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The identification of Teachers' Difficulties in Designing of Learning Materials Based on STEM at Central Aceh Senior High School

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ABSTRACT

The problem in this research is what componentsare the difficulties for high school physics teachers at Central Aceh in designing STEM-based learning tools? This study aims to determine the difficulties of high school physics teachers in Central Aceh in designing STEM-based learning tools. The approach used in this research is a quantitative approach and descriptive type. The subjects of this study were all high school physics theacher in Central Aceh. Data colecctions was carried out by means of a questionnaire. The questionnaire data was processed with a descriptive percentage. The conclusion in this study is that the diffuclty level of teachers is the highest in designing STEM-based learning tools on the Pedagogical Content Knowledge (PCK) component as many as 18,20 % of teachers, on the Content Knowledge (CK) component as many as 15,15 % of teachers and on the Technological Content Knowledge (TCK) component as many as 14,05 % of teachers. It is recommended for teachers to master mathematics/science in order to equip teachers's knowledge in designing classroom learning tools and mastering technology to determine student needs in learning such as twitter, blog, facebook to support the teaching and learning process.

Keywords: : High School Physics Teacher, STEM Based, Degree of Difficulty Cognitive Abilities, Physics

INTRODUCTION

In the 21st century, the rapid development of information and communication technology has resulted in an increase in educational competition in Indonesia. Through STEM-based learning will form the character of students who are able to recognize a concept or knowledge (science) and apply that knowledge with the skills (technology) they master to create or design a method (engineering) with analysis and based on mathematical data calculations (math) in order to find a solution to solving a problem so that human work becomes easier.

Teachers who will be dedicated to teaching STEM must be equipped with technological knowledge, pedagogical knowledge, in-depth content knowledge about STEM and high pedagogical skills to teach students in order to help students achieve a deep understanding of STEM. STEM for later use in their life and career. The curriculum and preparation of STEM

teachers must emphasize these three points. In addition, teachers should be motivated to participate in their professional development to help them achieve in-depth knowledge of STEM content and mastery of STEM pedagogy.

STEM education does not mean only strengthening educational praxis in separate STEM fields, but rather developing an educational approach that integrates science, technology, engineering, and mathematics, by focusing the educational process on solving real problems in everyday life and professional life. STEM education provides opportunities for teachers to show students how concepts, principles and techniques from science, technology, engineering, and mathematics are used in an integrated manner in the development of products, processes and systems used in their daily lives. Therefore, according to Reeve (2013), "adopting the definition of STEM education as an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics in a real context that connects schools, the world of work, and the global world, so that develop STEM literacy that enables students to compete in the new knowledge-based economic era.

It is hoped that STEM education-based physics learning experience can develop students' understanding of science content, innovation and problem solving skills, soft skills (including communication, cooperation, leadership). The further impact of STEM-based science learning is to increase the interest and motivation of students to continue their studies and careers in the science and technology profession, as needed by the country today and in the future.

This research was conducted based on the quality of education in the district of Central Aceh until now it is still considered a concern and is ranked 17th out of 23 districts / cities in Aceh for 2019 (aceh.antaranews.com). This research was previously conducted by Syukri, et al with the title "Analysis of the difficulties of teachers in the field of science (physics, chemistry, biology) in high school in designing learning tools based on the STEM approach" in 2019 in Central Aceh. The data that I got from previous journals as well as the results of observations made by researchers show that there are still many physics teachers who have difficulty designing STEM-based learning tools in SMA Aceh Tengah.

From the description above, the author wants to do research on "The identification of Teachers' Difficulties in Designing of Learning Materials Based on STEM at Central Aceh Senior High School".

Problem of Research

Based on the background of the problem, the formulation of the problem is: what components are the difficulties for high school physics teachers in Aceh Tengah in designing STEM-based learning tools?

Research Focus

Based on the description of the problem formulation above, the objectives of this study are: to determine the difficulties of high school physics teachers in Central Aceh in designing STEM-based physics learning tools.

