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STEAM learning implementation in Makassar: SWOT analysis

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ABSTRACT

The aim of this study is to identify the strengths, weaknesses, opportunities, and threats (SWOT) of science, technology, engineering, art, and mathematics (STEAM) learning at the elementary school level in Makassar. This study employed a mixed methods approach, specifically the QUANqual type of explanatory sequential design. The survey method was used to collect and analyze quantitative data, while interviews and documentation methods were used for qualitative non-numerical data. The respondents consisted of elementary school teachers in Makassar who were selected using simple random sampling. The results showed that using SWOT analysis and internal strategic factors analysis summary-external strategic factors analysis summary (IFAS-EFAS) calculations, the strengths-opportunities (SO) strategy has the highest score of 4.27. In addition, the weaknesses-opportunities (WO), strengths-threats (ST), and weaknesses-threats (WT) strategies received consecutive scores of 3.25, 2.71, and 1.69, respectively. It suggests that STEAM learning in Makassar is in a growth stage due to its strengths and opportunities that support the development of STEAM education in the city.

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1. INTRODUCTION

The dynamic learning landscape of the 21st-century, driven by advances in technology and evolving educational needs, demands individuals equipped with specific skill sets [1]. Education, in response to these changes, is expected to equip individuals with the necessary skills [2]. In response, Industry 4.0 emphasizes the science, technology, engineering, arts, and mathematics (STEAM) framework, which is recognized for its alignment with both 21st-century skills and their development [3], [4].

The implementation of STEAM learning in children's education represents an educational revolution [5]. This approach integrates various areas of STEAM into the learning process and supports the development of students' scientific inquiry skills along with their ability to design processes [6]. The STEAM framework is intentionally designed to be both pedagogical and mutually beneficial in its approach [7].

Education that integrates STEAM has the potential to cultivate a positive impact on students' creative abilities, critical thinking skills, collaboration, and communication [8], [9]. STEAM learning has the ability to integrate both hard and soft skills that are essential for students, encouraging them to construct knowledge about the world through observation, inquiry, and questioning [10]. In addition, STEAM is recognized as a valuable and meaningful learning tool that promotes student activity [11] and enables them to

think critically in constructing knowledge [12]. The relevance of STEAM learning is particularly noteworthy in the context of the Merdeka Curriculum, which is characterized by teacher flexibility and a focus on essential materials [13].

To spread the positive impact of STEAM learning, the Indonesian government has undertaken various initiatives, including socialization efforts, teacher training programs, and government initiatives such as Kihajar STEM [14]. However, the practical implementation in schools remains limited [15]. A study of 167 science teachers in Makassar found that while 93% were familiar with STEAM, only 40% had integrated it, and 50% faced implementation challenges [16], [17]. In addition, Mabsutsah and Yushardi [18] found that teachers faced difficulties in STEAM learning due to constraints such as limited time and insufficient teacher expertise [17].

Several studies on STEAM learning in Makassar focus on perceptions and their impact on the achievement of elementary school students [19], [20]. The study by Nasrah [19] at SD Pertiwi Makassar Elementary School showed a positive response to the incorporation of STEAM integration into the learning process. The results showed a highly significant difference in students' mean scores before and after exposure to STEAM learning, specifically 31.25 and 84.18, respectively [19]. Meanwhile, Naufal and Asdar [20] investigated preservice mathematics teachers' perceptions of STEAM learning in schools. The results showed that through STEAM learning, preservice mathematics teachers believe that it can increase students' activity, creativity, and learning concentration so that students can find and develop new ideas in designing and completing STEAM projects. This finding underscores the positive impact of STEAM integration on student learning outcomes.

Although there have been numerous studies on STEAM learning, mainly focusing on its impact on student learning outcomes [19], [20]. However, a comprehensive assessment of the potential strengths, weaknesses, opportunities, and threats (SWOT) associated with STEAM learning is still lacking. In fact, the government has shown significant interest in the widespread implementation of STEAM learning [21], [22].

