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Identifying preliminary analysis for Developing an Integrated STEM (Science, Technology, Engineering and Mathematics) Learning Model on Chemistry Teaching in High Schools

Vera Roni Setiawan[1*], Manihar Situmorang[2], Ramlan Silaban[3]

[1]Department of Chemistry Education, Universitas Negeri Medan, North Sumatera, Indonesia
[2,3]Departement of Chemistry, Universitas Negeri Medan, North Sumatera, Indonesia

*Corresponding Author: veraroni1109@gmail.com

Abstract. *Developing a learning model at an early stage requires a needs analysis to identify the needs required by teachers, students and the applicable curriculum. This research aims find out how to implement learning models in schools in order to accommodate the learning needs of the 21st Century. The research subjects were chemistry teachers and students studying chemistry at high school level in Southwest Aceh Regency, Aceh Province. Overall, the research used the ADDIE approach, initial analysis carried out data collection using a questionnaire in the form of a questionnaire distributed via Google Form. The data obtained is the first step in further research. Based on the research results obtained, 64.3% of teachers have implemented learning that stimulates students to think at a higher level. as many as 51.7% of teachers have implemented learning models in teaching chemistry; 78.6% knew something about STEM learning, 7.1% did not know; as many as 57.1% have tried STEM learning but 50% are not satisfied with the results achieved; 85.5% acknowledged difficulties in implementing STEM in the classroom; 50% believe the STEM model influences students' thinking skills; 92.9% need a STEM integrated project learning model book. Meanwhile, of the students who obtained the results: 42.5% stated that they had difficulty understanding chemistry; 92.5% are happy if chemistry learning is connected to the real world; 92.5% stated that school textbooks were a learning resource; 55% experienced learning obstacles based on school learning resources; 90% need a learning model that connects chemical material with the real world.*

Keywords: *learning model development, STEM, preliminary analysis*

1. Introduction

The National education curriculum was developed based on strengthening thought patterns, several learning patterns including: strengthening active, interactive, independent and group/team-based learning patterns, strengthening networking patterns where students can learn from any relevant source, strengthening plural (multidisciplinary) knowledge and strengthening critical learning patterns (Permendikbud 36, 2018). The new policy on curriculum is intended to give teachers the authority to develop learning activities that are relevant to students' needs, the real conditions of the school, and the need to relate them to the surrounding environment (Suprapto, Prahani, and Cheng, 2021).

In order to prepare students to continue to a higher level of education, the learning process at the high school level must reflect a learning process that stimulates students to carry out high-level reasoning (Ahmad et al., 2018; Lailly and Wisudawati, 2015). High order thinking skills (HOTS) are really needed by students in studying science and technology. High order thinking skills are scientific skills in building knowledge from available information and analyzing it for use in solving problems and drawing conclusions, thereby leading students to a deep understanding of the material being studied (Situmorang et al., 2022).

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Entering the era of globalization in the 21st century, in order to play a meaningful role in life, every citizen is required to have abilities in accordance with the demands of current developments. 21st century learning requires innovation in the way of thinking, formulating ideas and acting (Ichsan et al., 2020; Sepriyanti et al. 2022). To create quality human resources, high-level thinking skills are needed by students in facing real-world problems in facing 21st century learning (Misrom et al. 2020; Stehle and Peters-Burton, 2019). The ability to think at a high level really determines the quality of a person's thinking to foster a positive attitude in developing their knowledge skills (Heong et al. 2016; Sepriyanti et al. 2022). Higher order thinking skills such as critical thinking and problem solving are one of the skills needed by 21st century individuals (Mater et al. 2020; Stehle and Peters-Burton, 2019).

