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THE TEACHERS' ABILITY TO DEVELOP THE STEM-BASED SCIENCE LEARNING PLAN

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Abstract

This study aims to determine the teachers' ability in developing STEM-based science learning plan. This study departs from the science teachers' problem that are required to prepare a science learning plan using STEM approach. It is the linking approach between Science, Technology, Engineering and Mathematics which is categorized as new approach for teachers. This study involved 29 science teachers in Ciamis regency who joined STEM-based science learning workshop held by Biology Education department of Galuh University. The study employed documentation studies which was carried out by analysing the STEM-based science learning plan prepared by workshop participants. The findings showed that the teachers' ability in developing STEM-based science learning plans was moderate.

Keywords: *Science Learning Plan, STEM Approach*

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Introduction

The government has made various efforts to improve education quality in general and science education in particular. Science education is an effort or process to teach students (learning) to understand the essence of science namely products, processes, and develop scientific attitudes and be aware of the values that exist in society (Devi et al. 2018). Improving quality of science learning is in line with the various challenges faced by students today, namely the challenges of the 21st century. As we know that in the 21st century the development of science, technology, information and communication is so fast (Kavila and Iskander, 2014 in Permanasari, 2016; Stohlmann et al. 2012). Therefore, students must be prepared so that they have 21st century skills.

The STEM approach in science learning can use several learning models. The application of STEM learning can be done with various models (Khoeroningtyas et al., 2016). Among several learning models that can support the application of the STEM approach such as PBL (Problem Based Learning); PjBL (Project Based Learning), Inquiry/discovery, and Cooperative Learning. STEM education was aimed to shift teaching practices from traditional lecture-based teaching into those that are inquiry, project-based and problem-based learning as a means to present interdisciplinary, meaningful learning experiences that could include two or more of the four main disciplines identified in STEM education (Deghaidy et al.2015). Learning strategies for integrating STEM education can be complimented by prevailing teaching and learning approaches such as project-based, problem-based, inquiry-based, and theme-based learning (Mustafa et al.2012; Apriana, 2015).

Problem Based Learning (PBL) can provide opportunities for students to apply knowledge to problems as a form of problem solving. The use of PBL also encourages students to master the knowledge needed to solve problems. STEM education develop problem-solving skills, promote student centered learning, and cultivate higher order thinking skills (Mustafa et al.2016). STEM education is an integrated approach to education for the purpose of instilling creative problem-solving techniques in students and the development of future innovators (Roberts, 2012). Problem solving is a key concept to integrated STEM subjects and also is the main focus of STEM integration (Wang et al. 2011).

The use of PjBL is not different from PBL, which guides students to solve problems, but emphasizes more on the products produced (ChanLin, 2008, in Permanasari, 2016). Permanasari (2016) reveals further that the products produced can be ideas / ideas or devices that can be seen. Solving problems and making these products can be done individually or in groups. Working in groups can encourage students to work together, but still be responsible for their work independently. This learning pattern can be accommodated by cooperative learning (Filippatou and Kaldi, 2010, in Permanasari, 2016).

Science education can be enhanced by infusing an engineering design approach because it creates opportunity to apply science knowledge and inquiry as well as provides an authentic context for learning mathematical reasoning for informed decisions during the design process (Kelley, 2016). While Lehtamo (2018) suggests that inquiry-based science education has been suggested as an asolution to this problem of engaging students in science learning.

The teacher is required to develop a science learning plan with the STEM approach. The initial part of the learning plan is Identification of Basic Competencies to determine the topic of science learning, develop Competency Achievement Indicators through STEM analysis. In the 2013 curriculum, identification of the characteristics of STEM learning presented in the design of learning, the concept of preconditions, learning scenarios according to the chosen model, techniques and forms of assessment and student worksheets. Sciences learning in curriculum 2013 have given a reference in choosing learning models appropriate to scientific approach (Aprina, 2016).

The problem in this study is how much the teacher's ability to develop plan STEM-based science learning. The purpose of this study was to see how much the teacher's ability to develop a STEM-based science learning plan.

