JISE 12 (1) (2023): 97-106

Journal of Innovative Science Education

http://journal.unnes.ac.id/sju/index.php/jise

Science Literacy Ability of High School Students in the Integration of Steam Learning with Mind Mapping Techniques on Virus Materials

Aulia Afia Rochmah✉, Aditya Marianti, Nana Kariada Tri Martuti

Pascasarjana, Universitas Negeri Semarang, Indonesia

Article Info

Article History :
November 2022
Accepted
January 2023
Published
April 2023

Keywords:
scientific literacy, STEAM, mind mapping, virus

Abstract

STEAM learning provides opportunities for students to apply science as a body of knowledge, a way of investigating, a way of thinking, and the interaction of science, technology and society. This study aims to improve the scientific literacy skills of class X students through the integration of STEAM learning using the mind mapping technique on viruses. This research is a pre-experimental design pre-test and post-test applied to 10th grade students of senior high school using random sampling technique. A total of 75 students from 3 different classes were accepted as participants and treated for pre-test and post-test. The instruments used to collect data were multiple choice test designs and essays based on indicators of scientific literacy ability. This study provides an explanation of the application of STEAM learning with mind mapping techniques to viral material to empower students' scientific literacy abilities. In addition, there is an assessment of creativity as an application of the art aspects of STEAM in learning. The application of STEAM learning has proven to be effective in empowering students' scientific literacy skills from low to high levels. Student creativity also received good categories through making posters and mind mapping to meet the demands of KI (Core competency) and KD (Basic competencies) in the curriculum.

✉ correspondence :
Jalan Kelud Utara III No.37, Kota Semarang,
Jawa Tengah, Indonesia 50237
E-mail: afiarachma95@students.unnes.ac.id

p-ISSN 2252-6412
e-ISSN 2502-4523

INTRODUCTION

The ability that must be mastered to be ready to face the globalization era in the 21st century is science literacy. Science literacy is a skill that utilizes science knowledge as the effort to problem solving. Furthermore, mastering science literacy is a must for students in relation to the way students understand the environment and the problems in society (Toharudin, 2011). Therefore, mastering science literacy is a must for the students to prepare them to face the challenges in the globalization era. In accordance with the quote from Treacy et al (2010) regarding the topic; it is necessary to prepare the younger generation to be better in terms of scientific thinking and attitudes, thus, they will be able to communicate the science and research results to the community. Those who master the science literacy are the ones able to utilize science concepts, skilled to make scientific decisions in every day life when dealing with other people, society, and their environment.

Apparently, in Indonesia, the secondary school students' science literacy skills are still relatively low compared to the other countries, and this fact is believed to be caused by the classroom learning patterns that still prioritize theory and memorization. The statement is evidenced by the data from PISA showing that the science literacy of the Indonesian students in the science domain in 2018 was ranked 70 out of 78 countries participating in the program (OECD, 2018)

There have been so many efforts to improving the students' science literacy skills, starting from the elementary to university level. Angraini (2014) in her research on the science literacy skills of high school students resulted in low scores. She revealed that the less-supportive learning process is the main cause of the problem stated. Furthermore, Karim et al. (2017) suggested that learning strategies must be well determined and built to improve science literacy, including explaining the natural phenomena, building and evaluating experiments, and interpreting the data obtained from the scientific evidence. The results of the research conducted by Fuadi et al. (2020) show that one of the factors contributing to low science literacy in Indonesia is the misconceptions and the non-contextual learning. This condition requires education practitioners to improve the learning implementation design. Thus, it is necessary to have a learning strategy used to measure the science literacy to strengthen the competitiveness in the 21st century.

The rising efforts in improving the students' science literacy to prepare for the 21st century brings out many learning approaches and strategies that can help the students develop their science literacy skills. One of the lessons related to these needs is STEAM learning (Science, Technology, Engineering, Art, and Mathematics) which is able to connect the aspects of the learning process to every day life to built science lioteracy skills. Mu'minah et al. (2020) explained that the application of STEAM is considered suitable since it does not only develop the cognitive aspects, but also the learning skills where the students are strived to build their own understanding and knowledge through certain projects or their every day life. Students learn how to adjust well in team based on the roles they have collaboratively (Hadinugrahaningsih, et al. 2017).

STEAM has 5 disciplines; those are, science, technology, engineering, art, and math. Those combinations enhance the dynamic synergy between the modelling process and science content (Zubaidah, 2019). Those combined disciplines are easy to understand and learn by utilizing the mind-mapping techniques. Therefore, Prastiwi et al. (2020) used mind-mapping in their research which was considered to be helpful in the attempts to improve the students' science literacy in biology; a subject that has complex discussion. The discussion of the learning material about viruses is one of the potential matters to the application of STEAM learning because the indicators contained in that matter can be integrated into STEAM aspects (Halim et al. 2021).

