Journal of Turkish Science Education, 2022, *19*(4), 1237-1253.
DOI no: 10.36681/tused.2022.172

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

Article Review: Integration of Science, Technology, Entrepreneurship in Learning Science through Bibliometric Analysis

Sri Jumini[1,2], Sutikno Madnasri[3], Edy Cahyono[4], P Parmin[5]

[1]*Universitas Negeri Semarang, Indonesia, srijumini@unsiq.ac.id, ORCID ID: 0000-0002-5664-7749*
[2]*Physics Education Departement, Universitas Sains Al-Qur'an, Indonesia, ORCID ID: 0000-0002-5664-7749*
[3]*Physics Departement, Universitas Negeri Semarang, Indonesia, ORCID ID: 0000-0003-2652-274X*
[4]*Department of Chemistry, Universitas Negeri Semarang, Indonesia, ORCID ID: 0000-0001-7225-3291*
[5]*Universitas Negeri Semarang, Indonesia, ORCID ID: 0000-0002-8473-2270*

ABSTRACT
Today, science is often regarded as a discipline that is more theoretical and less applicable. It is not clear how science works in society. The problems examined in this literature review are how the development of research on the integration of science, technology, and entrepreneurship in science learning in addition to how bibliometric networks and learning research trends integrate science, technology, and entrepreneurship. The search for articles using the Publish or Perish software was carried out on December 18, 2020. The data generated was in the form of metadata extracted from Google Scholar and Scopus through the API key, with the keyword science learning, STS, STEM, STEAM, and entrepreneurship from 2015-2020. As the result, 851 article was downloaded with their metadata which is stored in ris and tidied up in the delay. The data that has been obtained is excluded from proceedings, theses, book chapters, modules, theses, reports, and comments. Visualization with VOSviewer is carried out in three visualizations, namely network, overlay, and density. The results of the analysis show that the dominant topics are educational technology and environmental science. Research trends in 2020 are PjBL, entrepreneurship, and STEM. The less researched topics are the relationship between learning outcomes and entrepreneurship, and science technology.

RESEARCH ARTICLE

ARTICLE INFORMATION
Received:
11.12.2021
Accepted:
25.10.2022

KEYWORDS:
Publish or perish, VOSviewer, NVIVO, science technology, entrepreneurship.

To cite this article: Jumini, S., Madnasri, S., Cahyono, E., & Parmin, P. (2022). Article review: integration of science, technology, entrepreneurship in learning science through bibliometric analysis. *Journal of Turkish Science Education*, *19*(4), 1237-1253.

Introduction

The essence of science learning in the form of products, processes, and scientific attitudes is the spirit of learning science, regardless of the material, method, and media (Jumini & Sutikno, 2019; Jumini et al., 2021). However, today's society considers technology to be more important and more applicable, so it is more in demand by society than pure science. (Yalvac et al., 2007; Akcay & Yager, 2010; Rosana et al., 2019). Science, especially physics and chemistry, is considered a difficult subject both in school and in college. Most of the concepts are abstract. So. they cannot always be understood properly and easily. The Science Technology Society (STS) approach seeks to overcome this problem by enabling students to play a role in providing the latest solutions related to local, national, and international problems (Dinh et al., 2018; Mustadi & Atmojo, 2020). Students are trained to design solutions from taking responsible decisions to identifying problems. Local problems such as floods, landslides, and volcanic disasters often occur in Indonesia since it is included in the Asian, Pacific, and Indo-Australian Eurasian collision plates (Atmojo et al., 2018). Geographically, Indonesia is also located on the ring of fire which causes high volcanic eruptions (Siagian et al., 2014). This problem is a real event that often occurs in the environment around students. Students need to be provided with provisions on how to cope with, prevent, or protect when a disaster occurs. In this way, science learning needs to be directed at how science works to provide solutions to solve natural disasters in society. In addition, it can also be directed to design and create natural disaster prevention tools. The role of science learning in solving these problems requires integration between Science, Technology, Environment, and Society (SETS) (Agustihana & Suparno, 2019; Fernandes, 2015).

Science learning syntax is a learning process that is up to date with any curriculum development and the times. The process is carried out by the scientific method in gaining knowledge from existing developments. However, science learning is still mostly conducted in the classroom, limited to theory and mathematical calculations. The concepts of science being studied need to be linked to their application technology in society so that students understand the benefits of the concepts being studied. In schools and universities, science learning should reflect a learning model for finding knowledge and introducing knowledge products (Irwandani, 2007; Munawar et al., 2019; Quigley et al., 2020). Science concept application knowledge products help students understand science concepts more clearly. Science concept application technology products facilitate human work to increase human welfare. Various problems can also be solved with the presence of science product technology. Learning science is expected to develop and improve the ability of students to face with problems, respond to problems, and provide solutions to problems that arise both in learning and in the real world (Jumini, 2016; Mildenhall et al., 2019; Soetomo, 2017). However, science, especially physics, is still making poor achievements, physics is considered a difficult subject and is not of interest to most students (Abdurrahman et al., 2011; Hamdan, 2020; Williams, 2017). Science seems only mathematical and theoretical as well as being far from real life.

The graduation qualifications that students must acquire should be directed towards skills that support the development of 21st century skills. (Yuliati, 2017; Zainurrisalah et al., 2018). These skills include 6c: creativity and innovations, communication, critical thinking and problem solving, collaboration, computational logic, and compassion (Pamungkas Stiyamulyani & Sri Jumini, 2018; Bakry & Md Nor Bakar, 2015). Learning science by analyzing problems that occur in society can train students' abilities to be sensitive, and critical in analyzing problems, and also train systems thinking skills (computational logic). Computational logic directs students to think about cause and effect relationship, so they can find the right solution. Students need a lot of skills to be able to compete in society. An understood concept needs to be represented in a real product. Authentic assessment needs to be done so that student skills are formed or not (Jumini et al., 2020; Shi et al., 2019). The assessment carried out not only covers cognitive aspects, but also affective and psychomotor aspects of students in the problems identified in learning. Assessment is carried out on activities that are carried out by students during learning, completion of experiments, and the ability to design and complete possible products as one of the solutions to overcoming problems in society (Mustadi & Atmojo, 2020; Wijayanti, 2014). Since elementary school, students need to be trained to have preparedness in dealing with disasters and problems that occur in their environment.

The Family Resemblance Approach (FRA) is an approach that can be used practically in science learning. It woul be helpful to transform theoretical knowledge about the issues on how science works in society (Erduran, 2014; Kaya et al., 2018). This approach provides an example of a learning process that connects the knowledge products produced by universities with the business world and the industrial world. Companies as business/industrial worlds need creative ideas generated by lecturers and student. Universities experience funding constraints in developing their creative ideas. So that universities and the business/industry world can complement to each other. There is a link between Natural Science (NOS) and Economics of Science (EOS). To conceptualize the relationship between NOS and EOS as well as entrepreneurship in explaining how science works in society, the SAMI cycle framework is used (Kaya et al., 2018; Muhamad Adlim & Saminan, 2015; Samila & Sorenson, 2017). This cycle describes the relationship among State/government, Academics, Markets, and Industry. This is to address the gap in relations among the State/government, academics, markets, and industry. The government needs the role of academics and industry to revive the market to sustain the increase the national economy. Higher education institutions have many research products but have limited funds to develop in industry and marketing. One side of the industry requires the development of good products and works that have been produced by Higher Education (Giudici et al., 2019; Kasemsap, 2016). This is the need for the integration of entrepreneurship in learning in higher education (Elia et al., 2017; Kurowska-Pysz, 2016). Learning science, technology, environment, society, and entrepreneurship is expected to be able to overcome the gap in the relationship among the State/government, academics, markets, and industry (Hahn et al., 2017; Sun, 2015).

