Paper ID	Definition/Frameowrk in the paper)	Literacy statement
1	1.Acquiring scientific, technological, engineering, and mathematical knowledge and using that knowledge to identify issues, acquire new knowledge, and apply the knowledge to STEM-related issues. 2.Understanding the characteristic features of STEM disciplines as forms of human endeavors that include the processes of inquiry, design, and analysis. 3.Recognizing how STEM disciplines shape our material, intellectual, and cultural world. 4.Engaging in STEM-related issues and with the ideas of science, technology, engineering, and mathematics as concerned, affective, and constructive citizens.**(Page 31)**	STEM literacy refers to acquiring (new or not)scientific, technological, engineering, and mathematical knowledge. STEM literacy refers to using STEM knowledge to identify STEM-related issues. STEM literacy refers to understanding the characteristic features of STEM disciplines as forms of human endeavors that include the processes of inquiry, design, and analysis. STEM literacy refers to recognizing how STEM disciplines shape our material, intellectual, and cultural world. STEM literacy refers to engaging in STEM-related issues and with the ideas of science, technology, engineering, and mathematics as concerned, affective, and constructive citizens
2	STEM literacy involves much more than just content knowledge; it also require an understanding of the representation and interpretation of scientific data, scientific explanations and projections, and the process of science. Further, STEM literacy involves cognitive and metacognitive abilities, collaborative teamwork, effective use of technology, and the abilities to engage in scientific discourse around global issues, synthesize disparate concepts, and persuade others to take informed action based on scientific evidence. **(Page 57)**	STEM literacy involves content knowledge STEM literacy involves understanding of the representation and interpretation of scientific data, scientific explanations and projections, and the process of science. STEM literacy involves cognitive and metacognitive abilities STEM literacy involves collaborative teamwork STEM literacy involves effective use of technology STEM literacy involves the abilities to engage in scientifi c discourse around global issues STEM literacy involves synthesize disparate concepts STEM literacy involves persuade others to take informed action based on scientific evidence
3	Cognitive apprenticeship theory emphasizes the need to foreground authentic and broadly transferable cognitive skills through instruction. In the context of engineering education, STEM literacy is a term that is used to define such skills.(Page 20)	STEM is defined by authentic and broadly transferable cognitive skills
4	STEM literacy for Thai vocational education consists of six components: identifying a STEM problem, exploring and acquiring new knowledge, applying STEM concepts, solving the STEM problem, communicating STEM information and making a STEM decision.**(Page 527)**	STEM literacy consists of identifying a STEM problem STEM literacy consists of exploring and acquiring new knowledge STEM literacy consists of applying STEM concepts STEM literacy consists of solving the STEM problem STEM literacy consists of communicating STEM information STEM literacy consists of making a STEM decision
5	STEM knowledge(Science knowledge, Technology knowledge, Engineering knowledge, Mathematical knowledge); STEM skills(Observation, guessing and testing, problem identification and goal setting, informatin collection, planing and designing, implentation, communication, explanation and representation); STEM disposition(Curiousity and enthusiasm, perseverance, initiative, collaboration, creativity)**(Page 623)**	STEM literacy includes STEM knowledge(Science knowledge, Technology knowledge, Engineering knowledge, Mathematical knowledge) STEM literacy includes STEM skills(Observation, guessing and testing, problem identification and goal setting, informatin collection, planing and designing, implentation, communication, explanation and representation) STEM literacy includes STEM disposition(Curiousity and enthusiasm, perseverance, initiative, collaboration, creativity)
6	STEM literacy practices including: posing and solving problems in the world and in the design process; identifying, organizing, and integrating information across sources; creating representational forms and traversing representational systems and materials; communicating information in new ways to different audiences; and documenting making processes and/or milestones.**(Page 3, Table 1)**	STEM literacy practices include posing and solving problems in the world and in the design process STEM literacy practices include identifying, organizing, and integrating information across sources STEM literacy practices include creating representational forms and traversing representational systems and materials STEM literacy practices include communicating information in new ways to different audiences STEM literacy practices include documenting making processes and/or milestones
7	The first category of program goals consists of building a strong foundation for scientific and STEM literacy. This includes not only an understanding of basic math and science but also experience with critical thinking and problem solving. These skills are valuable for nearly all citizens, not just those actively working in STEM fields.(Page 428)	STEM literacy includes understanding of basic math and science STEM literacy includes experience with critical thinking STEM literacy includes experience with problem solving
8	This study proposed that STEM literacy consists of three aspects – knowledge, ability and attitude (Figure 1)**(Page 871)**.	STEM literacy consists of knowledge STEM literacy consists of ability STEM literacy consists of attitude
9	The development of STEM literacy was a unifying theme across literature. This was positioned at the core of K-12 STEM education, defining its purpose and desired outcomes from STEM curriculum. These outcomes can be summarised as follows: learning STEM discipline knowledge, recognising how STEM shapes our world, understanding the nature of STEM-based endeavour and engaging constructively with STEM-related issues and challenges. (Page 375)	STEM literacy includes learning STEM discipline knowledge STEM literacy includes recognising how STEM shapes our world STEM literacy includes understanding the nature of STEM-based endeavour STEM literacy includes engaging constructively with STEM-related issues and challenges
10	Literacy is about communicative competency, the ability to do and share. To that end, a STEM-literate student: • Demonstrates problem-framing and problem-solving skills, applying them across disciplines. • Articulates that technology is used to expand knowledge and ability. • Draws connections to the opportunities specific technologies create for individuals. • Persists through productive struggle to attain success, especially as it relates to technology and engineering design. • Makes informed decisions using sound reasoning that can be appropriately expressed. • Articulates reasoning based in mathematical and scientific concepts and processes. • Evaluates information for relevancy and accuracy.**(Page 23)**	A STEM-literate student can demonstrate problem-framing and problem-solving skills, applying them across disciplines. A STEM-literate student can articulate that technology is used to expand knowledge and ability. A STEM-literate student can draw connections to the opportunities specific technologies create for individuals. A STEM-literate student can persist through productive struggle to attain success, especially as it relates to technology and engineering design. A STEM-literate student can make informed decisions using sound reasoning that can be appropriately expressed. A STEM-literate student can articulate reasoning based in mathematical and scientific concepts and processes.