Openness of information and knowledge where knowledge is very easy to obtain and collect in this era. Therefore, the concept of learning must be packaged so that it can build the skills needed by students to be successful in the 21st Century, namely learning that can contribute to the development and ability of cooperation, problem solving, creativity and innovation which has the potential to support the economy. STEM-based learning is one solution in answering this educational challenge. Science, Technology, Engineering and Mathematics (STEM) is a learning approach that uses an inter-science approach where the application is carried out using problem-based active learning. One active learning can be done using the project method. Project learning has a positive effect on the quality of science education and makes students actively investigate phenomena that occur in the natural environment (Lee, Chai, and Hong 2019; Purwaningsih et al. 2020). STEM is implemented in classrooms by implementing many activities that integrate science, technology, mathematics and engineering which enable students to ask questions, investigate problems based on real-world contexts, develop critical thinking skills, and make them productive students (Mater et al. 2020). STEM learning accommodates 21st century skills (Stehle and Peters-Burton, 2019), improves students' problem-solving skills (Duc, Linh, and Yuenyong, 2019; Purwaningsih et al. 2020), increases critical thinking abilities (Mutakinati, Anwari, and Yoshisuke, 2018), enhancing arts and entrepreneurship (Aydın-günbatar, 2020).

From the description above, the development of an integrated STEM learning model is very interesting to develop in order to welcome the 21st century and increase students' HOTS to face the real world. The implementation of this research will use the ADDIE design development steps. ADDIE is an abbreviation for Analyze, Design, Develop, Implement, and Evaluate. ADDIE is a product development concept. The ADDIE concept is applied to build performance-based learning. The philosophy in implementing ADDIE is that intentional learning must be student-centered, innovative, authentic, and inspiring. The concept of systematic product development has existed since the formation of social communities. developing products using the ADDIE process remains one of the most effective process tools (Branch, 2009). In the Analyze Stage, an initial needs analysis was carried out for the development of innovative learning models based on integrated STEM projects. This article highlights the initial needs analysis in the context of developing a STEM integrated learning model. Field factors include teacher needs, learning conditions at school, student needs, obstacles to learning and the applicable curriculum. The information obtained becomes the basis for developing innovative integrated STEM-based learning models.

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2. Method

This research as a whole uses the ADDIE approach. The first stage of the ADDIE approach is the analysis stage (Branch, 2009) which is the initial stage of developing the learning model that will be developed. The ADDIE Approach consists of several phases, namely: Analysis, design, development, implementation and evaluation. Where each phase of the ADDIE approach is an input for the process in the next phase. Analysis of the initial needs of teachers and students was carried out using instruments in the form of questionnaires which were distributed to teachers and students through the Google Form application and interviews. An analysis was carried out of the ongoing conditions of chemistry learning including teaching and learning activities, application of related models with HOTS learning and the obstacles faced by both teachers and students as well as the solutions offered. This research took place in Southwest Aceh District. The population in this study were all teachers and students in Southwest Aceh District High School, Aceh Province. The sample in This research includes teachers who teach chemistry subjects and students who study chemistry at high school. The collected data is then processed and displayed in the form of diagrams and graphs which are then analyzed as input for the next phase of learning model development. The data analysis technique uses descriptive statistical analysis techniques, where the data collected is analyzed by describing the collected data as it is without intending to simplify things in general (Sugiono, 2013).

3. Results and Discussions

The results of the analysis of the description of the initial conditions in high school chemistry learning in Southwest Aceh Regency as a whole are seen from the teaching staff, in this case teachers who teach chemistry subjects and the impact achieved by students studying chemistry. The current conditions of chemistry learning and the efforts made to improve high order thinking skills (HOTS) of high school students are described as follows.

Teacher Analysis

A description of the teacher's knowledge of HOTS learning can be seen in the following Table 1.

