Jurnal Penelitian Pembelajaran Fisika
Vol. 15 Issue 3 – July 2024, p263-271
p-ISSN 2086-2407, e-ISSN 2549-886X
Available Online at http://journal.upgris.ac.id/index.php/JP2F
DOI: 10.26877/jp2f.v15i3.18724

The Influence of The STEM Learning Approach on Students Communication and Collaboration Abilities on Elasticity Materials

Solatun Khoiriyah[1], **Vandan Wiliyanti**[1,2] **and Indra Gunawan**[1]
[1]Program Studi Pendidikan Fisika Universitas Islam Negeri Raden Intan Lampung, Jl. Letkol Endro Suratmin, Sukarame, Bandar Lampung

[2]E-mail: vandanwiliyanti@radenintan.ac.id

Received: 25 March 2024. Accepted: 02 June 2024. Published: 31 July 2024.

Abstract. This research aims to determine the influence of the STEM learning approach on students' communication and collaboration abilities in elasticity materials. The type of research is quasi-experimental, with a non-equivalent control group design. The population of this study consists of students from grade XI MIA at MAN 1 Bandar Lampung. We used simple random sampling as the sampling technique, designating XI MIA 3 as the experimental group and XI MIA 4 as the control group. The instruments used are questionnaires and observation sheets. We employ the questionnaire, which uses a Likert scale with five answer options, to measure students' communication and collaboration abilities. We use the observation sheet to assess the implementation process of STEM learning. We conduct data analysis using the t-test with SPSS version 25.0. The research findings indicate that the communication and collaboration abilities of students in the experimental group are higher than those in the control group, with a Sig. (2-tailed) value of 0.000, showing a significant difference in communication and collaboration abilities between students using STEM learning and those using conventional learning. This study concludes that there is a significant influence of the STEM approach on students' communication and collaboration abilities in the subject of elasticity.

Keywords: STEM, communication, collaboration, elasticity

1. Introduction

Education has an important role in providing knowledge and experience for students[1]. So, the young generation is prepared to be individuals and groups that will take an important part in the future by providing preparation in the form of skills, both soft skills and hard skills[2]. We expect education to equip students to navigate the challenges and opportunities of the digital era, which necessitate academic knowledge as well as essential skills like collaboration and communication. Soft skills are personal qualities that enable individuals to interact, communicate effectively, and coordinate with others. Soft skills are considered as important as hard skills[3].

In general, education aims to teach two types of skills: hard skills and soft skills. Hard skills are skills in mastering knowledge, technology, and technical skills that are relevant in their field[4]. Meanwhile, soft skills refer to abilities and expertise related to social interactions (interpersonal skills) and self-management (intrapersonal skills) that can enhance an individual's performance in various situations[5].

Students' soft skills develop through learning processes that involve practicing effective communication, boosting self-confidence, collaborating with groups, developing creativity, critical thinking, and problem-solving. By getting accustomed to these activities, students can become knowledgeable individuals while also instilling good ethics and morals. Physics education aims to balance cognitive, affective, and psychomotor aspects, which are always the main concerns of educators during the learning process. However, in reality, the cognitive domain tends to dominate, resulting in a

more visible development of hard skills compared to soft skills (affective and psychomotor), which may lag behind[6].

The soft skills provided to students are aimed at helping them develop communication and collaboration skills. Although soft skills are not directly visible, their impact can be felt in an individual's personal success, such as communication ability, collaboration, teamwork, responsibility, and discipline. Therefore, to strengthen soft skill education, a balance between academic and non-academic aspects must be achieved[7].

Soft skills are skills closely tied to an individual's awareness of their environment. These skills focus on psychological aspects and produce perceptible abstract effects, such as communication, collaboration, and the desire to help each other[8]. Basically, everyone has soft skills, but sometimes they need to be trained consistently so that they can become habits and ultimately form an individual's personality. Soft skills will make a person's real existence in society, such as communication and cooperation skills[9].

Communication skills are a crucial asset for students. Without effective communication skills, they will have difficulty expressing their ideas. In daily life, human interaction is crucial because humans are social beings that are inseparable from communication activities. Collaboration is one of the most important forms of interaction. Therefore, every individual needs communication as an essential element[10].

