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Affective Assesment Instrument to Assess Student Attitudes Towards Science, Technology, Engineering and Mathematics

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ABSTRAK

Instrumen penilaian merupakan bagian dari perangkat pembelajaran yang meliputi proses mengukur dan mengumpulkan data dan informasi untuk diolah dan diinterpretasikan di dalamnya untuk mempertimbangkan bagaimana keputusan hasil belajar siswa tercapai sesuai dengan tujuan pembelajaran. Instrumen digunakan untuk mengukur dimensi kognitif, psikomotor, dan afektif. Sejauh ini masih belum banyak penelitian pengembangan suatu instrumen afektif, kebanyakan berfokus pada kognitif dan psikomotorik siswa. Sehingga, penelitian ini bertujuan untuk mengembangkan instrumen afektif, yakni sikap siswa terhadap STEM (Science, Technology, Engineering and Mathematics). Penelitian ini merupakan penelitian pengembangan (Research and Development) dengan menggunakan model pengembangan ADDIE. Model ADDIE terdiri dari lima langkah yaitu: analisis, desain, pengembangan, implementasi, dan evaluasi. Instrumen awal yang dikembangakan berjumlah 45 item yang memuat setiap aspek STEM yang selanjutnya diujicobakan pada subjek uji coba yang berjumlah 72 orang siswa SMA. Berdasarkan hasil analisis data, maka telah dihasilkan sebuah instrument penilaian sikap yang baik dan efektif untuk menilai sikap siswa untuk melihat sikap siswa terhadap STEM. Melalui pengembangan ini diharapkan dapat menjadi landasan yang dapat digunakan oleh para pendidik sebelum memberikan perlakuan yang tepat kepada siswa dalam mempersiapkan siswa yang memiliki sikap terhadap aspek STEM agar siswa dapat menghadapi berbagai tantangan abad 21 yang begitu ketat dan berkembang pesat.

ABSTRACT

The assessment instrument is part of the learning toolkit which includes the process of measuring and collecting data and information to be processed and interpreted in it to consider how decisions on student learning outcomes are achieved in accordance with learning objectives. Instruments are used to measure cognitive, psychomotor, and affective dimensions. So far there has not been much research on the development of an affective instrument, mostly focusing on students' cognitive and psychomotor aspects. Thus, this study aims to develop affective instruments, namely students' attitudes towards STEM (Science, Technology, Engineering and Mathematics). This research is research and development using the ADDIE development model. The ADDIE model consists of five steps: analysis, design, development, implementation, and evaluation. The initial instrument that was developed was 45 items which contained every STEM aspect which was then tested on test subjects totaling 72 high school students. Based on the results of data analysis, a good and effective attitude assessment instrument has been produced to assess students' attitudes to see students' attitudes towards STEM. Through this development, it is hoped that it can become a foundation that can be used by educators before giving appropriate treatment to students in preparing students who have an attitude towards STEM aspects so that students can face various challenges of the 21st century which are so tight and growing rapidly.

1. INTRODUCTION

In the current 21st century, there is a lot of competition in various aspects of life, such as in the economic, social and educational fields. The increasingly rapid development of the digital era and technology at this time, of course, demands the skills and quality of human resources which are also balanced with the development of the industrial revolution 4.0 era. In the era of technological development, students are required to have critical, creative, innovative thinking skills, communication and collaboration skills and problem solving (Wardani et al., 2017). Every human resource is faced with demands to be able to compete and compete to solve various problems in the 21st century. One of the things to be able to help students in facing the 21st century is through STEM *(Science, Technology, Engineering and Technology). Mathematics)*. STEM *education* is currently an option for science learning that can uphold a generation that is able to overcome the challenging 21st century (Permanasari, 2016). Furthermore, the many challenges of the 21st century, STEM education is the right choice to be a science