As mentioned above, this study aims to provide a comprehensive overview of the implementation of STEAM learning in elementary schools, particularly in Makassar, Indonesia. The study aims to achieve four main objectives. Firstly, to identify the benefits of implementing STEAM learning in elementary schools in Makassar. Secondly, to identify potential weaknesses that may arise in the application of STEAM learning in elementary school in Makassar. Thirdly, to explore the opportunities associated with the implementation of STEAM learning at elementary school in Makassar. Finally, to assess potential threats that may arise if STEAM learning is not implemented at elementary school in Makassar. Consequently, this study aims to provide insights that can serve as a reference point regarding the implementation of STEAM learning in schools to facilitate its proper implementation in the future.

2. METHOD

This study used a mixed-methods QUANqual explanatory sequential design type with survey methods to collect and analyze numerical data quantitatively, and interviews, documentation, and observation for non-numerical data qualitatively [23]. The study design is shown in Figure 1. Based on Figure 1, several stages of the study were carried out to achieve the study objectives, including i) theoretical studies, ii) instrument development, iii) instrument validation, iv) surveys, v) analysis of survey data results, vi) interviews, vii) documentation, viii) observation, ix) triangulation, and x) conclusions. This study also aimed to provide an overview of four aspects such as the SWOT of STEAM learning in Makassar. The four indicators in STEAM learning are shown in Table 1.

Table 1 shows the STEAM learning indicators used in the development of instruments such as questionnaires, interviews, and observations, which are an integral part of the survey implementation. Therefore, a survey was conducted by distributing questionnaires to elementary school teachers in Makassar whether they have implemented STEAM learning or not. The survey was conducted both online and offline in July 2023. The population considered in this study consists of 7,340 elementary school teachers in Makassar. By implementing a simple random sampling technique using the Slovin formula [24], 379 teachers were selected. The data collected from this survey, which includes quantitative information, would be subjected to descriptive statistical analysis for subsequent application in calculating the internal strategic factors analysis summary (IFAS) and external strategic factors analysis summary (EFAS) in August 2023.

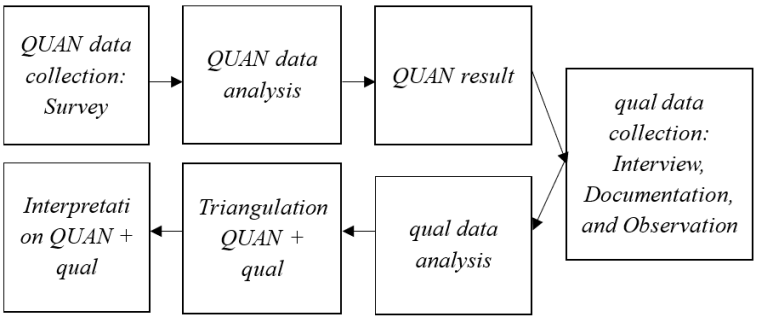

Figure 1. QUANqual mixed approach schema with triangulation design of validating quantitative data model type

Table 1. STEAM learning indicators

No.	Aspect		Indicator
1.	Strengths	i.	Students are active in the learning process.
		ii.	Critical thinking skills in problem-solving.
		iii.	Students' learning outcomes.
		iv.	Professional teachers who have teaching skills.
2.	Weaknesses	i.	Teachers have not dared to implement STEAM.
		ii.	Limited time in carrying out STEAM learning.
		iii.	Availability of school facilities.
3.	Opportunities	i.	Implementation of the Merdeka Curriculum.
		ii.	STEAM learning shutdown program.
		iii.	School operational assistance as known as *bantuan operasional sekolah* (BOS) fund policy.
4.	Threats	i.	Schools from Java Island dominate more to become excellent schools.