Method

The method used in this research is descriptive qualitative. The research instrument is a STEM-based Science learning plan document. The analysis was carried out on the STEM-based science learning plan documents that had been prepared by science teachers. The analysis was carried out by referring to the STEM-based learning plan rubric compiled for STEM Training Technical Guidance activities for junior high school teachers in West Java Province. data collection on 29 science teachers who made STEM-based science learning plans. They are junior high school science teachers in Ciamis Regency as participants in the STEM-Based Science Learning Workshop and Simulation held by the Faculty of Teacher Training and Education, Galuh University. This research is to explore the ability of junior high school science teachers in preparing STEM-based science learning plans.

Result and Discussion

Learning design with STEM approach with the preparation of Learning Implementation Plans, consisting of basic competencies, indicators of competency achievement, learning objectives, prerequisite abilities, 21st century skill development, development of strengthening character education, material analysis, learning scenarios (approaches, models and descriptions activities) learning resources, tools and materials and assessment. (Devi et al.2018; Toto, 2018). Data of the study results are obtained as shown in Table 1 below:

Table 1 Score Acquisition of STEM Learning Plan

No.	Elements of Learning Plan	Score	Description
1.	Basic Competencies	82	
2.	Indicators of Achievement of Competence	80	
3.	Learning Objectives	75	
4.	Analysis of STEM Learning Materials	45	
5.	Learning Design	60	
6.	Prerequisite Ability	30	
7.	21st Century Skill Development	45	
8.	Development of Character Education Strengthening	68	
9.	Learning Scenarios	55	
10.	Approach, Model and Method	80	
11.	Steps of Learning	70	
12.	Learning Resources	50	
13.	Tools and Materials	80	
14.	Learning Assessment	55	
15.	Bibliography	50	
16.	Appendix	70	
Average		62,19	Moderate

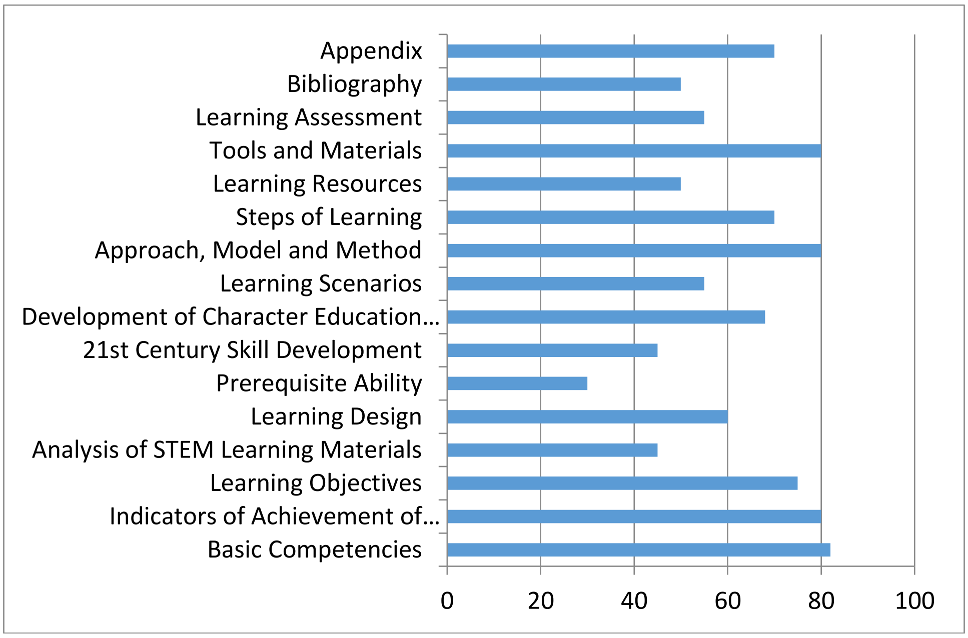

Figure 1 Ability to Develop Learning Plans

Table 2 Percatage of Number of Respondents that Include Elements of the STEM Learning Plan

No	Elements of Learning Plan	%	Description
1.	Basic Competencies	100	
2.	Indicators of Achievement of Competence	100	
3.	Learning Objectives	100	
4.	Analysis of STEM Learning Materials	80	
5.	Learning Design	80	
6.	Prerequisite Ability	50	
7.	21st Century Skill Development	50	
8.	Development of Character Education Strengthening	60	
9.	Learning Scenarios	100	
10.	Approach, Model and Method	90	
11.	Steps of Learning	100	
12.	Learning Resources	100	
13.	Tools and Materials	100	
14.	Learning Assessment	100	
15.	Bibliography	60	
16.	Appendix	80	
	Average	84,38	High

