

## Implementation and challenges of project-based learning of STEAM in the university during the pandemic: A systematic literature review

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### ABSTRAK

Agar hasil pendidikan yang diharapkan dapat tercapai, maka perlu diterapkan model pembelajaran yang menitikberatkan pada pembelajaran yang berpusat pada siswa. Berdasarkan penelitian yang dilakukan di perguruan tinggi, dosen masih mendominasi proses pembelajaran, dan kemampuan berpikir kritis mahasiswa masih rendah. Penerapan STEAM dalam Pembelajaran Berbasis Proyek (*Project-Based Learning* atau PjBL) adalah salah satu metode pada pengembangan keterampilan siswa di abad ke-21 ini. STEAM merupakan singkatan dari *science, technology, engineering, arts, and mathematics* (sains, teknologi, teknik, seni, dan matematika). STEAM merupakan istilah yang dibuat setelah memasukkan seni (*arts*) ke dalam komponen pengajaran STEAM. Penelitian ini bertujuan untuk mengkaji implementasi dan tantangan *Project-Based Learning* berbasis STEAM di tingkat universitas pada masa pandemi. Penelitian ini menggunakan metode tinjauan pustaka. Penelitian ini menggunakan beberapa publikasi nasional dan internasional yang berisi informasi teoretis atau terverifikasi. Penelusuran publikasi dilakukan secara terorganisir dan komprehensif untuk kemudian dibahas dan dapat digunakan dalam menyelidiki dampak pembelajaran berbasis proyek terintegrasi STEAM pada pengembangan kompetensi di masa sekarang. Hasil penelitian menunjukkan bahwa penerapan pembelajaran berbasis proyek terintegrasi STEAM mendorong perkembangan keterampilan mahasiswa. PjBL terintegrasi STEAM memungkinkan mahasiswa mendapat kesempatan belajar langsung untuk mengaplikasikan topik yang sedang mereka pelajari dalam aktivitas proyek dengan menggabungkan beberapa domain studi. Melalui kegiatan belajar, siswa dapat mempraktikkan kemampuan komunikasi, literasi sains, kemampuan berpikir kritis, berpikir kreatif, dan pemrosesan secara sains.

**Kata Kunci:** Project-Based Learning; STEAM; Pandemi.

### ABSTRACT

*To achieve the intended educational outcome, a learning model that puts a focus on student-centered learning must be implemented. According to investigations of university education, lecturers still dominate the learning process, and students' critical thinking skills are still insufficient. Using STEAM in Project-Based Learning (PjBL) is one method for fostering 21st-century skills. STEAM is an acronym for science, technology, engineering, art, and mathematics. STEAM is a term that was coined after incorporating art into the STEAM teaching component. This research aims to examine the implementation and challenges of Project-Based Learning of STEAM at the university during the pandemic. This research employs literature review as its method. Furthermore, within the method it uses several national and international publications that contain theoretical or verifiable information. An organized and comprehensive examination of the publications is discussed in order to investigate the impact of STEAM-integrated project-based learning on the development of 21st-century qualifications. The results showed that the implementation of STEAM-integrated Project-Based*

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*Learning fosters students' development of 21st-century skills. STEAM-integrated PjBL allows students a hands-on learning chance to apply the topics they have studied in a project activity by fusing many domains of study. Through the learning activities, students can put their communication, scientific literacy, critical thinking, creative thinking, and scientific process abilities into practice.*

**Keywords:** Project-Based Learning; STEAM; Pandemic.

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## INTRODUCTION

Learning in the 4.0 era is defined as the accomplishment of educational outcomes in accordance with the requirements of the 4.0 era (Bonfield et al., 2020; Mital' et al., 2021). Individuals with a noble character, the capacity for critical and creative thought, good social skills, including the capacity for cooperative learning and interpersonal communication, and information technology expertise are the academic results that are in line with the 4.0 era. The application of a learning model that prioritizes student-centered learning is the approach used to attain the desired educational outcome (Bujang et al., 2020). The findings of investigations into education at universities indicate that lecturers continue to dominate the learning process and that students' critical thinking abilities are also still lacking. The majority of students are inactive when the lecturer poses a question for them to respond to throughout the learning process in the classroom (Puspaningtyas et al., 2022).