Qualitative data were obtained by conducting face-to-face interviews to explore the implementation of STEAM learning in elementary schools. At least three teachers were interviewed in August 2023. In addition, supporting information was obtained through documentation, including instructional materials and photo documentation of STEAM learning activities, as well as observations conducted in September 2023. The qualitative data was then analyzed by transcribing the interview results, then coding and grouping based on the categories of strengths (S), weaknesses (W), opportunities (O), and threats (T).

The final data analysis for QUANqual involved combining the quantitative data as the primary dataset, which served as the basis for drawing conclusions. Validation of the information discovered in the qualitative data analysis was conducted by referring to the results of the quantitative data analysis, using a triangulation design approach. The results were then derived based on QUANqual analysis, providing an overview of S, W, O, and T arising from the implementation of STEAM learning in Makassar, addressing the problem formulation. To further enhance the analysis and provide recommendations, a SWOT analysis matrix was prepared, incorporating validated aspects of S, W, O, and T.

3. RESULTS AND DISCUSSION

Testing of the initial data scale with 30 respondents yielded results indicating the presence of an invalid item. Consequently, the invalid items were excluded from the questionnaire [25]. Subsequently, validity and reliability tests were conducted on the survey data using the statistical package for the social sciences (SPSS) Statistics 22 software, which confirmed the validity of the data obtained.

Data collection was conducted through surveys, interviews, and documentation of all elementary school teachers in Makassar who have implemented STEAM learning. The results of a survey of 421 teachers showed that 108 of them have implemented STEAM, while 313 have not implemented STEAM learning in the classroom. In addition, the data obtained was calculated by IFAS and EFAS. Before calculating IFAS and EFAS, the data from the questionnaire results were grouped and given coding of internal and external factors. The internal and external factor questionnaire statements are shown in Tables 2 and 3. Then, the data from the questionnaire results were given a rating for each aspect of the statement in the questionnaire. There was information about the number of respondents who gave a rating scale to each statement shown in Tables 4 and 5.

Table 2. Internal factor questionnaire statement

No.	Strength	No.	Weaknesses
S_1	Students develop critical thinking skills through STEAM learning.	W_1	Teachers are not sure about what exactly STEAM is, so it is difficult for them to teach students with this learning.
S_2	Students are able to improve their ability to identify and analyze problems.	W_2	Teachers need a long time to prepare teaching materials that are in accordance with STEAM learning.
S_3	Students progress in understanding the material after the teacher applies STEAM to learning.	W_3	The teacher needs a considerable allocation of time to align and 7:8 connects concepts from STEAM.
S_4	Student learning outcomes can develop when STEAM is applied in the classroom.	W_4	Lack of learning support tools that can help teachers apply STEAM in the classroom.
S_5	Professional teachers are able to improve pedagogic competence through STEAM learning in schools.		

Table 3. External factor questionnaire statement

No.	Opportunity	No.	Threat
O_1	The Merdeka curriculum is very relevant to STEAM learning which involves collaboration from 5 disciplines so as to facilitate student learning in the classroom.	T_1	Outside schools first developed quality learning that focused on STEAM.
O_2	Mobilizing teachers are active in participating in STEAM learning training.		
O_3	BOS funds are used to support the completeness of improving facilities in schools.		

Table 4. Data on questionnaire results and ratings from internal factors

No.	Strength	Rating			
		STS	TS	S	SS
1.	Students develop critical thinking skills through STEAM learning.	0	2	62	44
2.	Students are able to improve their ability to identify and analyze problems.	0	2	73	33
3.	Students progress in understanding the material after the teacher applies STEAM to learning.	1	2	67	38
4.	Student learning outcomes can develop when STEAM is applied in the classroom.	0	3	68	37
5.	Professional teachers are able to improve pedagogic competence through STEAM learning in schools.	1	3	48	56
No.	Weaknesses				
1.	Teachers are not sure about what exactly STEAM is, so it is difficult for them to teach students with this learning.	18	56	29	5
2.	Teachers need a long time to prepare teaching materials that are in accordance with STEAM learning.	9	50	36	13
3.	The teacher needs a considerable allocation of time to align and 7:8 connects concepts from STEAM.	2	31	62	13
4.	Lack of learning support tools that can help teachers apply STEAM in the classroom.	11	36	53	8