		A STEM-literate student can evaluate information for relevancy and accuracy.
11	The five aspects of STEM literacy initially specified for the STEM-CIS items were: self-efficacy/perception of ability (12 items), attitude and interest (willingness to engage, career belief, disposition; 32 items), role and utility of STEM in society (10 items), sense of community (16 items), and family influence (14 items).(Page 87)	STEM literacy includes self-efficacy/perception of ability STEM literacy includes attitude and interest (willingness to engage, career belief, disposition) STEM literacy includes role and utility of STEM in society STEM literacy includes sense of community STEM literacy includes family influence
12	Thus, a deictic description for developing STEM literacy needs to spotlight three strata: (1) literacies of science, technology, engineering, mathematics, and other associated areas; (2) personal, societal, and economic needs; and (3) cognitive, affective, and psychomotor learning domains.(Page 15)	STEM literacy promotes literacies of science, technology, engineering, mathematics, and other associated areas STEM literacy promotes personal, societal, and economic needs; STEM literacy promotes cognitive, affective, and psychomotor learning domains
13	Based on the review of the literature, we found similar trends and lines of inquiry in the way scientific, mathematical, technological/engineering literacies have been conceptualised and studied by researchers in their respective communities. These similarities offer a common ground that could be used as a basis for defining a collective STEM literacy across the disciplines. • The creation, use and conversion of codified multimodal representations • The mastery of common visual resources such as annotated diagrams and geometric drawings • The application of cognitive and metacognitive strategies involving problem identification, planning, evaluation and self-monitoring(Page 14, Page 15)	STEM literacy is defined by the creation, use and conversion of codified multimodal representations STEM literacy is defined by the mastery of common visual resources such as annotated diagrams and geometric drawings STEM literacy is defined by the application of cognitive and metacognitive strategies involving problem identification, planning, evaluation and self-monitoring
14	STEM literacy is the ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and to innovate to solve them.(Page 7)	STEM literacy is the ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and to innovate to solve them.
15	Thus, another goal of STEM education is to increase STEM literacy—defined as the knowledge and understanding of scientific and mathematical concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity for all students.(Page 5)	STEM literacy is defined as knowledge and understanding of scientific and mathematical concepts and processes STEM literacy is defined as personal decision making STEM literacy is defined as engagement in civic and cultural affairs, as well as economic productivity
16	This article is a non-empirical, polemic arguing for a critical STEM literacy, brought into sharper focus by the requirements of the pandemic for people in all situations to engage with STEM issues, knowledge and information so that personal health decisions are informed rather than relying on hearsay, myth and false information.(Page 341)	A STEM literate individual can engage with STEM issues, knowledge, and information A STEM literate individual can make decisions based on information including hearsay, myths, and misinformation.
17	The frameworks developed in this study mainly focused on systems of oppression and privilege, and it consisted of six aspects, respectively the empathy, dispositions, STEM identity development, empowerment, critical thinking & problem solving, utility & applicability.(Page 6, Fig 1, Page 6)	STEM literacy consists of empathy STEM literacy consists of dispositions STEM literacy consists of STEM identity development STEM literacy consists of empowerment STEM literacy consists of critical thinking & problem solving STEM literacy consists of utility & applicability(Applied further, students get to visualize and see the utility and applicability of the solutions to the complex problems)
18	STEM literacy is the dynamic process and ability to apply, question, collaborate, appreciate, engage, persist, and understand the utility of STEM concepts and skills to provide solutions for STEM-related personal, societal, and global challenges that cannot be solved using a single discipline.(Page 33)	STEM literacy is the ability to use STEM concepts and skills to provide solutions for STEM-related challenges
19	The results showed that STEM literacy consisted of: 1) the ability to identify STEM problems, 2) the ability to seek new knowledge, 3) the application of the STEM concept, 4) the ability to solve problems using STEM, 5) the ability to communicate information relating to STEM, and 6) the ability to make decisions based on STEM.(Page 230)	STEM literacy consists of the ability to identify STEM problems STEM literacy consists of the ability to seek new knowledge STEM literacy consists of the application of the STEM concept STEM literacy consists of the ability to solve problems using STEM STEM literacy consists of the ability to communicate information relating to STEM STEM literacy consists of the ability to make decisions based on STEM
20	Nature of STEM; STEM concepts and contents; STEM motivation; STEM career interests; STEM attitude;Psychomotor skills;Engineering skills(Page 156, Fig 2)	STEM literacy has a dimension of nature of STEM STEM literacy has a dimension of STEM concepts STEM literacy has a dimension of STEM motivation STEM literacy has a dimension of STEM career interests STEM literacy has a dimension of STEM attitudes STEM literacy has a dimension of psychomotor skills STEM literacy has a dimension of engineering Skills
21	STEM literacy is the ability to apply concepts from science, technology, engineering, and mathematics to solve problems that cannot be solved using a single discipline.(Page 43)	STEM literacy is the ability to apply concepts from science, technology, engineering, and mathematics STEM literacy is the ability to solve problems that cannot be solved using a single discipline.
22	Understand, apply, analyses, evaluation, create different types of knowledge(factual, conceptual, procedual and metacognitive knowledge)(Page 99 Appendix A)	STEM literacy entails understanding, applying, analysis, evaluation, creation of factual knowledge STEM literacy entails understanding, applying, analysis, evaluation, creation of conceptual knowledge STEM literacy entails understanding, applying, analysis, evaluation, creation of procedual knowledge STEM literacy entails understanding, applying, analysis, evaluation, creation of metacognitive knowledge
23	STEM literacy from systematic-narrative literature review (n=14 from 28) found 16 domains, grouped into 5 categories: STEM concepts, STEM practices, STEM applications, STEM attitudes, and STEM related context (Page 030013-6)	STEM literacy has the category of STEM concepts STEM literacy has the category of STEM practices STEM literacy has the category of STEM applications