Based on the scope of the above problems, the problem formulations discussed in this study are: 1) How effective is the application of STEAM Learning with mind mapping techniques on virus material in improving students 'scientific literacy; 2) Is there any increase in each aspect of scientific literacy after applying STEAM Learning with mind mapping techniques on virus material; 3) How is the implementation of STEAM Learning with mind mapping techniques on virus material in improving students' scientific literacy abilities. Thus, the research objectives are: 1. To describe the effectiveness of STEAM Learning with mind

mapping techniques on virus material in improving students ' science literacy; 2. To measure the improvement of each aspect of science literacy after applying STEAM Learning with mind mapping techniques on virus material; 3. To analyze the implementation of STEAM Learning with mind mapping techniques on virus material in improving students ' science literacy skills.

METHODS

This reseach is conducted using the *pre-experimental design;* in which the external variables affect the dependent variable because the experiments carried out involve only one group without comparison or control. This is a *one-group pretest-posttest design*.

The study design is shown in Table 1.

Table 1. One group Pretest Posttest Study Research Design

Pretest	Treatment	Postest
O1	X	O2

This study involved only 1 test group consisting of 3 classes, the researchers would do the measurement at the beginning (pretest) then provide treatment and re-tested (posttest). The pretest results were used as a basis for students' initial science literacy ability, while the post-test results were used as a final score to determine whether students' science literacy ability has improved.

The subjects of this study were 75 students from class X MIPA consisting of 25 MIPA 1 students, 25 MIPA 2 students and 25 MIPA 3 students of SMA Negeri 1 Tirtayasa. Those are only some of the students who take part in offline learning, because the research was conducted during the *new normal* period, thus, there were only some students attended school. The selection of the sample subjects used *purposive sampling;* i.e. the sample was selected by considering the previous test scores and selected based on the teacher's recommendations about the classes that have the equal standards of student abilities.

The science literacy indicators tested were based on the indicators by Chiappetta et al. (1991). namely, science as the body of knowledge, science as the way to investigate, science as the way of thinking, and the interaction of science, technology and society. Students' science literacy skills were measured through multiple choice and essay questions that have been validated by data and professionals. The total questions used were 20 multiple choice questions and 5 science literacy-based essay questions. The questions were tested before the virus material learning (pretest), and after the learning process (posttests).

The analysis technique used the paired sample t-Test test. The statistical analysis techniques used the SPSS 25 program by previously using prerequisite tests, namely homogeneity and normality tests. The next step was to analyze the value with the N Gain Score test. This test was used to determine the effectiveness of the application of STEAM learning with mind mapping on the related material to empower the students' science literacy skills.

RESULTS AND DISCUSSION

The effectiveness of STEAM learning with mind mapping technique to improve students' science literacy skills

The effectiveness of STEAM learning with mind mapping techniques on virus material in improving students' science literacy skills shows different results in the pretest and posttest of class X. The increasing value in each class that became the distinction is the pretest and posttest, the average value of the posttest is higher than the average pretest value in all research samples. The average posttest score was 78.4 compared to the average pretest score of 48.8. Based on this, the posttest value after the application of STEAM learning with mind mapping techniques has met the KKM which is 75 compared to the pretest value which has not met the KKM value. The effectiveness of the application of STEAM learning with mind mapping techniques on virus material is obtained through the N-Gain test, the data on the average value of students can be presented in Table 1.

Table 2. Student N-Gain mean scores on science literacy skills.

Class	Pretest	Posttest	Skor maks	*N-Gain*
A	59	81	100	
B	54.4	77.8	100	0.51
C	33.6	76.6	100	

Table 2. shows that the students' science literacy skills increase, meaning that there is an effective effect of the application of STEAM learning with mind mapping techniques on students' science literacy skills, since the average value of N-Gain is included into the medium category with between 0.30 <<g><0.70, which is 0.51. The effectiveness of STEAM learning with mind mapping techniques on virus material is also shown in the classical completeness of the pretest getting 0% while the classical completeness on the posest score is 78.7% so that there is completeness after the application of STEAM learning with mind mapping techniques on virus material. The achievement of classical completeness shows that STEAM learning with mind mapping techniques on virus material is effectively applied to empower students' science literacy skills.