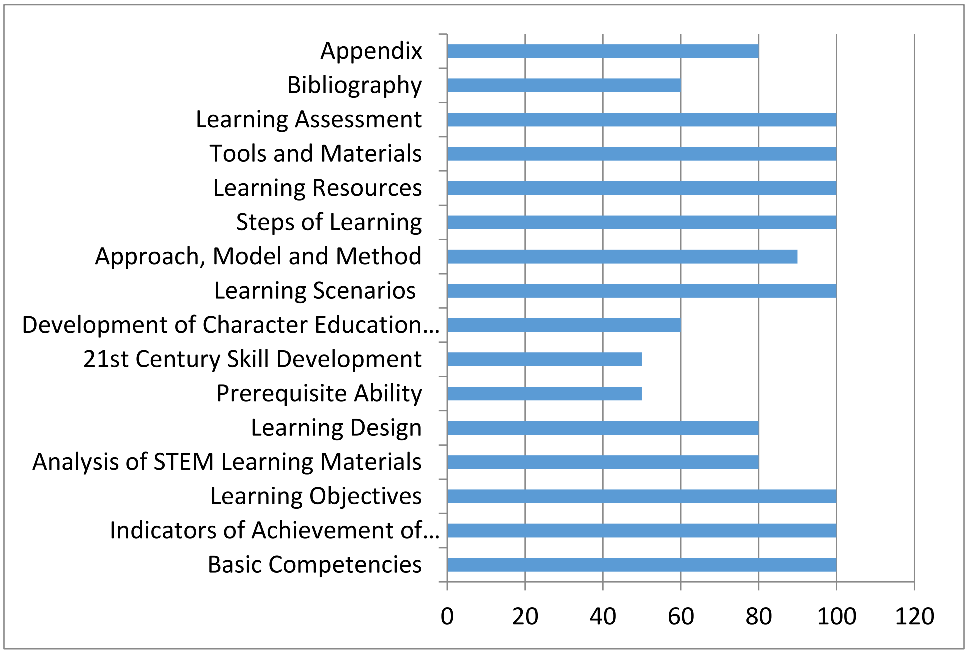

Figure 2 Percentage of Number of Respondents that Include Elements of the STEM Learning Plan

All respondents have develop basic competencies for the domain of knowledge and skills that are in accordance with the STEM topic (100%), but the accuracy of choosing them is not perfect, so the average score is 82. This indicates that the respondent's ability to develop basic competencies is not perfect. Likewise in formulating indicators of competencies achievement in accordance with selected basic competencies and in accordance with the writing criteria, all respondents formulated them (100%) with a score of 80. But in learning objectives section, respondents described the learning objectives as not in accordance with the indicators formulated, the respondent's ability to formulate learning objectives is shown through the acquisition of a score of 75, and all respondents included it (100%). Between the formulation of the objective there is a formula that is not in accordance with the indicator. Devi et al revealed. (2018) that the learning objectives are in accordance with the indicators formulated.

In the analysis of STEM learning material, teachers are required to identify the learning process that is in accordance with the four domains, namely Science, Technology, Engineering, and Mathematics. This section is a special section that characterizes the STEM approach. The weakness of the respondents was in identifying the learning process for the engineering domain between the four STEM domains. As many as 80% of respondents who have tried to analyze STEM learning material, even though the score was only reached 45, which indicates the ability of respondents in this element. The teacher's ability in the element of material analysis needs to be improved, because the teacher plays an important role so that students are interested in STEM learning, as Ramli and Talib (2017) stated that teacher play an important role in the formation of interest in STEM.

Learning design describes the essential concepts, learning models, scientific & engineering practice and crosscutting concepts used in presenting a topic with the STEM approach. In this section most of respondents still use the old format, meaning that it is not in accordance with the STEM-based learning design format. Among them there were several respondents who did not include scientific elements & engineering practice and crosscutting concepts. 50% of respondents included the scientific and engineering practice and crosscutting concepts. These two elements need to be given special attention to be presented again in a meeting, for example in the activities of teacher discussion in the field of science. Scoring was only reached 60 which shows the ability of respondents in that element.

