution prototypes. To ensure comparable learning conditions across countries, a standardized educational toolkit (SpaceBlock, AVAD Co., 2026) was adopted. All teams used the same toolkit for project development. Regular project work was conducted locally within each school; however, as shown in **Figure 1**, all participants joined a shared monthly online session via Zoom, conducted in English and lasting approximately one hour. While students from several participating countries demonstrated high English proficiency, Japanese students engaged in a linguistically and culturally challenging environment.

The session schedule was structured as follows:

- April: School introductions and self-introductions
- May: Introduction to and practice with SpaceBlock
- June: Presentation of project themes
- July: Group discussions on identified issues
- October: Final confirmation and refinement
- November: Final presentations

Each session included cultural exchange, clarification of social issues, discussion of

prototype concepts, and progress sharing. Interaction was structured around collaborative production tasks rather than language accuracy, thereby encouraging participation within a psychologically supportive environment. The final presentation session functioned as an evaluative showcase, where each team presented its completed project and received feedback from judges.

Project themes varied across countries but were aligned with the designated SDGs. For example, the Malaysian team developed a smart climate and safety monitoring system for houses built on hillsides or slope areas, which are vulnerable to heavy rain, soil movement, and sudden water flow. Their system used sensors and simple AI logic to detect environmental changes and provide early warnings to families at risk.

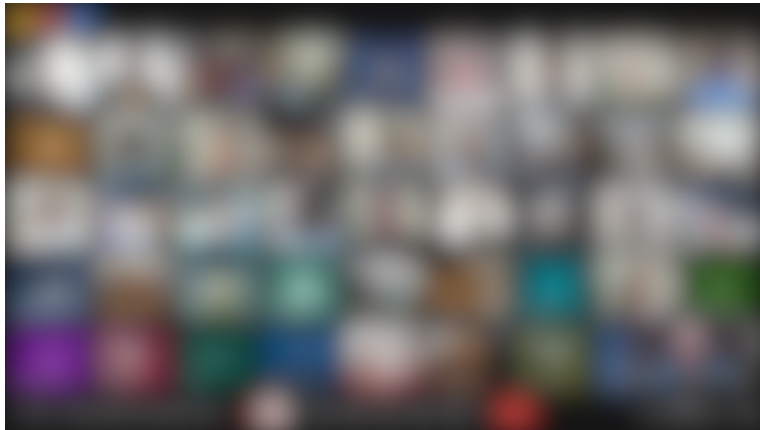
The Indonesian team designed a temperature warning system aimed at promoting energy efficiency. The device alerts users to temperature changes, encouraging the appropriate use of cooling devices and reducing unnecessary electricity consumption.

The Philippine team developed the “Color-to-Emotion Communicator,” a device supporting non-verbal children, particularly those with speech delays, in expressing their emotions. Using an Arduino UNO, color sensor, OLED screen, and LED matrix, the system translates selected color cards into emotional expressions through text, visuals, and audio output. The project aimed to foster empathy, improve communication, and promote inclusive education.

The Japanese team addressed challenges faced by students with color blindness, which affects more than 3.2 million people in Japan. To reduce barriers in classroom learning, they developed two tools: the Color Seeing Experience Robot, which uses LEDs and sound to simulate difficulties in color distinction, and the Board Writing Display App, which enhances visibility through text conversion, color-scheme checking, and diagram adjustment. Developed using Kotlin in Android Studio, the application has received positive feedback from users with color vision deficiencies. The project aims to promote equitable and accessible learning environments (**Figure 2**).

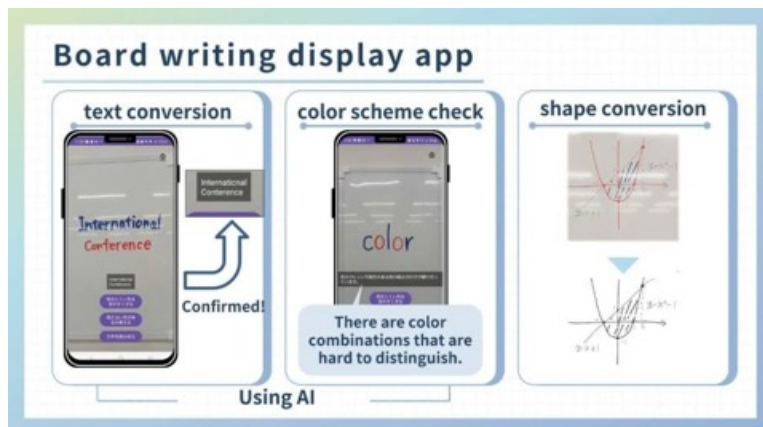
## **Figure 1**

*Monthly online session conducted as part of the international STEAM collaboration*



**Figure 2**

*Educational support application developed by the Japanese team to accommodate color vision diversity*



## 2.3 Participants

The analysis included 22 students whose pre- and post-survey responses were successfully matched. Participants were enrolled in lower or upper secondary education in the four participating countries. All identifying information was anonymized prior to analysis.