This literature review with bibliographic mapping has found articles on the results of interdisciplinary and transdisciplinary research. Interdisciplinarity requires a research strategy that involves the transfer of disciplines of science, technology, environment, society, and entrepreneurship to solve problems that occur in society (Guzey et al., 2019; Taub et al., 2015). Meanwhile, trans disciplinarity requires the involvement of other stakeholders outside of academia, in this case entrepreneurs and industry. So that, research results can have a higher probability of being applied in society. Several interdisciplinary studies have been carried out, among others, the Science Technology Society (Mustadi & Atmojo, 2020; Atmojo et al., 2018); Science, Environment, Technology, and Society (Arnó-Macià & Rueda-Ramos, 2011; Tseng, Chang, Lou, & Chen, 2013). Science Learning Program, Technology, and Society (Russell, 2017). Science, Technology, Engineering, and Mathematics (STEM) (Jauhariyyah, Hadi Suwono, & Ibrohim, 2017; Nugent et al., 2015; Han, Capraro, & Capraro, 2016; Stevens, Andrade, & Page, 2016; Sahin, Ekmekci, & Waxman, 2017). However, there is not much studies have been conducted about the STEM approach which connects knowledge and skills from the four disciplines that are needed simultaneously to solve problems.

The development of subsequent researches carried out innovation by incorporating elements of art (Munawar et al., 2019; Quigley et al., 2020). This is to meet the increasing demands of science and technology-based products in society that require the ability not only to master science and technology but also art related to creativity, innovation, and design. Students' abilities in the art that are integrated with mastery of science and technology can be stimulated by Science, Technology, Engineering, Art, and Mathematics (STEAM) learning (Kang, 2019; Quigley, Herro, Shekell, Cian, & Jacques, 2020; Saddhono, Sueca, Sentana, Santosa, & Rachman, 2020). STEAM is very important in connecting higher education products so that they can be produced by industry and ultimately improve the national economy. Elements of the art lead to more attractive products, so they are in great demand. STEAM can increase students' interest in learning and make it more meaningful (Quigley et al., 2020). STEAM is effective in increasing student innovation and creativity (Glass & Wilson, 2016). STEAM is effective in cognitive and affective learning, but is higher in affective (Kang, 2019). However, there are very few studies dealing with the relationship between STEAM and entrepreneurship, has examined the direct relationship of STEAM learning to the entrepreneurial character. The current character of entrepreneurship is very much needed to overcome the increasingly limited job opportunities due to the transformation of human labor to machine power and information technology (Hidayat, 2019). The relationship among Natural Science (NOS), Economic Science (EOS), technology, and entrepreneurship has not been explored much. Therefore, the main objective of this research is to explore the extent to which the integration of science, technology, and entrepreneurship is carried out in science learning.

Exploration is done by "science mapping" through visualization of bibliometric networks (Van Eck et al., 2010) about science learning using STS, STEM, STEAM, and entrepreneurship approaches. This technique is used so that mapping can be done easily. Visualization techniques in network analysis are carried out to map the relationship among journals, co-authors, researchers, and the emergence of keywords (Aribowo, 2019; Van Eck & Waltman, 2010). This technique also reveals the main topics, how the relationship between topics and the development of topics over time (Waltman et al., 2010). Therefore, this research was conducted to answer the following questions.

a) How is the development of research on the integration of science, technology, and entrepreneurship in science learning?
b) What about the productivity of the writer?
c) How do bibliometric networks and learning research trends integrate science, technology, and entrepreneurship?

Method

The method used in this literature review considers several steps that have been carried out by previous research (Waltman et al., 2010; Van Eck et al., 2010; Aribowo, 2019). The first stage, exploration is carried out using publish or perish software to explore and map the results of science learning research with STS, STEM, and STEAM approaches and their developments. The database search using publish or perish software is conducted on Google Scholar, and Scopus with the "API Key" use the keywords Science Learning, Technology, Entrepreneurship; Science Learning, STS; Science Learning, STEM; Science Learning, STEAM; and Science Learning, Entrepreneurship. At the beginning, the year of the search was not limited to the aim of seeing the initial year of publication, and to focus on the next it was limited to the last 5 years, namely from 2015 to 2020. The results of the data search with the publish or perish software were in the form of metadata and then stored in the form of Research Information System (RIS), and included in the delay, and equipped with metadata. The obtained data is excluded from proceedings, theses and book chapters, modules, theses, reports, and comments. The results of downloading those papers on December 18, 2020, amounted to 851 article metadata which is summarized in Table 2. The information recorded from each article can be shown in Table 1 as follows.

Table 1

CSV Document Setup Downloaded from Google Scholar and Scopus Database

Item	Recorded data
Citation	Author, article title, year published, journal name, volume, edition, page, total citation, document type
Bibliography	Journal abbreviation, ISSN, Publisher, Editor, language, affiliation, correspondence address
Abstract and Keywords	Abstract, keywords
Funding	Sponsor, funding text
Other Information	References

The data visualization was built from the data in Table 1. Exploration was carried out on the articles that were cited the most, to the keywords that were used the most. This information is used to build the data visualization. Metadata visualization is done with VOSviewer software version 1.6.16. Visualization is carried out on metadata that has been downloaded and stored in the form of RIS based on the VOSviewer software algorithm (Jeong & Koo, 2016). This VOSviewer is used to analyze trends in science learning using the STS, STEM, and STEAM approaches and their development, as well as their integration with entrepreneurship. Keywords are extracted from the title and abstract. Two or more keywords appear in this article's metadata as research topics or themes.

The metadata visualization step begins by clicking the create button, selecting the data type to create a map based on text data, and then Next button is selected. For the selected data source read data from reference manager files, the exported RIS file is taken from downloading articles using publish or perish. Next click the title and abstract field to be extracted and check the two options and wait for some time. Binary counting method, then fill in the threshold with 5 (by default it is 10) so that from 9374 terms, 611 keywords are found that often appear, then the Next button is selected, and by default, it will be filled with numbers obtained from 60%, and 367 keywords are selected. The next stage is term verification, keywords are sorted alphabetically and less specific terms related to science learning studies are ignored, then Finish button is selected.

Findings and Discussion

In this literature review study, bibliographic information is used to determine research trends in the integration of science, technology, society, and entrepreneurship. This is an important step to find out the development of research in the theme of science, technology, society, and entrepreneurship, the authors who play a role in writing articles and research results. In this research, the mapping is presented in the form of images showing interrelated item points. Before mapping, this research also presents clusters of research on science, technology, society, and entrepreneurship, and the most cited works are described in the results of this study.

The Development of Research Integration of Science, Technology, and Entrepreneurship in Science Learning

Science learning with the Science Technology Society (STS) approach began to be published in reputable international journals in 1964. Then the Science, Technology, Engineering, and Mathematical (STEM) approach was developed in 2007. The next learning innovation was to add art (Art) to Science, Technology, Engineering, Art, and Mathematics (STEAM). However, not so many have integrated entrepreneurship into these science learning approaches. The data obtained from the search results with this software can be seen in Table 2 as follows.