Most respondents did not include prerequisite abilities. This means that very few respondents included prerequisites (55%), both for teachers and for students. This section explains the abilities that must be possessed beforehand, both by teachers and students before STEM learning is carried out. This part is very important to see the prerequisite concepts that must be mastered before learning the selected material, but saying the score is only at 50 is far from expectations.

The development of 21st century skills explains the 21st century skills that are trained in learning. 21st century skills that can be developed through this learning are as follows:

1. Critical thinking; it is developed when students follow the activities of designing, making, testing, and repairing products;
2. Creative thinking; it is developed when students follow the activities of designing, making, testing and repairing products;
3. Communicate; it is developed when students discuss to design, create, test and repair products and present them;
4. Collaborate; it is developed when students take part in designing, making, testing and repairing products.

This section has very few respondents (50%) who include 21st century skills that must be developed through learning selected material. The score is only 45, which shows the teacher's ability in that element. Likewise few teachers (60%) with score acquisition 68 in the section on the development of character strengthening which explains the values of the development of character strengthening that is trained in learning. The development of the STEM learning unit integrates strengthening character education in the implementation of learning. Character values that are expected to emerge in learning are:

1. Religious; include thankfulness, tolerance, confidence, not imposing the will, loving and maintaining the integrity of God's creation;
2. Nationalists; covering compliance with regulations was developed when students followed learning '
3. Independence; includes hard work, creative and innovative, discipline that is not easy to give up, and lifelong learners which are developed when students carry out activities to design, blind, test and improve products;
4. Mutual cooperation; includes cooperation developed when participants carry out discussion activities, gather information, design, make, and improve products..

Score acquisition in the element of development of affordable character reinforcement is at a score of 68. Of course the ability in this element needs to be improved because the current curriculum is character building.

Devi et al. (2018) revealed that the part of learning scenario consists of: a) Learning approaches, models and methods that will be used in learning. The percentage of respondents who included elements of the scenario in the learning plan was reached 100% with a score of 55. While the approach used by STEM Education; Learning models that are suitable for STEM options are: PBL, PjBL, Inquiry / discovery, and cooperative learning The learning model used is adjusted to the material to be discussed. Respondents who included learning approaches, model and learning method as much as 100%, Respondents who included learning approaches, learning models and methods were as much as 100%, but some of them did not suitable with the material characteristics. The acquisition number reaches a score of 80. The acquisition score reaches a score of 80. Likewise the learning method used is adjusted to the learning model used; b) Learning Steps; described for each class meeting into Learning Activities; STEM Learning Syntax (several possibilities PBL, PjBL, Inquiry / deicovery); Description of Activities and Allocation The time needed is in accordance with the number of meetings that have been determined. All respondents (100%) have described the learning steps according to the chosen learning model for each selected material. Unfortunately, among them there are steps that are still not in accordance with the steps of STEM-based learning. They only achieve a score of 70 in this element.

The Learning Resources section presents learning resources that are used as references in STEM learning on selected topics. Some learning resources such as the internet; textbooks, and other reading resources. 100% of respondents included learning resources, but some of them included only one learning resource, namely a reference book prepared by the government. There were a number of respondents who included references to other books that supported but did not include the title of the book ... The ability seemed easy, but it was not accompanied by action to find learning resources and include them in this element in the learning plan. The score was only reached 50 in this element.

The Tools and Materials section presents the needs of tools and materials used as references in STEM learning on selected topics. Tools and materials are adapted to selected learning models for selected material as well. All respondents (100%) included tools and materials in their learning plans, but the tools and materials were not in accordance with STEM-based learning models. This ability is also not affordable, but only 80 is achieved.