Based on the results of the normality test, the results of the prerequisite test of the students' science literacy skills before and after the application of STEAM learning with mind mapping techniques on virus material for the normality test between students' science literacy skills before and after applying STEAM learning with mind mapping techniques on virus material show the average pretest value of 0.200 and posttest 0.328 shows normal distribution because the significance value is greater than 0.05. The results of the homogeneity test show homogeneous data presented from the resulting significance value of 0.243>0.05. The conclusion based on the prerequisite test above is that the data is normally distributed and homogeneous.

The prerequisite test generated from the N-Gain data shows that the data is normally distributed and homogeneous, so the next test carried out on the N-Gain data is a different test in the form of a parametric Paired Sample T-test or T test. Table 3 below is the result of the N-Gain data difference test.

Tabel 3. Result of Paired Sample T Test

Data	Uji Beda	Sig. (2-tailed)	Information
N-Gain	Paired Sample T Test	0.000	significantly different

Table 3 shows the results of hypothesis testing from the N-Gain data. Based on the results of the T test conducted, the significance value of N-Gain is 0.000 which means that H_0 is rejected or H_a is accepted. The conclusion from the resulting data shows that there is a significant difference in students' science literacy skills between before and after the application of STEAM learning with mind mapping techniques on virus material. Furthermore, the data for each aspect of science literacy result in a different average value between before and after applying STEAM learning with mind mapping techniques on virus material, a recap of the average value of each aspect can be presented in table 4.

Table 4. Recap of the Average Value of Student Science Literacy Aspects

Aspect	average value		
	Pretest	Postest	Enhancement (%)
Science as the body of knowledge	26	52	26
Science as the way to investigate	50	86	36
Science as the way of thinking	45	72	32
Interaction between science, technology, and society	45	79	34

Table 4 shows the data on the average value of students' science literacy aspects, it can be seen that there is an increase in scores indicated by higher posttest scores in each aspect of students' science literacy. Experienced an increase in each aspect of science literacy. The highest increase in aspects with the highest average is science as a way to investigate (36%); Interaction between science, technology and society (34%); Science as a way to think (32%); Science as a body of knowledge (26%). The general literacy assessment is also supported through the assessment of each aspect of science literacy. The results are as follows:

1. Science as a body of knowledge

The aspect with the lowest average score from before and after the application of STEAM learning with *mind mapping* techniques on virus material in the first aspect is science as a body of knowledge. The percentage of success in the first aspect is 26%. Its application to the learning process is to emphasize the concrete theory of science related to everyday life. One example of its application is the explanation of the characteristics and structure of the virus body. In fact, to describe the characteristics and structure of the virus body in real life is a little difficult if it only relies on links to everyday life. According to Fu'adah's research (2017), what affects the low level of this aspect is students who do not understand the basic concepts of a material and do not have sufficient factual knowledge. If presented in practice, this is the factor that causes the lowest scores of students before and after the application of STEAM learning with mind mapping techniques on virus material in the first aspect of science literacy, namely science as a body of knowledge. Concept errors arise due to students' errors in constructing their knowledge (Rusilowati, 2016).

2. Science as the way to investigate

The aspect of science as a way to investigate ranks first in terms of success, with an increase of 36%. This shows that students have successfully understood the material through the thinking process. Activities in activities to develop science literacy in this aspect are related to the ability of students to build links between science materials in STEAM learning. According to Fatonah et al. (2014), activities that involve students to answer, analyze or do something like thinking activities make students able to connect the connection between the material learned and the understanding they experience directly

3. Science as the way of thinking

The aspect of science as a way of thinking result in average improvement category, which is in the third position of the four existing aspects. It can be seen that the presentation of the increase in this aspect is 32%. The indicators emphasized in this aspect are the ability of students to think deductively-inductively analyze causal relationships and analyze data. Learners are also invited to discuss the facts used in the material with evidence in the surrounding phenomena. In fact, the research of Fitriani et al (2018) shows that there are still very few high school Biology textbooks in grade X that invite students to science literacy. Basam's research (2018) shows that the aspect of science as a way to think is in the low category, which means that improvements are needed in the application of conceptual learning, scientific attitudes and thinking process skills to be more balanced.

4. Integration between science, technology, and society

This last aspect has the second highest rank after the aspect of science as a way to investigate. The increase in this aspect shows a fairly high number, namely with a percentage increase of 34%. Diana et al (2015) also proved in their research that the highest assessment of the science literacy aspects of students is the realm of science and society. Science and technology related to society have many real examples, especially in virus material. In line with Astuti's research (2016) that science literacy and technological literacy can be developed to improve science inquiry through understanding the application of the relationship between science, technology and society.