An individual with good communication skills is someone who can effectively convey their ideas to others. Soft skills place a high priority on communication skills. Schools should prioritize teaching communication and collaboration skills. Therefore, educators need to implement learning methods that can enhance communication skills, innovation, and problem-solving abilities through negotiation and cooperation. Students learn to interact with educators and peers, and they practice sharing with others through collaborations designed by educators[11].

Collaboration skills are also a crucial factor for students. In the learning process, students require cooperation with their peers to achieve common goals. Therefore, achieving these goals requires optimal collaboration. Therefore, it becomes imperative to prioritize skills in collaboration[12].

Collaborative skills refer to the ability to participate in activities with the aim of building good relationships with others, respecting each other, and working together to achieve goals. It guides learners to live a harmonious life where they actively contribute, work productively, are flexible, responsible, and value each other. Collaboration in learning has become crucial because it enables students to work together in diversity, becoming an important capital in the face of the continuing evolution of globalization[13].

Based on observations at MAN 1 Bandar Lampung and interviews with physics teachers, it appears that students' communication and collaboration skills are still low. The implementation of monotonous teaching methods, such as lectures, question-and-answer sessions, and in-class assignments, is inefficient as it does not directly involve students with learning resources optimally. As a result, students rely solely on textbooks, failing to explore the potential of their surrounding environment as a learning tool. The limitations in developing this teaching model are due to a lack of instructional tool orientation. The student worksheets (LKS) used tend to be closed-ended, lacking comprehensive support for the development of technical skills. Therefore, there is a need for learning methods that can enhance these abilities.

The main reason for the low communication and collaborative skills of students is the lack of human resources in schools, including teachers, to implement effective learning strategies. Still using a conventional approach. Less attractive teaching methods can result in low student involvement, which in turn results in less learning activity. Choosing inappropriate learning strategies can hamper communication and have a negative impact on their learning outcomes.

Communication is necessary for individuals to express their thoughts and opinions. Conversely, achieving optimal results and completing tasks quickly requires collaboration. Improving students' communication and collaboration skills in schools can be achieved through various methods, such as

classroom learning processes. The learning process involves creating conditions that encourage students to learn, which in turn can result in positive changes in themselves[14].

The learning process can sharpen communication and collaboration if students are trained to communicate effectively, collaborate to work together in groups, demonstrate creativity, and boost self-confidence. Habits like these will produce students with excellent knowledge, supported by good attitudes and morals. However, in physics education, efforts to achieve a balance between cognitive, affective, and psychomotor domains always remain the focus of educators in every learning process. However, the dominant focus still tends to be on the cognitive domain, resulting in students' hard skills being more prominent than their soft skills (affective and psychomotor), which still need significant development.

Educators have direction to improve communication and collaboration skills indirectly. They can conduct training through learning models that combine communication and collaboration activities. However, in reality, educators still tend to use conventional learning approaches[15]. Therefore, we need an effective learning model to help students develop these skills. Currently, the learning model that can enhance students' communication and collaboration skills is the STEM approach[16].

The STEM (Science, Technology, Engineering, and Mathematics) approach involves integrating science, technology, engineering, and mathematics. Its integration can evolve by considering the environment and creating learning connected to everyday real-world situations. This means that with the STEM approach, students not only memorize concepts but also gain a deep understanding aligned with scientific concepts and their applications in daily life[17].

The implementation stages of STEM learning integrate knowledge, technology as learning facilities, engineering as planning and design skills, and mathematics as the science of calculation. The STEM approach has the potential to enhance students' skills in sharpening integrated concepts, principles, and techniques during the learning process[18].

The STEM approach is a potential focus to help students develop good interpersonal skills. This is due to the STEM orientation aspect of the development of life competencies in learners, who will later become self-reliant, disciplined, and easy to interact with others. So the application of the STEM learning approach is the answer to the challenges of the evolution of the times, as well as a solution to the less satisfying output of the education that exists in Indonesia, especially in interpersonal skills that are less observed[19].

2. Method

This research was carried out at MAN 1 Bandar Lampung for the 2023–2024 academic year. The type of research is quasi-experimental research (quasi-experimental research) with a quantitative approach. Research design: non-equivalent control group design. The independent variable is the STEM learning approach research, and the dependent variable is students' communication and collaboration skills. The research population was all students in class XI, MIA. The sampling technique used random sampling to obtain class XI MIA 3 experimental classes using a STEM learning approach and class XI MIA 4 control classes using a conventional approach.