		STEM literacy has the category of STEM attitudes
		STEM literacy has the category of STEM related context
24	The research instrument consisted of 40 multiple-choice questions on environmental change issues, covering seven STEM literacy indicators: explaining phenomena scientifically, evaluating and designing scientific investigations, interpreting data and evidence scientifically, understanding technological principles, developing solutions to achieve goals, formulating situations mathematically, and using concepts, facts, procedures, or reasoning.**(Page 203)**	STEM literacy has a dimension of explaining phenomena scientifically
		STEM literacy has a dimension of evaluating and designing scientific investigations
		STEM literacy has a dimension of interpreting data and evidence scientifically
		STEM literacy has a dimension of understanding technological principles
		STEM literacy has a dimension of developing solutions to achieve goals
		STEM literacy has a dimension of dormulating situations mathematically
		STEM literacy has a dimension of using concepts, facts, procedures, or reasoning
25	The research instrument was a STEM literacy test comprising six open-ended questions to assess six components of STEM literacy: STEM concepts, STEM integration, STEM practice, STEM participation, STEM evaluation, and STEM awareness.**(Page 265)**	STEM literacy comprises STEM concepts
		STEM literacy comprises STEM integration
		STEM literacy comprises STEM practice
		STEM literacy comprises STEM participation
		STEM literacy comprises STEM evaluation
		STEM literacy comprises STEM awareness
26	Based on STEM elements and combined with the reality of primary and secondary school students, the STEM literacy framework is proposed and constructed. As shown in figure 2, it mainly consists of STEM knowledge, STEM thinking, STEM ability and STEM attitude.**(Page 371)**	STEM literacy consists of STEM knowledge
		STEM literacy consists of STEM thinking
		STEM literacy consists of STEM ability
		STEM literacy consists of STEM attitude
27	STEM concepts, STEM integration, STEM practice, STEM participation, STEM evaluation, and STEM awareness.**(Page 494)**	STEM literacy has a component called STEM concepts
		STEM literacy has a component called STEM integration
		STEM literacy has a component called STEM practice
		STEM literacy has a component called STEM participation
		STEM literacy has a component called STEM evaluation
		STEM literacy has a component called STEM awareness
28	The ability of digital literacy, information literacy, media literacy and mastering information and communication technology actually includes science, technology, engineering, and mathematics which is currently called STEM literacy (Science, Technology, Engineering, and Mathematics).**(Page 3)**	STEM literacy includes digital literacy
		STEM literacy includes information literacy
		STEM literacy includes media literacy
		STEM literacy includes mastering information and communication technology
29	More specifically, STEM literacy is the ability to apply concepts from science, technology, engineering, and mathematics to solve problems that cannot be solved using a single discipline.(Page 68)	STEM literacy is the ability to apply concepts from science, technology, engineering, and mathematics to solve problems that cannot be solved using a single discipline
30	STEM literacy is defined as the ability of a student to apply, identify, and integrate STEM concepts to solve complex problems and innovate in various areas.**(Page 26)**	STEM literacy is defined as the ability of a student to apply, identify, and integrate STEM concepts to solve complex problems and innovate in various areas
31	The expected outcomes for employing this five-step paradigm to promote STEM literacy will: • Attract and bring awareness to students in grades K-12 about S.T.E.M. careers and how the relevancy of the field is incorporated within their everyday life. • Build social teamwork, presentation skills and ability to articulate critical thinking skills which are necessary to excel in any academic discipline or career. • Give students the knowledge to actively and confidently resolve engineering problems, and develop original solutions and designs. • Retain student enrollment to attain S.T.E.M. degrees by fostering real-world socially relevant uses of engineered solutions and designs.**(Page 3)**	STEM literacy includes the awareness of STEM careers
		STEM literacy includes the awareness of how STEM careers fields are relevant to their everyday lives
		STEM literacy includes the social teamwork skill to excel in any academic discipline or career