Science literacy skills are important for students to possess as an effort to form a perspective on a more innovative world, thus, they understand science not only as a memorized concept but how to apply science to everyday life (Sutrisna, 2021). Virus material has a key concept of scientific knowledge that has a lot to do with society, is applicable in everyday life problems, so that it can stimulate students' understanding of the relationship between viruses in the material and real events around (Dewi, 2016). Teachers as learning facilitators must try to change the mindset of students from "teachers and what will be taught" to "students and what will be done" (Sudibjo, 2013) so that in order to explore the science literacy potential of students through virus material, teachers benefit from the current situation. STEAM learning according to Suryaningsih, et al (2021) is able to increase students' interest and motivation to learn. In addition, learning that is associated with STEAM aspects helps students to solve problems and connect a problem with other problems (Handayani, 2014).

The Students' Creativity in STEAM Learning with Mind mapping Technique.

The sttudents' creativity in this study refers to the art aspect of STEAM learning, where students

are invited to understand learning material through the creativity of each student. The application of STEAM learning with mind mapping techniques on virus material and creativity assessment are the same in all classes as attitude assessment (group work) and skills assessment, namely by making mind mapping after learning is complete to test understanding of the material.

The Creativity in the Poster Making Process

The assessment of the students' poster making process is measured by making posters in groups. The assessment is not only about the creativity of students in making posters but most aspects of the assessment of how the manufacturing process takes place. The results of process creativity after the application of STEAM learning with mind mapping techniques on virus material have an average value of 79 including the good category with details of class A value 81 good category; class B value 78 good category; and class C value 77 good category. Assessment of student process creativity through poster making is done by observing the process of making the poster. The indicators assessed in this assessment are more about the process of making posters but the assessment of the creativity of the results of making posters is also included in the assessment indicators. Some of the indicators used in the assessment of the poster making process are: 1) Preparation, 2) Collecting information, 3) Cooperation of group members, 4) Making design, 5) Workmanship. A summary of the creativity assessment on each indicator is presented in Figure 1.

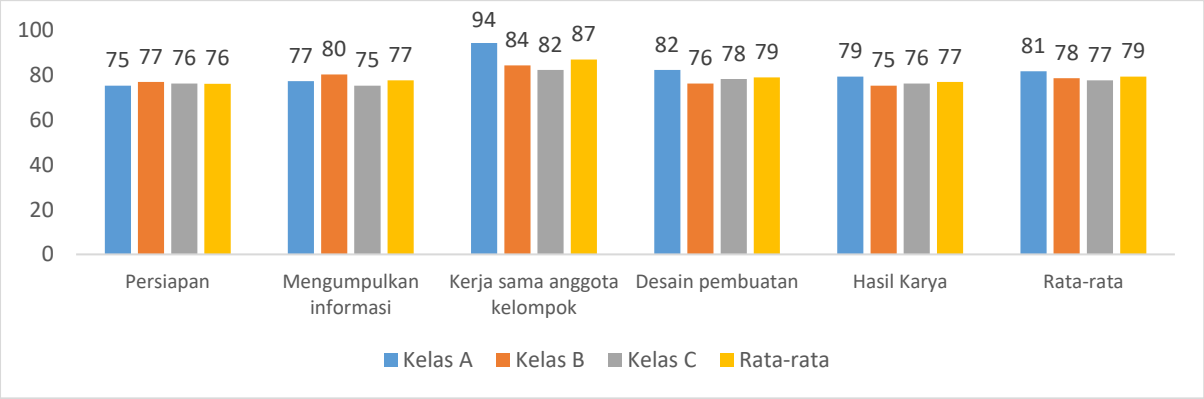

Figure 1. Percentage Value of Each Indicator of Student Process Creativity

Based on Figure 4, it can be seen that the average percentage of students' process creativity per indicator when STEAM learning is applied with mind mapping techniques on virus material shows the highest value in the 3rd indicator; that is the group cooperation in making posters calling for vaccination has the highest average value of 87%, including the very good category with details of class A value 94% very good category; class B value 84% good category; and class C value 82% good category. Meanwhile, the lowest value is the preparation indicator, which is 76%, including the good category with details of class A, 75%, fair category; class B, 77%, good category; and class C, 76%, good category.