METHODOLOGY OF RESEARCH

General Background of Research

Judging from the author's title "Identification of the difficulties of high school physics teachers in Central Aceh in designing STEM-based learning tools". So this writer uses a quantitative approach and descriptive type, namely a study that aims to identify the difficulties of teachers in designing STEM-based learning tools. This research was conducted at SMA Aceh Tengah. This research was conducted on January 19, 2020.

Subject of Research

The population in this study were all physics teachers at SMA Aceh Tengah who would design STEM-based learning tools. The research samples were 44 high school physics teachers in Aceh Tengah.

Instrument and Procedures

Research instruments are tools or facilities used for researchers to collect data so that their work is easier and the results are better, meaning that it is faster, more complete and systematic so that it is easy to process. The research uses a quantitative approach and descriptifve type.

Data Analysis

The questionnaire uses a Likert scale which usually uses the TD, D, A, SA categories. This Likert scale negates the answer category in the middle (R) for three reasons:

1. The undecided category has a double meaning, it means that they have not been able to decide or give an answer (according to the original concept, bias was interpreted as neutral, agreed not, did not agree or did not, or even doubted).
2. The availability of answers in the middle creates a central tendency effect, especially for those who are unsure about the direction of the answer towards agreeing or disagreeing.
3. The purpose of the TD, D, A, SA answer categories is to see the tendency of the respondent's opinion to agree or disagree.

Therefore, the researcher eliminates the R answer (doubtful). It is feared that respondents who have not been able to decide to give neutral answers will cause a tendency for answers to the middle. In addition, to see the tendency of the answers to agree and disagree. (Sugiyono, 2011: 61)

In this study, the authors used a favorable item group, the score range on this scale was from 1-4. At aitem favorable rating system are:
TD = 1, D = 2, A = 3, SA = 4
Information :
TD = Totally Disagree
D = Disagree
A = Agree
SA = Strongly Agree

RESULTS AND DISCUSSION

Based on the research objective, namely to find out about the identification of high school physics teachers in Central Aceh in designing STEM-based physics learning tools, the researchers have obtained the results of their research after distributing questionnaires given to high school physics teachers in Central Aceh.

This chapter will discuss the results of research that has been carried out in accordance with the title that has been formulated. Data obtained from the teacher through a questionnaire through a questionnaire that has been given to the teacher which contains STEM-based learning tools. The following is a table of respondents' answers:

Komponen TK (Technological Knowledge).

Table 1. Alternative answer respondents for component TK (item number 1 to 5)

No	Question	frequency				**Amount**	**Percentage (%)**
		TD	**D**	A	SA		
1	I can follow technological develpoments that are important for the learning process	**0**	**0**	28	16	**0**	**0 %**
2	I can use power point or similar software to design teaching materials	**0**	**0**	29	15	**0**	**0 %**
3	I can find current information on the web about the required material optics	**0**	**1**	24	19	**1**	**2,30 %**
4	I can create documents wits text and images in the word program	**0**	**0**	29	15	**0**	**0 %**
5	I have the technical skills I need to use technology	**0**	**5**	34	5	**5**	**11,40 %**
	Amount						**13,70 %**
	Average						**2,74 %**

Based on table 1 it can be concluded that as many as 2.74% of physics teachers experience difficulties in the component field of Kindergarten (Technological Knowledge). As for the 3 points, the lowest percentage of teachers did not experience difficulties with technology in the form of power points and word programs. Power point is one of the programs created by Microsoft Corporation which is referred to in Microsoft Office, while the Word program is Microsoft's mainstay word management software (Hujair AH. Sanaky, 2009: 127).

As many as 11.40% of physics teachers experienced difficulties in technical skills to use technology. Technical skills are technical skills that are used or possessed to make something more useful and useful related to hard skills. Where hard skills are technical abilities that include science, technology, and also share other types of abilities and skills related to the knowledge pursued. This is because not all physics teachers are able to master technology (Arum Widya Safitri, 2018: 01).

Komponen PK (Pedagogical Knowledge).