In Learning Assessment section identified techniques and forms of assessment used in viewing the achievement of basic competencies based on indicators of competencies achievement that have been formulated and assessment instruments used. All respondents (100%) included an assessment of the three aspects, namely attitudes, knowledge, and skills, but there were still several respondents who only included aspects of attitude and knowledge, complete with the assessment format. The ability of the respondents in the assessment elements reached a score of 55, because many of their assessment does not reflect the involvement in STEM

Table 3 Techniques and Forms of Assessment:

No.	Aspect	Technique	Instrument's form

1.	Attitude	- Discussion Activities Observation - Self-assessment - Evaluation Between Students - Journal	- Observation sheet - Assessment Format - Assessment Format - Notes
2.	Knowledge	- Written test - Assignment	- Multiple Choice Questions - Task
3.	Skill	- Practice Assessment - Project Assessment - Presentation Assessment	- Observation Sheet - Project Task Assessment Rubric - Presentation Rubric

The bibliography element presents various references that are used in compiling units in accordance with the rules of writing bibliography. This element was largely forgotten by respondents, so that only a small number (50%) of respondents included bibliography in the framework of preparing their learning plans, and obtaining 60 points to describe their ability to provide bibliography. While in the attachment section consists of: 1. Student Worksheet; and 2. Teacher's Instructions. Most teachers (80%) complete the attachments in the form of student worksheets, but forget the instructions of the teacher. This ability is fairly good, reaching 70.

The average score of 62.19 shows the ability of the teacher to develop the STEM-based science learning plan in the moderate category. While the number of teachers who included the elements in the science learning plan amounted to 84.38% (high category), this means that not all teachers include the whole elements in their learning plan documents.

Conclution

STEM-based science learning really needs to be implemented in junior high schools. To achieve this goal, it is strongly supported by the teacher's ability to make STEM-based science learning plans. Based on the analysis that their abilities in preparing STEM-based science learning plans are still diverse. Based on the results of the study above it can be concluded that the teacher's ability to develop STEM-Based Science Learning Plans is moderate.

References

Afriana J, Permanasari A, dan Fitriani A (2016). Project Based Learning Integrated to STEM to Enhance Elementry School's Students Scientific Literacy. *Jurnal Pendidikan IPA. Indonesia.* http://journal.uny.ac.id/indexphp/jipi. JPII 5 (2), p. 265-267.

Appianing, J. Eck, R.N.V. (2018). Development and Validation of the Value-Expectancy STEM Assessment Scale for Students in Higher Education. *International Journal of STEM Education.* 5 (24), p. 1-16

Chittum, J.R. Jones, B.D. Akalin, S. and Schram, A.B. (2017). The effects of an Afterschool STEM program on Students' Motivation and engagement. International Journal of STEM Education. 4 (11). P. 1-16

Dare, E.A., Ellis, J.A., and Roehrig, G.H. (2018). Understanding Science Teachers' Implementations of Integrated STEM Curricular Units Through a Phenomenological Multiple Case Study. *International Journal of STEM Education*. 5 (4), p. 2-19.

Deghaidy H E, Mansour N, Alzaghibi M, and Alhammad, K. (2016). *Context of STEM Integration in Schools: Views from In-service Science* Teachers. *Eurasia Journal of Mathematics Science and Technology Education* p. 2459-2474

Deghaidy H.E. and Mansour, N. (2015). Science Teachers' Perceptions of STEM Education: Possibilities and Challenges. International Journal of Learning and Teaching. 1 (1). p. 51-54

Devi P K, Herliani E, Setiawan R, Yanuar, Y, and Karyana, S. (2018). *Bimtek Pembelajaran Berbasis STEM Dalam Kurikulum 2013.* Jakarta: Direktorat Pembinaan Sekolah Menengah Pertama, Kementerian Pendidikan dan Kebudayaan.

Fraenkel, J.R., Wallen, N.E. & Hyun, H.N. (2011). How to Design and Evaluate Research in education (eighth ed.) New York: Mc. Graw-Hill

Ismail, Permanasari, A., and Setiawan, W. (2016). STEM Virtiual Lab: An Alternative Practical Media to Enhance Student's Scientific Literacy. *Jurnal Pendidikan IPA Indonesia*. 5 (2), p. 239-246.