Table 1. Results of analysis of HOTS learning in class

No	Description	already (%)	Not yet (%)
1	Are you familiar with HOTS learning?	92,9	7,1
2.	Have you attended HOTS training?	71,4	28,6
3.	Do you understand HOTS learning?	71,4	28,6
4.	Have you implemented HOTS learning?	64,3	35,7
5.	Have you implemented models, methods or techniques according to 21st Century skills?	85,7	14,3

(Source: Research Data, 2022)

From Table 1 above, teachers are aware of HOTS learning, but its implementation in class is less than 65%. This means that even though teachers already know and understand the learning that triggers students' HOTS, they still experience problems in implementing it in the classroom. In developing an innovative STEM integrated project-based learning model, it is necessary to pay attention to the learning climate in terms of both teachers and students. Innovative learning is very necessary to motivate students in the learning process. Innovation in learning has also proven effective in improving

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learning activities, facilitating students' cognitive development and providing a pleasant learning environment (Sinaga, Situmorang, and Hutabarat, 2019). The availability of innovative learning resources equipped with projects is able to guide students to learn organic chemistry in a more enjoyable environment, facilitate students to create projects so that learning becomes active and meaningful and the chemical material studied is remembered longer and of course can improve student achievement (Situmorang, Purba, and Silaban, 2020).

In using the learning model, data was obtained that 100% of teachers carried out planning in teaching and understood the learning model applied and the learning model was adapted to the material being taught. 92.9% of teachers stated that it was necessary to apply models in classroom learning, 85.7% of teachers agreed that the use of models in learning helped teachers achieve learning goals. The use of learning models in a month is 57.1% of teachers using > 2 times; 28.6% < 2 times and 14.3% always use models in learning. The initial analysis in using the learning model in the classroom is good and planned in the teacher's RPP. It's just that this learning model has not been specifically designed to improve students' high-level thinking skills. Teachers already know the learning that triggers students' HOTS but still experience obstacles in implementing it.

A description of teacher knowledge about STEM learning can be seen in the following Figure 1.