The rapid advancements in technology have made it necessary to update education, especially schooling. In order for a learning program to be successful, students should have the ability to learn at any time and from any location. Online education has been made available at various international institutes throughout the past 20 years. However, many schools, colleges, and universities do not utilize this style of instruction, and their staff may not be familiar with the specifics of what e-learning entails (Mahyoob, 2020). Student involvement in the perception and knowledge of the nature of the learning material is one of the most efficient strategies to teach them new things. A comparison of traditional versus active learning provides evidence in support of the theory, which is based on a meta-analysis of a significant number of studies on students' learning in STEAM courses. Other popular active learning strategies include Instruction-Based Learning (IBL), Problem-Based Learning (PBL), learning by doing and gamification (Boychev & Boycheva, 2020).

Problem-solving training and development are the foundation of the Project-Based Learning (PjBL) educational approach (Bagheri et al., 2020). The development of PjBL curricula is founded on constructivist theory principles, which place an emphasizing learning new information and expanding on previously accumulated knowledge to complete various activities. The tenets of this learning theory include three aspects. First, learning is active and social, students determine what new knowledge is necessary. Second, students

determine how to learn while actively participating in the learning of the course material. Knowledge is created and built upon prior knowledge and experiences. In other words, learning is not only something that is transmitted from instructor to student; rather, students are expected to actively seek out material and make connections to it in their own life. Additionally, PjBL emphasizes social constructivism, which prioritizes the collaborative learning process in which students collaborate, communicate, and learn to respect one another's differences in order to construct their knowledge (Simonton et al., 2021).

Project-based learning that incorporates STEAM is one way to develop 21st-century abilities. Five elements make up the STEAM learning approach: science, technology, engineering, art, and mathematics. The final result is STEAM, which incorporates art into the instructional component. The goal of STEAM education is to equip students with the innovative, creative, critical thinking, teamwork, and communication skills necessary to solve problems and learn new things (Zayyinah et al., 2022).

Several studies on STEAM in education have been conducted. Bush and Cook (2016) have demonstrated the significance of preservice teachers experiencing modeled integration points, such as STEAM, during their teacher preparation programs. To engage preservice teachers in meaningful STEAM-related learning and teaching, teacher educators are expected to develop partnerships with their university, local K-5 schools, and the community. Moreover, according to Sastre-Merino et al. (2020), merely applying face-to-face teaching methods to a virtual distance learning environment is insufficient. To accomplish competencies, the educational practice must be transformed to include a variety of learning activities. Due to the COVID-19 pandemic, the Institute of Educational Sciences (ICE) at the Universidad Politécnica de Madrid (UPM) was required to redesign its STEAM educator training programs.

According to Pasani and Amelia (2021), introducing the integrated STEAM approach during the COVID-19 pandemic was effective in generating interest and enhancing comprehension among South Kalimantan's instructors and student aides. In addition, Garcia et al. (2021) demonstrate that the COVID-19 pandemic has disrupted conventional teaching practices, compelling instructors to reevaluate their educational methodologies, evaluation methods, and overall teaching approaches. This affords professors the opportunity to contemplate on and potentially alter their existing beliefs regarding STEAM education.

Examining the efficacy of PjBL represents a significant research gap in the field of STEAM education during the COVID-19 pandemic. In particular, there is a lack of comprehension regarding the outcomes and effects of PBL on student engagement, learning outcomes, and the development of STEAM-related competencies in the university setting. This research should investigate the efficacy of PjBL in virtual or integrated learning environments and the challenges and adaptations necessary for its successful implementation. In addition, it is necessary to investigate the role of partnerships and collaboration in supporting project-based learning initiatives during the pandemic, as well as strategies for transforming educational practices and addressing pedagogical challenges in PBL during this difficult period. By resolving these gaps, researchers can contribute to a deeper understanding of the implementation and challenges of project-based learning in the university setting, particularly in the context of STEAM education during the COVID-19 pandemic.

In addition, comprehending the perceptions and experiences of both students and teachers engaged in project-based learning in virtual or blended learning environments is another research gap. This research should investigate their perspectives, obstacles, and benefits to shed light on the efficacy and practicability of implementing project-based learning strategies during the pandemic. Researchers can provide valuable guidance for the successful implementation of project-based learning in a university setting by identifying the specific pedagogical challenges encountered by educators and investigating strategies and best practices employed to overcome these challenges. Overall, addressing these research voids through a systematic review of the literature will contribute to a better understanding of the implementation and challenges of project-based learning in the context of STEAM education during the COVID-19 pandemic. Therefore, this research aims to examine the implementation and challenges of Project-Based Learning of STEAM at the university.

