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Improve Student Learning Outcomes through the Development of Quantum Learning-Based Learning Instruments on Hydrocarbon and Petroleum

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Abstract: The study aims to develop a quantum learning-based learning instrument on hydrocarbon and petroleum; determine the feasibility of quantum learning-based learning instrument on hydrocarbon and petroleum, and determine the effectiveness of quantum learning-based learning instrument on hydrocarbon and petroleum to improve student's learning outcomes. This type of research is research and development (R&D) using the ADDIE model (analysis, design, development, implementation, and evaluation). The product developed consists of a syllabus, lesson plans, teaching materials, and assessment instruments. The validation results were analyzed using Aiken's validation obtained a validity coefficient of more than 0.80 or categorized as valid and suitable for use. The effectiveness test results were analyzed using SPSS22 obtained t-count > t-table, so it could conclude that quantum learning-based learning tools on hydrocarbon and petroleum materials were effective for improving student learning outcomes.

Keywords: Development; Learning instrument; Learning outcomes; Quantum learning

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Introduction

Education is a necessary element in human life. Education aims to provide information, skills, experience (Kartini, et al., 2022), build good human resources (Widowati, et al., 2017), form a competent society (Susetyarini & Fauzi, 2020), and have a good attitude and morals (Oktaviani & Sumardi, 2016). Likewise, chemical education has great potential and a strategic role in preparing quality human resources to face the industrial and globalization era (Siagian, 2020). Whenever and wherever humans are, education always will be needed by every human being throughout his life (Hermawanti, et al., 2018), because principally, education makes students as lifelong learners. Through learning, humans become aware of previously not knowing.

Learning as a process should do by teachers based on design and planning. Before teaching, the teacher must plan a lesson (Warsah & Nuzuar, 2018), because one of the necessary tasks that teachers must carry out is designing, delivering, and evaluating learning (Setyosari, 2020). Therefore the success of the learning process is determined by these components (Kirana & Al-Badri, 2020). A good teacher must master the subject matter and teaching methods. Learning design helps teachers choose the most effective strategy for conveying subject matter so that easy to learn by students (Piskurich, 2015). Experienced teachers still need teaching planning, both for something new or already have taught, because that is a necessary part of teaching (Cruickshank, et al., 2014). Learning design is an iterative process that begins from planning goals, determining strategies, selecting media, selecting or developing teaching material, and evaluation (Branch,

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2009). Each phase of teaching (planning, implementation, evaluation, and reflection) is a process that is related to and has a direct effect on teacher teaching planning (Koni & Krull, 2015).

The teachers' task is to present the knowledge they have back in form the learning instruments so easily understood by students (Bucat, 2004). Therefore, teachers must know their teaching abilities because it can help them transform knowledge about material into a form that is accessible to students (Geddis, 1993). In other words, the learning process requires a learning instrument to achieve learning objectives (Rahman & Atun, 2016).

Developing learning instruments is one of the preparations that the teacher must have done before starting the learning process (Yulius, et al., 2017). Learning instruments is tools used in the learning process, consisting of a syllabus, lesson plan, activity sheets, assessment sheets, student books, teacher handbooks, and learning media (Kirana & Al-Badri, 2020; Susdarwati, et al., 2016). That all aims to make it easier for students to understand the material taught. One of the components that support of successful learning is teaching materials (Prabawati, et al., 2019), for example textbooks. Textbooks are learning instruments that function to describe the characteristics of science through the material presented in them (Ayık & Coştu, 2020), providing learning experiences that can facilitate the development of students' thinking skills (Yamtinah, et al., 2020). Textbooks can foster student motivation if the tasks conceive within them encourage them to work collaboratively, improve skills, and increase their understanding (Romero, et al., 2020). Therefore, the learning instrument needs to be developed by the teacher as a form of planning and learning design because the teacher best understands the characteristics of students (Zebua, et al., 2018). Learning tools developed by teachers describe how to teach and activities to be carried out in learning (Sholihah, et al., 2016).

