Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 7, July 2021: 10808 - 10817

Research Article

Scientific Literacy Of Science Pre-Service Teachers According To The Sts Approach

Rungtiwa Kongson
School of Education, University of Phayao, Thailand
Email: rungtiwa.ko@up.ac.th

ABSTRACT

This research aims to: (1) study scientific literacy of pre-service science teachers according to the STS Approach and (2) compare scientific literacy of pre-service science teachers according to the STS Approach, categorized as by scientific competencies in three dimensions: 1) explaining phenomena scientifically (EPS), 2) evaluate and design scientific enquiry (EDS), and 3) interpret data and evidence scientifically (IES). The case study group consisted of 31 undergraduate students. The data was collected by evaluation forms for scientific literacy of pre-service science teachers. The data was analyses to find mean, standard deviation, and test independent. The research indicates that scientific literacy of pre-service science teachers according to the STS Approach, the overall scientific literacy score a high level (85.79%) by attribute, interpret data and evidence scientifically at the highest level (90.85%). The high level scientific literacy attributes were: explain phenomena scientifically, 83.13%, evaluate and design scientific inquiry, 83.39%. The data analysis of mean, standard deviation, and t-test independent indicates that pre-service science teachers have promoted scientific literacy between the pre and post learning with a statistical significance of 0.5.

Keywords: Scientific Literacy, Pre-service Science Teachers, STS Approach

BACKGROUND AND SIGNIFICANCE OF THE PROBLEM

Preparation of Thai people for the 21st century by improving the learning model towards the teaching and learning system of science, technology, engineering, mathematics, programmers and foreign languages, promoting language learning computer (Coding) linking education with practical reality including cultivating, morals, ethics needed to live (The Secretariat of The Cabinet, 2019, p.12) enhance the quality of education and lifelong learning, the curriculum should be adjusted to produce teachers who focus on competence with the spirit of the teacher as a guide and can stimulate the learning of learners, and create incentives for those with high potential to become a teacher. (Office of the National Economic and Social Development Council [NESDC], 2018) United States announced the Project 2061: Science for all Americans by The American Association for the Advancement of Science: AAAS indicate that " Persons who know science is an awareness that science, mathematics and technology will support or limit the activities of human beings to understand the essential concepts of science, to understand the important concepts of science and nature of the world as diverse but with patterns. Become a user of scientific concepts, knowledge of science for self and society." (Office of Science and Technology, Royal Thai Embassy, Washington D.C 2016[OSTDC], p.7)

Scientific literacy is a global matter, that all nations are interested in science because science brings new innovations, technology and science is becoming an indicator of the quality and power of each country. The key point is that scientific literacy is the creation of knowledge based on a thorough understanding of scientific principles and theories, proficient in both scientific processes and skills to integrate the interrelationships of other disciplines together and must have both a scientific mind and a

good attitude towards science. Turiman, Omar, Mohd Daud & Osman (2012, p. 112) said scientific literacy to develop learners to understand the nature of science and the relationship of other disciplines, society and the environment by using basic scientific concepts, scientific principles including using scientific process skills that emphasize on building cooperation in solving life challenging problems valuable for life. On evidence verifiable fact. Which will become a daily routine. That is a habit to realize that science has a meaningful connection with life, society and the environment. The Institute for the Promotion of Teaching Science and Technology (IPST, 2020) defines it as scientific literacy is the ability to critically connect things to science related issues and scientific concepts. Scientifically literate person is a person who can communicate or argue rationally on issues related to science and technology. Techakosit & Wannapiroon (2015, p. 2109) present scientific literacy is the ability to use scientific knowledge to identify questions, and to draw evidence-based conclusions to understand and help make decisions about the natural world and the changes caused by man-made activities and ReiskaKatrin, MöllitsMiia & Soobard (2015, p. 353) said scientific literacy as "developing an ability, to creatively utilize appropriate evidence-based scientific knowledge and skills, particularly with relevance for everyday life and a career, in solving personally challenging yet meaningful scientific problems as well as making, responsible socio-scientific decisions."