The instruments used were questionnaires and observation sheets. The questionnaire was used to gather data on students' communication and collaboration skills, while the observation sheet was used to observe the implementation process of STEM learning. The physics subject teacher filled out the observation sheet for learning. In assessing the observer, guidelines in the form of a rubric for assessment instruments were provided. Communication skills consist of a number of indicators adopted by Budiono and Abdurrohim, including the ability to effectively express ideas and thoughts, to listen effectively, to communicate information well, and to use good and effective language, while the indicator of collaboration consists of some of Greenstein's adopted indicators that include contributing actively, working productively, showing responsibility and showing appreciation.

Hypothesis testing was conducted using an independent sample t-test. Prior to conducting this paired sample t-test, prerequisites for analysis were first checked, namely normality and homogeneity tests, with the assistance of SPSS version 25. The results of the questionnaire on students' communication and collaboration skills were analyzed using a Likert scale with alternative choices in table 1.

Table 1. Alternative questionnaire answer choices.

Alternative Options	Value interpretation of statements	
	(+)	(-)
Very Agree	5	1
Agree	4	2
Neutral	3	3
Disagree	2	4
Very Disagree	1	5

To calculate the value of responses to the questionnaire regarding students' communication and collaboration skills, you can use the formula below:

$$Value = \frac{Scores\ obtained\ by\ students}{Maximum\ Score} X\ Maximum\ Value \quad (1)$$

Scores obtained from communication and collaboration skills are calculated and interpreted according to the categories in table 2.

Table 2. Score interpretation criteria.

No	Interval	Criteria
1	$85\% < A \leq 100\%$	Very High
2	$68\% < A \leq 85\%$	High
3	$52\% < A \leq 68\%$	Enough
4	$36\% < A \leq 52\%$	Low
5	$20\% \leq A \leq 36\%$	Very Low

In addition to the questionnaire, the research instrument uses the observation sheet. We use the observation sheet to measure the implementation of the STEM learning approach. (Science, Technology, Engineering, and Mathematics). Table 3 displays the criteria for observing the percentage of learning.

Table 3. Categories percentage sheet implementation learning model.

Sig	Category
$81\% \leq P \leq 100\%$	Very good
$61\% \leq P \leq 81\%$	Good
$41\% \leq P \leq 61\%$	Good enough
$21\% \leq P \leq 41\%$	Less good
$0\% \leq P \leq 21\%$	Very Less Good

3. Result and Discussion

The data resulting from the communication and collaboration skills of the students is obtained from the communications and collaborations that are given after the end of the learning of 30 statements. The objective of the data is to find out if there are differences in communication and cooperation between the experimental and control classes. The data are presented in Table 3.

Table 3. Results of student communication and collaboration questionnaires.

Dependent Variable	Experimental Class		Control Class	
	Average	Criteria	Average	Criteria
Communication	76,08%	High	68,19%	Enough
Collaboration	75,43%	High	67,16%	Enough
Average	75,76%	High	67,68%	Enough

Based on the table, there are differences in communication and collaboration skills between the experimental and control classes. The data showed a higher level of communicative and collaborative abilities after applying the STEM (experimental class) approach than the control class.

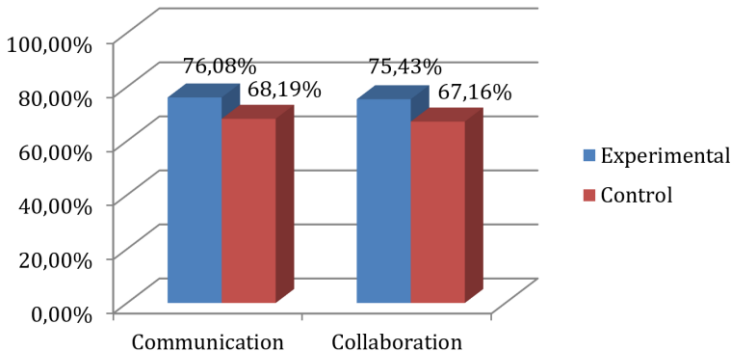

Figure 1. Results of communication and collaboration skills

Figure 1 presents the average communication and collaboration abilities of students in the control class, which are higher than those in the conventional control class. The percentage of communication ability in the experimental class is 76.08%, and collaboration ability is 75.43%, whereas in the control class, communication ability is 68.19%, and collaboration ability is 67.16%.