Table 5. Data on questionnaire results and ratings from external factors

No.	Opportunities	Rating			
		STS	TS	S	SS
1.	The Merdeka curriculum is very relevant to STEAM learning which involves collaboration from 5 disciplines so as to facilitate student learning in the classroom.	1	2	66	39
2.	Mobilizing teachers are active in participating in STEAM learning training.	0	5	68	35
3.	BOS funds are used to support the completeness of improving facilities in schools.	8	4	50	46
No.	Threat				
1.	Outside schools first developed quality learning that focused on STEAM.	0	11	71	26

3.1. IFAS and EFAS calculations

The IFAS and EFAS were calculated to determine the weight, rating, and score. The calculation of weight was done under the condition that the total weight should not exceed 1.00. Meanwhile, determining the rating value aimed to measure the importance of aspects in the SWOT analysis. Then, the score was calculated by multiplying the weight by the rating of each aspect. Therefore, from the calculation of IFAS and EFAS matrix scores, it can be seen in Tables 6 and 7 that the total scores for S, W, O, and T were 1.99, 0.97, 2.28, and 0.72, respectively.

Table 6. IFAS matrix

No.	Strength	Weight	Rating	Score
1.	Students develop critical thinking skills through STEAM learning.	0.13	3	0.39
2.	Students are able to improve their ability to identify and analyze problems.	0.12	3	0.36
3.	Students progress in understanding the material after the teacher applies STEAM to learning.	0.12	3	0.36
4.	Student learning outcomes can develop when STEAM is applied in the classroom.	0.12	3	0.36
5.	Professional teachers are able to improve pedagogic competence through STEAM learning in schools.	0.13	4	0.52
	Total	**0.63**		**1.99**
No.	Weaknesses	Weight	Rating	Score
1.	Teachers are not sure about what exactly STEAM is, so it is difficult for them to teach students with this learning.	0.08	2	0.16
2.	Teachers need a long time to prepare teaching materials that are in accordance with STEAM learning.	0.09	2	0.18
3.	The teacher needs a considerable allocation of time to align and 7:8 connects concepts from STEAM.	0.10	3	0.30
4.	Lack of learning support tools that can help teachers apply STEAM in the classroom.	0.09	3	0.27
	Total	**0.37**		**0.87**
	Total Internal Factors	**1.00**		**2.96**

Table 7. EFAS matrix

No.	Opportunities	Weight	Rating	Score
1.	The Merdeka curriculum is very relevant to STEAM learning which involves collaboration from 5 disciplines so as to facilitate student learning in the classroom.	0.26	3	0.78
2.	Mobilizing teachers are active in participating in STEAM learning training.	0.25	3	0.75
3.	BOS funds are used to support the completeness of improving facilities in schools.	0.25	3	0.75
	Total	**0.62**		**2.28**
No.	Threat	Weight	Rating	Score
1.	Outside schools first developed quality learning that focused on STEAM.	0.24	3	0.72
	Total	**0.38**		**0.72**
	Total External Factors	**1.00**		**3.00**

3.2. Cartesian diagram SWOT analysis

The results of the IFAS and EFAS calculations can be used to find the coordinates of the SWOT diagram using the formula Internal Analysis Coordinates; External Analysis Coordinates are $\frac{s-w}{2}; \frac{o-t}{2}$ so the coordinate point is located at (0.51; 0.78). The SWOT diagram is shown in Figure 2. From the SWOT diagram in Figure 2, it can be concluded that the implementation of STEAM learning in Makassar is experiencing positive development (growth). In other words, it is in the stage of growth/development. It indicates a favorable situation because having the power to seize opportunities will support the growth of STEAM learning in Makassar.