Aikenhead (1988, p. 8) suggested conceptual learning STS approach that is focused on the scientific content, consistent with the purpose of connecting science with social, technology in daily life of learners, that can help learners make appropriate decisions about issues related to science, technology and society. Yuenyong (2009), Pedretti and Forbes (2000, pp. 39-41) commented, STS Approach is a process that brings together understanding between science, society, and technology. The main goal is helping students learn the importance of developing science in daily life and promoting activities in people's lives in society. Yager and Akcay (2008, p. 2) mention of STS approach is the concept of science teaching and learning in the context of experience that focus on solving problems related to actual science and technology. This encourages learners to analyze and apply concepts and processes. Yörük, Morgil & Secken (2009, p. 69) concluded that this approach focuses on students and helping students to practice research, or test and observation. Moreover, that will also apply or practice experiences both within and outside of school related to science, technology, motivating and arising from the interest of the learners as well as improving attitudes towards science.

Therefore, Learning management according to the STS approach by Bryant (Narjaikaew and TipJoi, 2013, pp. 49-52), Carin and Soud (1975, p. 247) which consists of 6 step (1) Search (2) Solve (3) Reflecting (4) Create (5) Share (6) Action , will help encourage students to create scientific literacy. In the field of Scientific Competencies, This consists of three dimensions (1) Explain Phenomena Scientifically (2) Evaluate and Design Scientific Enquiry and (3) Interpret Data and Evidence Scientifically, that will lead to personal and professional development of teachers.

Scientific Literacy and Science-Technology-Society Approach (STS Approach)

Learning science that focuses on linking knowledge with processes and important skills in researching and creating knowledge by using the process of seeking knowledge and solving a variety of problems. Allowing learners to participate in learning every step of the way. There are many practical activities and focus on the learners to discover knowledge for themselves as much as possible. The knowledge of processes and knowledge from the observation, method, Surveys, examinations, experiments, and then the results are organized into principles, concepts and knowledge. (Ministry of Education [MOE], 2017, p.3) The Institute for the Promotion of Teaching Science and Technology (IPST, 2020) defines it as scientific literacy is the ability to critically connect things to science related issues and scientific concepts. Scientifically literate person is a person who can communicate or argue rationally on issues related to science and technology including the situation or context of science is perception of life situations at an individual, national and global

level, whether present or past. Scientific literacy refers to knowledge of facts, concepts and theories that lead to scientific knowledge and scientific competencies refer to bring able to explain phenomena scientifically, assessment and design of scientific research processes, the ability to interpret data and use scientific testimony.

Scientific literacy is defined here as knowing basic facts and concepts about science and having an understanding of how science works. It is important to have some knowledge of basic scientific facts, concepts, and vocabulary. (Altun-YalçÕn , AçÕúOÕ & Turgut, 2011, p. 783) Reiskaa, KSoikaa, Möllitsa, Rannikmäeb , & Soobard (2015, p. 353) define scientific literacy as "developing an ability, to creatively utilize appropriate evidence-based scientific knowledge and skills, particularly with relevance for everyday life and a career, in solving personally challenging yet meaningful scientific problems as well as making, responsible social scientific decisions." Which those who have the scientific literacy will appear as Sülüna, Dilek Yurttaú, & Onur Ekiz (2009, p. 724) define the individual who understands the nature of the science and scientific developments; internalizes the basic concepts, principles and theories and use them appropriately; uses scientific processes while solving the problems and making decisions; understands the relations between the science and nature and their interactions with the society; has interests leading to more enriched and satisfactory life styles as science and technology literate. In this respect, science and technology literacy has seven dimensions: (1) Nature of the science (2) Key terms of science (3). Scientific process skills (4). Science-Technology-Society-Environment interactions (5). Scientific and technical psychomotor skills (6). Values laying the basis of the science (7) Interest in and attitudes towards science. Altun-YalçÕn et al. (2011) indicate that the scientific-literate person : including (1)understands the nature of scientific knowledge; (2) accurately applies appropriate science concepts, principles, laws and the theories in interacting with his/her universe; (3) uses processes of science in solving problems; making decisions and furthering his/her own understanding of the universe; (4) interacts with the various aspects of his/her universe in a way that is consistent with values that underlie science; (5) understands and appreciates the joint enterprises of science and technology and the interrelationships of these with each other and with other aspects of society; (6) has developed a richer, more satisfying and more exciting view of the universe as a result of his/her science education and continues to extend this education throughout his/her life; (7) has developed numerous manipulative skills associated with science technology.