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learning option (Pertiwi et al., 2017). So it can be seen that with STEM, students can develop their abilities and skills in order to be successful in facing this 4.0 revolution era where there is a lot of competition in it, one of which is competition in the field of work. National Research Council considers Science, Technology, Engineering, and Mathematics (STEM) to be Cultural outcomes that reflect the humanity of our society that drive our economy, and become an important indicator in life related to us as citizens, workers, consumers, and parents. The advancement of knowledge, skills and attitudes in the STEM field is very important for national security, economic growth, citizens' health and the stability of the nation. STEM development continues to be a determinant for the development of the modern world. Creative innovation and technological progress are important elements for improving the quality of human life and protecting the environment. Nonetheless, reports indicate that currently the number of students studying STEM fields is insufficient to meet the future needs of society (Ardianti et al., 2020) and student interest in STEM learning is declining (Kelley & Knowles, 2016). As a result, many countries are seeking measures to remedy this situation (Kyaruzi et al., 2021). The American education system, for example, seeks to increase the number of students who choose education and careers in STEM fields, increase the workforce in STEM fields and develop the STEM abilities of students, including those who are not interested in studying STEM fields. Great attention is paid to attracting women and minorities to STEM education. STEM is a very important field of education and research is being conducted from time to time to investigate: a) attitudes of students and youth towards the STEM field (Perdana et al., 2021); b) students' motivation to choose a career in the STEM field (Shin et al., 2018); c) student opinion about engineering career (Morris et al., 2020); d) how girls can be motivated to pursue careers in the STEM field (Sya'bandari et al., 2020; Talley & Martinez, 2017).

According to Mardhiyah, *et al* , (2021) As a developing country, Indonesia has competitiveness in the world economy and requires a lot of manpower to answer the challenges of the 21st century. Unfortunately, the number and quality of Indonesian graduates with STEM skills is still very low . On the other hand, the demand for qualified workers in the 21st century in the STEM field is also on a large scale (Anggraini & Huzaifah, 2017). The increase in the population of Indonesia forces the community to meet more and more needs, so that Indonesia needs experts in order to meet the needs of the community with the help of technology and science. In order to prepare students to compete in the world of work in the current era, of course, an update of models, methods or learning media is needed that can foster student interest, especially in the STEM field. Before compiling and determining the renewal or learning innovation that will be used, a teacher must know the extent of the initial abilities or attitudes of students towards something, such as how students' attitudes towards STEM fields are. Steps that can be taken to find out how students' attitudes towards STEM are through an assessment instrument.

The assessment instrument is part of the learning device which includes the process of measuring and collecting data and information for processing and interpretation in it to consider how decisions on student learning outcomes are achieved in accordance with learning objectives. Evaluation activities include at least 3 components that must be evaluated such as knowledge that has been learned, skills acquired to attitudes that have changed from the learning process so that the evaluation needs are adjusted to the goals and competencies that will be taken from the learning process (Suharsimi & Arikunto, 2009) . Assessment instruments also continue to develop along with the needs of students by adjusting the development of science and technology. Various kinds of research have developed rapidly to develop these assessment instruments, one of which is an instrument for assessing students' attitudes or affective. The assessment instrument for assessing student attitudes is to use an affective assessment instrument. Assessment of the affective domain can be a determinant of a person's success in a particular subject. According to Krathwohl, Bloom, & Masia (1973) suggests that learning that is more emphasized on rejection, acceptance level, emotion or feeling is learning on affective aspects. So far, there has not been much research on the development of an affective instrument, mostly focusing on students' cognitive and psychomotor skills, whereas assessing student attitudes is of course also very important. As concluded in Kusumawati's research (2015) that affective assessment is often ignored by teachers in the learning process where its implementation is always oriented to the cognitive aspect while the mandate of 21st century abilities and the curriculum that applies to learning requires a review from various sides of evaluation, not only cognitive such as attitude student. This urgency is also based on the importance of the affective aspect in the learning process, especially now that it has begun to emphasize character building learning to prepare the best students personally to join the community in the life of the nation and state. The importance of this affective aspect as stated by Krathwohl, Bloom, & Masia (1973) that learning is more emphasized on rejection, acceptance level, emotion or feeling is learning on affective aspects. The results of affective assessment will be seen through several characteristics seen in the behavior of students, such as enthusiasm in learning, discipline, high motivation in finding out something, as well as respect and respect for the subjects being studied (Epinur, Yusnidar, & Fuldiaratman, 2016).

So far, there has not been much research on the development of an affective instrument, mostly focusing on students' cognitive and psychomotor skills, whereas assessing student attitudes is of course also very important. As concluded in Kusumawati's research (2015) that affective assessment is often ignored by teachers in the learning process where its implementation is always oriented to the cognitive aspect while the mandate of 21st century abilities and the curriculum that applies to learning requires a review from various sides of evaluation, not only cognitive such as attitude student. This urgency is also based on the importance of the affective aspect in the learning process, especially now that it has begun to emphasize character building learning to prepare the best students personally to join the community in the life of the nation and state. The importance of this affective aspect as stated by Krathwohl, Bloom, & Masia (1973) that learning is more emphasized on rejection, acceptance level, emotion or feeling is learning on affective aspects.