Learning instruments should integrate learning strategies so that learning goals can be achievable (Yulius, et al., 2017). Learning activities that are not based-learning strategies will not be well done and will cause low student learning outcomes (Soebiyanto, et al., 2016). A good learning strategy is a strategy that involves students being active in learning and creating a comfortable learning environment. Designing a learning environment that actively involves students, provides space for independent and guided learning, and forms positive social relationships is the best way to gain knowledge and lifelong learning (Hascher, 2013). A relaxed and comfortable learning environment makes students actively involved in his study (Sarnoto & Romli, 2019), improve student concentration so that it makes learning easy (Harjali, et al., 2016), and can positively change student behavior patterns (Asyhari, et al., 2014). A person's emotional state can affect their learning conditions, so students who enjoy learning will not show faces that are stressed or depressed (Zaki, et al., 2020).

One of the learning strategies that create a comfortable, relaxed, fun learning environment and still prioritizes student activity is quantum learning. Quantum learning is tips, instructions, strategies, and the entire learning process that can sharpen memory and understanding; and make learning a fun and helpful process (DePorter & Hernacki, 2015). Quantum learning can improve the quality of learning (Sudirman, et al., 2017), increase student concentration and participation (Yanuarti & Sobandi, 2016), and increase student learning outcomes (Yahya, 2017). Students' active learning can improve their memory of the learning information (Puspita, et al., 2017). It is because student-centered and interactive learning can encourage students to find new information, develop their abilities, and effectively improve learning outcomes (Duran & Dökme, 2016).

The stages in quantum learning are grow, experience, label, demonstrate, repeat, and celebrate (DePorter, et al., 2010). The first stage: grow; this is the stage of arousing student motivation and curiosity by relating the topic of discussion to phenomena in life. Second stage: experience; providing information through experiences so students can associate with their concepts. Third stage: label; building concepts from their experience and previous knowledge. The fourth stage: demonstrate; creating conditions that help students apply their understanding about learning topics. Fifth stage: repeat; providing repetition in various ways so that students' knowledge sticks in the memory. Sixth stage: celebrate; celebrate student successes through verbal rewards and prizes to build positive emotions and student motivation.

Quantum learning helps teach abstract concepts such as chemistry materials because of experience stages and demonstration. Both provide an overview of the topics studied through the activities in them. Chemistry materials need to convey to students through direct experience (Suyanti, 2010) because understanding the concept of material is related to how the information can be received by students so that the learning objectives can be achieved (Ningrum, et al., 2021).

The characteristics of chemical concepts and how to represent them make chemistry assumed a complicated subject. Most students think that the material of chemistry is quite complex because it uses abstract symbols and terms that must be memorized (Handayani, et al., 2021). It causes students to have a poor perception of chemistry lessons (Sausan, et al., 2019). One of them is organic chemistry (Sirhan, 2007). The materials related to organic chemistry at the high school level are hydrocarbon. Hydrocarbon is the basis of many high school chemicals. One of the materials associated with it is petroleum.

Based on the description above, learning instruments with quantum learning approaches are needed to develop. That is to support the learning so that learning objectives can be achievable. This research aims to develop quantum learning-based learning instruments on hydrocarbon and petroleum; determine the feasibility of quantum learning-based learning instruments on hydrocarbon and petroleum; and determine the effectiveness of quantum learning-based learning instruments on hydrocarbon and petroleum to improve student learning outcomes.

Method

The implementation of the research is in two senior high schools in Sragen. This study is research and development (R&D) using the ADDIE model (analysis, design, development, implementation, evaluation) (Branch, 2009). Development procedure showed in Figure 1.