Table 2

Search Results with Publish or Perish

Keywords	Database			
	Google Scholar	Year	Scopus	Year
Science Learning-STS	194	1964	14	1964
Science Learning-STEM	406	2000	110	2007
Science Learning-STEAM	59	2011	7	2016
Science Learning-Entrepreneurship	44	2000	7	2007
Science Learning-Technology-Entrepreneurship	8	2006	2	2017
Total	711		140	

If you look at the data in Table 2, from the keyword theme in the article download that science learning with the STEM theme was found the most articles were found even though the publication of research only started in the 2000s. While the STS theme, which was published in 1964, has not developed as much as STEM. Then followed the STEAM theme which also began to be widely researched in 2011. While the publication theme that integrates learning science, technology, and entrepreneurship is only about 8 even though the publication started quite early, namely in 2006. This provides many opportunities for research on learning that integrates science, technology, and entrepreneurship. Entrepreneurship and science learning have almost the same goals (Deveci & epi, 2017), so it is possible to integrate them. Government policies that require entrepreneurship content to be integrated into educational programs also encourage the integration of learning science, technology, and entrepreneurship to be implemented with various appropriate formulas.

Author Productivity

A total of 851 (99.41%) articles were found written in English and only 5 (0.59%) articles were written in Korean. The origin of authors of the articles found in this research is dominated by the USA, then there are authors from Taiwan, Malaysia, Germany, Barcelona, Korea, New York, Tokyo, France, and Indonesia. Furthermore, for the productivity of the authors, it can be seen from the number of writings in Citation, as shown in Table 3, the themes studied, and the research objectives.

Table 3

List of Frequently Cited Articles

No.	Theme	Database, Journal	Publication	Number of Citations
1.	SL-STS	Scopus, Q1 Journal of Science Education and Technology	Hakan Akcay & Robert E. 2010.Yager. The Impact of a Science/Technology/Society Teaching Approach on Student Learning in Five Domains. 19, 602–611	94
2.		Scopus School Science and Mathematics	Erminia Pedretti. 1996. Learning About Science, Technology, and Society (STS) Through an Action Research Project: Co-Constructing an Issues-Based Model for STS Education. 96 (8), 432-440	57
3.		Scopus, Q1 Journal of Science Teacher Education	Dana Caseau, Katherine Norman. 1997. Special Education Teachers Use Science-Technology-Society (STS) Themes to Teach Science to Students With Learning Disabilities. 8(1), 55-68.	29
4.		Scopus, Q2 Jurnal Pendidikan IPA Indonesia (JPII)	U. Usmeldi, R. Amini, S. Trisna. 2017. The Development of Research-Based Learning Model with Science, Environment, Technology, and Society Approaches to Improve Critical Thinking of Students. 6(2), 318-325	27
5.		Scopus, Q1 Journal of English for Academic Purposes	Elisabet Arnó, Macià Carmen Rueda Ramos. 2011. Promoting reflection on science, technology, and society among engineering students through an EAP online learning environment. 10(1), 19-31.	24
6.		Scopus, Q1 International Journal of Science Education (IJSE)	Marwan M.A. Abualrob, Esther Gnanamalar Sarojini Daniel. 2015. The Delphi Technique in Identifying Learning Objectives for the Development of Science, Technology and Society Modules for Palestinian Ninth Grade Science Curriculum. 35(15), 2538–2558.	22
7.		Scopus, Q2 Jurnal Pendidikan IPA Indonesia (JPII)	S. E. Atmojo, A. Rusilowati, S. I. A. 2018. Dwiningrum, M. Skotnicka. The Reconstruction of Disaster Knowledge through Thematic Learning of Science, Environment, Technology, and Society Integrated with Local Wisdom. 7(2), 204-213.	15
8.		Scopus, Q3 Elementary Education Online (EEO)	Ali Mustadi, Setyo Eko Atmojo. 2020. Student's disaster literation in 'SETS' (Science Environment Technology and Society) disaster learning. 19(2). 667-678	14
9.		Scopus, Q4 Bulletin of Science, Technology & Society	Robert E. Yager. 1995. Science Technology Society And Learning. 15(5), 225-227.	9
10.		Scopus, Q2 Jurnal Pendidikan IPA Indonesia (JPII)	D. Rosana, N. Kadarisman, A. Maryanto, A. Sugiharsono. 2017. The Evaluation of Science Learning Program, Technology and Society Application of Audio Bio Harmonic System with Solar Energy to Improve Crop Productivity. 6(1).	8
11.	SL-STEM	Scopus, Q1, International Journal of Science and Mathematics Education (IJSME)	Sunyoung Han, Robert Capraro & Mary Margaret Capraro. 2015. How Science, Technology, Engineering, And Mathematics (Stem) Project-	401

			Based Learning (Pbl) Affects High, Middle, And Low Achievers Differently: The Impact Of Student Factors On Achievement. 13, 1089–1113	
12.		Scopus, Q1, Journal of Science Education and Technology	S. Selcen Guzey, Tamara J. Moore, Michael Harwell & Mario Moreno. 2016. STEM Integration in Middle School Life Science: Student Learning and Attitudes. 25,550–560.	89
13.		Scopus, Q1, International Journal of Science and Mathematics Education (IJSME)	Christina Chalmers, Merilyn (Lyn) Carter, Tom Cooper & Rod Nason. 2017. Implementing "Big Ideas" to Advance the Teaching and Learning of Science, Technology, Engineering, and Mathematics (STEM). 15, 25–43.	61
14.		Scopus, Q2 Journal of Turkish Science Education	Sunyoung HAN, Roslinda Rosli, Mary M. Capraro, Robert M. Capraro. 2016. The Effect of Science, Technology, Engineering and Mathematics (STEM) Project Based Learning (PBL) on Students' Achievement in Four Mathematics Topics. 13, 3-29.	45
15.		Scopus Q1 Cultural Studies of Science Education	Martin Storksdieck. 2016. Critical information literacy as a core skill for lifelong STEM learning in the 21st century: reflections on the desirability and feasibility for widespread science media education. 11, 167-182.	43
16.		Scopus Q2 Theory into Practice	Jane L. Newman John Dantzler April N. Coleman. 2015. Science in Action: How Middle School Students Are Changing Their World Through STEM Service-Learning Projects. 54, 47-54.	43
17.		Scopus Q1 Journal of Science Education and Technology	Sally Stevens, Rosi Andrade & Melissa Page. 2016. Motivating Young Native American Students to Pursue STEM Learning Through a Culturally Relevant Science Program. 25, 947-960.	41
18.		Scopus Q2 Eurasia Journal of Mathematics, Science & Technology Education	Niyazi Erdogan, Bilgin Navruz, Rayya Younes, Robert M. Capraro. 2016. Viewing How STEM ProjectBased Learning Influences Students' Science Achievement Through the Implementation Lens: A Latent Growth Modeling. 12(8), 2139-2154.	40
19.		Scopus Q1 International Journal of Science Education	Alpaslan Sahin , Adem Ekmekci & Hersh C. Waxman. 2017. The relationships among high school STEM learning experiences, expectations, and mathematics and science efficacy and the likelihood of majoring in STEM in college. 39(11), 1549-1572.	39
20.		Scopus Q1 International Journal of Science and Mathematics Education	S. Selcen Guzey, Elizabeth A. Ring-Whalen, Michael Harwell & Yadira Peralta. 2019. Life STEM: A Case Study of Life Science Learning Through Engineering Design. 17, 23–42.	37
21.		Scopus Q1 Art Education	Don Glass & Colleen Wilson. 2016. The Art and Science of Looking: Collaboratively Learning Our Way to Improved STEAM Integration. 69(6), 8-14.	12
22.		Shinta S5 Jurnal Ceria	Muniroh Munawar, Fenny Roshayanti, Sugiyanti. 2019. Implementation Of Steam (Science Technology Engineering Art Mathematics) - Based Early Childhood Education Learning In Semarang City. 2(5), 2614-6347.	9
23.	SL-STEAM	Scopus Q1 International Journal of Science and Mathematics Education volume	Hye-Eun Chu, Sonya N. Martin & Jennifer Park. 2019. A Theoretical Framework for Developing an Intercultural STEAM Program for Australian and Korean Students to Enhance Science Teaching and Learning. 17, 1251–1266.	6
24.		Scopus Q1 International Journal of Science and Mathematics Education volume	Cassie F. Quigley, Dani Herro, Calli Shekell, Heidi Cian & Lori Jacques. 2020. Connected Learning in STEAM Classrooms: Opportunities for Engaging Youth in Science and Math Classrooms. 18,1441–	4