Communication skills are an essential aspect for students in the 21st century. Communication skills include the ability to convey observations and messages, thoughts, and ideas through various means, whether verbally, in writing, or through gestures. We cannot ignore the role of communication, as effective communication skills significantly influence student learning success. Effective communication facilitates the delivery of ideas as well as the exchange of information in a learning context. Collaboration skills are a must for students in the 21st century. Good collaboration skills make every job easier and can solve problems better[20].

The communication and collaboration skills obtained by class XI 3 and 4 students at MAN 1 Bandar Lampung who implemented learning using a STEM approach reached the high category. One way to evaluate the implementation of the STEM approach is through observation sheets. The observer receives the observation sheet prior to the start of the learning process. Observers, specifically physics subject teachers, will monitor the researchers during learning activities. Depending on the number of research meetings, observers can fill the observation sheet three times. Figure 2 presents the results of the learning implementation observation sheet.

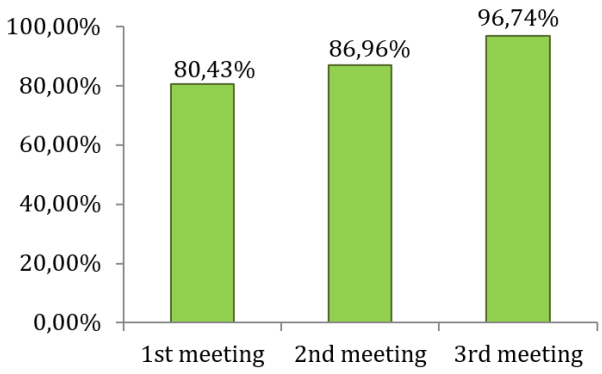

Figure 2. Average STEM learning implementation score per meeting.

Based on figure 2, the average implementation of STEM learning from the first to the third meeting improved significantly. STEM learning consists of three phases: the introductory phase, the core phase, and the closing phase. In the initial stage, educators begin with greetings, ask students to pray, take attendance, provide motivation, and explain the learning objectives. The core phase comprises 8 stages, and in the final closing phase, educators ask students to summarize the lessons, assess their understanding, and lead them in prayer. We categorized the average percentage of learning implementation per meeting as excellent. Thus, descriptively, STEM meets the criteria for effectiveness and impact.

The data prerequisites, including normality and homogeneity tests, were used to analyze the obtained data. The normality test was used to determine whether the sample comes from a population with a normal distribution or not. If the significance value is < 0.05, then the data is considered not normally distributed; conversely, if the significance is > 0.05, the data is normally distributed. The normality test used the Kolmogorov-Smirnov method, assisted by SPSS version 25. The results of the normality test for both classes are listed in table 4.

Table 4. Results of the normality test on students' communication and collaboration skills.

Dependent Variable	Sig Value Experimental Class	Sig Value Control Class	Sig. α Value	Desc.
Communication	0,200	0,173	0,05	Normal
Collaboration	0,169	0,065	0,05	Normal

Table 4 shows that the significance values (Sig.) for the communication and collaboration abilities of the experimental and control group students are > 0.05, indicating that H_0 is accepted and H_1 is rejected, demonstrating that the data is normally distributed. After conducting the normality test, the next step is to test homogeneity in both data groups.

The homogeneity test aims to determine whether the variance of the examined data is uniform or not. If the significance value is > 0.05, then the variance is homogeneous; conversely, if the significance is < 0.05, the data is considered non-homogeneous. SPSS version 25.0 assisted with the homogeneity test, and Table 5 displays the results.

Table 5. The homogeneity test results of students' communication and collaboration skills.

Dependent Variable	**Sig Value**	**Sig. α Value**	**Desc.**
Communication	0.295	0,05	Homogeneous
Collaboration	0.060	0,05	Homogeneous

Table 5 presents significance values (Sig.) > 0.05, thus accepting H_0 and rejecting H_1. This implies that the data variance is homogeneously distributed.

Next, hypothesis testing was conducted to determine whether the implementation of the STEM approach has an effect on students' communication and collaboration skills. Hypothesis testing used the independent sample test with the condition that the data must be normally distributed and homogeneous. The testing criteria state that if the significance probability value is > 0.05, then H_0 is accepted and H_1 is rejected. Conversely, if the significance is < 0.05, then H_0 is rejected and H_1 is accepted.