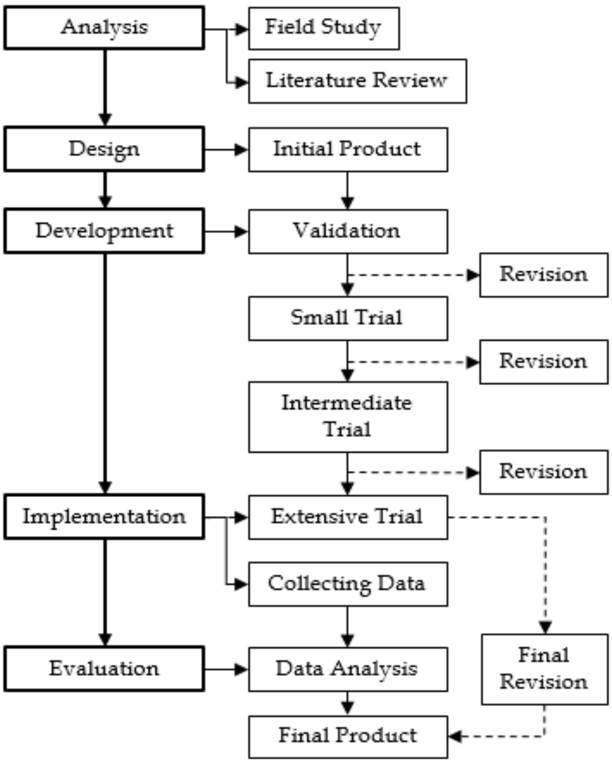

Figure 1. Development procedure

The analysis stage is a preliminary study to map the problems in schools and what is needed to support the learning process. The design stage is a learning design process starting from formulating learning objectives to determining evaluation tools to determine the success of the learning process. The development stage is the developing learning tools that will use in the learning process. At this stage were also validation, small trials, and intermediate trials.

The products developed were validated by experts (learning experts, material experts, media experts, and linguists), practitioners, and peers to determine their eligibility. The data were obtained through a questionnaire and analyzed using Aiken's validation (Aiken, 1985; Azwar, 2016).

$$V = \sum S/[n(c-1)],\ S = r - lo \quad (1)$$

Note:
V = validity coefficient
lo = lowest scale
c = number of grading scale
r = validator's assessment
n = number of validators

The subjects of the small trial consisted of 9 students of grade 12 and 2 teachers, while intermediate trial subjects consisted of 18 students of the grade 12 and 3 teachers. This trial aims to determine the legibility of content, presentation, language, and graphics. Data obtained through student and teacher questionnaires were analyzed using the following equation:

$$\% = \frac{Result\ score}{Maximum\ score} \times 100 \quad (2)$$

Determination of the range of response criteria follows the method of Azwar (1993) by considering the minimum-maximum percentage and assuming that the data were scattered evenly or normal. The response criteria of students and teachers can see in Table 1.

Table 1. Student and Teacher Response Criteria

Percentage (%)	Category
$x \leq 43.75$	Very bad
$43.75 < x \leq 56.25$	Bad
$56.25 < x \leq 68.75$	Enough
$68.75 < x \leq 81.25$	Good
$81.25 < x$	Very good

The implementation stage is an extensive trial stage, namely implementing the product developed in the learning process. The extensive trial (implementation stage) uses a quasi-experimental method to test the effectiveness of quantum learning-based learning instruments in improving student learning outcomes on hydrocarbon and petroleum. The quasi-experimental design used was the pretest-posttest control group design (Creswell, 2012). The subjects of the extensive trial were 136 grade 11 students from two schools. Each school consists of 2 classes, namely the experimental and control class. The experiment class uses instruments based on quantum learning, while the control class uses teacher learning instruments.

Data on learning outcomes in the knowledge aspect obtained by tests. The experimental and control class have given pretest and posttest to determine the increase in learning outcomes (N-Gain) which were analyzed using the following equation (Sundayana, 2015):

$$N - Gain\ (g) = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score} \quad (3)$$

N-Gain scores were then consulted in Table 2 to find out the criteria for learning outcomes obtained. Learning outcomes in attitudes and skills aspects are measured using observation sheets and analyzed using formula 2. In the extensive trial, a questionnaire was also given to 70 experimental class students and five teachers to determine the legibility of the product.

