

STEAM-PJBL EFFECTIVENESS ON 6C 21ST-CENTURY SKILLS IMPROVEMENT IN BILINGUAL EDUCATIONAL PROGRAM

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Abstract: The study uncovered the effectiveness of project-based learning activities using STEAM (Science, Technology, Engineering, Arts, and Mathematics) in ESL (English as a Second Language) environments that are operating under bilingual educational programs. The primary finding of this study is to examine its effects on the acquisition of 21st-century skills based on the 6C model (Communication, Collaboration, Critical Thinking, Creativity, Citizenship, and Character). In addition, this STEAM-PjBL initiative is also regarded as the turning point in implementing the Content and Language Integrated Learning (CLIL) approach in the school. Although previous studies reported positive results in the development of 2C or 4C skills with the integration of STEAM-PjBL and CLIL, the present study tries to provide a more comprehensive explanation by examining the growth of all six dimensions of 6C skills at the same time. Pre-tests, STEAM-PjBL application, final project presentations, and post-tests constituted the eight weeks of activities undertaken by 160 seventh-grade students from a public school. After six weeks of intervention, the results showed an upward trend towards improvement, as 45% of students were able to progress in all six 6C competencies, 30% showing wide progress in five of the six, 15% showing progress in four, and just 10% showing slight improvement in three. According to this research, the integration of STEAM-PjBL in ESL instruction can not only improve the students' English language skills but also provide them with 21st-century skills, especially in CLIL instruction.

Keywords: STEAM-PjBL; ESL; 6C skills; 21st-Century Skills; Bilingual Education; CLIL

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INTRODUCTION

Pedagogical approaches that prepare pupils to handle the complex skills necessary for survival in the twenty-first century are demanded by the changing educational landscape. These crucial abilities include the 6Cs (Communication, Teamwork, Critical Thinking, Creativity, Citizenship, and Character). These are increasingly recognized as necessary for academic achievement, professional readiness, and full participation in a society that is becoming more interconnected by the day. (Schlechty, 2009) (Teo, 2019) While theoretical models highlight the interrelationship of second language acquisition and the development of these higher-level skills, there has been a noticeable gap identified in empirical research that comprehensively examines the simultaneous impact of

integrated instructional models on all six dimensions of the 6C framework, particularly in the context of English as a Second Language (ESL) learning under bilingual school programs. This theoretical void increases the need for such research that delves into the rich intersection between innovative pedagogical approaches and the holistic development of these vital 21st-century competencies in language learners. (Spolsky & Hult, 2008) (Varas, Santana, Nussbaum, Claro, & Imbarrack, 2023) (Tan, Choo, Kang, & Liem, 2017)

Additionally, the fusion of Science, Technology, Engineering, Arts, and Mathematics (STEAM) with Project-Based Learning (PjBL) is especially with potential for the development of these competencies through experiential and substantial learning experiences. The interdisciplinarity of STEAM also naturally tends to encourage critical thinking and problem-solving, and PjBL provides a collaborative platform for the communication and enactment of innovative solutions. Although theoretical foundations suggest great potential for the convergence of STEAM-PjBL and the nurturing of 21st-century skills, actual mechanisms by which this convergence impacts the whole spectrum of the 6C model within bilingual English as a Second Language (ESL) settings are not explored in depth. This theoretical lacuna in our understanding necessitates empirical research to clarify the particular manner in which STEAM-PjBL can develop the integrated formation of these crucial competencies in language learners within bilingual education. (Imamyartha, et al., 2024) (Kuo, 2024) (Mohsen, Khalil, AlZahrani, Awaji, & Abdullah, 2025)

The previous research has explored the impact and joint impact of STEAM and PjBL on student learning from various perspectives as follows.