		STEM literacy includes the presentation skill to excel in any academic discipline or career
		STEM literacy includes the critical skills to excel in any academic discipline or career
		STEM literacy includes the STEM knowledge to actively and confidently resolve engineering problems, and develop original solutions and designs.
		STEM literacy includes recognizing the real-world, socially relevant applications of engineering solutions and designs
32	In the current study, the dimensions of STEM Literacy that represented the most common elements among several studies were: understanding the scientific, mathematical, technological, and engineering principles and how to integrate them into the STEM approach, ability to identify problems and seek new knowledge in STEM approach, and desire to participate and take decisions about issues related to STEM education.**(Page 4)**	STEM literacy has a dimension called understanding and seeking the scientific, mathematical, technological, and engineering principles
		STEM literacy has a dimension called integrating STEM principles into the STEM approach
		STEM literacy has a dimension called identifying problems
		STEM literacy has a dimension called desiring to engage with STEM-related issues
		STEM literacy has a dimension called taking decisions about STEM-related issues
33	The STEM literacy indicators are (1) Developing questions and identifying problems, (2) Building explanations (science) and designing solutions (engineering), (3) Applying mathematics, information technology, computers and computational thinking, (4) Creating and using models, (5) Plan and carry out investigations, (6) Collect, evaluate, and convey information, (7) Engage in evidence-based arguments, (8) Analyze and interpret data.**(Page338)**	An STEM literacy indicator is developing questions and identifying problems
		An STEM literacy indicator is building explanations (science) and designing solutions (engineering)
		An STEM literacy indicator is applying mathematics, information technology, computers and computational thinking
		An STEM literacy indicator is creating and using models
		An STEM literacy indicator is planning and carrying out investigations
		An STEM literacy indicator is collecting, evaluating, and conveying information
		An STEM literacy indicator is engaging in evidence-based arguments
		An STEM literacy indicator is analyzing and interpreting data.
34	Generally, the current study focuses on a set of main dimensions through which it is possible to define a broad conception of STEM Literacy, which are as follows: • Acquiring and using the application of scientific, technological, engineering and mathematical knowledge. • Understanding the integration of STEM as human endeavours. • Having awareness of how STEM builds and shapes our physical, intellectual and cultural world. • Having desire to participate in issues related to STEM education by physics teachers through e-learning. • Taking decisions on issues related to STEM education and their practical application in elearning by secondary school physics teachers.**(Page 798)**	An STEM literacy dimension is acquiring and using the application of scientific, technological, engineering and mathematical knowledge.
		An STEM literacy dimension is understanding the integration of STEM as human endeavours
		An STEM literacy dimension is having awareness of how STEM builds and shapes our physical, intellectual and cultural world.
		An STEM literacy dimension is having desire to participate in STEM-related issues
		An STEM literacy dimension is making informed decisions on STEM-related issues and their pratical application
35	Based on these definitions, we propose that to be literate in STEM is: To be able to identify and apply core ideas and the ways of thinking, doing, talking and feeling of Science, Engineering and Mathematics in a relevant integrated way, so that we can both understand, make decisions and/or act in front of complex problems and build creative solutions, using the necessary technologies in a collaborative way.**(Page 22)**	To be STEM literate is to be able to identify and apply core ideas
		To be STEM literate is to be able to identify and apply the ways of thinking, doing, talking and feeling of Science, Engineering and Mathematics in a relevant integrated way
		To be STEM literate is to be able to understand complex problems
		To be STEM literate is to be able to make decisions and take action in response to complex problems.
		To be STEM literate is to be able to build creative solutions