## METHOD

The research method used is a literature review of several national and worldwide journals as literature that can be accounted for the verifiable sources (Sugiyono, 2019). The impact of STEAM-integrated Project-Based Learning on the development of 21st-century abilities is examined using a systematic and structured literature review. The researcher used search engines *Google Scholar* to search the related articles. Keywords for selecting the articles are “Project+Based+Learning+STEAM”. The inclusion criteria for selecting articles in this review are as follows: the articles must be written in English or Indonesian, published between 2020 and 2022, and published in peer-reviewed journals or conference proceedings. They should also address the research questions by including relevant terms and present an implementation initiative. These criteria ensure that the selected articles are credible, recent, relevant, and provide practical insights into implementation initiatives.

Meanwhile, the exclusion criteria for this review are as follows: inaccessible or unavailable studies, studies not in the form of papers (e.g., books, dissertations), studies not published in peer-reviewed journals or conference proceedings, studies that do not directly address the topics and research questions of this study despite including the search terms, and studies that merely redefine general concepts without providing substantial insight. Furthermore, qualitative-descriptive analysis is used to examine the acquired data (Arikunto, 2019). Figure 1 illustrates the article selection process used in the review.

This systematic review of the literature seeks to examine the implementation and challenges of PjBL in the context of STEAM education during the pandemic as seen in Figure 1. This investigation examined the following research questions: 1) During the pandemic, what strategies are employed to implement PjBL in STEAM education, and how do these strategies enhance instruction? 2) What obstacles are encountered when implementing PjBL in STEAM education, and how are they overcome? 3) How does PjBL contribute to students' skills, creativity, and motivation in STEAM education? 4) How does the integration of PjBL and STEAM education affect language acquisition among online learners? 5) What resources and support are necessary

for the successful implementation of PjBL in STEAM education at the university level?

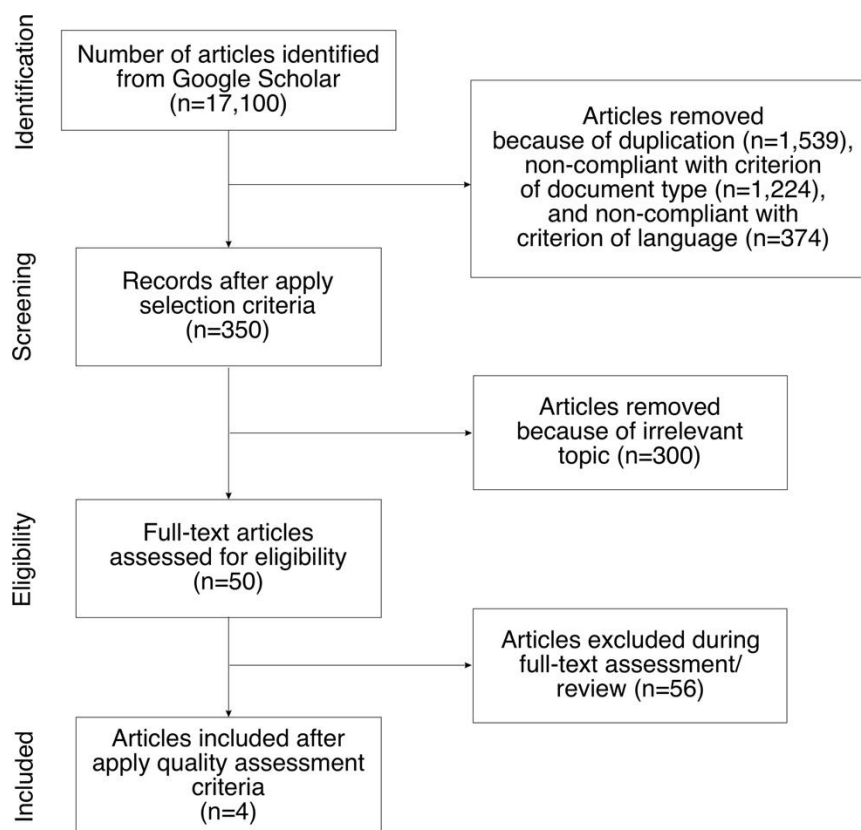


Figure 1. Flowchart of article selection process

## RESULTS AND DISCUSSION

### Results

Table 1. Several Studies Related to STEAM Project-Based Learning

No.	Authors	Title	Method	Results
1	(Nuragnia et al., 2021)	<i>Pembelajaran Steam di Sekolah Dasar: Implementasi dan Tantangan (STEAM Learning in Elementary Schools: Implementation and Challenges)</i>	Quantitative Descriptive	Teachers have employed a variety of strategies to conduct STEAM classes, including integrated lessons, PjBL, PBL, IBL, evaluation, reflection, and collaboration (skills and knowledge). There are many challenges in implementing STEAM education, including a lack of pedagogical, practical, physical, and STEAM resource support as well as time management issues. Finally, the teachers have created lessons that will be used for STEAM learning. To support the technical implementation of STEAM in elementary schools, teachers must be trained in this area, and facilities, particularly