Science Technology and Social is a teaching that integrates both science and technology and social dimensions together. Therefore, teaching science according to the STS approach requires expertise in broader teaching strategies, such as divergent thinking, working in small groups, students are the center in class discussions, problem solving, simulation, decision, critiques, argument for reasons and including the media and use of resources in the community. (AIikenhead, 2005, p. 1) Which that Klahan & Yuenyong (2013, p. 5086) said the Science Technology and Society (STS) approach of science learning according to teaching and learning is started from society realm and moved to acquiring technology, and science unit through STS approach that consisted of five stages including identification of social issues, identification of potential solutions, need for knowledge, decision-making, and socialization stage. As for the STS learning approach based on constructivism theory that emphasizes the development of the concept in cognitive structure independently by students. The learning approach emphasizes that students can think, assess, solve problems, and make decisions. The constructivist foundation of STS is an advantage that can equip students to face the challenges of competition in the 21st century. The STS learning approach requires that students be included in setting, planning, implementing, how to obtain information, and evaluation of learning. (Kongson, R. 2021, p.244) The principle of learning STS is a discussion of issues in society related to science and technology, so that issue in the community is the organizer in learning STS. The implementation of the STS learning approach is aimed at engaging students in the problem solving

activities they have identified. Students focus on problems and questions related to problems in the environment and daily life. (Primastuti & Atun, 2018, p. 2)

.

RESEARCH METHODOLOGY

The case study group consisted of 31 undergraduate students in Chemistry, 4th year, courses 161434 Development of Instruction Media in Chemistry. The research instrument was a learning management method to promote of scientific literacy according the STS Approach. Consists of scientific literacy evaluation in the field of Scientific Competencies Assessments. This consists of three dimensions (1) Explaining Phenomena Scientifically (EPS), (2) Evaluate and Design Scientific Inquiry (EDS), (3) Interpret Data and Evidence Scientifically. (IES) during the experiment as follows

Process of learning	Activities
Pre-learning	Pre- assessed learning evaluation with two evaluation forms: 1. Examination form to examine scientific literacy of science pre-service teachers according to the STS Approach 2. Evaluation form to evaluate scientific literacy of science pre-service teachers according to the STS Approach
During learning Organise learning activities using STS Approach 6 step as follows (1) Search: Students together asked questions about the problems of teaching in chemistry and teaching media. (2) Solve: Students will practice using scientific methods to solve problems. Students will be able to practice, research, design, plan, and prepare teaching materials of various types according to the problem. (3) Reflecting: The students connect the problems, analyze, reflect and come to a conclusion of the problem with the theory and principles of creating teaching media in chemistry. (4) Create: Bringing information to form information the results show the appearance graph outlines the various types of teaching materials. (5) Share: Students present the results of their studies and presenting the design of the teaching media outline to friends and teachers to help criticize exchange learning. (6) Action: Practice for creating teaching media in chemistry and presenting the finished chemistry teaching materials to friends and	Activity 1: Media and Instruction Media in Chemistry Activity 2: Instructional Media in Chemistry Design and Development Activity 3: Instructional Media Design in Chemistry Activity 4: Evaluation of Chemistry Instructional Media

teachers to assess and improve and applied learning in real life situations.	
Post- learning : Assessment after the training	Post- assessed learning with 2 evaluation forms: 1. Examination form to examine scientific literacy of science pre-service teachers according to the STS Approach 2. Evaluation form to evaluate scientific literacy of science pre-service teachers according to the STS Approach