		To be STEM literate is to be able to use the necessary technologies in a collaborative way
36	The research instrument used in this study is a test specifically designed to measure STEM literacy. This test consists of two types of questions, namely 8 multiplechoice questions and 6 essay questions. The multiplechoice questions aim to test the basic understanding and application of STEM concepts, while the essay questions assess critical thinking skills, analysis, and the application of knowledge in real contexts. **(Page 10801)**	STEM literacy consists of understanding, analysis and application of STEM concepts or knowledge
		STEM literacy consists of critical thinking skills
37	(1) Information processing and STEM literacy: We view IP(Information processing) as aligning well with one of Laugksch's conceptions of STEM literacy, which they call "literate as competent." This definition of literacy is characterized by the extent to which an individual is "competent," which is marked by their ability to carry out certain tasks, as well as their ability to communicate to a third party about scientific matters, suggesting some involvement in society. Additionally, literate as competent interpretations view science content knowledge as existing outside the mind, to be mastered by the individual. (2) Constructivism and STEM literacy: STEM literacy conceptualized in this manner emphasizes the way that an individual is interpreting the content and how the text is allowing interpretation from the reader, which parallels the constructivist view of a subjective reality based on an individual's experiences. A final aspect of literacy that Norris and Phillips characterized is that neither the text nor the reader is supreme. Constructivism places value on the individual learner's active role in knowledge building and, thus, does not view the text as superior to the learner. (3) Sociocultural theory and STEM literacy: Discourse about STEM is what Solomon viewed as leading to an identity of participation, and thus STEM literacy **(Page 2, Pages 2-3, Table 1 page 4)**	STEM literacy includes carrying out certain tasks STEM literacy includes ability to communicate to a third party about scientific matters STEM literacy includes involvement in society STEM literacy includes mastering science content knowledge STEM literacy includes interpreting the STEM content STEM literacy includes discourse about STEM STEM literacy includes STEM identity of participation