The Creativity of Mind mapping Making

The assessment of mind mapping skills is carried out individually, thus, the creativity of each student can be measured optimally according to their understanding. The average result of product creativity in the form of making mind mapping during STEAM learning with mind mapping techniques on virus material is 82 including the good category with details of class A value 84 good category; class B value 81 good category; and class C value 80 good category. The assessment of the students' skills is done through the creativity of mind mapping products. One of the things that are emphasized in the product assessment indicators is the creativity of product art, this is intended from the artistic aspect of STEAM learning. It is hoped that the students will be able to pour their understanding of the material into art in the form of mind mapping products. Indicators observed in the assessment of mind mapping product skills include: 1) Presenting material, 2) Shows an interrelated chart (STEAM), 3) Integrated and detailed, 4) Balanced composition,

5) Originality. A summary of the percentage assessment of student product creativity per indicator is presented in Figure 6.

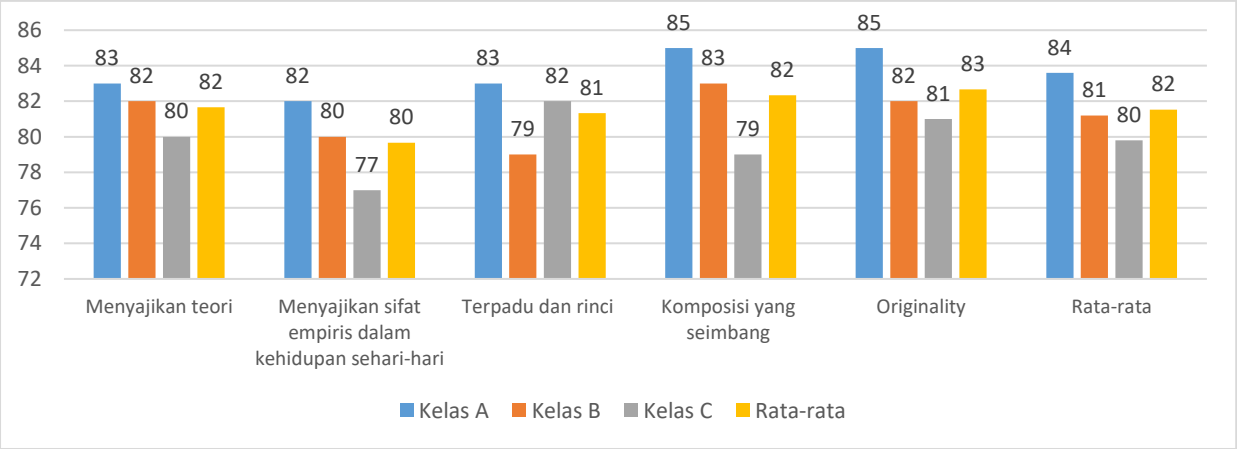

Figure 2. The Average Percentage Value of Each Indicator of the Students' Product Creativity

Figure 2 shows the average percentage value per indicator of the students' creativity using STEAM learning with mind mapping techniques on virus material. The indicator with the highest value is in the 5th aspect, namely originality, with a percentage value of 83% including the good category for details of class A value of 85% good category; class B value 82% good category; and class C value 81% good category. Furthermore, for the lowest score; which is in the 2nd aspect about presenting empirical properties in daily life, the linkage of mind mapping charts shows a percentage value of 80% including the good category for details of class A, value 82% good category; class B value 80% good category; and class C value 77% good category. The art aspect in STEAM is a student's effort to increase creativity, meet the demands of the era of society, (Fadhilah, 2022). Furthermore, in this study, the students' creativity is used as secondary data observed through the process of making posters as an attitude assessment and creativity in compiling mind mapping as a skills assessment.

Improving the Students' Science Literacy through STEAM Learning with Mind mapping Technique

STEAM learning is proven to be able to invite the students to furtherly improve science literacy according to many researchers who recommend (Sumarno, 2021). According to Tatyana (2020), if one evaluates the prospects of these two concepts (STEM and STEM with a creative/art component), the more desirable one is STEM with a creative component, so STEAM effectively responds to the challenges of the times and the future of learning concepts. In terms of the implementation, the framework as described above requires teachers who are skilled in STEAM learning because such an educational framework is what is needed in era 4.0 learning; which are, being skilled in various disciplines for global and community needs (Morales et al, 2021), including being skilled in science literacy which is also a skill needed in the globalization era.

STEAM learning according to Halim et al (2021) gives more freedom to learners to explore and gain more understanding of various disciplines. So it is expected that students can find their own understanding through STEAM learning in school materials. The experience of researchers in Korea in the field of STEAM education proves that making direct observations during the learning process related to humanities and arts is better, even they have developed STEAM learning for educational and extracurricular organizations in schools as an effort to strengthen students' skills (Paik et al., 2018). STEAM learning is an integration of science, technology, engineering, art and math, so it is necessary to have a context or real events that can mediate STEAM (Lee, 2012). It is important to prepare teachers as the main facilitator in terms of knowledge transfer, especially STEAM learning which requires a lot of integration of aspects of knowledge and experience (Sartono, 2020). STEAM learning according to Nurhikmayati (2019) that at

the end of the learning process, students can make learning products related to the aspects contained in STEAM. STEAM learning with mind mapping techniques is also considered effective for improving students' science literacy.