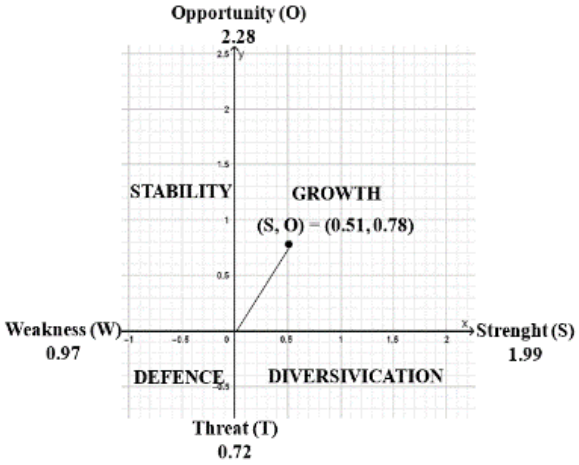

Figure 2. SWOT diagram

3.3. SWOT matrix

The SWOT matrix is a tool used to formulate alternative strategies for implementing STEAM in Makassar. Through this matrix, potential internal and external factors can be more clearly presented and appropriate strategies can be formulated. The four strategies offered can be seen in Table 8. After knowing the results of the analysis of data input based on the SWOT classification above, strategies can be described that can be used in implementing STEAM in Makassar. The following are strategies for implementing STEAM in Makassar according to the SWOT matrix.

Table 8. SWOT matrix

IFAS / EFAS	Strength (S)	Weakness (W)
	S1 Students develop critical thinking skills through STEAM learning. S2 Students are able to improve their ability to identify and analyze problems. S3 Students progress in understanding the material after the teacher applies STEAM to learning. S4 Student learning outcomes can develop when STEAM is applied in the classroom. S5 Professional teachers are able to improve pedagogic competence through STEAM learning in schools.	W1 Teachers are not sure about what exactly STEAM is so it is difficult for them to teach students with this learning. W2 Teachers need a long time to prepare teaching materials that are in accordance with STEAM learning. W3 Teachers need a considerable amount of time to align and connect concepts from STEAM. W4 Lack of learning support tools that can help teachers apply STEAM in the classroom.
Opportunity (O) O1 The Merdeka Curriculum is very relevant to STEAM learning which involves collaboration from 5 disciplines so as to facilitate student learning in the classroom. O2 Mobilizing teachers are active in participating in STEAM learning training. O3 BOS funds are used to support the completeness of improving facilities in schools.	SO strategy: a. Integrating STEAM learning in the Merdeka Curriculum can improve critical thinking skills and problem-solving abilities so that students can experience progress in learning. (S1, S2, S3, 01). b. Improve teachers' pedagogic abilities through government programs such as teacher training (S5, O2).	WO strategy: a. Involve teachers in STEAM learning training to improve teachers' ability to prepare teaching materials and connect STEAM concepts in learning (W2, W3, O2). b. The presence of the Merdeka Curriculum in accordance with STEAM learning will provide encouragement to teachers to increase their understanding and confidence in applying STEAM concepts in the classroom (W1, O1). c. Utilizing BOS funds to overcome the lack of supporting tools can help teachers in applying STEAM in the classroom (W4, O3).
Threats (T) T1 Outside schools first developed quality learning that focused on STEAM.	ST strategy: a. Teachers need to improve pedagogic skills to improve the quality of STEAM-oriented learning so that schools can compete with other schools outside Makassar (S5, T1).	WT strategy: a. Teachers need to increase their understanding and confidence in applying the STEAM concept in the classroom so that they can compete with outside schools that first develop the quality of STEAM learning (W1, T1).