1 Bybee, R. (2010). Advancing STEM education: A 2020 vision. Technology and Engineering Teacher, 30-36.

2 Lawless, K., Brown, S. W., & Boyer, M. A. (2016). Educating students for STEM literacy: GlobalEd 2. In R. D. Lansiquot (Ed.), Tehnology, theory, and practice in Interdisciplinary STEM progrms. DOI 10.1057/978-1-137-56739-0_4

3 Browell, B. A B. (2021). Understanding the nature of mentoring relationships during an undergraduate research experience. Unpublished doctoral dissertation, Purdue University.

4 Wannapiroon, P., Nilsook, P., Techakosit, S., & Kamkhuntod, S. (2021). STEM literacy of students in vocational education. International Journal of Technology in Education and Science (IJTES), 5(4), 527-549. https://doi.org/10.46328/ijtes.253

5 Wu, Z., Huang, L., Liu, Y-K, & Chiang, F-K (2024). Developing a framework of STEM literacy for kindergarten children. Research in Science Education, 54, 621-643. T https://doi.org/10.1007/s11165-024-10157-6

6 Tucker-Raymond, E., Gravel, B. E.,Kohberger, K., & Browne, K. (2016). Source code and a screwdriver: STEM literacy practices in fabricating activities among experienced adult makers. Journal of Adolescent & Adult Literacy, March, 2-11.

7 Crawford, A. J., Hays, C. L., Schlichte, S. L., et al. (2021). Retrospective analysis of a STEM outreach event reveals positive influences on student attitudes toward STEM careers but not scientific methodology. Advances in Physiology Education, 45, 427-436. DOI: 10.1152/advan.00118.2020

8 Huang, X., Erduran, S., Luo, K., Zhang, P., &Zheng, M. (2024). Investigating in-service teachers' STEM literacy: the role of subject background and gender, Research in Science & Technological Education, 42(3), 867-887, DOI:10.1080/02635143.2022.2153243

9 Falloon, G., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020). Understanding K-12 STEM education: A framework for developing STEM literacy. Journal of Science Education and Technology, 29, 369–385.

10 Peterson, B. (2017). Exploring STEM literacy. https://www.researchgate.net/publication/329464731_Exploring_STEM_literacy

11 Cavalcanti, M. A. (2017). Assessing STEM literacy in an informal learning environment. Unpublished doctoral dissertation, Lexington, KY: University of Kentucky.

12 Zollman, A. (2012). Learning for STEM literacy: STEM literacy for learning. School Science and Mathematics, 112(1), 12-19.

13 Tang, K., & Williams, J. P. (2019). STEM literacy or literacies? Examining the empirical basis of these constructs. Review of Education, 7(3), 675-697.

14 Balka, D. (2011). Standards of mathematical practice and STEM: Math-Science connector newsletter (pp. 6-8). Stillwater, OK: School Science and Mathematics Association.

15 National Research Council (2011). Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics. Washington, DC: National Academies Press.

16 Braund, M. (2021). Critical STEM literacy and the COVID-19 pandemic. Canadian Journal of Science, Mathematics, and Technology Education, 21, 339–356. https://doi.org/10.1007/s42330-021-00150-w

17 Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Roberts, T., Yost, C., & Fowler, A. (2021). Equity-Oriented Conceptual Framework for K-12 STEM literacy. International Journal of STEM Education, 8(38), 2-16.

18 Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., & Nickes, M. (2020). Moving toward an equity-based approach for STEM literacy. In C. Johnson, M. J. Mohr-Schroeder, T. J. Moore, & Lyn D. English (eds.), Handbook of Research on STEM Education (Chapter 3, pp. 29-38). New York: Routledge.

19 Techakosit, S., & Nilsook, P. (2018). The development of STEM literacy using the learning process of scientific imagineering through AR. International Journal of Engineering Technologies in Learning, 13(1), 230-238. https://doi.org/10.3991/ijet.v13i01.7664

20 Donmez, I. (2020). STEM education dimensions: From STEM literacy to STEM assessment. In S. Idin (Ed.), Research highlights in education and science 2020 (pp. 154-170). Istanbul, Turkey: ISRES Publishing.

21 Jackson, C. D., & Mohr-Schroeder, M. J. (2018). Increasing STEM literacy via an informal learning environment. Journal of STEM Teacher Education, 53(1), article 4.