The Implementation of STEAM Learning with Mind mapping Technique on Virus Material

The implementation of STEAM learning with mind mapping techniques on virus material can be known through student and teacher response questionnaires given after the learning takes place. Students' responses regarding STEAM learning with mind mapping techniques can be known through questionnaires, which produce a fairly good percentage regarding STEAM learning with mind mapping techniques on virus material. It can be seen that 12% of students gave a very strong response, 41.07% of students gave a strong response, 35.35% of students gave a moderate response and 10.71% of students gave a weak response. Based on the results shown by the data, STEAM learning with mind mapping techniques on virus material gets a positive response from students and can be accepted well too. The advantage in choosing virus material is not only because the material is very supportive for the application of STEAM learning but also because the recent pandemic is about viruses, which supports students to be more interested and build curiosity about the ongoing pandemic and explore more deeply the causes of this pandemic (Halim et al, 2021).

The results of the teacher's response regarding the STEAM learning process with mind mapping techniques, including the delivery of objectives, delivery of material, learning media used to evaluate learning and student interest, are positive in the phenomena that occur around through the science process. It is because in its application, STEAM learning gives students the freedom to explore the knowledge gained and they can gain more understanding as a form of knowledge transfer process (Halim et al, 2021). The material discussed is about viruses; in which it is the topic that is being discussed lately, so that the discussion in the class is more lively and active. The study by Wilson et al (2019) also shows that STEAM learning is able to make students appreciate how the course of art and science run together by using various types of creative, critical thinking skills, and by building imagination as they try to understand the real problems in line with the material they are learning.

Sartono et al (2020) explained that it is necessary to improve teachers' skills through workshops or teacher training regarding the preparation of STEAM lesson plans to the process of implementing learning in the classroom. In addition, according to Huryah et al's research (2017), students' science literacy achievement is also affected by the way teachers deliver material. Therefore, by applying any type of learning, including STEAM, the presence of the teacher as a facilitator will be impactful for students. The confusions about the definition of art in STEAM is stated by Quigley et al (2017), where some experts interpret art as a representation of visual arts such as painting, drawing, media arts and design while other experts explain art as a plural term that refers to various types of art including visual arts such as performance, aesthetics and crafts. Furthermore, the other experts consider art as a broader matter including the liberal arts and humanities. Even in the United States, most practitioners find it difficult to discover the effective strategies to intergrate the arts into their curriculum despite the fact that the country acknowledges the benefits of art-based learning (Zubaidah, 2019).

CONCLUSIONS

Regarding the research results, it can be concluded that STEAM learning with mind mapping techniques on virus material is effectively applied. The statement is proven by the N-Gain value before and after the application of STEAM learning with mind mapping techniques on virus material getting an N-Gain value of 0.51 including the medium category. Students' science literacy skills in general show the posttest value after the application of STEAM learning with mind mapping techniques on virus material produces a higher average than the pretest value. The STEAM learning process with mind mapping techniques is also well implemented. Students and teachers gave positive responses, indicated by the questionnaire score which received a strong response predicate.

REFERENCES

Adriyawati, Utomo, E., Rahmawati, Y., & Mardiah, A. (2020) Steam-Project-Based

Learning Integration to Improve Elementary School Students' Scientific Literacy on Alternative Energy Learning. *Universal Journal of Educational Research*, 8 (5), 1863–1873.

Angraini, G. (2014). Analisis Kemampuan Literasi Sains Siswa SMA Kelas X Di Kota Solok. *Prosiding Mathematics and Sciences Forum*. FMIPA UPI.

Annisa, R., Effendi Hsb, M.H., & Damris, M. (2018). Peningkatan Kemampuan Berpikir Kreatif Siswa dengan Menggunakan Model Project Based Learning Berbasis STEAM (Science, Technology, Engineering, Arts dan Mathematic) pada Materi Asam dan Basa di SMAN 11 Kota Jambi. *Journal of The Indonesian Society of Integrated Chemistr, 10 (2), 42-46.*

Ahmad, D.N., Astriani, M.M., Alfahnum, M., Setyowati, L. (2021). Increasing Creative Thinking Of Students by Learning Organization with STEAM Education. *Jurnal Pendidikan IPA Indonesia*, 10(1), 103-110.