			146	
25.		Scopus Q4 International Information Institute	Yoon, Mabyong. 2016. Action Research on Applying the STEAM Program Based on Mt. Mai's Ice Spikes and Science Learning Area to Foster Topophilia. 19(4), 1115-1120.	4
26.		Google Scholar	Nam-Hwa Kang, Na-ri Lee, Minjeong Rho, Jin Eun Yoo. 2018. Meta-Analysis of STEAM (Science, Technology, Engineering, Arts, Mathematics) Program Effect on Student Learning. 38(6), 875-883.	3
27.		Scopus Q1 Journal Of Physics	K Saddhono, I N Sueca, G D D Sentana, W H Santosa, R S Rachman. 2019. The application of STEAM (Science, Technology, Engineering, Arts, and Mathematics)-based Learning in Elementary School Surakarta District.	3
28.		Scopus Q4 International Information Institute	Yoon, Mabyong. 2016. Action Research on Applying the STEAM Program Based on Mt. Mai's Ice Spikes and Science Learning Area to Foster Topophilia. 19(4), 1115-1120.	4
29.		Google Scholar	Nam-Hwa Kang, Na-ri Lee, Minjeong Rho, Jin Eun Yoo. 2018. Meta-Analysis of STEAM (Science, Technology, Engineering, Arts, Mathematics) Program Effect on Student Learning. 38(6), 875-883.	3
30.		Scopus Q1 Journal Of Physics	K Saddhono, I N Sueca, G D D Sentana, W H Santosa, R S Rachman. 2019. The application of STEAM (Science, Technology, Engineering, Arts, and Mathematics)-based Learning in Elementary School Surakarta District.	3
31.	SL-Entrepreneurship	Scopus Q1 Journal of Business Venturing	Vangelis Souitaris, Stefania Zerbinati, Andreas Al-Laham. 2007. Do entrepreneurship programs raise the entrepreneurial intention of science and engineering students? The effect of learning, inspiration, and resources. 25,566–591.	922
32.		Scopus Q1 Journal of European Industrial Training	Fayolle, A., Gailly, B. 2008. From craft to science: Teaching models and learning processes in entrepreneurship education.32(7), 569-593.	278
33.		Scopus Q3 Journal of Engineering and Applied Sciences	Yuliana, Hidayat, H. 2017. How to implement technology science for entrepreneurship by using a product-based learning approach and participatory action learning system in higher education?. 23(11), 10918-10921.	8
34.		Scopus Q1 Journal of Technology Transfer	Klofsten, M., Jones-Evans, D., Pereira, L. 2020. Teaching science and technology Ph.D. students in entrepreneurship-potential learning opportunities and outcomes.	1
35.	SL-Technology-Entrepreneurship	Scopus Q1 Science & Education	Sila Kaya, Sibel Erduran, Naomi Birdthistle, Orla McCormack. 2018. Looking at the Social Aspects of Nature of Science in Science Education Through a New Lens The Role of Economics and Entrepreneurship	15

Learning science with the STS approach shows research articles with the theme of the impact of science learning with the STS approach on the 5 most cited domains. This article examines the effectiveness of the STS approach in mastering basic science, understanding science processes, creative skills, increasing student attitudes towards science, and the ability to apply it in new situations (Akcay & Yager, 2010). STS is the teaching and learning of science and technology in the context of human experience (Association, 2007). Learning with STS develops students' abilities in science and technology literacy. Technology directs learning towards making real products and the application of science in society. The integration of science, technology, and society in science learning has an important role in realizing scientific literacy. Students are directed to understand science products and their relevance in everyday life and to understand that the scientific process is based on social values in social life. Article's research results use the Chautauqua Program in terms of improving students: (1) mastery of concepts; (2) the ability to define and use process skills; (3) develop a more positive attitude toward science; (4) development of special creativity skills; and (5) the ability to use key concepts and processes in new situations.

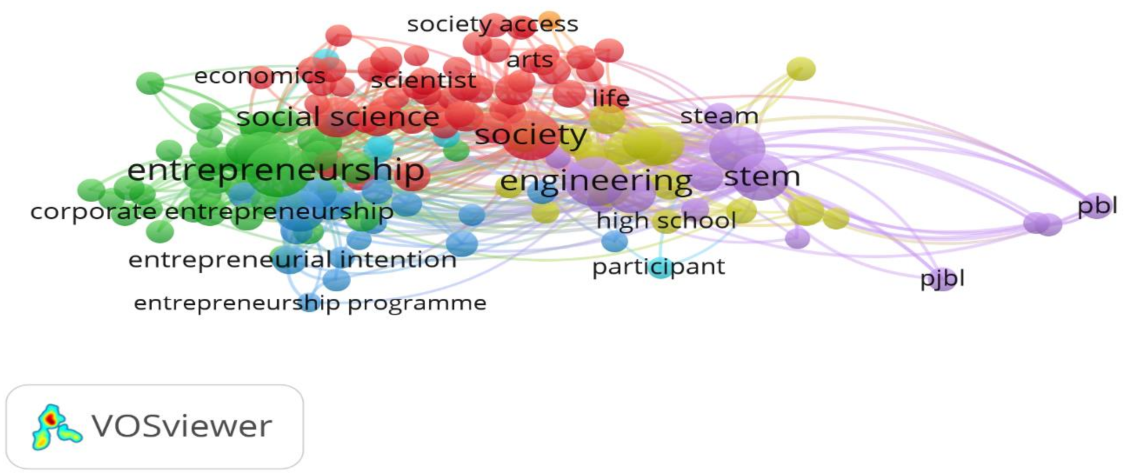
Learning science with the highest STEM citation approach in research articles that integrate the Project Based Learning (PjBL) method. Conceptualizing STEM education through the practice of science and engineering and within broad objectives can strengthen 21st-century skills. The STEAM approach which emphasis the integration of art in the STEM approach is currently more needed because the demands of technology products require creativity in designing products with high artistic value. The highest citation in the STEAM approach is on the theme of how to integrate art into the STEM approach. STEAM (Science. Technology. Engineering. Art. and Mathematics) is seen as an approach to preparing the 21st century generation, which aims to stimulate creativity and prepare children for a world of work full of innovation and invention (Munawar, Roshayanti, & Sugiyanti, 2019).