Table 6. Results of the hypothesis test on students' communication and collaboration skills.

Independent Sample Test							
						95% Confidence Interval Of Difference	
Variable	*T*	*Df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Erroe Difference*	*Lower*	*Upper*
Communication	9.814	68	.000	5.914	.603	4.712	7.117
Collaboration	11.426	68	.000	6.029	.528	4.976	7.081

Based on Table 6, the sig. (2-tailed) value of 0.000 (0.00 < 0.05) indicates that H_0 is rejected and H_1 is accepted. Therefore, there is a significant influence of the STEM approach on students' communication and collaboration skills.

The Independent Sample Test's hypothesis testing results revealed that students using STEM learning had superior communication and collaboration skills compared to those using conventional learning. Looking at the results of the questionnaire in the experimental class, it was better because, using a STEM approach, students were motivated to learn individually and in groups. By using this STEM approach, based on the results of educators' observations, students' communication and collaboration skills improved compared to the control class.

The research results indicate a significant difference in the mean scores of students' communication and collaboration skills after being subjected to treatment between the STEM learning approach group and the conventional approach group. Descriptively, the STEM learning group showed higher communication and collaboration skills compared to the conventional learning group. This observation is based on the mean scores from Table 3.

The results of the independent t-test analysis in this study show that there is an influence of the STEM learning approach, with a significance value (2-tailed) of 0.000, where the significance level is < 0.05. This means that there is a difference in communication and collaboration skills between students who learn using the STEM approach and those who use the conventional approach in physics. The communication and collaboration skills of students in the experimental class are more effective compared to the control class.

The results of the independent sample test indicate that there is a difference in effectiveness between the STEM and conventional approaches regarding students' communication and collaboration skills. In STEM learning, students are required to connect concepts in science, technology, engineering, and mathematics with situations in their environment and collaborate to solve encountered problems. Through the STEM approach, students effectively address problems with good control, conduct joint analysis of issues, and work together with groupmates to achieve objectives.

Several factors contribute to the significant difference between the experimental and control classes, including weaknesses in the learning process and limitations in practical tools and materials. Additionally, external constraints also play a role, including shortages or weaknesses that may exist in the applied learning model[21].

The main principle in teaching and learning is communication. The learning process involves the interaction between educators and students. Students need to understand how to interact with educators and their peers. The continuity of the learning process relies heavily on this interaction, which also serves as a gauge for the achieved learning outcomes.

The research results indicate that the implementation of STEM learning went smoothly, as depicted in Table 2 and Figure 2. The three meetings yielded excellent average scores, demonstrating that educators effectively managed the class and the learning process, thereby positively contributing to the success of the learning outcomes.

STEM learning is used to teach students to apply knowledge from school to everyday problems. STEM is an approach that prioritizes students' independent abilities in forming ways of thinking with a variety of knowledge and honing their skills. The application of science in learning often involves case studies, where students analyze phenomena in that case. Technology, on the other hand, is the skill to use, develop, and analyze technology to help students develop thinking[22].

Application in the learning process is carried out through two methods, namely independent and collaborative learning using PowerPoint presentations. Engineering skills involve developing creativity and technological innovation by combining various fields of knowledge. Learning technique by doing practicum with the PhET simulation application. The use of mathematics is related to the ability to analyze and provide ideas, input, and mathematical questions, including in calculation activities[23].

Considering the rapid development of science and technology, learning paradigms need to adapt to developments in science and technology as well as the demands of the times. STEM-based education is expected to be able to form a generation that is ready to face the 21st century[24]. The STEM approach provides students with the opportunity to address existing problems and to persevere. As a result, students find solutions to their problems and learn to overcome challenges. Both individuals and groups strive to solve the challenges given within a set timeframe. They collaborate, share ideas, and exchange experiences to find solutions to the problems they face. This is of great value as it promotes communication activities and cooperation among individuals, which are important aspects of developing social skills.

In the control class, students showed a lack of involvement because, during the learning process, the teacher dominated the class, causing students to only listen and write what the teacher said; these were considered passive students. Educators act as learning centers, providing information, while students act as recipients of information and knowledge from educators. In this way, students have difficulty

understanding the learning process because they only accept concepts without trying to hone their knowledge. When asked to discuss with their classmates, students just silently work on their own without collaborating. These differences affect students' soft skills.