## 2.4 Measures

Psychological changes were assessed using structured questionnaires administered before and after the project. Technical self-evaluation was measured through 5-point Likert-scale items assessing confidence, interest, and motivation in programming and robotics/electronics. English proficiency was assessed using self-reported CEFR levels, along with items concerning prior international project experience.

Interpersonal psychological aspects of communication were measured using the Communicative Adaptability Scale (CAS; Duran, 1992), a 30-item instrument assessing social composure, social confirmation, social experience, appropriate disclosure, articulation,

and wit. Leadership characteristics were measured using the Student Leadership Practices Inventory (SLPI; Kouzes & Posner, 2005), which consists of 30 items evaluating five dimensions of leadership behavior. Both instruments employed 5-point Likert scales, and reverse-coded items were processed accordingly.

## **2.5 Data Analysis**

Pre- and post-project responses were paired at the individual level. Normality assumptions were examined for each variable prior to statistical testing. When normality was satisfied, paired-samples t-tests were conducted; otherwise, Wilcoxon signed-rank tests were applied. The significance level was set at  $p < .05$ . Given the exploratory nature of the study and the modest sample size, findings are interpreted cautiously as preliminary evidence of psychological and educational effects.

## **3. Results**

### **3.1 Confidence in Technology**

Pre-post comparisons were conducted to examine changes in programming experience and self-evaluation. No statistically significant differences were observed across any measured dimensions.

Programming experience showed a slight increase from  $M = 3.14$  (pre) to  $M = 3.23$  (post), but this difference was not statistically significant ( $\Delta = +0.09$ ,  $p = .46$ ). Similarly, programming confidence increased marginally from  $M = 3.41$  to  $M = 3.50$  ( $\Delta = +0.09$ ,  $p = .38$ ), without reaching statistical significance.

Interest in programming decreased slightly from  $M = 4.41$  to  $M = 4.05$  ( $\Delta = -0.36$ ,  $p = .14$ ), and motivation to continue learning programming showed a small decline from  $M = 4.45$  to  $M = 4.36$  ( $\Delta = -0.09$ ,  $p = .41$ ). Neither change was statistically significant. Overall, participation in the project did not produce measurable shifts in programming-related self-perceptions during the intervention period.

Similar patterns were observed in robotics and electronics. Years of experience increased slightly from  $M = 2.91$  to  $M = 3.00$  ( $\Delta = +0.09$ ,  $p = .48$ ), and confidence rose from  $M = 3.27$  to  $M = 3.36$  ( $\Delta = +0.09$ ,  $p = .44$ ), though neither change was statistically significant.

Interest decreased from  $M = 4.41$  to  $M = 4.05$  ( $\Delta = -0.36$ ,  $p = .14$ ), and motivation to continue learning declined slightly from  $M = 4.45$  to  $M = 4.36$  ( $\Delta = -0.09$ ,  $p = .41$ ), with no statistically significant differences observed. These results indicate stability in robotics- and electronics-related self-evaluations over the course of the project.

### **3.2 Confidence in English**

Regarding English communication, self-assessed CEFR levels showed a minimal increase from  $M = 3.18$  to  $M = 3.23$  ( $\Delta = +0.05$ ,  $p = .52$ ), which was not statistically significant. Self-reported international project experience similarly increased slightly from  $M = 2.73$  to  $M = 2.82$  ( $\Delta = +0.09$ ,  $p = .47$ ), without statistical significance.

Taken together, these findings indicate that participation in the 2025 STEAM International Collaboration did not result in significant short-term changes in technical experience, self-confidence, or English communication background indicators.

### **3.3 Confidence in Leadership Abilities**

Pre–post comparisons were conducted across all 30 leadership-related items. No statistically significant differences were observed in any of the items between pre- and post-intervention assessments.

Specifically, representative items related to responsibility, initiative, support for others, and the development of cooperative relationships—such as “I follow through on promises and commitments that I make,” “I take initiative in experimenting,” “I encourage others when they struggle,” and “I foster cooperative relationships”—did not show statistically significant changes in mean scores. The  $p$ -values across items ranged from .18 to .68.