Bibliometric Network and Research Trends Integrated Science learning, Technology, Entrepreneurship

Visualization of the results of downloading article metadata with publishing or perish software is done using the VOSviewer (van Eck & Waltman, 2010). Visualization is done in terms of network, overlay, and density. The bibliometric network consists of nodes and edges (Figure 1). The nodes represented by circles can be publications, journals, researchers, or keywords; whereas the edge indicates the relationship among pairs of nodes. In addition, the edge not only indicates a relationship between two nodes but also the strength of the relationship which is represented by distance. The closer the distance between one node and another indicates the high relationship between these nodes. The first stage of meta-data visualization found that there were 7 clusters, indicated by color, namely: 1. Red, 2. Green, 3. Blue, 4. Yellow, 5. Purple, 6. Purple-blue, and 7. Orange.

Figure 1

Article Meta Data Matching and Clustering



This mapping shows a detailed description of the structure of a bibliometric network of research on the integration of science, technology, society, environment, and entrepreneurship. Meanwhile, clustering shows more bibliometric grouping. The color shows the clusters, the closeness between words shows the closeness of the relationship, and the bigger the text the greater the intensity. Each circle in Figure 1 shows the keywords that often appear in the metadata obtained. The number of publications that have a relationship with a keyword is indicated by the size of the circle. The larger the size, the greater the number of published articles that have a relationship to the keywords. The keywords that are close together and often appear are located close to each other. The results of the 7 clusters visualization can be seen in Table 4 as follows.

Table 4

Making Clusters Based on Keywords that is Often Appear

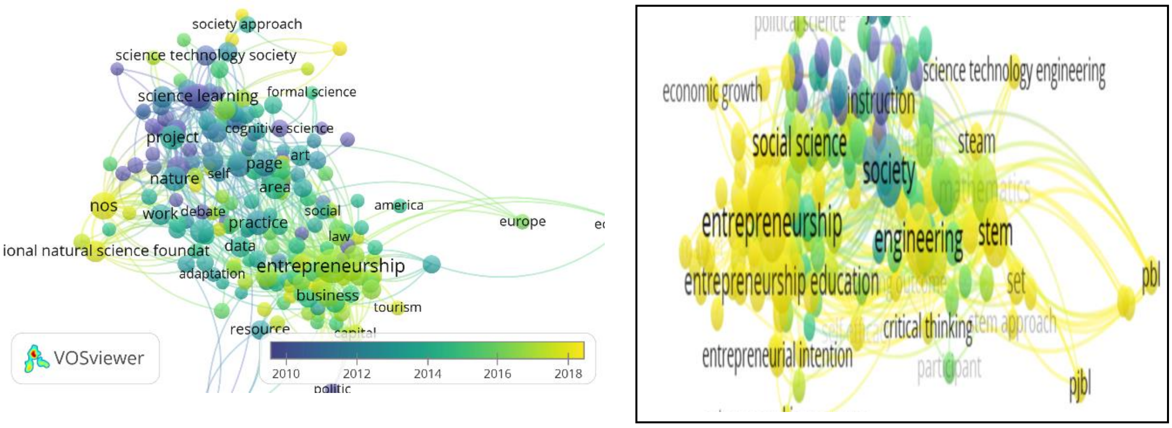
Cluster	Color	Items	Frequently Appearing Keywords
1	Red	53	Applied science, argumentation, arts, attention, AR, biological science, cognition, cognitive science, collaborative learning, conceptual change, discourse, earth, earth science, economic, educational science, educational research, educational technology, engineering, environmental science, experiment, game, higher education, humanities, informal learning, information technology, instruction, mobile learning, mobile technology, nature, physical science, political science, science classroom, scientific literacy, scientist, simulation, social science, society, STEM learning, sustainability science, sustainability development, technology-enhanced learning.
2	Green	44	Absorptive capacity, academic entrepreneurship, academy, administrative science, benefit, capability, communication technology, company, corporate entrepreneurship, creation, digital entrepreneurship, creation, economic growth, economy, enterprise, entrepreneur, entrepreneurial ecosystem, entrepreneurial university, entrepreneurship, entrepreneurship research, entrepreneurship theory, experiential learning, exploration, health science, ICT, incubator, industry, innovation, institution, international entrepreneur, life science, management science, market, ministry, new technology, organizational learning, orientation, potential, product, science park, service, social entrepreneurship, technology entrepreneur, technology transfer.
3	Dark blue	19	Behavioral science, critical thinking, e-learning, engineering education, engineering student, entrepreneurial intention, entrepreneurial learning, entrepreneurship education, entrepreneurship program, gender, high school student, information science, intention, internet, online, reflection, self-efficacy, social, university student
4	Yellow	14	Ability, achievement, active learning, attitude, biology, chemistry, high school, instrument, learning outcome, literacy, physics, problem, science environment, science technology, science technology engineering, science technology society, SET, society approach
5	Purple	15	21st century, academic achievement, demand, engineering, integrated science, mathematics, PBL, PjBL, Project, Science proses skill, STEAM, STEM, STEM approach, STEM education, STEM project.
6	Light blue	6	Machine, machine learning, materials science, observation, participant, social learning
7	Orange	1	Gender difference

If you pay attention to cluster 6 which consists of 6 keywords that often appear to have a large distance among words. This indicates a relationship between words that is not very close. Meanwhile, cluster 7, which only consists of one item, namely gender difference, is only connected to engineering and STEM, and there has not been much discussion regarding gender differences. From the results of the network visualization analysis, several terms that have not been widely studied including the relationship among entrepreneurship education-learning outcomes-science technology; gender difference-engineering-STEM; technology enhanced learning; 21st century-mathematics-STEM; environmental science-society.

The next analysis is overlay visualization which is shown by colors. The colors show the research trend by year. The dark color represents years of research. Yellow indicates recent research (Figure 2). Recent research trends are shown in the following terms: (1) Engineering, literacy, problem, mathematics, and STEM; (2) Learning outcomes with entrepreneurship and science technology.

Figure 2

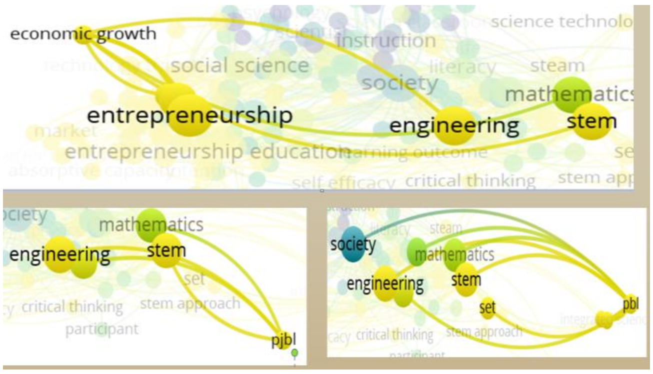
Overlay Visualization



The current research trend is shown in yellow and has not been much linked, as shown in Figure 3 below. This provides an opportunity to conduct research that links entrepreneurship, engineering, STEM, PBL, and PjBL.