Astuti, Y.K. (2016). Literasi Sains dalam Pembelajaran IPA. *E-Journal,* 7(3B), 67-71.

Basam, F., Rusilowati, A., & Ridlo, S. (2018). Profil Kompetensi Sains Siswa dalam Pembelajaran Literasi Sains Berpendekatan Inkuiri Saintifik. *Pancasakti Science Education Journal*, 3(1), 1-8.

Chiappetta, E.L., Fillman, D.A., & Sethna, G.H. (1991). A Quantitative Analysis of High School Chemistry Textbooks for Scientific Literacy Themes dan Expository Learning AIDS. *Journal of Research in Science Teaching*. 28(10), 939-951.

Dewi, F.I. (2016). Validitas Perangkat Pembelajaran Berbasis Literasi Sains Pada Materi Virus Kelas X SMA. *BioEdu*, 5(3), 166-173.

Diana, S., Rachmatulloh, A., & Rahmawati, E.S. (2015). Profil Kemampuan Literasi Sains Siswa SMA Berdasarkan Instrumen *Scientific Literacy Assesment* (SLA). *Seminar Nasional XII Pendidikan Biologi FKIP UNS,* 285-291.

Fadhilah, A.N., 2022. Pembelajaran Biologi Berbasis STEAM di Era Society 5.0. *Prosiding Seminar Nasional MIPA UNIBA*. 182-190.

Fitriani, N.L., Probosari, R.M., Suciati. (2018). Analisis Buku Ajar Biologi Kelas X Semester Ganjil berdasarkan Kategori Literasi Sains Chiappetta dan Fillman. *Jurnal Biotek*, 6(2), 142-151.

Fatonah. (2014). Students' Understanding of The Realization Of Nominalizations In Scientific Text. *Indonesian Journal of Applied Linguistics*. 4(3), 87-89.

Fu'adah, H., Rusilowati, A., & Hartono. (2017). Pengembangan Alat Evaluasi Literasi Sains untuk Mengukur Kemampuan Literasi Sains Siswa Bertema Perpindahan Kalor dalam Kehidupan. *Lembaran Ilmu Kependidikan*, 46(1), 51-59.

Fuadi, H., Robbia, A.Z., Jamaluddin, Jufri, A.W. (2020). Analisis Faktor Penyebab Rendahnya Kemampuan Literasi Sains Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, 5(2), 108-116.

Hadinugrahaningsih, T., Rahmawati, Y., Ridwan, A., Budiningsih, A., Suryani, E., Nurlitiani, A., & Fatimah, C,. (2017). *Keterampilan Abad 21 dan STEAM (Science, Technology, Engineering, Art And Mathematics) Project dalam Pembelajaran Kimia*. Jakarta : LPPM Universitas Negeri Jakarta.

Halim, A.P., & Roshayanti, F. (2021). Analisis Potensi Penerapan STEAM (Science, Technology, Engineering, Art, Mathematics) pada Kurikulum 2013 Bidang Studi Biologi SMA Kelas X. *Bioeduca: Journal of Biology Education.* 3 (2), 146-159.

Handayani, F. (2014). *Pengembangan Lembar Kerja Siswa (LKS) Berbasis Science,Technology, Engineering, and Mathematics (STEM) pada Materi Hidrolisis Garam*. Skripsi. Banda Aceh: Univeristas Syiah Kuala.

Huryah, F., Sumarmin, R., & Effendi, J. (2017). Analisis Capaian Literasi Sains Biologi Siswa SMA Kelas X di Kota Padang. *Jurnal Eksakta Pendidikan,* 1(2), 72-79.

Karim, S., Prima, E.C., Utari, S., Saepuzaman, D., & Nugaha M.G. (2017). Recostructing The Physics Teaching Didactic Based on Marzano's Learning Dimension on Training The Scientific Literacies. *Journal of Physics*: *Conference Series*, 812.

Morales, M.P.E., Mercado, F.M., Palisoc, C.P., Palomar, B.C., Avilla, R.A., Samiento, C.P., Butron, B.R., & Ayuste, T.O.D., (2021).

Teacher Professional Development Program (TPDP) for Teacher Quality in STEAM Education. *International Journal of Research in Education and Science (IJRES),* 7(1).

Mu'minah, I.H. & Suryaningsih, Y. (2020). Implementasi STEAM (Science, Technology, Engineering, Arts And Mathematics) dalam Pembelajaran Abad 21. *Jurnal Bio Educatio,* 5(1), 65-73.