No.	Authors	Title	Method	Results
				technological ones, must be made available.
2	(Hawari & Noor, 2020)	Project Based Learning Pedagogical Design in STEAM Art Education	Project Based Learning	The PjBL pedagogical design has the potential to replace traditional art classrooms with teacher-led instruction while also enhancing instructional methods. The strategy works well in assisting teachers in executing a real-world art lesson while benefiting the students by emphasizing the artistic process of developing a STEAM project while emphasizing the completion of the necessary creative content through active cooperation, study of real-world difficulties, and problem-solving in educational activities. The demand on the curriculum, the learning material, the attitudes of the teachers and students, and the availability of tools were all challenges, though. Therefore, a variety of ideas and counsel are put forth to aid in overcoming the difficulties.
3	(Pugar et al., 2022)	STEAM Project Based Learning in Enhancing Japanese Speaking Skill in Online Classrooms	True experimental research with pre-test and post-test control group design	The students' ability to speak Japanese in online classrooms is improved via STEAM project-based learning. The pupils' increased speaking ability demonstrates the beneficial outcome of STEAM project-based learning. After a few treatments, compared to the control group, the participants were more enthusiastic to talk in Japanese. It also demonstrates how the STEAM PjBL strategies have an impact on the kids' drive to speak Japanese. The results of the questionnaire, which showed that the experiment class's pupils would be willing to speak Japanese in an online classroom if STEAM projects were utilized as a teaching method, supported the data. In light of this, STEAM PjBL might be used to improve Japanese speaking abilities in an online classroom.
4	(Puspaningtyas et al., 2022)	Collaborating Project-Based Learning and	Case Study Method	The author needs supporting documentation and better outputs in the form of relevant

No.	Authors	Title	Method	Results
		STEAM Practices at Indonesia's Universities Using Technology Support System		technology in order to establish teaching strategies that might be used in academic institutions. The result also has a substantially higher use-value in terms of applying science. Supporting paperwork, such as SOPs for implementing PjBL report formats, deadlines, and phases, must all be made available to the public in order for PjBL and STEAM to be integrated into education.

## Discussion

### STEAM (Science, Technology, Engineering, Arts, and Mathematics)

The implementation of STEAM-based learning in the teaching and learning process is crucial because it offers a number of benefits, including the ability to prepare the next generation to be ready to face the times, helping develop innovations in life, increasing student interest in STEAM-related careers, making learning more applicable to real-world situations, assisting students in actively developing their own self-concepts, and improving student literacy about STEAM. The development of students' critical thinking, creativity, cooperation, and communication skills—all of which are essential for the 21st century—can also be connected to STEAM-based learning. In keeping with this, STEAM-based learning calls for students to identify a problem, devise a solution, work with peers to find a solution, and communicate clearly while giving thoughtful consideration to one another's views. Students are urged to use systematic and iterative design methods to create things, processes, and systems that satisfy human needs and desires (engineering). STEAM engineering can start with a problem, a need, or a want, and then use measurable criteria that are checked to find limits or constraints (Direktorat Sekolah Menengah Pertama, 2021).

Students' perspectives on physical education may drastically change if they find purpose in their life and work through issues with peers that are related to the subject matter. Higher order thinking can be stimulated by making connections between the material covered in class and the social environment there. The Comprehensive School Physical Activity Programs (CSAPAP) and STEAM programming effectively set up the classroom to adopt a PBL style (Simonton et al., 2021).

### Implementation of STEAM Project-Based Learning in the University During the Pandemic

During the pandemic, the integration of STEAM and PjBL) has become even more significant in promoting student engagement and fostering creativity. The crucial processes of creativity and innovation are incorporated into one of the programs to encourage creativity in kids. It enables students to relate to the well-established STEM components of artistic practices, design concepts, and evaluation. These STEAM components include an integrated method of instruction that necessitates a deliberate link between standards, tests, and lesson planning. The fundamental principles of STEAM emphasize project-based

learning, collaboration, and encouraging inquiry, all of which incorporate the authenticity of art education. Therefore, the syllabus in schools or colleges should be changed to match the idea of STEAM by including these activities into the existing teaching and learning process of education (Hawari & Noor, 2020).