In the experimental class using the STEM approach, students tend to be more active and have the opportunity to discuss in groups and present their discussion results. Conversely, in the control class using a conventional approach, students are more passive because the educator predominantly uses lecturing methods. The lack of involvement from students results in a lack of enthusiasm and motivation for understanding the taught material. With effective implementation, the STEM learning model has the potential to create a generation capable of competitiveness. Integrating all these aspects into learning will provide a deeper meaning to knowledge[25].

The analysis results show a significant difference in communication and collaboration skills between the experimental class and the control class. The experimental class has a higher percentage compared to the control class. This indicates that students in the STEM-based learning process are able to improve their communication and collaboration skills.

Collaboration fosters solidarity, ownership, responsibility, and attention among its members. It is beneficial in formulating effective plans, as students can explore solutions or approaches from various perspectives. In the collaboration process, it is important to manage personal ego and ambitions to achieve optimal results. Another advantage is the ability to combine diverse experiences and ideas, which is beneficial in designing plans[26].

Based on the discussion results, it appears that the STEM learning approach is suitable for improving students' soft skills in learning physics, particularly in the topic of elasticity. Therefore, we can conclude that STEM learning significantly enhances students' communication and collaboration skills.

4. Conclusion

This research concludes that implementing the STEM approach has a significant influencehas a significant influence on students' communication and collaboration skills. This conclusion is based on the results of prerequisite tests, namely normality and homogeneity, which show significant or normal and homogeneous probabilities. Furthermore, an independent sample t-test was conducted, with a significant value of 0.000, indicating that it is less than 0.05 ($0.00 < 0.05$), meaning that H_0 is rejected and H_1 is accepted. Therefore, it is concluded that there is an influence of the STEM learning approach on students' communication and collaboration skills on elasticity materials.

Acknowledgements

The author extends their gratitude to all parties who contributed to the competion of this article.

References

[1] Indy R 2019 Peran Pendidikan Dalam Proses Perubahan Sosial Di Desa Tumaluntung Kecamatan Kauditan Kabupaten Minahasa Utara *HOLISTIK, Journal Of Social and Culture* **12** 1–18

[2] Sriwahyuningsih V and Barseli M 2022 Efektifitas Pengembangan Soft Skill Peserta Didik dalam Berpikir Kritis melalui Kegiatan Ko/Estra Kurikuler di Sekolah *Jurnal Pendidikan Tambusai* **6** 16451–6

[3] Islam U and Ulum D 2022 Gamification : An Effective Strategy For Developing Soft Skills And Stem In Students **14** 663–76

[4] Syahputra M A D 2022 Pentingnya Pendekatan Interpersonal Skills untuk Mengembangkan Hard Skill & Soft Skill pada Mahasiswa *JEJAK : Jurnal Pendidikan Sejarah & Sejarah* **1** 82–90

[5] Darwanto and Sari N 2020 Pengintegrasian Soft Skills pada Setiap Pembelajaran (Sebagai Upaya Menghadapi Tantangan Revolusi Industri 4.0 / Era Disrupsi) *Eksponen* **2** 42–9

[6] Rosmiati R and Hendriani S 2023 Implementasi Model Pembelajaran Soft-Skills Dalam Membentuk Moralitas Siswa Di SMP N 11 Sijunjung *Jurnal Kajian dan Pengembangan Umat* **6**

[7] Nengsi A R, Sartika D, Islam A and Takengon N 2022 Pelatihan Soft Skill Komunikasi untuk Meningkatkan Peluang Kerja Mahasiswa sebagai Calon Tenaga Kerja Baru kalau soft skill

tersebut meliputi komunikasi , kerja tim , pemecahan masalah , *Jurnal Ibrah: Jurnal Pengabdian kepada Masyarakat* **1** 65–76

[8] Mulyajati E and Winama R 2020 Persepsi Siswa Terhadap Soft Skills Bagi Pendidikan dan Karir di Era Industri 4 . 0 *Pengabdian Masyarakat Bakti Parahita* **01** 19–31

[9] Miguel Gregory Junior Togo, Jeaneta Rumerung and Martine Lapod 2022 Kajian Kompetensi Hard Skill Dalam Peningkatan Kinerja Pegawai Pada Sekretariat Daerah Provinsi Sulawesi Utara *Jurnal MABP* **4** 25–37

[10] Batoebara M U 2021 Inovasi Dan Kolaborassi Dalam Era Komunikasi Digital *Jurnal prosiding* 21–9