STS Approach learning on the developed of scientific literacy of science pre-service teachers according to the STS Approach, checks from three experts for content validity, language, to find index of Item Objective Congruence: IOC, evaluation of the suitability and conformity of the activities with the conformity index at 0.60 – 1.00. (Kongsat & Thummawong, 2015**)** Overall, there is conformity, indexed at 0.88

Equipment for data collection consists of: An examination form to examine student scientific literacy according to the STS Approach. It is a type of open-ended questions or scenarios, five-part rating scale, posing two instruction media in chemistry issues/problems. Check from expert content by validity, language, to find index of Item Objective Congruence: IOC evaluation of the suitability and conformity of the activities with the conformity index at 0.60 – 1.00. Overall, there is conformity, indexed at 0.85, then came the reliability ≥ 0.70. The reliability is rated at 0.89 by its Alpha coefficient. (Srisa-ard, 2010, p. 117)

Data analysis as the following: scientific literacy of science pre-service teachers according to the STS Approach, by calculating mean and standard deviation, resulting in the following: 4.51 - 5.00 indicate top scientific literacy; 3.51 – 4.50 indicate high scientific literacy; 2.51 – 3.50 indicate moderate scientific literacy; 1.51 – 2.50 indicate less scientific literacy; and 1.00 – 1.50 indicate least scientific literacy. (Srisa-ard, 2002). Pre and post student scientific literacy of science teacher students according to the STS Approach. Comparing pre and post testing of student scientific literacy of science pre-service teachers according to the STS Approach, categorised by students characteristics. This consists of three dimensions:1. Explaining Phenomena Scientifically (EPS), 2. Evaluate and Design Scientific Enquiry (EDS), 3. Interpret Data and Evidence Scientifically (IES), by an Independent t-test.

RESEARCH RESULTS

The results of the research on scientific literacy of science pre-service teachers according to the STS Approach indicate that science pre-service teachers have a high level of scientific literacy. The best of those scientific literacy is interpret data and evidence scientifically (IES) as indicated by Table 1.

Table 1: Shows scientific literacy of science pre-service teachers according to the STS Approach —a case study of science pre-service teachers, Chemistry major—by four questions or scenarios lesson plan.

scientific literacy of science teacher students	$\bar{x}$	***S.D.***	**Level**
1. Explaining Phenomena Scientifically (EPS)	83.27	6.88	High
2. Evaluate and Design Scientific Enquiry (EDS)	83.33	5.59	High
3. Interpret Data and Evidence Scientifically (IES)	92.16	5.90	Very High
Total	**86.25**	**6.12**	**High**

Table 1 indicates that the mean of scientific literacy of science pre-service teachers according to the STS Approach — case study of scientific literacy of science pre-service teachers, chemistry

major— four questions or scenarios lesson is at high level. The best of those interpret data and evidence scientifically (IES), which is at very high level is 92.16 (*S.D.*= 5.90).

The comparison results of scientific literacy of science pre-service teachers according to the STS Approach —a case study of scientific literacy of science pre-service teachers, chemistry major— in both pre and post learning, analysing data by mean, standard deviation, and paired samples T-Test.

Table 2: Shows scientific literacy of scientific literacy of science pre-service teachers according to the STS Approach a case study of scientific literacy of science pre-service teachers, chemistry major in both pre and post learning.

Experimental group	*n*	$\bar{x}$	*S.D.*	*t*	*p*
Pre- post learning	31	13.53	1.42	26.068*	.000
Post - learning	31	33.27	4.63		
p ≤ .05*					

Table 2: indicates that the mean of scientific literacy of science pre-service teachers because of the learning being in accordance with the STS Approach — in post learning is 33.27 which is higher than pre learning at 13.53. The analysis of the difference between pre and post learning by T-Test results is $t = 26.068$ and $p \leq .05$. The result indicates higher science literacy of scientific literacy of science pre-service teachers because of the learning being in accordance with the STS Approach, which results in a significant increase of .05.