These results indicate that participation in the program did not produce immediate measurable shifts in self-reported leadership tendencies during the intervention period.

### **3.4 Confidence in Communication Abilities**

In contrast to the domains of technical confidence and leadership, statistically significant reductions were observed in several anxiety-related aspects of interpersonal communication, as measured by the Communicative Adaptability Scale (CAS).

Significant decreases were identified in items associated with social composure. Self-reported nervousness in social situations decreased from  $M = 3.50$  (pre) to  $M = 2.95$  (post), representing a mean difference of  $-0.55$  ( $p = .0249$ ). General feelings of tension and constraint declined from  $M = 3.27$  to  $M = 2.73$  ( $\Delta = -0.55$ ,  $p = .0335$ ). Perceived physical tension during speaking—such as awkward or tense posture—showed a larger reduction from  $M = 3.09$  to  $M = 2.45$  ( $\Delta = -0.64$ ,  $p = .0097$ ). Similarly, perceived vocal nervousness decreased from  $M = 3.41$  to  $M = 2.86$  ( $\Delta = -0.55$ ,  $p = .0184$ ).

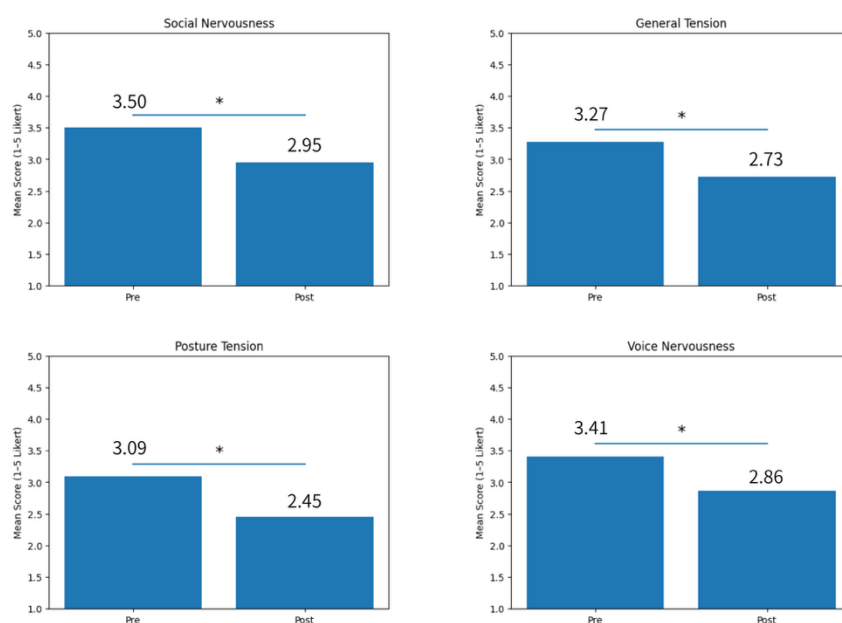
As illustrated in **Figure 3**, All four items demonstrated consistent decreases in mean scores from pre- to post-assessment, with statistically significant differences ( $p < .05$ ).

Importantly, these statistically significant changes were confined to anxiety- and tension-related dimensions. Other interpersonal aspects within the CAS did not show significant pre-post differences. For example, enjoyment of social interaction (“I enjoy meeting new people”), prosocial orientation (“I try to make the other person feel good”), and positive engagement in social groups remained statistically stable (all  $p \geq .05$ ). Likewise, dimensions related to appropriate self-disclosure, articulation (e.g., concerns about grammar or word usage), and wit did not demonstrate significant changes.

Taken together, these findings indicate a selective psychological effect. Participation in the international STEAM project was associated with a measurable reduction in interpersonal anxiety and communicative tension, while other dispositional or skill-based communication traits remained unchanged during the short-term intervention period.

**Figure 3**

*Pre-post comparison of psychological aspects of interpersonal communication. Significant reductions were observed in social anxiety (upper left), general tension (upper right), physical tension during speaking (lower left), and vocal tension during speaking (lower right).*



## 4. Discussion

### 4.1 Confidence in Technology

No statistically significant changes were observed in learners' confidence in programming, robotics, or electronics. Although minor fluctuations occurred, overall self-evaluations remained stable across the intervention period. This stability may be partially explained by a ceiling effect. Participation in the program was voluntary, and students who chose to engage were likely already motivated and relatively confident in STEAM-related domains. When baseline self-evaluations are high, short-term measurable growth becomes statistically difficult to detect.