Table 1. Impact and Joint Impact of STEAM and PjBL

No.	Author(s) and Year	Title	Key Findings	Journal
1	(Zayyinah, Erman, Supardi, Hariyono, & Prahani, 2022)	STEAM-Integrated Project Based Learning Models: Alternative to Improve 21st Century Skills	STEAM-integrated Project-Based Learning (PjBL) significantly improves a number of 21st-century abilities, encouraging further research into its deployment during the Covid-19 pandemic by development suitable online learning materials.	Advances in Social Science, Education and Humanities Research
2	(De La Cal, Ortiz-Revilla, Alonso-Centeno, & Greca, 2023)	Co-teaching among English pre-service teachers for integrated STEAM+CLIL education	Pre-service English as a Foreign Language (EFL) teachers' pedagogical competencies in creating integrated STEAM+CLIL didactic units were significantly upgraded by a co-teaching program, and their perceived confidence	Porta Linguarum

			in their ability to teach EFL using CLIL also increased.	
3	(Sulaiman & Mansyur, 2023)	21st Century Learning Model Integrated to 6C to Increase Students' Engagement in English Subject: Lesson Study based Classroom Action Research	The Project-Based acquisition (PjBL) approach, which was used in Cycle 2, revealed the highest level of student behavioral and emotional involvement in English language acquisition among class VII junior high school students.	Jurnal Sinestesia
4	(Imamyartha, et al., 2024)	STEAM pedagogy in foreign language education: An endeavour to broaden CLIL pedagogy through 6E's framework	STEAM pedagogy, as implemented through the 6Es framework (engage, explore, explain, engineer, enrich, and evaluate), effectively addresses CLIL teaching dilemmas by providing critical frameworks for discipline-specific literacies through scientific inquiry, resulting in intensive multidimensional learning, positive academic emotions, and positive attitudes among Indonesian EFL learners.	Indonesian Journal of Applied Linguistics
5	(R, Iskandar, & Halim, 2024)	Teachers' Implementation Strategies of 21st Century Skills in Teaching English at SMP UNISMUH Makassar	Most English teachers at SMP UNISMUH Makassar comprehend and apply 21st-century skills well, except "Citizenship," which is not successfully applied due to teacher misunderstanding.	The 2nd International Conference on Language Teaching 2024

Project-Based Learning (PjBL) improves communication, collaboration, and critical thinking, while STEAM education improves the motivation of learners and a variety of thinking abilities. PjBL further improves language skills and the use of functional language in ESL. Through analysis of the impact of STEAM-PjBL on the 6C model of 21st-century skills within a bilingual ESL setting, this research fills important gaps in previous research. It will measure the effect of this intervention on seventh-grade students' communication, collaboration, critical thinking, creativity, citizenship, and character. Furthermore, it will measure STEAM-PjBL as a CLIL pedagogical method, by investigating its capacity to learn language and subject matter simultaneously alongside

the necessary 21st-century skills area that has not been rigorously explored for the full 6C model in multilingual ESL contexts so far.

This research hypothesizes that the integration of STEAM into Project-Based Learning in a bilingual ESL classroom will measurably and significantly enhance all six aspects of the 21st-century skills Model (Communication, Teamwork, Critical Thinking, Creativity, Citizenship, and Character). The general hypothesis of this working hypothesis is the proposition that the interdisciplinary studies of STEAM and the active and social constructivist nature of PjBL support an idealistic environment for learning. This allows the students to create and apply these skills in real contexts at the same time as building their English language competence through Content and Language Integrated Learning (CLIL).

METHOD

The research method was Action Research (AR), which takes collaborative action, incorporates students' active participation in STEAM-PjBL learning, and allows the researcher to adjust research variables according to the learning responses and needs. (Ari & Ciftci, 2022) The study was conducted during the even semester at a public school in Madiun, where English is the Second Language in the bilingual educational program. There were pre-tests, STEAM-PjBL application, final project presentations, and post-tests that constituted the 8 weeks of activities undertaken by 160 seventh-grade students in 5 classes (A-E) as follows.

RESULT AND DISCUSSION

In addition to the general improvement of competences, it is important to confirm the degree of student involvement during the intervention. The percentage of students who participated in each of the five classes (A-E) for the eight-week study is displayed in the line graph that follows.