Table 2. Alternative answer respondents for component PK (item number 6 to 15)

No	Question	frequency				**Amount**	**Percentage (%)**
		TD	**D**	A	SA		
1	I can use proper, STEM based teaching tools to explain concepts	**0**	**6**	35	3	**6**	**13,60 %**
2	I can use a differnts teaching approach (STEM Approach) in the context	**0**	**6**	33	5	**6**	**13,60 %**
3	I can guide students to adopt approaciate Science/Math learning strategies	**0**	**7**	30	7	**7**	**15,90 %**
4	I can help students to monitor their own learning	**0**	**1**	34	9	**1**	**2,30 %**
5	I can help students to rfelect on students' STEM learning strategies	**0**	**5**	31	8	**5**	**11,40 %**
6	I can plan group activities for students	**0**	**0**	32	12	**0**	**0 %**
7	I can know to organize and manage classroom management	**0**	**1**	37	6	**1**	**2,30 %**
8	I can develop students' thinking by creating challenging assignments for them	**0**	**5**	33	6	**5**	**11,40 %**
9	I can find out the students' prior knowledge before starting class	**0**	**5**	37	2	**5**	**11,40 %**
10	I can find out about student' general understanding and misconseptions	**0**	**5**	39	0	**5**	**11,40 %**
	Amount						**93,30 %**
	Average						**9,33 %**

Based on table 2, it can be concluded that as many as 9.33% of physics teachers experienced difficulties in the field of PK (Pedagogical Knowledge) components. In number 6, no teacher has difficulty planning group activities for students in the classroom. This is because teachers are used to making groups in class every time they present physics subject matter (Subkhiyah, 2017: 13).

As many as 15.90% of physics teachers experienced the highest difficulty guiding proper Science / Mathematics learning. Whereas physics teachers should be obliged to master the basic science / Mathematics competencies in order to deepen and improve the physics subject being taught (Bambang Ruwanto, 2009: 21). As for numbers 1 and 2 as much as 13.60% of physics teachers experienced difficulties with STEM-based teaching tools and the STEM approach in their context. Then there are 4 points as many as 11.40% of physics teachers have difficulty reflecting on students for STEM learning, creating assignments to challenge students, knowing students 'abilities before entering the classroom and knowing about students' general understanding and misconceptions. Misconceptions are misunderstandings in connecting other concepts, between new concepts and concepts that already exist in students' minds, so that wrong concepts are formed and contradict the conceptions of physicists (Eka, 2014: 09).

Komponen CK (Content Knowledge).

Table 3. Alternative answer respondents for component CK (item number 16 to 21)

No	Question	Frequency				**Amount**	**Percentage (%)**
		TD	**D**	A	SA		
1	I can explain Science/Mathematics material cleary using the STEM approach	**0**	**5**	32	7	**5**	**11,40 %**
2	I can be familiar with or understand the contect of the subject matter taught using the STEM approach	**0**	**5**	33	6	**5**	**11,40 %**
3	I have sufficient knowledge about Science/Mathematics material to answer students question in learning using the STEM approach	**0**	**6**	30	8	**6**	**13,60 %**
4	I can use various approacaches or stratgeies in teaching such as the STEM approach to develop math/science knowledge	**0**	**8**	34	2	**8**	**18,20 %**
5	I can be familiar or understanding the entire structure and direction of science/mathematics learning materials using the STEM approach	**0**	**10**	31	3	**10**	**22,70 %**
6	I can develop a deeper understanding of the content of Science/Mathematicd using the STEM approach	**0**	**6**	32	6	**6**	**13,60 %**
	Amount						**90,90 %**
	Avarage						**15,15 %**

Based on table 3, it can be concluded that as many as 15.15% of physics teachers experienced difficulties in the CK (Content Knowledge) component field. As for the 2 points, as many as 11.40% of physics teachers experienced the lowest difficulty in explaining the Science / Mathematics material clearly using the STEM approach and understanding the content of the subject matter taught using the STEM approach. (Oroszla, 2007)

As many as 22.70% of physics physics teachers experienced the highest difficulty understanding the structure and direction of Science / Mathematics learning materials using the STEM approach. Then there are as many as 18.20% of physics teachers having difficulty using various approaches or strategies such as the STEM approach to develop Science / Mathematics knowledge (Bybee, 2010).