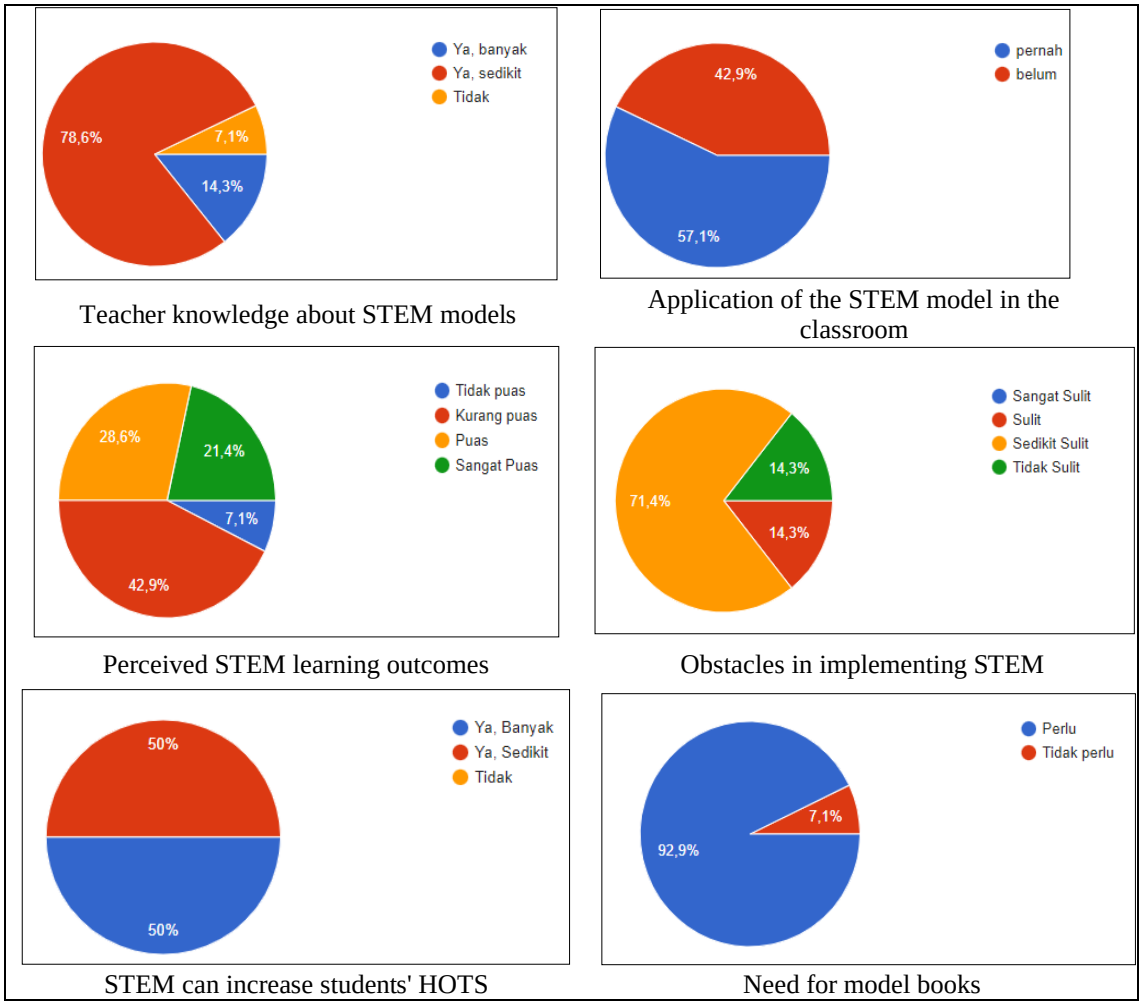

Figure 1. A description of teacher knowledge about STEM

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Figure 1 shows that 78.6% know little about STEM learning and even 7.1% do not know about STEM learning. As many as 42.9% have not implemented STEM learning in class and 57.1% have implemented it. However, the level of satisfaction with the STEM model implemented is relatively low, namely: 42.9% are not satisfied, 7.1% are not satisfied, which means that 50% of teachers are not satisfied with the results of learning using STEM. 71.4% of teachers said it was a little difficult and 14.83% found it difficult or 86.2% still felt it was difficult to implement STEM in the classroom. However, 50% of teachers think that it has a lot of influence and 50% has little influence on STEM learning on improving students' HOTS according to the demands of 21st century learning. To overcome the obstacles faced in STEM learning, 92.9% of teachers need STEM learning model books to improve HOTS students.

The use of varied learning models is very important to support students in achieving the learning goals that have been set based on the applicable curriculum. In the development of the world of education, 21st century skills are one of the educational indicators that must be applied in learning so that students are able to compete globally with various kinds of challenges. Stehle and Peters-Burton (2019) assume that 21st century core skills facilitate knowledge construction and real-world problem solving, while student self-regulation creates efficiencies that result in increased knowledge construction. Innovation in learning is really needed both in terms of model development and teacher abilities. Innovation in teaching materials has proven effective in improving student learning achievement. Situmorang et al. (2018) have developed innovative learning materials with complete and systematic guided assignments that can be provided in book, module and e-book formats to facilitate students to study chemistry according to students' needs and be able to improve their learning outcomes. (El Nagdi, Leammukda, and Roehrig, 2018) state STEM has evolved into "a meta-discipline, an integrated effort that removes traditional barriers between STEM subjects, and instead, focuses on innovation and the applied process of designing solutions to complex contextual problems. Integration in curriculum design and implementation, connecting classroom practice with the real world, and focusing on innovation and application. With the development of a STEM-based project learning model, it has become a reference in developing students' high-level thinking skills (HOTS), especially at high school level in chemistry learning.

Student Analysis

The situation of students when studying chemistry at school can be seen from various problems such as difficulties in understanding chemistry, abstract material in chemistry learning, learning that triggers improving students' high-level thinking skills and learning resource books that become references for students learning and learning needs that are in accordance with current development. The results of the analysis of students' conditions in the field are depicted in Figure 2.