22 Hayford, B., Blomstrom, S., & Mumpower, L. A. (2015). Formation and Assessment of a Tool to Evaluate STEM Literacy in Service-Learning Projects. Journal on Excellence in College Teaching, 26(4). Retrieved from https://commons.erau.edu/publication/526

23 Chamrat, S., Manokarn, M. & Thammaprateep, J. (2019). STEM literacy questionnaire as an instrument for STEM education research field: Development, implementation and utility. AIP Conference Proceedings. https://doi.org/10.1063/1.5094011

24 Dewi, S., N., Kusnadi., & Hamdiyati, Y. (2024). Student STEM Literacy Ability Profile on Environmental Change Issues. Quagga: Journal of Education and Biology, 16(2), 203-208. DOI: 10.25134/quagga.v16i2.344.

25 Pitiporntapin, S., Butkatanyoo, O., Piyapimonsit, C., Thanarachataphoom, T., Chotitham, S., & Lalitpasand, U. (2024). The influence of outdoor STEM activities on students' STEM literacy: A study of elective subjects, extracurricular activities, and student clubs. Jurnal Pendidikan IPA Indonesia, 13 (2), 265-273.

26 Chen, F., Zhu, L., & Liu, L. (2019). Design and evaluation of science teaching using STEM literacy. Advances in Social Science, Education and Humanities Research, 371.

27 Pitiporntapin, S., Butkatanyoo, O., Piyapimonsit, C., Thanarachataphoom, T., Chotitham, S., & Lalitpasand, U. (2023). The development of a professional development model focusing on outdoor learning resources to enhance in-service teachers' STEM literacy. Kasetsart Journal of Social Sciences 44 (2023) 489–496.

28 Ibrohim1, Abdurrahman, & Jalmo, T. (2020). STEM literacy profile of junior high school students in Lampung Province, Indonesia. Journal of Physics: Conference Series 1572 (2020) 012063. doi:10.1088/1742-6596/1572/1/012063

29 Jackson, C., Cavalcanti, M., Mohr-Schroeder, & Schroeder, D. C. (2015). Bolstering teachers' STEM literacy via informal learning experiences. In M. J. Mohr-Schroeder, & J. N. Thomas (Eds.), Proceedings of the 114th annual convention of the School Science and Mathematics Association (Vol. 2). Oklahoma City, OK: SSMA.

30 Rahmadani, N. F., Ariani, S. R. D., Mulyani, S., & Indriyanti, N. Y. (2023). Effectiveness of virtual STEM laboratories for enhancing high school students' creativity and STEM literacy. Jurnal Kimia dan Pendidikan Kimia, 8(1), 26-36.

31 Dharam Persaud-Sharma, D. (nd). Pedagogical methods to promote S.T.E.M. literacy with case-study. The International Journal of Science, Mathematics and Technology Learning
Common Grounds Publishing, Champaign, IL, USA

32 Ezzeldin, S. M. Y. (2022). A web-based training program for developing professional attitudes and literacy of STEM among science teachers. International Journal of Online Pedagogy and Course Design, 12 (1), 1-16.

33 Kenedi1, A. K., Haryanto, Salido, A., Putri, D. A A., & Zefrin (2023, November). The influence of the use of argumented reality media on the STEM literacy of primary school students. Paper presented at the International Conference on Teaching and Learning Proceeding, Faculty of Education and Teacher Training, Universitas Terbuka UTCC, South Tangerang, Banten, Indonesia.

34 Abdullah Al-Jubouri, W. H. H., Shabib, A. K., & Aziz, M. S. (2021) E-learning applications according to the levels of STEM literacy for teachers of physics at the secondary stage. Review of International Geographical Education (RIGEO), 11(9), 797-806. Doi: 10.48047/rigeo.11.09.68

35 Couso, D. (2020). STEM literacy is bsed on STEM knowledge, practices, transversal competences and values. In Ş.Ünlü Çetin, K. Bilican and M. Üçgül (Eds.), Key points for STEM in Early Childhood Education an involving parents: A guidebook for early childhood educators (pp.22-25), An intellectual output of the 2018-1-TR01-KA203-059568.

36 Zaky, M., Astija, Supriyatman, Muslimin, Jamhari, M., & Ratman. (2024). STEM literacy proficiency in prospective physics educator: A comprehensive analysis using Rasch measurement theory. Jurnal Penelitian Pendidikan IPA, 10(12), 10799–10810. https://doi.org/10.29303/jppipa.v10i12.8970

37 Tenney, K., Stringer, B. P., LaTona-Tequida, T., & White, I. (2023). Conceptualizations and limitations of STEM literacy across learning theories. Journal of Microbiological and Biological Education, 24(1).