Students can learn more about the creative process through art. The creative component of STEAM broadens the scope of learning and can inspire pupils to explore their creativity. Thus, the incorporation of art components in STEAM can benefit in the development of creativity in pupils (Nuragnia et al., 2021). This research also highlighted another crucial element of PjBL: the lecturers' capacity to absorb curriculum material and integrate it into the project through good pedagogical design. Lecturers can also create suitable lesson plans, compile lists of relevant resources, and choose evaluation tools to help them manage their creative projects. Lecturers also need to understand how to analyze the final result, starting with planning, the production process, and the project's ultimate assessment (Suryaningsih & Nisa, 2021).

On the other hand, lecturers would receive explicit instructions on how to teach in a more engaging and practical manner by adopting the PjBL pedagogical design process in lectures. Students will be inspired by a practical, cross-curricular PjBL lesson to participate, collaborate, and actively interact in the classroom, which will allow them to learn more and acquire important skills. PjBL also allows students the self-assurance to evaluate the work of other groups from the project's inception through the stages of idea, artwork creation, and presentation with better parameters (Herro et al., 2017; Stanley, 2018).

### **Challenges of STEAM Project-Based Learning**

According to the literature written by Milara and Cortés (2019), there are two major obstacles that lecturers must overcome in order to apply STEAM education in their classrooms. First obstacle is an integrative approach which requires content from several topics to be applied simultaneously. Second barrier is transdisciplinary education (lecturers must teach content outside their comfort zone or speciality). The following challenges were mentioned by in-service lecturers who are currently implementing STEAM education in their classrooms: a lack of time for participatory planning, a lack of time for instruction, an insufficient educational structure and organization (e.g., scheduling), difficulty evaluating STEAM accomplishments, a limited number of resources, and insufficient lecturers' preparation (pre-service education should focus more on inter-disciplinarity while in-service).

Aside from the constraints, lecturers face several challenges in STEAM implementation, including curriculum challenges in universities, structural challenges, concerns about implementation to students and how to assess, support from fellow lecturers on the course team, and challenges in adjusting technological aspects (Arsy & Syamsulrizal, 2021; Mejias et al., 2021). STEAM implementation is considered difficult to implement if there are no clear guidelines prepared by qualified experts. To ensure the implementation of STEAM teaching related to the problems encountered, a needs analysis of the STEAM teaching strategy must be performed (Awang et al., 2020; Perignat & Buonincontro, 2019).

The implementation of STEAM learning must start with developing a curriculum that uses the STEAM approach in the design and planning of their



learning. Therefore, it brings impact that cause the students understand STEAM through activities planned in accordance with their development based on the STEAM approach. A learning plan that needs to be prepared by lecturers in the STEAM implementation is determined by paying attention to signs about the end of student achievement, core competencies that are adjusted to the achievement of learning outcomes, and the determination of the material to be taught as a gift of experience to students (Arsy & Syamsulrizal, 2021; Gunawan et al., 2020).

Furthermore, all research results indicated that STEAM-integrated project-based learning might be used to enhance students' 21st-century skills (Priantari et al., 2020). Due to the COVID-19 pandemic, the most recent difficulty in education is converting the educational system to an online one. It is necessary to assess once more how learning with STEAM-integrated project-based learning, which is known to enhance 21st-century abilities, affected learning during the COVID-19 pandemic. Project-Based Learning that incorporates STEAM is envisioned as an alternative to traditional classroom settings, both offline and online (Adlina, 2022; Salsabila & Muhid, 2021; Zayyinah et al., 2022).

## CONCLUSION

Adopting project-based learning incorporating STEAM enhances students' development of 21st-century abilities. By combining several fields of knowledge, STEAM Project-Based Learning gives students a hands-on learning opportunity to apply the concepts they have studied in a project activity. Students can practice 21st-century skills through the learning activities, such as communication, scientific literacy, critical thinking, creative thinking, and scientific process skills. The limitation of this research is that STEAM Project-Based Learning during the COVID-19 pandemic is still inadequate to examine its efficiency in boosting one of the 21st-century abilities, which is since learning during the pandemic era emphasizes the online system.

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