From Figure 2, it can be seen that 42.5% agree and 2.5% strongly agree that understanding chemistry is difficult. 92.5% of students stated that they preferred learning chemistry that was connected to the real world. So, the development of an innovative STEM integrated project-based learning model is a solution to the obstacles experienced by students in the field. Research results (Mater et al. 2020) show students expressed their enjoyment of learning through STEM activities and considered it a special learning experience. students can understand three main things in STEM learning: 1) positive changes in their attitudes towards science, technology and Mathematics. 2) Able to

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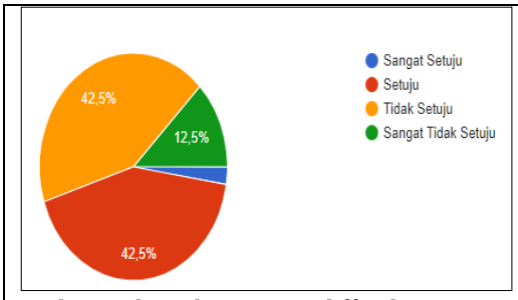
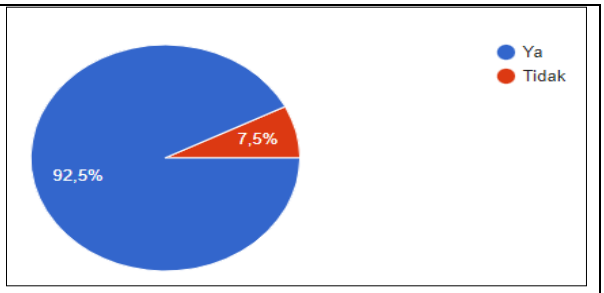
connect learning theories in school with the real world. 3) Provides new learning experiences and ways of thinking. STEM learning connects knowledge in school with real life, so that with high creativity it will produce products that are useful. STEM activities give students the opportunity to use scientific knowledge, solve problems, and design and produce the materials they make. Furthermore, they also have a lot of fun when they try to market their products.

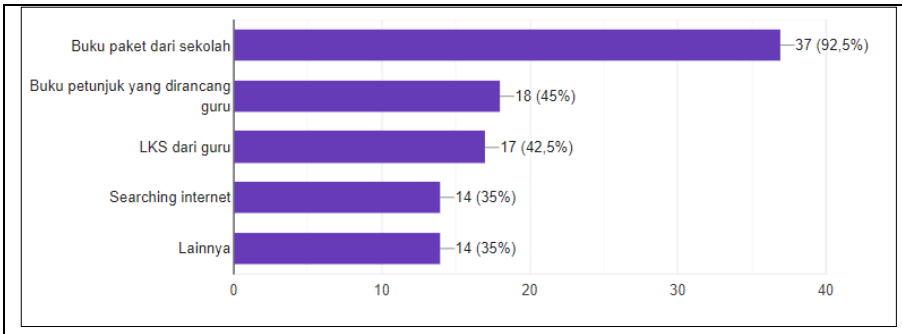


Understanding chemistry is difficult

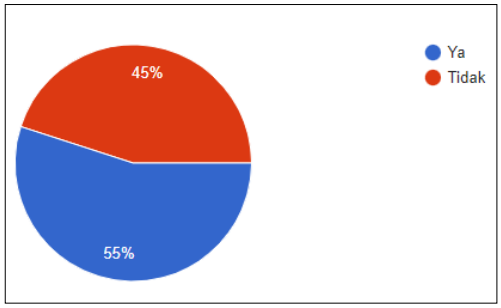


Enjoy studying chemistry if connected to the real world

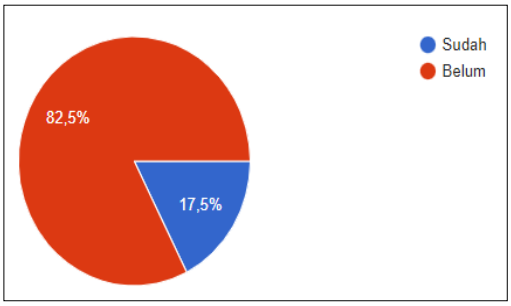
Figure 2. Students' understanding and studying in chemistry



Learning resources commonly used in chemistry learning



Are there any obstacles to learning from current learning sources?