Komponen TCK (Technological Content Knowledge).

Table 4. Alternative answer respondents for component TCK (item number 22 to 32)

No	Question	Frequency				**Amount**	**Percentage (%)**
		TD	**D**	A	SA		
1	I can use digital technology in STEM learning to observe things that sould be difficult to observe	**0**	**9**	28	7	**9**	**20,50 %**
2	I can use any suitable technology (eg multimedia, simulation) to represent Science/Mathematics material using STEM approach	**0**	**5**	33	6	**5**	**11,40 %**
3	I know about the technology that must be used to teach science/mathematics using the STEM approach	**0**	**6**	30	8	**6**	**13,60 %**
4	I can use technology to determine student needs, related to the material in the pre-teaching process	**0**	**6**	30	8	**6**	**13,60 %**
5	I can guide students in the process of designing technology-based products (presentations, games, films)	**0**	**10**	27	7	**10**	**22,70 %**
6	I can use innovative technology (facebook, blog, twitter) to support the teaching and learning process	**0**	**8**	32	4	**8**	**18,20 %**
7	I can work with disciplines regarding the use of technology to solve problems faced in the process of serving content	**0**	**6**	33	5	**6**	**13,60 %**
8	I know about technology that I can use to understand and do science	**0**	**3**	36	5	**3**	**6,80 %**
9	I can choose the right technology to improve teaching in a particular sub-material	**0**	**4**	36	4	**4**	**9,10 %**
10	I can use technology to find solutins to problems (compile, update and relate material to real life)	**0**	**5**	33	6	**5**	**11,40 %**

11	I can optimize the duration of learning using technology (education, software, virtual laboratories, etc)	**0**	**6**	33	5	**6**	**13,60 %**
	Amount						**154,50 %**
	Avarage						**14,05 %**

Based on table 4 it can be concluded that as many as 14.05% of physics teachers experience difficulties in the component field of TCK (Technological Content Knowledge). Physics teachers experienced the lowest difficulty as much as 6.80% on the technology used to understand and do science.

Then as many as 22.70% of physics teachers experienced the highest difficulty regarding designing various technology products such as presentations, games and films. Then as many as 20.50% of physics teachers have difficulty using digital technology in STEM learning to observe things that should be difficult to observe. Example: computers, laptops, telephones and so on. Then as many as 18.20% of physics teachers have difficulty using innovative technology such as: Facebook, blog and Twitter for the teaching and learning process. Innovative technology includes: basic knowledge, forming attitudes, a decision to take or reject, application and use and confirmation of decisions (Sutarno, 2012: 134).

Komponen PCK (Pedagogical Content Knowledge).

Table 5. Alternative answer respondents for component PCK (item number 33 to 39)

No	Question	Frequency				**Amount**	**Percentage (%)**
		TD	**D**	A	SA		
1	I know how to choose effective teaching approaches to guide students to think creatively	**0**	**5**	35	4	**5**	**11,40 %**
2	I can use different teaching approaches and cooperative learning to teach science/mathematics material	**0**	**4**	38	2	**4**	**9,10 %**
3	I can choose a STEM approach to teaching that is effective in guiding student learning and thinking	**0**	**5**	38	1	**5**	**11,40 %**
4	I can use the STEM approach to teaching to turn the subject matter into comprehensive	**0**	**6**	36	2	**6**	**13,60 %**
5	Without using technology, I can overcome common misconceptions students have about science	**0**	**12**	30	2	**12**	**27,30 %**
6	Without using technology, I can help students to understand the content of science knowledge in various ways	**0**	**12**	28	4	**12**	**27,30 %**
7	Without using technology, I can involve students in solving real-worl problems related to science/mathematics	**0**	**12**	29	3	**12**	**27,30 %**
	Amount						**127,40 %**
	Avarage						**18,20 %**

Based on table 5, it can be concluded that as many as 18.20% of physics teachers experienced difficulties in the PCK (Pedagogical Content Knowledge) component field. As many as 9.10% of teachers experienced the lowest difficulty in different teaching approaches and cooperative learning to teach Science / Mathematics material. Cooperative learning is a set of teaching strategies designed to educate teamwork and student interaction. This statement is considered not difficult by the teacher because the teacher is able to interpret the following 3 things, namely: academic learning outcomes, acceptance of diversity and the development of social skills (Sugiyanto, 2010: 37).