Table 3: Shows scores of scientific literacy of science pre-service teachers according to the STS Approach—a case study of scientific literacy of science pre-service teachers, chemistry major characteristics by scientific literacy in during learning.

scientific literacy of science pre-service teachers	**Lesson plan1 %**	**Lesson plan2 %**	**Lesson plan3 %**	**Lesson plan4 %**	**Overall %**	**Level**
EPS: students recognize and offer explanations for a range of natural and technological phenomena.	82.10	84.45	79.84	86.13	83.13	High
EDS: students describe scientific investigations and propose ways of addressing questions scientifically.	84.35	82.10	80.48	86.61	83.39	High
IES: students analyze and evaluate data and draw appropriate scientific conclusions.	85.16	90.48	93.87	93.87	90.85	Very High
Total	**83.87**	**85.68**	**84.73**	**88.87**	**85.79**	**High**

Table 3 indicates that the overall scientific literacy score a high score of 85.79% by attribute, the high level scientific literacy attributes were: explain phenomena scientifically, 83.13%, evaluate and design scientific inquiry, 83.39%, and interpret data and evidence scientifically at the highest level, 90.85 percent.

DISCUSSION AND CONCLUSION

Scientific literacy of science pre-service teachers is higher because learners find solutions to the problems they face in real life. And then study research with principles, theory. Then design, plan, assess feasibility and take action on their own. This is in line with the main focus of learning according to the STS Approach. Which is based on constructivism theory as Primastuti, & Atun (2018, p. 2) STS learning approach based on constructivism theory that emphasizes the development of the concept in cognitive structure independently by students. The learning approach emphasizes

that students can think, assess, solve problems, and make decisions. Including know how to analyze and apply concepts with processes in real-life situations. Students can connect classroom learning to real life situations. **(**Anantasook, 2020) Yuenyong (2013) indicate that the key point is that the STS approach focuses on enabling learners to practice research. Practice or evaluation and observation. (Yörük, Morgil, & Secken, 2009, p. 69) Divergent thinking , working in small groups, student center class, discussion, problem solving, simulation, decision making, criticism, disagreement, argument and reasoning. (Aikenhead, 2005, p. 384), Yörük *et al*., 2009) According to the learning method of Carin (1997, pp. 27-28) present the STS Problem-Solving Model that trains and builds students through each step, including search, solve, create, share, actions, and reflecting to interpret and connect their conclusions to theory.

Learning according to the STS Approach has an important focus is applying the scientific knowledge gained from learning to find answers that are connected to real life. (Portjanatanti, 2005, p.163), (Carin.1997, p. 593), (Chonwanich, Latwong & Panprueksa, 2019, p. 953) As with Chantaranima & Yuenyong (2014, p. 2287) Scientific, technological and social instruction helps learners to develop the concept, the utilization, the creativity, attitude to sciences, and knowledge and competency of fundamental of sciences including troubleshooting and lead learners to see both abstract and concrete objects due to association social or community context with real life condition of those students as well as social responsibility. Bettencourt, Lopes Velho & Albergaria Almeida (2011, p. 3149) emphasize that, according to this STS Approach vision of education, the goals of education go beyond the mere acquisition and application of knowledge. Therefore, it is necessary to create an educational culture that facilitates understanding, analysis and problem solving.

Scientific Competencies is a framework for assessing scientific knowledge in accordance with the guidelines of PISA 2015. (IPST, 2018, p. 20) Individuals will demonstrate competence in Explain Phenomena Scientifically, Evaluate and Design Scientific Inquiry and Interpret Data and Evidence Scientifically. Found that the overall score a high score. This is because in the six-step learning management process of the STS Approach, such as identifying, using and designing instructional media in chemistry, then there is a presentation of information for use in explaining the aspects of EPS. In the learning process, Create, Share and Action, which arises from facing these problem situations by taking action based on the needs of the learners cause a challenge interest in learning and the problems chosen to solve are real problems that learners have faced, thus motivating them to succeed. (Reiska, Soika, Aet Möllits, Rannikmäe & Soobard, 2015, p. 353) And they also found that giving freedom to think and the opportunity to reflect on the needs of the learners, giving feedback to learners at the right time and actions. (Dragos & Mih, 2015, p. 171) Including having a variety of teaching media samples, help learners see how to create chemistry teaching materials, study and research with a targeted direction enabling learners to analyze, interpret scientific data and conclusions, as well as assess scientific arguments and evidence from a variety of sources in the IES field at the highest. (Nukrak, Sirikolkajorn & Kijkuaku (2016, p. 1329)