[11] Purnamawati H 2021 Mengembangkan Keterampilan Komunikasi dan Kolaborasi Melalui Pembelajaran Aktif dengan Pendekatan MIKiR *Jurnal Ilmiah Universitas Batanghari Jambi* **21** 664

[12] Dakabesi E D and Wicaksono L 2022 Kepemimpinan Kolaborasi Kepala Sekolah Dalam Membangun Tim Kinerja Guru Di Era Society 5.0 *JISIP (Jurnal Ilmu Sosial dan Pendidikan)* **6** 2598–9944

[13] Nurjanah S, Rudibyani R B and Sofya E 2020 Efektivitas LKPD Berbasis Discovery Learning untuk Meningkatkan Keterampilan Kolaborasi dan Penguasaan Konsep Peserta Didik *Jurnal Pendidikan dan Pembelajaran Kimia* **9** 27–41

[14] Muslihati M E M 2023 Penguatan Soft Skill Pada Siswa Atudi Fenomenologi Di SMK Negeri 2 Sangatta Utara *Pendidikan, Sanis dan Teknologi* **10** 1029–46

[15] Sunardi H, Sartika D and Saluza I 2019 Peningkatan Efektivitas Pembelajaran Melalui Kolaborasi Pembelajaran Konvensional Dan Pembelajaran Virtual *Jurnal Abdimas Mandiri* **3** 94–8

[16] Fiorintina E, Sukmaningrum A, Rohana S and ... 2023 Pendekatan Stem Dalam Mendukung Pembelajaran Era Digitalisasi Abad 21 Tingkat Sekolah Dasar *Prosiding Seminar Nasional Hasil Riser dan Pengabdian* 3078–85

[17] Thovawira F A, Safitri I, Supartik S, Sitompul N N S and Anggriyani I 2021 Systematic Literature Review: Implementasi Pendekatan Stem (Manfaat Dan Tantangan) Di Indonesia *HISTOGRAM: Jurnal Pendidikan Matematika* **4** 355–71

[18] Shafiul A. M, Agus S. D and Nurhadi D 2020 Mengkombinasikan Project-Based Learning dengan STEM untuk Meningkatkan Hasil Belajar Teknikal dan Karakter Kerja Siswa SMK *Februari* **43** 41–50

[19] Heru N, Wagiran W and Daryono R W 2021 Chassis Maintenance and Vehicle Power Transfer Learning: The Effectiveness of STEM on Students' Critical Thinking Ability *Journal of Education Technology* **5** 588–95

[20] Wahyu Sumardeni, Ida Bagus Made Astawa and Tuty Maryati 2023 Pengaruh Task-Based Learning Model terhadap Keterampilan Komunikasi dan Kolaborasi Siswa dalam Pembelajaran IPS *Media Komunikasi FPIPS* **22** 80–92

[21] Sari A L and Salamah S 2022 Blended Learning sebagai Alternatif Model Pembelajaran IPS di Masa Pandemi Covid-19 *Proceedings Series on Social Sciences & Humanities* **3** 443–9

[22] Davidi E I N, Sennen E and Supardi K 2021 Integrasi Pendekatan STEM (Science, Technology, Enggeenering and Mathematic) Untuk Peningkatan Keterampilan Berpikir Kritis Siswa Sekolah Dasar *Scholaria: Jurnal Pendidikan dan Kebudayaan* **11** 11–22

[23] Wahyunita I and Subroto W T 2021 Efektivitas Model Pembelajaran Blended Learning dengan Pendekatan STEM Dalam Upaya Meningkatkan Kemampuan Berfikir Kritis Peserta Didik *Edukatif : Jurnal Ilmu Pendidikan* **3** 1010–21

[24] Rusminati S H and Juniarso T 2023 Studi Literatur: STEM untuk Menumbuhkan Keterampilan Abad 21 di Sekolah Dasar *Journal on Education* **5** 10722–7

[25] Ardianto D, Firman H, Permanasari A and Ramalis T R 2019 What is Science, Technology, Engineering, Mathematics (STEM) Literacy? **253** 381–4

[26] Putra R A, Widiyanti W and Sutadji E 2020 Keterampilan Berkomunikasi dan Berkolaborasi untuk Mempersiapkan Lulusan Siswa SMK *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan* **5** 1072