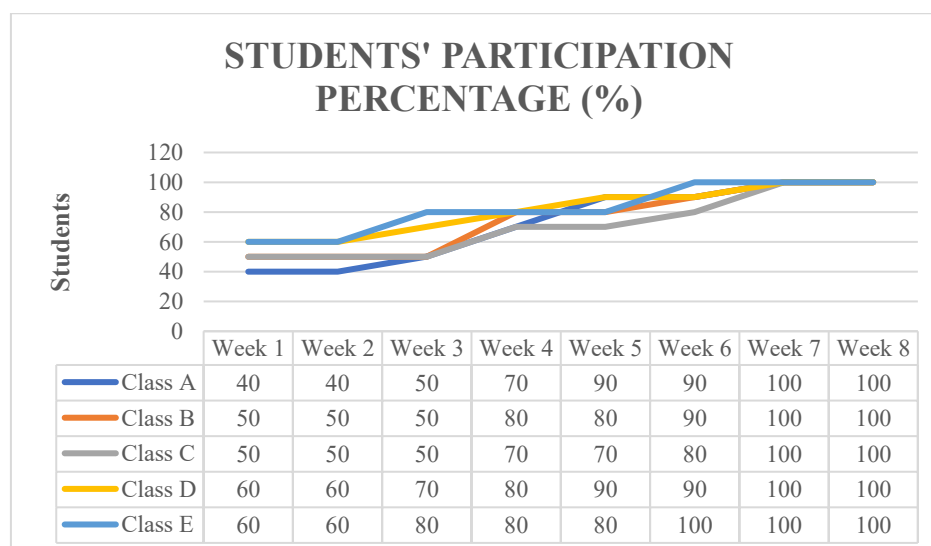


Chart 1. Students' Participation Percentage (%)

This chart shows students' participation percentage across five classes (A-E) over 8 weeks. The initial low attendance, illustrated in the initial weeks, was a one-time fallow from a prior academic requirement that resulted in a significant number of students missing class. The roll-out of the STEAM-PjBL activities, however, appeared to initiate a substantial shift in attendance starting at week four. The heightened participation suggests growing interest and dedication to the project-based learning approach, potentially aiding in enabling the later acquisition of their 21st-century skills. (Afzal & Tumpa, 2025) The growth value might correlate with the implementation of STEAM basic knowledge, which impacted the classes as follows.

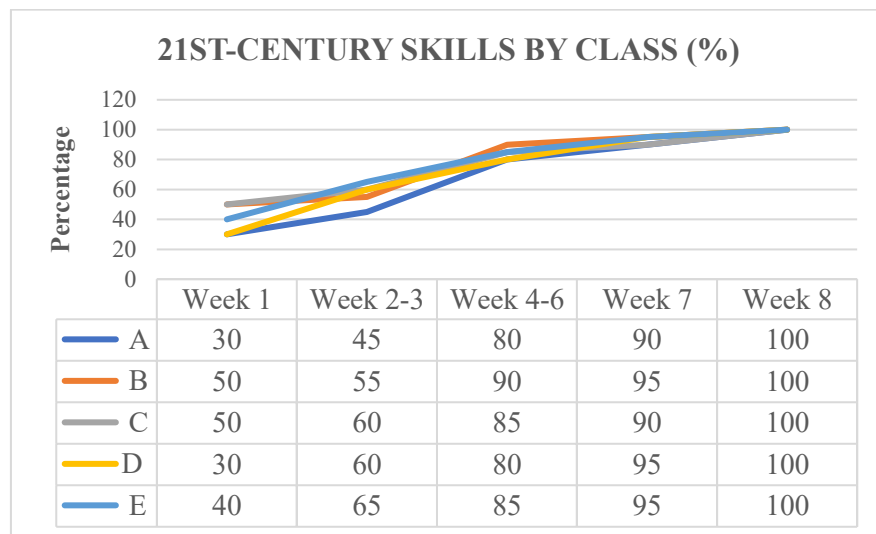


Chart 2. Students' 21st-entury Skills per Class (%)

The graphical trend of the line graph clearly illustrates the positive increase of a growing positive relationship between the pattern of the STEAM-PjBL activity and development of the 6C skills over time, i.e., weeks 2-3 and 4-6 intensive periods. The increase indicates that active intervention through PjBL engagement in project work assisted in developing skill acquisition. Furthermore, the co-dependency of content and language learning in the STEAM model likely had a synergic effect, facilitating linguistic capacity and cognitive knowledge and therefore contributing to general skill acquisition.