As the research results of Jaruanlikitkawin, W & Chaikit, N. (2020, p.162) was found that pre-service teachers had significantly higher science intelligence because of the activities that provided students to learn and practice explaining, take an example applying scientific knowledge to explain different situations until it becomes a skills. Moreover, learning that is integrated with the career goals of the learners is the motivation for learning that is meaningful to life. (Dichev, C. & Dicheva, D. (2017), p. 2159) As with M.A. Abualrob, M. & Madiha Shah, M. (2012, p. 813) teaching is organized according to STS, helping learners to see the relevance of science to daily life. The use of the Science Technology and Society (STS) teaching, for enhancing learners interest in learning science. In addition, these approach can assist students in seeing the relevance of their science learning in everyday life. Contribute to knowledge and deep understanding, implementation of the goals and values. That will see the clarity that appears on the IES has the highest score. Both

that learners are able to assess themselves through analytical thinking and can be interactive self-assessment. (Maria Mion Pop & Mihaela Giurgiulescu. 2015, p. 387) Including being able to interpret identify assumptions through evidence with witnesses, arguments with evidence. Scientific reasoning is a characteristics of scientific literacy. Chung-ParsonsJanelle M. Bailey (2019, p. 45) present the discovery that the development of scientific literacy of science pre-service teachers until becoming a science teacher identity. Understanding the nature of science make science teachers know themselves, self-awareness and learn through demonstration, simulation problem solving, That will help to know the real science.

ACKNOWLEDGMENT

This research was supported by Unit of Excellence Project FF64-UoE045 University of Phayao.

REFERENCES

1. Aikenheae. G. (2005). *Research Into STS Science Education*. Retrieved June 05, 2021, from
2. https://andoni.garritz.com/documentos/ciencia_sociedad/Aikenhead%20Research%20into%20STS%20Educ%20EQ%202005.pdf
3. Aikenhead, G. (1988). *Teaching Science Through a Science-Technology-Society-*
4. *Environment Approach: And Instruction Guide*. Canada: Saskatchewan Instructional
5. Development and Research Unit: University of Regina.
6. Altun-YalçÕn, S., AçÕúOÕ, S. & Turgut, Ü. (2011, March). Determining the levels of
7. pre-service science teachers' scientific literacy and investigating effectuality of the education faculties about developing scientific literacy. In the Faculty of Education (Ed.), *WCES–2011* (pp. 783-787). Turkey: Erzincan University.
8. Anantasook. S. (2020). *Definitions of science, technology and society concepts*. Retrieved June 05, 2021, from https://krusmart.wordpress.com/2010/07/10/niyamsts/
9. Bettencourt, C., Lopes Velho, J. & Albergaria Almeida, P. (2011). Biology teachers'
10. perceptions about Science-Technology-Society (STS) education. *WCES-2011*
11. (pp. 3148–3152). Portugal: University of Aveiro.
12. Bharathi ,S. & Anbazhagan, K. (2021). The Impact of Teaching Critical Thinking through
13. Reading Comprehension. *PSYCHOLOGY AND EDUCATION*, 58(5), 78-82.
    Carin, A. (1997). *Teaching Modern Science*. (7th ed.). New Jersey: Practice-Hall, Inc.
14. Carin, A., & Soud, B. (1975). *Teaching Modern Science Second Edition*. Columbus Ohio:
15. Charies E.Merrill Publishing Co.
16. Chung-ParsonsJanelle M. Bailey, R. (2019). *The hierarchical (notfluid) nature of preservice*
17. *secondary science teachers' perceptions of their science teacher identity*. Retrieved
18. June 05, 2021, from https://www.sciencedirect.com/science/article/pii/S0742051X18301197
19. Chonwanich, U., Latwong, T. & Panprueksa, K. (2019). A Study of Problem Solving Ability
20. And Learning Achievement of Seventh Grade Students Through Science Technology
21. And Society Approach (Sts) With Problem Solving Method. *Veridian E-Journal*,
22. 12(4), 950-966.
23. Chantaranima, T. & Yuenyong, C. (2014). The Outcomes of Teaching and Learning About Sound Based on Science Technology and Society (STS) Approach. In Academic World Education and Research Center (Ed.) *5th World Conference on Educational Sciences - WCES 2013* (pp. 2286 – 2292). Khon Kaen Unversity: Thailand.
24. Dichev, C. & Dicheva, D. (2017, *June12-14*). Towards Data Science Literacy.In scientific
25. committee of the International Conference on Computational Science, *International*
26. *Conference on Computational Science, ICCS 2017*. Zurich, Switzerland:
27. Dragoș, V. & Mih, V. (2015, *July 3-4*). Scientific Literacy in School. In Cluj-Napoca,