Moreover, technical competence typically develops through sustained practice, structured feedback, and iterative refinement. The present intervention emphasized collaborative design and intercultural dialogue rather than intensive technical training. Therefore, the absence of immediate increases in technical confidence does not necessarily indicate a lack of educational value but rather reflects the developmental timeframe required for measurable skill acquisition.

#### **4.2 Confidence in English**

Similarly, no significant changes were observed in English self-assessment or perceived international experience. Although students engaged in monthly English-mediated sessions, communication was embedded within task-oriented collaboration rather than language-focused instruction. As such, improvements in language proficiency were not directly targeted.

Exposure to fluent English-speaking peers may also have triggered comparative recalibration processes. In intercultural settings, learners may reassess their own proficiency standards after observing others' performance, potentially stabilizing or even moderating self-evaluative inflation. Thus, the absence of significant growth in English confidence may reflect reflective adjustment rather than stagnation.

#### **4.3 Confidence in Leadership Abilities**

Leadership-related dispositions likewise remained statistically unchanged. The five dimensions measured by the SLPI did not demonstrate significant pre-post differences, suggesting that short-term participation in the project did not immediately alter self-reported leadership tendencies.

Leadership behaviors typically emerge through extended responsibility-taking, repeated group coordination, and structured reflection. Because the project prioritized collaborative production over explicit leadership training, substantial shifts in leadership self-perception were not necessarily anticipated. Additionally, international peer interaction may have

encouraged realistic self-appraisal, contributing to stable rather than inflated leadership ratings.

#### **4.4 Confidence in Communication Abilities**

In contrast to technical confidence, English self-assessment, and leadership-related characteristics, statistically significant reductions were observed in several indicators of interpersonal anxiety and communicative tension. Participants reported lower levels of social nervousness, general tension, posture-related tension during speaking, and vocal nervousness following participation in the project (all  $p < .05$ ). Post-intervention mean scores were consistently lower than pre-intervention scores across these items.

No significant changes were observed in other communication-related dimensions, such as enjoyment of social interaction, prosocial orientation, self-disclosure, articulation, or wit. The observed effects were therefore specific to anxiety- and tension-related aspects of communication.

One plausible explanation for this pattern relates to the shared structure of the project. Students from different cultural and linguistic backgrounds worked toward the same SDG goals and used the same standardized toolkit (SpaceBlock) to develop their projects. Because all participants engaged in similar tasks and relied on the same technological tools, communication was grounded in a common objective and shared references. This may have reduced uncertainty during interaction, as participants were not required to generate conversation topics independently but instead communicated within a clearly defined collaborative framework.

In this sense, the combination of a shared goal and shared tools may have provided a stable interactional structure that supported communication across cultural boundaries, contributing to the observed reduction in self-reported communicative tension.

### **5. Conclusion and Future Perspectives**

The present study examined the impact of participation in a digitally mediated international STEAM collaboration on learners' confidence in technology, English communication, leadership abilities, and communication-related psychological characteristics. The findings indicate that the short-term effects of the program were observed primarily in communication-related dimensions rather than in technical or leadership domains. While no significant changes were found in technical confidence, English self-assessment, or leadership-related dispositions, statistically significant reductions were identified in interpersonal anxiety and communicative tension.

The stability in technology and English confidence suggests that short-term international collaboration may not immediately translate into heightened self-perceived competence. Similarly, leadership-related characteristics remained unchanged, indicating that measurable development in these domains may require longer-term engagement or more structured leadership responsibilities. In contrast, consistent reductions were observed in nervousness and tension during interpersonal interaction.

One plausible explanation is that students across four countries worked toward the same SDG goals using the same standardized toolkit. The presence of shared objectives and shared technological tools may have provided a common framework for interaction, reducing uncertainty during communication. Rather than interacting in an unstructured conversational setting, participants communicated within clearly defined collaborative tasks, which may have contributed to lower self-reported tension.

Future research should employ longitudinal designs to determine whether reductions in communicative anxiety are associated with subsequent improvements in collaborative performance, leadership behavior, or technical skill development. Incorporating behavioral indicators and cross-cultural comparative analyses would further strengthen empirical understanding.

Several limitations should be noted. The modest sample size ( $n = 22$ ), reliance on self-report measures, short intervention duration, and potential cultural differences in response styles limit the generalizability of the findings.

Overall, the results suggest that international STEAM collaboration may contribute to improved communication-related psychological conditions, providing a structured environment that supports intercultural interaction in the short term.

## **6. Acknowledgments**

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