Figure 3

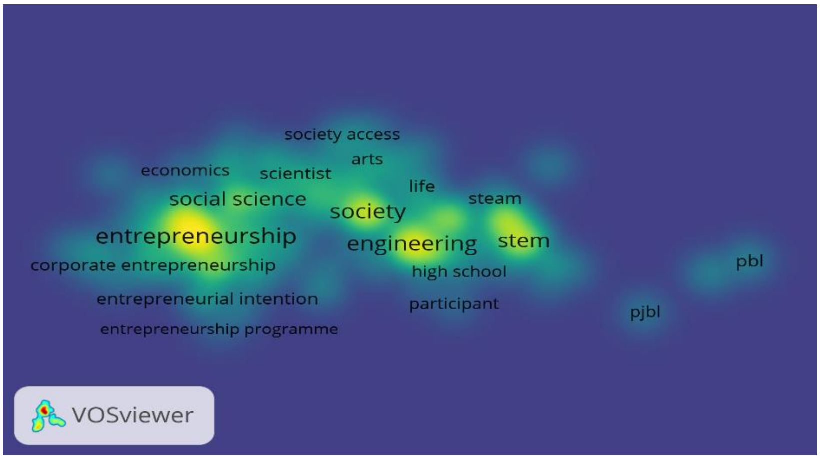
Connected Terms that Have Not Been Studied Much



The next analysis is density visualization. This analysis shows saturation, in other words the color blue has not been studied much, yellow has begun to be studied a lot, and red has been frequently studied, Figure 4.

Figure 4

Density Visualization



What has not been widely researched is including the keywords such as economic growth, learning outcomes, entrepreneurship programs, science technology engineering, integrated science, PBL, and PjBL.

Learning physics is currently starting to shift from knowledge to a more practical direction. Learning must be more applicable and efficient and have a broad role in improving the community's economy. The learning process is directed at providing an experience. so that students will experience a learning process (Hidayat, et all., 2018). The Ministry of Education and Culture's policy on learning as stipulated in Regulation of the Ministry of Education and Culture number 3 of 2020 calls for entrepreneurial content. So, in learning physics, it is necessary to combine technology and entrepreneurship. The development of science learning in the 21st century has begun to be developed with technology-based learning, both in the process, assignment, and evaluation. The integration of science is inseparable from the demands of society that science and technology have an important role in the nation's socio-economic independence (Yalvac, Tekkaya, Cakiroglu, & Kahyaoglu, 2007). Economic of Science (EOS) and Natural of Science (NOS) are applied in learning science together (Al-Laham, A., Souitaris, A., & Zerbinati, 2007). Nature of Science in learning is realized in the learning of Community Technology Science (STM)/STS/SETS, Science, Technology, Engineering, and Mathematics (STEM), and Science, Technology, Engineering, Art, and Mathematics (STEAM).

STS learning is effective in increasing student creativity, STEM has provided basic skills for entrepreneurs who have successfully run their businesses (Colombo & Piva, 2020). Technology integration in the form of STEM-based modules has been effective in improving science process skills and students' entrepreneurial character (M. Adlim, Saminan, 2015). A curriculum that integrates STEM-PBL for high-need students in the Hispanic category who has differences in language and culture can improve communication and collaboration skills in the classroom (Han et al., 2016). Improving science and technology-based products in society requires the ability not only to master science and technology but also the art related to creativity, innovation, and design. Students' abilities in the art that are integrated with mastery of science and technology can be stimulated by STEAM learning (Wijaya, Dina, & Amalia, 2015). Seeing research trends and opportunities to carry out interdisciplinary and transdisciplinary research, as well as the importance of integrating science, technology, and society, and entrepreneurship in solving problems in society and overcoming gaps in industrial and tertiary relations, it is necessary to conduct research with more in-depth studies related to integrated science learning innovations. Science, Technology, and Entrepreneurship (STP).

Conclusion and Implications

This study has elaborated the mapping and clustering of research themes on the integration of science, technology, society, and entrepreneurship from the metadata of 851 articles from the Google Scholar and Scopus databases. The use of VOSviewer in visualizing the results of downloading metadata articles with publish or perish software has shown three main points that form the basis for researching integrated science learning with technology and entrepreneurship. The results of the network visualization analysis of several terms that have not been widely studied and provide research opportunities include the relationship between entrepreneurship education-learning outcome-science technology; gender difference-engineering-STEM; technology-enhanced learning; 21st century-mathematics-STEM; environmental science-Society. The results of the overlay visualization provide an overview of research trends and opportunities to conduct research that connects entrepreneurship, engineering, STEM, PBL, and PjBL. The results of the density visualization analysis provide an overview that has not been widely studied, including economic growth, learning outcomes, entrepreneurship programs, Science technology engineering, integrated science, PBL, and PjBL. In general, the dominant research topics are STS and STEM. STEAM is starting to grow, although not much. The results of this study also offer an opportunity for research to integrate science, technology, society, and entrepreneurship. The integration of interdisciplinary and transdisciplinary science provides a way of how science works in providing solutions in society.

References

Abdurrahman, Liliasari, Rusli, A., & Waldrip, B. (2011). Implementasi pembelajaran berbasis multi representasi untuk peningkatan penguasaan konsep fisika kuantum. *Cakrawala Pendidikan*, *1*, 30–45.

Agustihana, S., & Suparno, S. (2019). Development of HOTS Oriented Cognitive Problems in Thermodynamics for Senior High Schools. Jurnal Penelitian Fisika Dan Aplikasinya (JPFA), 9(1), 44. https://doi.org/10.26740/jpfa.v9n1.p44-54

Akcay, H., & Yager, R. E. (2010). The Impact of a Science/Technology/Society Teaching Approach on Student Learning in Five Domains. *Journal of Science Education and Technology*, *19*(6), 602–611. https://doi.org/10.1007/s10956-010-9226-7

Al-Laham, A., Souitaris, A., & Zerbinati, S. (2007). Do entrepreneurship programs raise the entrepreneurial intention of science and engineering students? The effect of learning, inspiration, and resources. *Journal of Business Venturing, 22(4), 566.*

Alam, M. K. (2020). A systematic qualitative case study: questions, data collection, NVivo analysis, and saturation. *Qualitative Research in Organizations and Management: An International Journal*. https://doi.org/10.1108/QROM-09-2019-1825

Aribowo, E. K. (2019). Analisis Bibliometrik Berkala Ilmiah Names: Journal of Onomastics Dan Peluang Riset Onomastik Di Indonesia. *Aksara*, *31*(1), 85. https://doi.org/10.29255/aksara.v31i1.373.85-105

Arnó-Macià, E., & Rueda-Ramos, C. (2011). Promoting reflection on science, technology, and society among engineering students through an EAP online learning environment. *Journal of English for Academic Purposes*, *10*(1), 19–31. https://doi.org/10.1016/j.jeap.2010.12.004

Association, N. S. T. *Science-technology society (NSTA position statement)*. , (2007).