As for the 3 points, 27.30% of teachers experienced difficulties without using technology. This statement is considered difficult because physics teachers also need technology to teach students in the classroom. Either during group work or a percentage in front of the class. It is impossible for a physics teacher to solve real-world problems without using technology. Because anything in this world is related to technology in communication. From that, science is always attached to the technology that we use in our daily life (Kemendikbud RI, 2013).

Komponen TPK (Technological Pedagogical Knowledge).

Table 6. Alternative answer respondents for component TPK (item number 40 to 51)

No	Question	Frequency				**Amount**	**Percentage (%)**
		TD	**D**	A	SA		
1	I can choose technology that enhances the teaching approach to science/mathematics subjects	**0**	**6**	34	4	**6**	**13,60 %**
2	I can choose technology that enhances students learning in science/mathematics	**0**	**7**	35	2	**7**	**15,90 %**
3	I can adapt the use of the technology learned to teach differently	**0**	**6**	35	3	**6**	**13,60 %**
4	I can facilitate students to use technology to plan and monitor their own learning	**0**	**5**	38	1	**5**	**11,40 %**
5	I can facilitate students to use technology to plan and monitor their own learning	**0**	**4**	38	2	**4**	**9,10 %**
6	I can facilitate students to use technology to construct various forms of knowledge representation	**0**	**5**	38	1	**5**	**11,40 %**
7	I can facilitate students to collaborate with each other using technology	**0**	**6**	35	3	**6**	**13,60 %**
8	I can use technology to develop activities based on student needs to enrich the teaching and learning process	**0**	**5**	35	4	**5**	**11,40 %**
9	I can plan the teaching and learning process according to the available technology resources	**0**	**4**	38	2	**4**	**9,10 %**

10	I can be an appropriate model for students in following a code of conduct for the use of technology in my teaching	**0**	**4**	38	2	**4**	**9,10 %**
11	I can use technology to update my knowledge to update my knowledge and skills in the area to be taught	**0**	**3**	35	6	**3**	**6,80 %**
12	I can solve any problem that might occur when using technology in any phase of the teaching-learning process	**0**	**6**	32	6	**6**	**13,60 %**
	Amount						**138,60 %**
	Average						**11,55 %**

Based on table 6, it can be concluded that as many as 11.55% of physics teachers experienced difficulties in the field of TPK (Technological Pedagogical Knowledge) components. As many as 6.80% of teachers experienced the lowest difficulty in mastering the field of technology in order to increase their knowledge and abilities while teaching. This statement is considered not difficult because all teachers are able to increase their knowledge and skills in using technology. Because every day the average teacher uses technology such as laptops and cellphones to learn to master material that is not yet understood. Then there are 3 points as many as 9.10% of teachers have the lowest difficulty regarding technology as a resource, real-world scenarios and following the learning model according to the code of ethics. This is because the teacher has fully mastered the new technology that was launched during his time (Hendi, 2018).

As many as 15.90% of physics teachers experienced the highest difficulty in choosing technology to improve student learning. This is because in Central Aceh not all students have contemporary technology such as Android cellphones or laptops. So students find it difficult to digest the technology learning delivered by the teacher. This is where the teacher does not understand which technology can be chosen so that students understand the material presented (BBC.com, 2020).

Komponen TPACK (Technological Pedagogical And Content Knowledge).