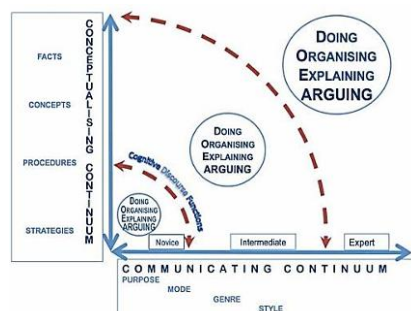


Image 1. Pluriliteracies Development Mapping (Meyer, Coyle, Halbach, Schuck, & Ting, 2015)

STEAM-PjBL and encourage active engagement in authentic meaning production within a resource-rich transdisciplinary setting; they complement each other's pluriliteracies approach. As they progress along the conceptual continuum, students examine four science activity domains: doing, organizing, explaining, and defending science, with a focus on effective communication, gradual rise in complexity, and depth. Students should therefore be able to place themselves on the continuum by accessing the discourse context, the target audience, and the purpose. (Meyer, Coyle, Halbach, Schuck, & Ting, 2015)

Apart from the overall impact and commitment, the study also examines the specific influence of the STEAM-PjBL intervention on each of the six individual 21st-century skills of the 6C model.

1. CHARACTER SKILL

The study aims to build character as one of the significant 21st-century skills in a dual-language ESL program using STEAM-PjBL. The study acknowledges the contributions of character and other skills to society and education. Lastly, the integration of STEAM-PjBL is also expected to help strengthen the character of the students.

2. CITIZENSHIP SKILL

Citizenship is among the key aspects of the 6C model which the current research investigates with regard to STEAM-PjBL applied in ESL education. Although there are some of the findings from the previous research covered in the chapter that reported difficulty in the application of citizenship skills by the teachers, the research would likely be looking into investigating its development within the collaborative strategy. The overall aim is to determine whether STEAM-PjBL can indeed increase the understanding and application of citizenship among the learners.

3. COLLABORATION SKILL

Literature expressly informs that Project-Based Learning (PjBL) when integrated with STEAM provides a collaborative setting for students. The collaborative setting is a necessity for communication and implementation of innovative solutions emanating from interdisciplinary learning. The study, therefore, seeks to measure the impact of STEAM-PjBL in improving collaboration skills of students in a bilingual ESL setting.

4. COMMUNICATION SKILL

Communication is termed as an essential 21st-century skill that STEAM-PjBL is said to promote in ESL learners. Pluriliteracies development mapping suggests emphasis on effective communication while the students progress through different science activity spheres. This study will thus establish the extent to which the STEAM-PjBL intervention promotes the communication skills of grade seven students.

5. CREATIVITY SKILL

STEAM and Project-Based Learning integration is the hallmark of its capability to cultivate creativity through experience and worthwhile learning activities. STEAM's interdisciplinarity in its operation mode guarantees it generates novel solutions, which are executed through the peer collaborative PjBL

process. The current research thus seeks to determine if the STEAM-PjBL method has a noteworthy influence on the creativity skill among bilingual students.

6. CRITICAL THINKING SKILL

The interdisciplinary nature of STEAM tends to enhance critical thinking and problem-solving skills in students. Project-Based Learning also contributes to this by providing an environment where students need to analyze information and design solutions. One of the most significant objectives of this research is, therefore to determine the potential of STEAM-PjBL for enhancing the critical thinking skills of seventh-grade ESL students. (Chistyakov, et al., 2023) (Imamyartha, et al., 2024) (R, Iskandar, & Halim, 2024) (Afzal & Tumpa, 2025)

It is interesting to examine the distribution of student gain across the six 21st-century skills, even though overall positive tendencies obtained after the STEAM-PjBL intervention are of concern. A pie chart illustrating the percentage of students who had improved by how much of these skills is presented below. It provides a more realistic picture of how learning gains are distributed across the cohort. It indicates the number of students who developed in all six competencies, five competencies, and so on, in a specific manner. (Kuo, 2024) (Mohsen, Khalil, AlZahrani, Awaji, & Abdullah, 2025) (Varas, Santana, Nussbaum, Claro, & Imbarrack, 2023)