Atmojo, S. E., Rusilowati, A., Dwiningrum, S. I. A., & Skotnicka, M. (2018). The reconstruction of disaster knowledge through thematic learning of science, environment, technology, and society integrated with local wisdom. *Jurnal Pendidikan IPA Indonesia*, *7*(2), 204–213. https://doi.org/10.15294/jpii.v7i2.14273

Bakery, & Md Nor Bakar. (2015). The process of thinking among junior high school students in solving

HOTS questions. *International Journal of Evaluation and Research in Education*, *4*(3), 138–145.

Colombo, M. G., & Piva, E. (2020). Start-ups launched by recent STEM university graduates: The impact of university education on entrepreneurial entry. *Research Policy*, *49*(6), 103993. https://doi.org/10.1016/j.respol.2020.103993.

Deveci, I., & Çepni, S. (2017). Studies conducted on entrepreneurship in science education: Thematic review of research. Journal of Turkish Science Education, 14(4), 126–143. https://doi.org/10.12973/tused.10209a

Dinh, T. Le, Vu, M. C., & Ayayi, A. (2018). Towards a living lab for promoting the digital entrepreneurship process. … Journal of Entrepreneurship. http://search.proquest.com/openview/0bca65be796a42a21e05fd6b323beea6/1?pq-origsite=gscholar&cbl=29727

Elia, G., Secundo, G., & Passiante, G. (2017). Pathways towards the entrepreneurial university for creating entrepreneurial engineers: an Italian case. … of Entrepreneurship and …. https://www.inderscienceonline.com/doi/abs/10.1504/IJEIM.2017.081486.

Erduran, S. (2014). *Beyond Nature of Science : The Case for Reconceptualising ' Science ' for Science Education*. *25*(1).

Fernandes, I. M. B. (2015). A perspetiva CTSA nos documentos oficiais curriculares e nos manuais escolares de Ciências da Educação Básica: estudo comparativo entre Portugal e Espanha. uvadoc.uva.es. https://uvadoc.uva.es/handle/10324/20474.

Giudici, G., Guerini, M., & Rossi-Lamastra, C. (2019). The creation of cleantech startups at the local level: the role of knowledge availability and environmental awareness. Small Business Economics. https://link.springer.com/article/10.1007/s11187-017-9936-9.

Glass, D., & Wilson, C. (2016). The Art and Science of Looking: Collaboratively Learning Our Way to Improved STEAM Integration. Art Education, 69(6), 8–14. https://doi.org/10.1080/00043125.2016.1224822.

Guzey, S. S., Ring-Whalen, E. A., Harwell, M., & Peralta, Y. (2019). Life STEM: A Case Study of Life Science Learning Through Engineering Design. International Journal of Science and Mathematics Education, 17(1), 23–42. https://doi.org/10.1007/s10763-017-9860-0.

Hamdan, M. A. (2020). Innovation and Entrepreneurship in Higher Education: Enhancing Achievement of the United Nations Sustainable Development Goals. Higher Education in the Arab World. https://link.springer.com/chapter/10.1007/978-3-030-37834-9_12.

Hahn, D., Minola, T., Gils, & A. Van, (2017). Entrepreneurial education and learning at universities: exploring multilevel contingencies. Entrepreneurship & …. https://www.tandfonline.com/doi/abs/10.1080/08985626.2017.1376542

Han, S., Capraro, R. M., & Capraro, M. M. (2016). How science, technology, engineering, and mathematics project-based learning affects high-need students in the U.S. *Learning and Individual Differences*, *51*, 157–166. https://doi.org/10.1016/j.lindif.2016.08.045

Hidayat, H., & . Y. (2018). The Influence of Entrepreneurship Education and Family Background on Students' Entrepreneurial Interest in Nutritious Traditional Food Start-Ups in Indonesia. *International Journal of Engineering & Technology*, *7*(4.9), 118. https://doi.org/10.14419/ijet.v7i4.9.20631

Hidayat, H., Herawati, S., Syahmaidi, E., Hidayati, A., & Ardi, Z. (2018). Designing of Technopreneurship Scientific Learning Framework in Vocational-based Higher Education in Indonesia. *International Journal of Engineering & Technology*, *7*(4.9), 123. https://doi.org/10.14419/ijet.v7i4.9.20632

Irwandani. (2007). *Multi Representasi sebagai Alternatif Pembelajaran dalam Fisika*. 1–10.

Jauhariyyah, F. R., Hadi Suwono, & Ibrohim. (2017). Science , Technology , Engineering and Mathematics Project Based Learning (STEM-PjBL) pada Pembelajaran Sains. *Pros. Seminar Pend.*

IPA Pascasarjana UM, *2*, 432–436.

Jeong, D., & Koo, Y. (2016). Analysis of Trend and Convergence for Science and Technology using the VOSviewer. *International Journal of Contents*, *12*(3), 54–58. https://doi.org/10.5392/ijoc.2016.12.3.054

Jumini, S., Sutikno, S., Edy Cahyono, Nurma Khusna Khanifa, & Firdaus, F. (2020). Authentic Assessment of Science Technopreneurship Skills in Learning Physics. *TEST Engineering & Management*, *83*(14518), 14518–14526.

Jumini, S., Rusilowati, A., Sutikno, S., Cahyono, E., Parmin, P., & Firdaus, F. (2021). Discrepancy evaluation models in physics project-based learning of student entrepreneurship character. Journal of Physics: Conference Series, 1918(2). https://doi.org/10.1088/1742-6596/1918/2/022042

Jumini; S., Sutikno, S. (2019). Physıcs Learnıng Integrated Scıence, Technology, Entrepreneurshıp. International Journal of Advanced Multidisciplinary Scientific Research (IJAMSR), 2(12), 1–16. https://doi.org/10.31426/ijamsr.2019.2.12.2511

Jumini, S. (2016). Problem Based Learning Berbasis Inquiry ditinjau dari Sikap Ilmiah dan Keativitas Mahasiswa. Spektra: Jurnal Kajian Pendidikan Sains, 2(1), 10–19. https://doi.org/http://dx.doi.org/10.32699/spektra.v2i01.3

Kang, N.-H. (2019). A review of the effect of integrated STEM or STEAM (science, technology, engineering, arts, and mathematics) education in South Korea. *Asia-Pacific Science Education*, *5*(1). https://doi.org/10.1186/s41029-019-0034-y.

Kasemsap, K. (2016). Advocating entrepreneurship education and knowledge management in global business. … of Research on Entrepreneurship in the Contemporary …. https://www.igi-global.com/chapter/advocating-entrepreneurship-education-and-knowledge-management-in-global-business/139885.

Kaya, S., Erduran, S., Birdthistle, N., & McCormack, O. (2018). Looking at the Social Aspects of Nature of Science in Science Education Through a New Lens: The Role of Economics and Entrepreneurship. *Science and Education*, *27*(5–6), 457–478. https://doi.org/10.1007/s11191-018-9990-y.

Kurowska-Pysz, J. (2016). Opportunities for cross-border entrepreneurship development in a cluster model are exemplified by the Polish–Czech border region. Sustainability. https://www.mdpi.com/2071-1050/8/3/230.

M. Adlim, Saminan, S. A. (2015). Pengembangan Modul Stem Terintegrasi Untuk Meningkatkan Keterampilan Proses Sains. *Jurnal Pendidikan Sains Indonesia*, *03*(02).