The relevance of affective assessment with STEM learning is a form of innovation in the development of assessment instruments while at the same time adapting to the needs of students, including in the process of implementing 21st century skills through the STEM learning model. Research by Mardhiyatirrahmah et al., (2020) states that the integration that occurs between affective assessment and STEM learning, namely the learning activities produced in it can describe the overall student responses that are more memorable with a series of activities that actively involve the students themselves. so that it is hoped that the process of observing student attitudes can be monitored more effectively in accordance with the stages of activities they go through. Based on this, this researcher is interested in developing affective instruments or integrated attitude assessments by the STEM system as an effort to meet student needs and also other forms of business in order to prepare students to face the 21st century through the existing learning process.

2. METHODS

This study aims to produce an attitude assessment instrument in assessing students' attitudes towards STEM. This research is development research with the *Research and* Development method and uses the ADDIE development model. According to Sutarti and Irawan (2017) The steps of this process are called the R&D cycle, which consists of studying the research findings, developing the product, the test area in the setting that will be used later, and revising it in the stage of submitting the test. Sari et al . (2016) stated that the ADDIE model consists of five steps, namely: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. The development procedures in this study are, (1) Analysis. Drljaca, *et. al* (2017) stated that it is necessary to create an overall picture at the analysis stage, where at this stage it is necessary to emphasize a student-centered approach to design research basic materials. The things that are done at the analysis stage are conducting needs analysis, identifying problems, and analyzing tasks (Aldoobie, 2015; Amir & Kusuma, 2018; Fajarini, 2018). (2) Design. The design stage is the stage that is carried out first before the development is carried out (Harjanta & Herlambang, 2018). At this stage, it begins with determining the development team, determining the required resources, compiling a development schedule, making storyboards, determining product specifications, to making product prototypes. According to Lee & Owens (2004) shows an illustration of the division of time required in the development process as shown in Figure 1. Below.

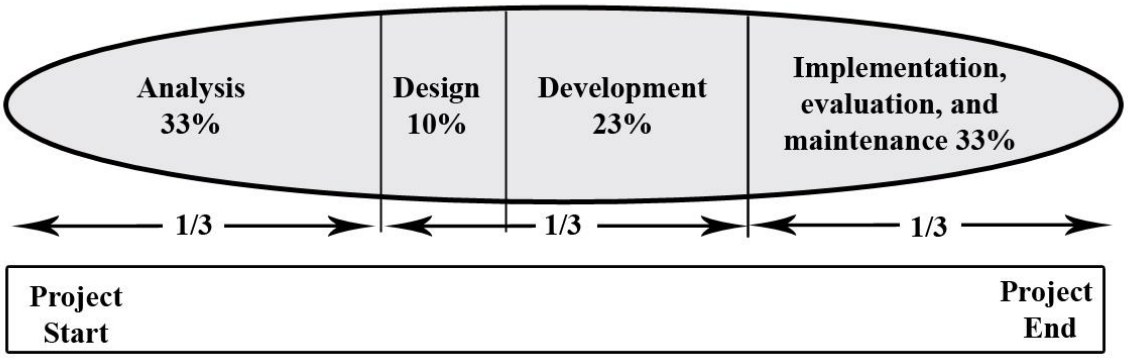

Figure 1. Ratio of Time in Development Process(Lee & Owens, 2004)

Next, the third stage of development. The development phase is the phase which involves producing and testing the methodology used in the project. This stage is carried out based on the previous two stages which are also refinements of the initial product that has been developed (Ghani, 2018; Setyosari, 2016) . The development phase includes the expert validation and product revision stages. The last is the implementation and evaluation stage. There are 45 instrument items that have been developed which will then be tested on 72 high school students selected by *random sampling*. Furthermore, the data from the test results will be analyzed using data analysis techniques using quantitative descriptive methods with the IBM SPSS Statistics 25 computer program to see the reliability and validity of the instruments that have been developed.

3. RESULT AND DISCUSSION

Results

This research begins with the analysis stage, at this stage the student analysis, needs analysis and other analyzes are the basis for this development, which were also obtained through previous studies on relevant research topics. Next is the design stage, at this stage the preparation of the instrument grid to be developed is carried out. The instrument indicator grid provided can be seen in Table 1.