Table 7. Alternative answer respondents for component TPACK (item number 52 to 60)

No	Question	Frequency				**Amount**	**Percentage (%)**
		TD	**D**	A	SA		
1	I can teach a subject that combines the math, technology and STEM teaching approaches just right	**0**	**6**	33	5	**6**	**13,60 %**
2	I can teach lessons that combine literacy, technology and STEM teaching approaches appropriately	**0**	**6**	35	3	**6**	**13,60 %**

3	I can teach lessons that properly combine science, technology and STEM teaching approaches	**0**	**5**	35	4	**5**	**11,40 %**
4	I am able to select the technology I use in the classroom to improve what is taught and what students learn	**0**	**5**	35	4	**5**	**11,40 %**
5	I was able to use a strategy that I combined with technology and the STEM approach I had learned in class	**0**	**5**	34	5	**5**	**11,40 %**
6	I am able to choose technology to improve science/mathematics subject matter	**0**	**6**	34	4	**6**	**13,60 %**
7	I can use the internet to find common student misconceptions related to science material	**0**	**4**	35	5	**4**	**9,10 %**
8	I can help students use digital technology to collect scientific data	**0**	**8**	34	2	**8**	**18,20 %**
9	I can customize methods, techniques and technology by evaluating their attributes in order to present content effectively	**0**	**7**	36	1	**7**	**15,90 %**
	Amount						**118,20 %**
	Average						**13,13 %**

Based on table 7, it can be concluded that as many as 13.13% of physics teachers have difficulty in the field of teacher knowledge components based on TPACK (Technological Pedagogical And Content Knowledge). As many as 9.10% of physics teachers experienced the lowest difficulty regarding using the internet to find common misconceptions of students related to science material. This statement is considered not difficult because teachers have been taught in college how to use the internet properly and correctly to find scientific material related to student misunderstandings (Mario Jordan, 2019).

As many as 18.20% of physics teachers experienced the highest difficulty regarding the use of digital technology to collect scientific data. Digital technology is a tool that does not use human labor manually, but rather an automatic operating system with a computerized system or a computer-readable format. Scientific data are all facts and figures that can be used as material to compile information based on research. This is because physics teachers have not been able to operate computers to collect scientific data. (N Fairu & Syukri 2014)

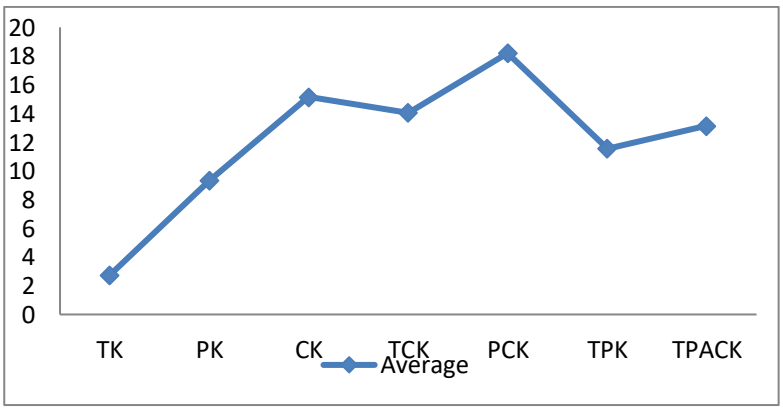

Figure 1. Graph of Average TPACK Score Teachers

Based on the results of research through giving questionnaires to high school physics teachers in Central Aceh, it is known that as many as 18.20% of physics teachers experienced the highest difficulty in the Pedagogical Content Knowledge (PCK) component, as many as 15.15% of physics teachers experienced difficulties with the Content component. Knowledge (CK) and as many as 14.05% of physics teachers experienced difficulties in the Technological Content Knowledge (TCK) component. It is known that 2.74% of physics teachers experienced the lowest difficulty in the Technological Knowledge (TK) component.

CONCLUSIONS

Based on the results of data analysis, it can be concluded that the highest level of teacher difficulty in designing STEM-based learning tools is 18.20% of the Pedagogical Content Knowledge (PCK) component of the teacher, 15.15% of the teacher's Content Knowledge (CK) component and the Technological component. Content Knowledge (TCK) as many as 14.05% of teachers. Suggestions for teachers are expected to master technology ang mathematics/science for knowledge of physics.

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