28. Romania, *International conference "Education, Reflection, Development", ERD*
29. *2015*. Romania: University of Bucharest.
30. Jaruanlikitkawin, W. & Chaikit, N. (2020). Scientific Literacy of Science Teacher
31. Students. *Journal of Education Thaksin University*. 20(2), 154-165.
32. Klahan, T. & Yuenyong, C. (2012). An analysis of grade 12 students' technological
33. capability in learning about electromagnetics through science technology and society
34. approach (STS approach). In Faculty of Education (Ed.), *WCES 2012* (pp. 5085 – 5093). Thailand: Khon Kaen Unversity.
35. Kongsat. S. & Thummawong. T. (2015). *Determination of the fidelity of the questionnaire (IOC)*. Retrieved June 05, 2021, from https://www.mcu.ac.th/article/detail/14329
36. Kongson, R. (2020). The Capabilities of Science Teachers in Providing Environmental Literacy According to the STSE-Approach for Schools in an Environmentally
37. Impacted Province. *International Journal of Innovation, Creativity and Change.*
38. 12(11), 242-259.
39. Ministry of Education, The institute for the Promotion of Teaching Science and Technology.
40. (2018). *PISA 2015 Assessment Results Science, Reading and*
41. *Mathematics Excellence and equality in education*. Bangkok: Author.
42. Ministry of Education, Office of the Basic Education Commission. (2020). *Indicators and*
43. *core learning content Science learning subject group (Revised Edition B.E. 2017)*
44. *According to the Core Curriculum of Basic Education B.E. 2008*. Bangkok: Author.
45. M.A. Abualrob, M. & Madiha Shah, M. (2012). Science technology and society modules
46. development process and testing on its effectiveness. In Hüseyin Uzunboylu (Ed.), *WCES 2012* (pp. 811 – 816). Palestine: Arab American University.
47. Maria Mion Pop & Mihaela Giurgiulescu. (2015, *July 3-4*). Educational Sciences between
48. Information Technology and Communications and Quality Assurance Techniques. In
49. Cluj-Napoca, Romania. *Internationalconference "Education, Reflection,*
50. *Development" ERD 2015.* Faculty of Psychology and Educational Sciences Romania.
51. Narjaikaew. P. & TipJoi**.** W. (2013). *The Effect of Science, Technology and Society Approach on Awareness and Knowledge of Science and Technology in Society of the First-year Undergraduates.* Retrieved June 15, 2021, from http://ejournals.swu.ac.th/index.php/JSTEL/index
52. Nukrak, S., Sirikolkajorn, A. & Kijkuaku, S. (2016). The Development Of Understanding And Scientific Literacy for Mathayomsuksa 6 Students By Learning Management
53. Through Science, Technology, Society and Environmental Approach Hydrocarbon
54. Compound. *Veridian E-Journal*, 9(2), 1322-1333.
55. Office of the National Economic and Social Development Council, Office of the Secretary of
56. the National Strategy Council. (2018). *National Strategy 2018 –2037 (abridged*
57. *version)*. Bangkok: Author.
58. Office of Science and Technology. (2016*). Science Literacy*. Retrieved June 12, 2021, from
59. http://www.indiamart.com/juran-tqm- technologies/benchmarking-programs- assessments-of-performance.html.
60. Pedretti, E., & Forbes. (2000). From curriculum rhetoric to classroom reality. *STSE*
61. *Education Orbit*, 31(3), 39-41.
62. Portjanatanti, N. (2005). *Science, Technology and Society Approach*. Prince of Songkla
63. University. Faculty of Education.
64. Primastuti, M. & Atun, S. (2018). Science Technology Society (STS) learning approach:
65. an effort to improve students' learning outcomes. In Journal of Physics (Ed.),
66. *Conference Series. IOP Conf. Series* (pp. 1-7). IOP Publishing Ltd: Yogyakarta.