Table 1. Grid of Attitudes towards STEM Instrument Indicators

STEM aspects	Indicator	Items
Science	Enjoyment of Science	1-17
	Positive response in learning Science	
	Career options in science	
	Awareness of the importance of science in life	
Mathematics	Fun for Math	18-29
	Positive response in learning Mathematics	
	Career options in mathematics	
	Awareness of the importance of mathematics in life	
Engineering and Technology	Passion for Engineering and Technology	30-45
	Positive response in learning Engineering and Technology	
	Career options in Engineering and Technology	
	Awareness of the importance of Engineering and Technology in life	

Furthermore, through the instrument grid, it enters the development stage, where an instrument for assessing student attitudes towards STEM is developed which produces 45 instrument items. Each item will be validated first by 2 (two) expert validators. The results of instrument validation were analyzed using a *Likert scale assessment* with 4 (four) criteria, namely very good with a score of 4, good with a score of 3, not good with a score of 2, and very bad with a score of 1. The results of expert validation can be seen in the following Table 2.

Table 2. Expert Validation Results

No	Aspect	Rating Indicator	Validator 1	Validator 2
1	Clarity	Clarity of statement items	3	3
2		Clarity of instructions for filling out the questionnaire	3	3
3	Accuracy	Statements related to research objectives	3	4
4		Statements according to aspects of STEM attitude indicators	3	3
5	Relevance	Conformity with the development of science and the latest	4	4
6		Statements reveal true information	4	3
7	language	The language in the questionnaire is easy to read and understand	3	3
8		The language used has clarity of information	4	3
9		The language used is ethical, communicative and in accordance with the target reader	3	3
10		Spelling, punctuation, vocabulary, sentences and paragraphs are in accordance with Indonesian rules	3	3
Average			**3.3**	**3.2**
			3.25	

Based on the results of the validation, it was obtained that the developed instrument obtained a value of 3.25 in the Good category so that it was ready to be tested on the test subject. The next stage is the implementation and evaluation stage, where at this stage, the instrument that has been validated is continued to be tested on the test subject, namely 72 high school students. At this stage, students will fill out a questionnaire that has been developed. Each item uses a Likert scale with a scale of 1-4. The test results of the developed product will be analyzed using IBM SPSS Statistics to see the reliability and validity of the product. Product validity is seen through the *Pearson correlation* which is compared with the r-table value, where the r-table value in this data is 0.235. If the value of r count < r table then the item is invalid and vice versa. For reliability value If the alpha value > 0.7 means sufficient reliability, while if alpha > 0.80 this suggests all items are reliable and all tests consistently have strong reliability. The results of the test data analysis to determine the validity of the items can be seen in Table 2 below.

Table 2. Validity test results

Items	r count	Information	Items	r count	Information
1	0.14	INVALID	24	0.486	VALID
2	0.305	VALID	25	0.56	VALID
3	0.4	VALID	26	0.301	VALID
4	0.344	VALID	27	0.377	VALID
5	0.499	VALID	28	0.361	VALID
6	0.378	VALID	29	0.388	VALID
7	0.475	VALID	30	0.295	VALID
8	0.298	VALID	31	0.398	VALID
9	0.485	VALID	32	0.328	VALID
10	0.517	VALID	33	0.398	VALID
11	0.552	VALID	34	0.353	VALID
12	0.397	VALID	35	0.22	INVALID
13	0.536	VALID	36	0.378	VALID
14	0.467	VALID	37	0.265	VALID
15	0.597	VALID	38	0.407	VALID
16	0.417	VALID	39	0.411	VALID
17	0.111	INVALID	40	0.343	VALID
18	0.342	VALID	41	0.298	VALID
19	0.459	VALID	42	0.175	INVALID
20	0.446	VALID	43	0.459	VALID
21	0.239	VALID	44	0.372	VALID
22	0.416	VALID	45	0.22	INVALID
23	0.56	VALID			

Based on the table, there are 5 (five) invalid items, namely items number 1, 17, 35, 42, and 45. So that these items can be revised or removed from the developed instrument. Furthermore, the data from the reliability of the test instrument after invalid items are removed can be seen in Table 3 below.

Table 3. Instrument Reliability Results

Reliability Statistics	
Cronbach's Alpha	**N of Items**
0.870	40

Based on Table 3, it is known that the value of Cronvach's Alpha instrument that has been developed is 0.870 so it is categorized as very good and has strong reliability.