Do you know HOTS Learning?

Figure 3. Students' learning resources in schools predominantly use textbooks

From Figure 3, it can be identified that students' learning resources in schools predominantly use textbooks provided by the school. However, 55% (Figure 3) of students stated that they experienced problems in learning based on learning resources from textbooks distributed at school. Thus, innovation in learning resources is also urgently needed to improve student learning outcomes. This is in accordance with research results (Situmorang et al. 2022) which state that the implementation of learning resource packages effectively guides students to carry out their own projects in learning and improves student learning outcomes. Figure 4 shows that students do not understand

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learning that can stimulate HOTS students, namely 82.5% do not understand what HOTS learning is. Learning resources must follow current technological developments. Learning resources must be innovated in order to improve student HOS and learning resources can also be used anytime and anywhere and can be accessed online or offline. So, in developing learning resources from the integrated STEM project model, learning resource links will be used that can be accessed by students and teachers.

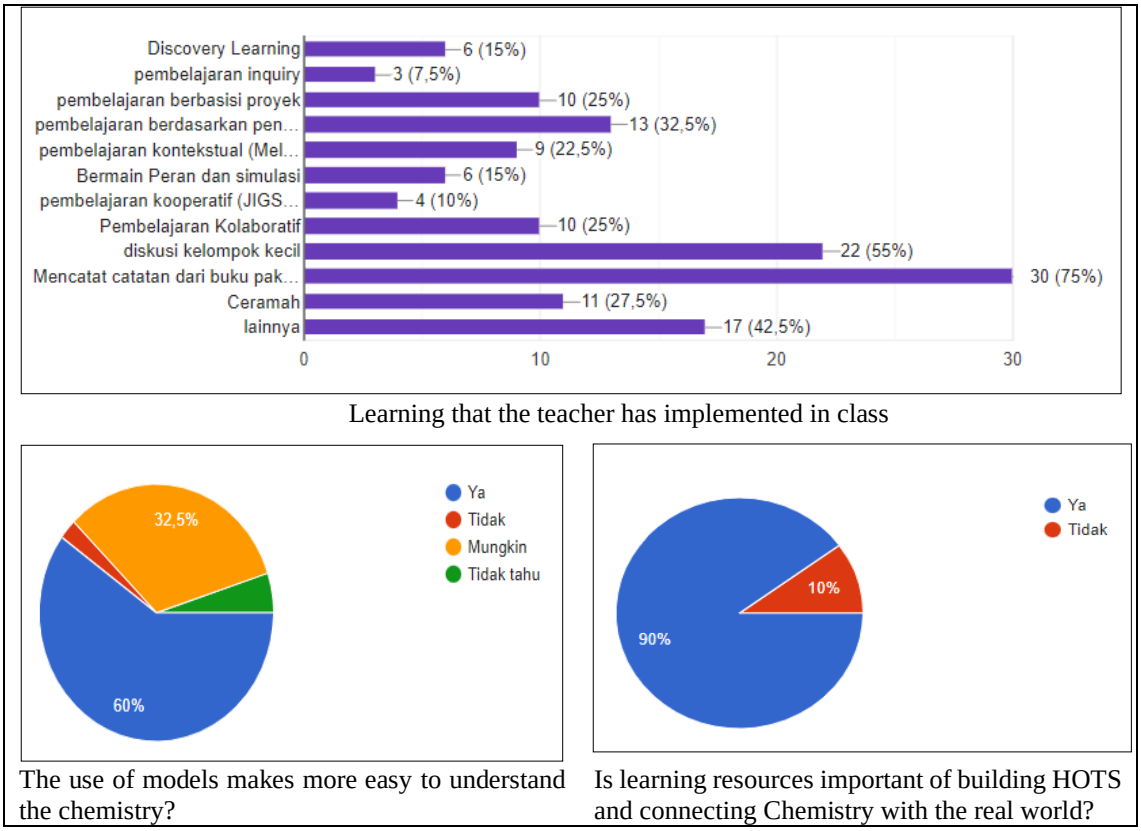

Figure 4. Students' opinions about the learning implemented by teachers

According to students' opinions about the learning implemented by teachers in the class, the dominant answer was to record summaries from school textbooks by 75%, small group discussions, 55%. From Figure 4, it can be seen that 60% of students admitted that using models in learning made it easier for them to understand chemistry material. And 90% of students really need learning resources that can build their HOTS and connect chemical material with the real world. Development of learning innovations to improve high-level thinking skills in junior high schools in Thailand. The research results show that students' high-level thinking abilities after experiencing learning innovation have a higher average score than before. From the student situation described above, it will become input in the development of an innovative STEM integrated project-based learning model which will be developed at the next stage (Kwangmuang et al. 2021).

Curriculum Analysis

The need for learning models cannot be separated from the standard standards of the applicable national learning curriculum. The application of learning models must be adapted to the demands of the curriculum that applies in Indonesia. Based on the analysis of the curriculum currently implemented in schools, it can be seen in Figure 5.