3.3.1 SO strategy

Seeing the strengths and opportunities in implementing STEAM in Makassar, by utilizing critical thinking and problem-solving skills, students will experience progress in learning. This is supported by the Merdeka Curriculum which integrates STEAM learning. The Merdeka Curriculum that integrates learning with a STEAM approach also provides great support in building an exciting, deep, and relevant learning environment for students' development in the face of today's challenges (S1, S2, S3, O1).

"Talking about the correlation between the Merdeka Curriculum and STEAM, it is very correlated. I see the only curriculum that has ever existed which blatantly implements STEAM is the Merdeka Curriculum". (AMZ/3A)

3.3.2 ST strategy

From the results of strengths and threats, it is necessary to enhance the pedagogical skills of teachers to improve the quality of learning that focuses on the STEAM approach so that schools can remain competitive with schools outside Makassar City. This is a crucial factor for the continued competitiveness of

schools outside Makassar City. In addition, there can be good competition related to STEAM learning at national and international levels (S5, T1).

"I always think that we are no different from Javanese and westerners, but the problem is that we can't learn, we can't help but develop ourselves, and this is what must be applied to students, because if we just read and we don't apply it will settle into deposits, but if it is often communicated often it will develop". (US/4A)

3.3.3 WO strategy

Based on the results of identifying weaknesses and opportunities, engaging teachers in STEAM learning training can be a strategic step to improve their ability to prepare open-ended materials and facilitate the synergistic connection of STEAM concepts in the learning process. This will improve the quality of instruction in the classroom. It can also broaden teachers' perspectives and skills to meet today's learning expectations (W2, W3, O2).

"If I give advice, my fellow mobilizing teachers should help the STEAM community. Mobilizing teachers in Makassar understand the concept of STEAM and understand EDP and then do good practices so that understanding STEAM can spread widely and quickly". (AMZ/3B).

3.3.4 WT strategy

Based on the results of the weaknesses and threats, it is important for teachers to increase their understanding and confidence in applying STEAM concepts in the classroom so that they can compete with outside schools that have already developed STEAM learning. This step will enable teachers to create a more comprehensive and relevant learning experience for their students. It can also help schools remain competitive in an ever-changing educational landscape (W1, T1).

"It is very possible, God willing, we only go back to how we upgrade, upgrade ourselves and students". S/4A).

After conducting a SWOT matrix analysis, the next step is to conduct a quantitative model analysis to be used in strategic planning to evaluate and select the most effective strategy. In this analysis, a quantitative strategy combination planning matrix is used as the basis for calculating the total score value in each S-O, W-O, S-T, and W-T strategy. For example, the S-O strategy is determined by summing the total Strength (S) score and the total Opportunity (O) score. As a result, the scores for the S-O, W-O, S-T, and W-T strategies are 4.27, 3.25, 2.71, and 1.69, respectively. The quantitative planner matrix for the strategy combinations is shown in Table 9.

Table 9. Quantitative strategy combination planner matrix

	Strength (S)	Weakness (W)
Opportunity (O)	S-O strategy: using strength to seize opportunities = 4.27	W-O strategy: minimize weaknesses by seizing opportunities = 3.25
Threats (T)	S-T strategy: using power to overcome threats = 2.71	W-T strategy: minimize weaknesses and avoid threats = 1.69

4. CONCLUSION

The implementation of STEAM learning in Makassar shows positive potential as it is currently in the growth stage and received the highest score of 4.27 in the SO strategy. This indicates a strength that can be leveraged to capitalize on existing opportunities. Consequently, the proposed strategies to support the development of STEAM implementation in Makassar include: i) integrating STEAM learning into the Merdeka Curriculum to enhance critical thinking and problem-solving skills, thereby facilitating students' learning progress, ii) enhancing teachers' pedagogical skills through government programs such as teacher training, and iii) utilizing BOS funds to support the provision of complete STEAM learning facilities to ensure an efficient learning process and improved student learning outcomes. This strategic approach is recommended to the government for consideration in formulating policies that can support the development of STEAM learning in Makassar.

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