Discussion

Through a series of development steps to data analysis that has been carried out, it can be said that the instrument for assessing student attitudes towards STEM that has been developed can be used and utilized in the assessment because it has been declared valid and has a high reliability value. The results of the study are in accordance with the theory where the statement items are valid and reliable, where the statement items are said to be valid if the value of r count < r table and reliability value. If the alpha value > 0.7 means sufficient reliability (sufficient reliability) (Arikunto, 2006) . The next analysis is viewed from how students' attitudes towards STEM are where the results of the assessment are

categorized based on learning which includes *Science, Technology, Engineering and Mathematics.* One of the students' attitudes towards *Science* is represented by an indicator of statement items on the positive response to the learning process of science and awareness of the important role of science in life. most of the students with a percentage of about 73.2% agree with the statement where STEM learning has a positive impact on the formation of student attitudes, especially respecting and realizing the importance of the science process in learning and its implementation later around them. The results obtained are relevant to previous studies where research by Septine *et al.,* (2019) stated that students' attitudes have increased with the existence of STEM learning, especially for students' scientific attitudes. The next indicator is for the *Technology component* which is represented by statement items that include interest and pleasure in technology-integrated learning as well as a desire for a career in the world of technology. A total of 64.56% of the total number of responses stated their positive attitude towards the statement items. The results of this study are in accordance with previous studies, namely Permanasari (2016) in his research, which states that STEM in addition to being able to train students' critical abilities can also develop the ability to use technology. This is also in line with the mandate of 21st century learning, namely planning for technological competencies that must be developed in it (Syahputra, 2018) .

The next review lies in the *Engineering aspect* , which indicators have been represented in the attitude assessment to include a positive response and a desire to be more involved in the development of the design/engineering capability. STEM learning is not only used to create more meaningful learning but also produces other skills needed in the 4.0 revolution, one of which is *engineering* . The percentage of 76.39% of students agree that the presence of STEM can increase awareness and curiosity about the world of *engineering* . The results of this study are relevant to previous studies by Alifa *et al.,* (2018) which concluded that collaboration that occurs in STEM learning is expected to raise awareness of attitudes to develop students' potential, especially in the field of engineering or design. This ability is not only based on learning theory but also based on direct application to a particular project. The last indicator used in the attitude assessment is the *Mathematics aspect* which is represented by the statement of a positive response and the development of mathematical ability in solving problems. A total of 79.39% of students agree with the statement. STEM learning is certainly closely related to the process of developing critical thinking skills based on a particular problem or project through various series of activities experienced by students. The results of this study are in line with the research of Mamahit *et al.,* (2020) which states that STEM is expected to develop students' mathematical abilities through the concepts of the material they have received so that they have a critical attitude towards a problem. The results of these studies indicate that STEM does not only carry out the mandate of 21st century abilities in learning but also its implementation can be seen to review student attitudes during the learning process.

The implementation of STEM in the learning process can also be studied to analyze students' critical attitudes as mandated by the curriculum which states that learning does not only prioritize understanding but also seeks to develop students' critical abilities for certain problems. STEM is a good collaboration for 4C abilities, namely *Communication, Creative, Critical thinking,* and *Collaboration* . Students' critical attitude can be observed on their ability to manage information and interpret scientific facts so that they can build their own arguments. The results showed that 80.56% of students gave a very positive statement that STEM learning had an impact on their curiosity about the process of analyzing a certain natural phenomenon so that *critical thinking* from students could be developed during the learning process. The next implementation of STEM can also be used to develop students' abilities, especially *Communicative* where the results of the study show that 59.72% agree that the STEM learning process not only helps them to solve problems but can also discuss and communicate to build the information and interpret the data into a conclusion. In addition to the *Communicative* process , there are also *Creative* and *Collaborative* that are trained during the STEM learning process. The results showed that 61.11% and 72.69% of students gave positive responses to both the attitude of the *Creative* and *Collaborative aspects* where STEM learning provides students with opportunities to develop their creativity to create something and indirectly through the communication process in which students will collaborate with each other to create certain ideas to solve the problem. Based on these conditions, it can be said that the urgency of implementation does not only play a role in improving the ability of *Science, Technology, Engineering and Mathematics* but is also relevant to the learning needs of students as mandated by the objectives of the existing curriculum. The results also show that there is a relevance to previous research regarding the impact of STEM on students' abilities and learning outcomes so as to prepare a competent generation in accordance with the needs of the global era, STEM learning and assessment deserves consideration for its implementation (Nurhaifa, Hamdu, & Suryana, 2020) .

4. CONCLUSION

The development of the current era of technology and digitalization has demanded an increase in the ability of human resources and interest in human work in the fields of digitalization of technology. The instrument for measuring student attitudes towards STEM that has been developed has met the reliable and valid criteria so that it is effective for use in trials on a wider scale. Reviewing the evaluation of students' attitudes towards STEM is able to improve students' abilities and awareness in the aspects of *Science, Technology, Engineering and Mathematics* through the activities they go through. Through this development, it is hoped that it can become a basis that can be used by educators before giving appropriate treatment to students in preparing students who have attitudes towards STEM aspects so that students can face various challenges of the 21st century that are so tight and growing rapidly.

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