Nugrahini, F.C. (2015). Media Rekam Jejak Tahapan Pra Desain dengan Poster : Meningkatkan Kinerja dan Luaran pada Studio Perancangan Arsitektur. *EMARA Indonesian Journal of Architecture*, 1 (2), 52-59.

Nurhikmayati, Iik. (2019). Implementasi STEAM dalam Pembelajaran Matematika. *Jurnal Didactical Mathematics*. 1(2), 41-51.

OECD. (2018). PISA 2015. *PISA Result in Focus*. Paris: PISA-OECD Publishing.

Paik, S.H., Kim, S.W., & Lee, Y.J. (2018). A Study on Teachers Practices of STEAM Education in Korea. *International Journal of Pure and Applied Mathematics*, 118(19), 1339-2365.

Prastiwi, N.H., Lukitasari, M., Utami, S. (2020). Pengembangan Biorivista (Majalah Biologi) Berbasis Mind Mapping untuk Meningkatkan Kemampuan Literasi Sains Siswa SMA/MA pada Materi Sistem Ekskresi. *Prosiding Seminar Nasional SIMBIOSIS V,* 284-292.

Quigley, C. F., Herro, D., & Jamil, F. M. (2017). Developing a conceptual model of STEAM teaching practices. *School Science and Mathematics*, 117 (1-2), 1-12.

Rusilowati, A., Nugroho, S.E., dan Susilowati, S.M.E. (2016). Development of Science Textbook Based on Scientific Literacy for Secondary School. *Jurnal Pendidikan Fisika Indonesia,* 12(2), 98-105.

Sartono, N., Suryanda, A., Ahmad, T.L.S., Zubaidah, Yulisnaeni. (2020). Implemetasi STEAM dalam Pembelajaran Biologi: Upaya Pemberdayaan Guru Biologi Madrasah Aliyah DKI Jakarta. *Jurnal Pengabdian Masyarakat*, 2(1), 7-14.

Silberman, M. 2009. *Active Learning: 101 Strategi Pembelajaran Aktif.* Yogyakarta: Pustaka Insan Madani.

Sudibjo, A., & Wasis. (2013). Penggunaan Media Pembelajaran Fisika dengan E- Learning Berbasis Edmodo Blog Education pada Materi Alat Optik untuk Meningkatkan Respons Motivasi dan Hasil Belajar Siswa di SMP Negeri 4 Surabaya. *Jurnal Inovasi Pendidikan Fisika*. 2(3), 187-190.

Sumarno, W.K., Shodikin, A., Rahmawati, Adinda, A., Shafira, P.D., & Solikha, N.I. (2021) Gerakan Literasi Sains melalui Pengenalan STEAM pada Anak di Komunitas "Panggon Moco" Gresik. *Jurnal Pemberdayaan Masyarakat.* 6(2), 702-709.

Suryaningsih, S., & Nisa, F.A. (2021). Kontribusi STEAM *Project Based Learning* dalam Mengukur Keterampilan Proses Sains dan Berpikir Kreatif Siswa. *Jurnal Pendidikan Indonesia*. 2(6), 1097-1111.

Sutrisna, N. (2021). Analisis Kemampuan Literasi Sains Peserta Didik SMA di Kota Sungai Penuh. *Jurnal Inovasi Penelitian*, 1(12), 2683-2694.

Tatyana, I.A., Fairuza, M.S., Olga, V.S. (2020). Formation of Design and Research Competencies in Future Teachers in the Framework of STEAM Education. *International Journal of Emerging Technologies in Learning,* 15 (2) 204-217.

Toharudin, U., Hendrawati, S., & Rustaman, A.(2011). *Membangun Literasi Sains Peserta Didik*. Bandung: Humaniora.

Treacy, D.J., & Kosinski-Collins, M.S. (2011). Using the Writing and Revising of Journal Articles to Increase Science Literacy and Understanding in a Large Introductory Biology Laboratory Course. *Atlas Journal of Science Education*, 1(2), 29-37.

Wilson, B., & Hawkins, B. (2019). Art and science in a transdisciplinary curriculum. *CIRCE MAGAZINE: STEAM EDITION, 27.*

Yakman, G., & Lee, H. (2012). Exploring The Exemplary STEAM Education in the U.S as Practical Educational Framwork for Korea. *J Korea Assoc. Sci. Edu*, 32(6), 1072-1086.

Zubaidah, Siti. (2019). STEAM (Science, Technology, Engineering, Arts, and Mathematics) : Pembelajaran untuk Memberdayakan Keterampilan Abad ke-21. *Research Gate, Universitas Negeri Malang,* 1-12.