Jolly, A. (2014). *Characteristics of a Great STEM Lesson* -Education Week Teacher. http://www.edweek.org/tm/articles/2014/06/17/ctq_jolly_stem.html.. p. 1-3

Kelly T R, Knowles J G, (2016). A Conceptual Framework for Integrated STEM Education. *International Journal of STEM Education 20163: 11.http://doi.org/10.1186/s40594-016-0046-z*

Khatri, R., Henderson, C., Cole, R., Froyd, J.E., Friedrichsen, D, and Stanford, C. (2017). Characteristics of Well-*Propagated Teaching Innovations in Undergraduate STEM. International Journal of STEM Education.* 4 (2), p. 1-13

Khoeroningtyas, N., Permanasarii, A. and Hamidah, I. (2016). *STEM Learning in Material of Temperature and its Change to Improve Scientific Literacy of Junior High School Students. Jurnal Pendidikan IPA Indonesia..* 5 (1), p. 94-100.

Lehtamo, S. Jutti, K. Inkinen, J. and Lavonen, J. (2018). Connection between academic emotions in situ and retention in the physics track: Applying experience sampling method. *International Journal of STEM Education*. 5 (25). p. 1-6

Mustafa, N, Ismail, Z, Tasir, Z, and Said, M. N. (2015). *A Metha- Analysis on Effective Strategies for Integrated STEM Education Advanced* Science Letters Vol. 12 American Scientific Publishers. p. 4225-4229

Mutakinati, L. Anwari, I. and Yoshisuke, K. (2018). Analysis of Students' Critical Thinking Skill of Middle School Through STEM Education Project- Based Learning. *Jurnal Pendidikan IPA Indonesia, 7(1), 54-65.*

Nagdi, M.E., Leammukda, F., and Roehrig, G. (2018). Developing Identities of STEM Teacher at EmergingSTEM Schools. *International Journal of STEM Education*. 5 (36), p. 1-3.

Ramli, N.F. and Talib, O. (2017). Can Education Institution Implement STEM? From Malaysian Teachers' View. International Journal of Academic Research in Business and Social Sciences. 7 (3). P. 721-`732

Ritter, O.N. (2017), Book Riview: Philosophy of STEM Education- A Critical Investigation. *Contemporary Education Technology*. 8 (1). p. 99-102

Ritter, M.D. (2016). STEM for All Children: Preschool Teachers Supporting Engagement of Children with Special Needs in Physical Science Learning Centers. Young Exceptional Children XX (X) p 1-13

Robert, A. (2012). A Justification for STEM Education. *Technology and Engineering Teacher*. 74 (8), p. 111-118

Robert, A. Cantu, D. (2012). *Applying STEM Instructional Strategies to Design and Technology Curriculum.* Departement of STEM Education and Professional Studies. Old Dominion Uversitity, USA. p. 111-118

Robert, T. Jackson, Ch. Schroeder, M.J.M. Bush, S.B. Maiorca, C. Cavalcanti, M. Schroeder, D.C. Delaney, A. Putnam, L. and Cremeans, Ch. (2018). Students' Perceptions of STEM Learning after Participating in a Summer Informal Learning Experience. International Journal of STEM Education. 5 (35). p. 1-16

Scott, C. An Investigation of Science, Technology, Engineering and Mathematics (STEM) Focused High Schools in the USA. *Journal of STEM Education.* 13 (5), p. 30-39.

Stohlmann, M. Moore, T.J. and Roehrig, G.H. (2012). Considerations for Teaching Integrated STEM Education. Journal of Pre-College Engineering Education Research (J-PEER). 2 (1). p. 27-34

Strimel, G. and Grubbs, M.E. (2016). Positioning Technology and Engineering Education as a Key Force in STEM Education. Journal of Technology Education. 2 (27). P. 21-36

Toto. (2018). *STEM-Based Science Learning Design in the 2013 Curriculum.* Yogyakarta: Proceeding on International Seminar- Universitas Negeri Yogyakarta.

Wang H, Moore T Roehrig G, and Park M, 2011 STEM Integration: Teacher Perceptions and Practice. *Journal of Pre- College Engineering Education Research, 1 (2),* p. 1-13

Wisudawati, A.W. (2018). Science Technology Engineering and Mathematics (STEM) Education Approach against a Microscopic Representation Skill in Atom and Molecule Concept. International Journal of Chemistry Education research. 2 (1). P. 1-5

Yildirim, B. (2018). Adapting the Teachers' Efficacy and Attitudes towards STEM Scale into Turkish. *Journal oof Turkish Science Education.* 2 (15). P. 54-65