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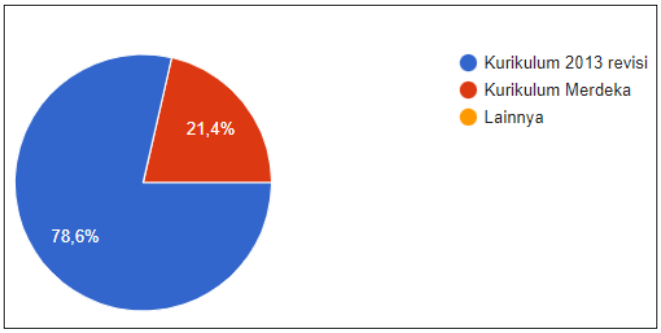

Figure 5. Curriculum currently being implemented in schools

From Figure 5, it can be seen that 78.6% of schools in Southwest Aceh Regency are still using the revised K-13 curriculum and 21.4% are using the independent curriculum. The use of the curriculum is based on developing student competencies. Curriculum development focuses on active learning so that students become creative and innovative. Based on this active learning, the development of an innovative STEM integrated project-based learning model is suitable for use in the K-13 curriculum or Merdeka curriculum. With this curriculum, it is hoped that teachers can adapt the learning carried out. Developing learning models is one solution in achieving national education goals, in accordance with the statutory mandate to make the nation's life intelligent.

4. Conclusions

Based on the results of the initial needs analysis survey of teachers teaching chemistry subjects and students studying high school chemistry in the Southwest Aceh district, it can be concluded that: not all teachers understand HOTS learning; the application of learning models is still an obstacle in achieving learning objectives; Relative learning resources only use textbooks at school. As many as 64.3% of teachers have implemented learning that triggers student HOTS; 51.7% have used models in teaching chemistry; 78.6% knew something about STEM learning, 7.1% did not know; STEM learning has been tried by 57.1% of teachers, but 50% are not satisfied with the results achieved; 85.5% admitted to having difficulty implementing STEM in the classroom; 50% believe the STEM model influences students' HOTS; 92.9% need a STEM integrated project learning model book that builds students' HOTS skills. Meanwhile, the results obtained for students: 42.5% stated that it was difficult to understand chemistry; 92.5% are happy if chemistry learning is connected to the real world; 92.5% stated that school textbooks were a learning resource; 55% experienced learning obstacles based on school learning resources; 82.5% do not know HOTS learning and 90% need a learning model that stimulates HOTS that connects chemical material with the real world. Based on these results, the researcher wants to carry out further research on the development of innovative learning models based on integrated STEM projects to improve the high-level thinking skills of high school students, especially in the Southwest Aceh district.

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