Mildenhall, P., Cowie, B., & Sherriff, B. (2019). A STEM extended learning project to raise awareness of social justice in a Year 3 primary classroom. International Journal of Science Education, 41(4), 471–489. https://doi.org/10.1080/09500693.2018.1560514.

Muhamad Adlim, Saminan, S. A. (2015). Pengembangan Modul STEM Terintegrasi Untuk Meningkatkan Keterampilan Proses Sains di SMA Negeri 4 Banda Aceh. Jurnal Pendidikan Sains Indonesia, 03(02), 112–121.

Munawar, M., Roshayanti, F., & Sugiyanti, S. (2019). Implementatıon Of Steam (Science Technology Engineering Art Mathematics) - Based Early Chıldhood Educatıon Learnıng In Semarang Cıty. *Cerıa (Cerdas Energik Responsif Inovatif Adaptif)*, *2*(5), 276. https://doi.org/10.22460/ceria.v2i5.p276-285

Mustadi, A., & Atmojo, S. E. (2020). Student's disaster literation in 'sets' (Science environment technology and society) disaster learning. *Elementary Education Online*, *19*(2), 667–678. https://doi.org/10.17051/ilkonline.2020.693118

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C. R., & Nelson, C. (2015). A Model of Factors Contributing to STEM Learning and Career Orientation. *International Journal of Science Education*, *37*(7), 1067–1088. https://doi.org/10.1080/09500693.2015.1017863

Pamungkas Stiyamulyani, P. S., & Sri Jumini, S. J. (2018). Pengaruh Menghafal Al-Qur'an Terhadap Hıghorder Thıngkıng Skıls (Hots) Dıtınjau Darı Motıvası Berprestası Mahasıswa. *SPEKTRA : Jurnal Kajian Pendidikan Sains*, *4*(1), 25. https://doi.org/10.32699/spektra.v4i1.43

Quigley, C. F., Herro, D., Shekell, C., Cian, H., & Jacques, L. (2020). Connected Learning in STEAM Classrooms: Opportunities for Engaging Youth in Science and Math Classrooms. *International Journal of Science and Mathematics Education*, *18*(8), 1441–1463. https://doi.org/10.1007/s10763-019-10034-z

Rosana, D., Kadarisman, N., & Suryadarma, I. G. P. (2019). Sets best practice model: Growth optimization and productivity of organic food plants through Rasmussen application. Jurnal Pendidikan IPA Indonesia, 8(2), 267–278. https://doi.org/10.15294/jpii.v8i2.19248

Russell, L. (2017). Can learning communities boost the success of women and minorities in STEM? Evidence from the Massachusetts Institute of Technology. *Economics of Education Review*, *61*(October), 98–111. https://doi.org/10.1016/j.econedurev.2017.10.008

Saddhono, K., Sueca, I. N., Sentana, G. D. D., Santosa, W. H., & Rachman, R. S. (2020). The application of STEAM (Science, Technology, Engineering, Arts, and Mathematics)-based Learning in Elementary School Surakarta District. *Journal of Physics: Conference Series*, *1573*(1). https://doi.org/10.1088/1742-6596/1573/1/012003

Sahin, A., Ekmekci, A., & Waxman, H. C. (2017). The relationships among high school STEM learning experiences, expectations, and mathematics and science efficacy and the likelihood of majoring in STEM in college. *International Journal of Science Education*, *39*(11), 1549–1572. https://doi.org/10.1080/09500693.2017.1341067.

Samila, S., & Sorenson, O. (2017). Community and capital in entrepreneurship and economic growth. American Sociological Review.

Shi, Y., Guo, W., Niu, Y., & Zhan, J. (2019). No-Reference Stereoscopic Image Quality Assessment using a Multi-task CNN and Registered Distortion. *Pattern Recognition*, 107168. https://doi.org/10.1016/j.patcog.2019.107168

Siagian, T. H., Purhadi, P., Suhartono, S., & Ritonga, H. (2014). Social vulnerability to natural hazards in Indonesia: Driving factors and policy implications. *Natural Hazards*, *70*(2), 1603–1617. https://doi.org/10.1007/s11069-013-0888-3

Soetomo, F. U. (2017). Pengembangan Keterampilan Berfikir Tingkat Tinggi dengan Menggunakan Strategi Metakognitif Model Pembelajaran. 2(2011), 63–71.

Stevens, S., Andrade, R., & Page, M. (2016). Motivating Young Native American Students to Pursue STEM Learning Through a Culturally Relevant Science Program. *Journal of Science Education and Technology*, *25*(6), 947–960. https://doi.org/10.1007/s10956-016-9629-1.

Sun, Z. (2015). Technology innovation and entrepreneurial state: the development of China's high-speed rail industry. Technology Analysis & Strategic Management. https://www.tandfonline.com/doi/abs/10.1080/09537325.2015.1034267.

Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. (2013). Attitudes towards science, technology, engineering, and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education*, *23*(1), 87–102. https://doi.org/10.1007/s10798-011-9160-x.

Taub, R., Armoni, M., Bagno, E., & Ben-Ari, M. (2015). The effect of computer science on physics learning in a computational science environment. Computers and Education, 87, 10–23. https://doi.org/10.1016/j.compedu.2015.03.013.

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Van Eck, N. J., Waltman, L., Dekker, R., & Van Den Berg, J. (2010). A comparison of two techniques for bibliometric mapping: Multidimensional scaling and VOS. *Journal of the American Society for*

Information Science and Technology, *61*(12), 2405–2416. https://doi.org/10.1002/asi.21421

Waltman, L., van Eck, N. J., & Noyons, E. C. M. (2010). A unified approach to mapping and clustering of bibliometric networks. *Journal of Informetrics*, *4*(4), 629–635. https://doi.org/10.1016/j.joi.2010.07.002

Wijaya, A. D., Dina, K., & Amalia. (2015). Implementasi Pembelajaran Berbasis STEAM (Science, Technology, Engineering, Art, Mathematics) Pada Kurikulum Indonesia. *Seminar Nasional Fisika Dan Aplikasinya*, (November), 85–88. Retrieved from http://portal.phys.unpad.ac.id/senfa2015/proseding/FP-09_Agusta_Danang.pdf.

Wijayanti, A. (2014). Pengembangan autentic assesment berbasis proyek dengan pendekatan saintifik untuk meningkatkan keterampilan berpikir ilmiah mahasiswa. Jurnal Pendidikan IPA Indonesia, 3(2), 102–108. https://doi.org/10.15294/jpii.v3i2.3107.

Williams, C. C. (2017). Entrepreneurship in the Informal Sector: an institutional perspective. books.google.com.

Yalvac, B., Tekkaya, C., Cakiroglu, J., & Kahyaoglu, E. (2007). Turkish pre-service science teachers' views on Science-Technology-Society issues. *International Journal of Science Education*, *29*(3), 331–348. https://doi.org/10.1080/09500690600708667

Yuliati, Y. (2017). Literasi Sains dalam Pembelajaran IPA. Jurnal Cakrawala Pendas, 3(2), 21–28.

Zainurrisalah, T. F., Suwarma, I. R., & Jauhari, A. (2018). Mengukur Kemampuan Literasi Teknologi dan Rekayasa (Engineering) Melalui Penerapan Pembelajaran STEM dalam Fisika. Prosiding Seminar Nasional Fisika (E-Journal), 131–135.