67. Reiskaa, P., Soikaa, K., Aet Möllitsa, A., Rannikmäeb, M. & Soobard, R. (2015, *July12-14*).
68. Using Concept Mapping Method for Assessing Students' Scientific Literacy. In the Scientific Committee of GLOBE-EDU 2014, *Global Conference on Contemporary Issues in Education, GLOBE-EDU 2014, Las Vegas* Estonia USA.
69. Secretariat of The Cabinet, Office of the National Economic and Social Development
70. Council. (2019). *National Strategy 2018 – 2037 (abridged version)*. Bangkok: Author.
71. Srisa-ard, B. (2010). *Preliminary research*. (8th edition). Bangkok: Suwiriyasan.
72. Srisa-ard, B. (2002). *Preliminary Research, Revised Edition.* (7th Edition).
73. Bangkok: Suwiriyasan.
74. Sülüna, Y., Yurttaú, G.D. & Ekiz, S.Q. (2009). Determination of science literacy levels of the
75. classroom teachers (A case of Mugla city in Turkey). In Faculty of Education (Ed.), Department of Elementary Science Education (Ed.), *World Conference on Educational Sciences 2009* (pp. 723–730). Turkey: Mugla University.
76. Techakosit, S. & Wannapiroon, P. (2015). Connectivism learning environment in augmented
77. reality science laboratory to enhance scientific literacy. In Sakarya University (Ed.),
78. *INTE 2014* (pp. 2108 – 2115). Bangkok: Thailand.
79. The institute for the Promotion of Teaching Science and Technology. (2020). *Scientific*
80. *Literacy*. Retrieved June 07, 2021, from https://pisathailand.ipst.ac.th/about- pisa/scientific-literacy/
81. Turiman, P., Omar, J., Daud, A.M. & Osman, K. (2012). Fostering the 21st Century Skills
82. through Scientific Literacy and Science Process Skills, Faculty of Education.
83. University Kebangsaan Malaysia. In the UKM Teaching and Learning Congress
84. 2011(Ed.), *UKM Teaching and Learning Congress 2011* (pp. 110 – 116). Malaysia:
85. Universiti Kebangsaan.
86. Yager, R.E., & Akcay, H. (2008). Comparison of Student Learning Outcomes in Middle
87. School Science Classes with an STS Approach and a Typical Textbook Dominated
88. Approach. *Research in Middle Level Education*, 31(7), 1-16.
89. Yuenyong. C. (2009). *Using Science technology and society in the management of science*
90. *learning*. Retrieved June 12, 2021, from
91. http://www.moe.go.th/moe/th/news/detail.php?NewsID=11796&Key=
92. news_research
93. Yuenyong. C. (2013). *Learning Theory and Instruction*. Retrieved June 12, 2021, from https://sites.google.com/a/kkumail.com/lesson-study-for-science/kar-sxb-baeb-sts.
94. Yörük, N., Morgil, I., & Secken, N. (2009). The Effects of Science, Technology, Society and
95. Environment (STSE) Education on Students' Career Planning. US – *China Education*
96. Review, 6(8), 68-84.