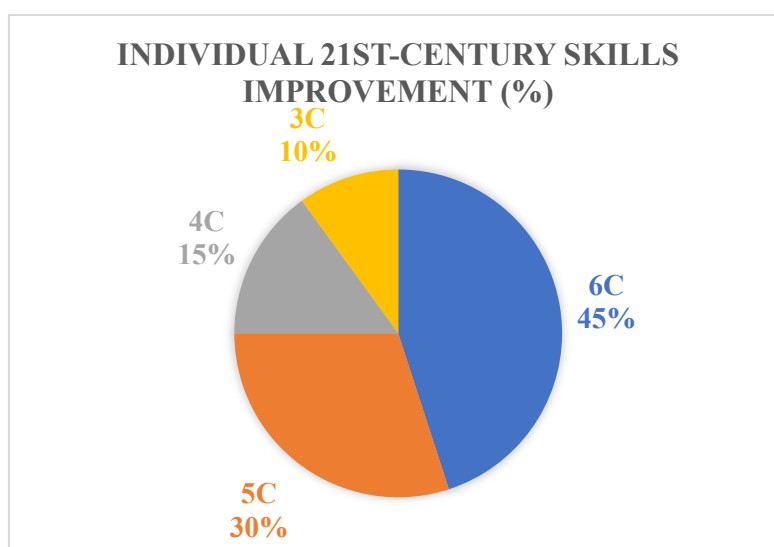


Chart 3. Individual 21st-century Skills Improvement (%)

The following pie chart, "Individual 21st-Century Skills Improvement (%)," graphically depicts the 160 seventh-grade students' improvement in achieving 21st-century skills after the six-week STEAM-PjBL intervention. The pie breaks down the population of students based on the number of the six core competencies (6C) in which they improved. This offers appreciation at a more detailed level than the overall rising trend described above.

As can be seen from the chart, a very high percentage of the students, that is, 45%, improved in all six 21st-century skills being tested. This indicates a very strong effect of the integrated STEAM-PjBL approach on the overall improvement of these critical abilities. Also, a significant 30% of the students improved significantly, with

improvement in five out of the six areas of skills. These two together represent a very large majority (75%) of students who made excellent gains on the majority of the 6C model.

The graph also, however, indicates that lower percentages of students made less constrained gains. Specifically, 15% of the students made four of the six competencies, and the lowest group, at only 10% of the cohort, showed marginal growth in only three of the 6C competencies. Even though these percentages imply that not all students developed as much growth in each skill area, the truth is that even the smallest percentage improvement group did develop progress in more than one of the major 21st-century skills.

Overall, the data that are presented on the pie chart evidence the general effectiveness of the STEAM-PjBL intervention to assist the seventh-grade learners to gain 21st-century skills. The highest percentage of students demonstrated overall improvement in all or a majority of the 6C competencies, indicating the promise of this pedagogy in a dual-language ESL setting. However, having students who are improving at different levels in the class also identifies a need for more intensive investigation of individual learning paths and possible areas of targeted intervention.

CONCLUSION

In conclusion, this action research bears strong witness to the value of implementing STEAM-PjBL in a bilingual ESL classroom in building seventh-grade students' 21st-century skills through the 6C framework. The study's outcome depicts the trend of peaks in skill development within the population following the intervention, with model improvement for all, if not most of the competencies, in sight among the majority of the students. That is, STEAM-PjBL interdisciplinarity and collaboration enable caring learning communities for concurrent development in both English language proficiency and future capability.

Furthermore, the investigation of individual student development demonstrates the broad applicability of this pedagogy with a very high percentage of students developing across all six 6C of 21st-century skills. Whilst entailing differences in improvement scores among the students, overall results form the foundation that STEAM-PjBL is an investment in valuable pedagogic practice in CLIL teaching. The research addresses the gap in existing empirical research studies that have questioned the generic effect of aligned teaching on all the dimensions of the 6C paradigm in ESL bilingual education and asserts its potential for applicability elsewhere in learning environments.

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