Table 2. N-Gain Score Criteria

N-Gain Score	Category
$-1.00 \leq g < 0.00$	Decrease
$g = 0.00$	Constant
$0.00 < g < 0.30$	Low increase
$0.30 \leq g < 0.70$	Medium increase
$0.70 \leq g \leq 1.00$	High increase

The evaluation stage is the analysis stage of the effectiveness of product application in learning based on student learning outcomes. Data were analyzed using SPSS22.

Result and Discussion

The product developed is a learning tool consisting of a syllabus, lesson plans, teaching materials (textbook), and assessment instruments. The learning instrument developed integrates quantum learning steps. Before using the product is validated first. Textbook validated by 12 validators and other products validated by eight validators. Then, the analysis results compare with the Aiken validity index at the 0.05 significance level. The validity index with 12 validators was 0.69, while the validity index with eight validators was 0.75 (Aiken, 1985). The data showed in Table 3.

Table 3. Aiken's Validation Result

Learning Instruments	Number of Validators	Validity Coefficient	Aiken Validity Index	Criteria
Syllabus	8	0.83	0.75	Valid
Lesson plan	8	0.83	0.75	Valid
Teaching material	12	0.85	0.69	Valid
Test question	8	0.90	0.75	Valid
Attitude observation sheet	8	0.85	0.75	Valid
Skill observation sheet	8	0.89	0.75	Valid

Table 3 shows that the products of the developed devices obtained a validation coefficient of more than 0.80. The validity coefficient obtained is higher than the validity index based on the number of validators. It means that the quantum learning-based learning instrument developed is valid and eligible to be tested.

The trial had carried out three times to determine students' and teachers' responses to product legibility. The aspects assessed are content, presentation, language, and graphics. The trial results showed in Table 4.

Table 4. Percentage of Students and Teachers Responses

Aspect	Small Trial		Intermediate Trial		Extensive Trial	
	Student	Teacher	Student	Teacher	Student	Teacher
Content	81.25	75.00	87.85	93.75	88.04	92.50
Presentation	77.78	81.25	85.76	81.25	87.23	93.75
Language	72.22	81.25	84.38	89.58	89.29	92.50
Graphic	81.94	81.25	89.58	91.67	90.98	91.25
Average	78.30	79.69	86.89	89.06	88.88	92.50

Table 4 shows that the average percentage of student and teacher responses to the small trial is less than 80 percent. Even so, the instrument developed was a good criterion. In this, the language aspect received the lowest percentage of student assessments. That is because there are several explanations that students find confusing. That needs to be improved using easy-to-understand sentences so as not to cause misconceptions. One of the difficulties in studying science is understanding the science language (Wellington & Osborne, 2001). The content aspect received the lowest percentage in teacher responses in the small trial. According to the teacher, some material explanations are still incomplete. If the material is weak and improperly structured, it can hinder learning. The teacher also suggested that the content to combined with the image. Images are a medium for conveying learning information (Smaldino & Russell, 2014). The existence of pictures will help students understand each explanation.

In the intermediate trial, student and teacher responses have increased. That is because of the improvements that have done. The responses received were 86.89% and 89.06% and were categorized as very good. The percentage of language aspects increased from 72.22 to 84.38% in student assessments. It meant that the sentences had been used easier for students to understand. The important thing needed to improve the quality of science learning is the language used (Wellington & Osborne, 2001). The percentage of content aspects also increased from the previous 75.00 to 93.75% in teacher assessments because the content has been improved based on the teacher's advice. However, in the intermediate trial were also some suggestions and improvements made. The results of the extensive trial also showed an increase. Although not as big as the increase in the previous test. Students and teachers judge that the developed learning instrument is very well in the extensive trial. Based on the results of these trials, the device is suitable for use.

Students were given tests before and after learning activities on the implementation stage (extensive trial). The pretest and posttest results showed in Figure 2.

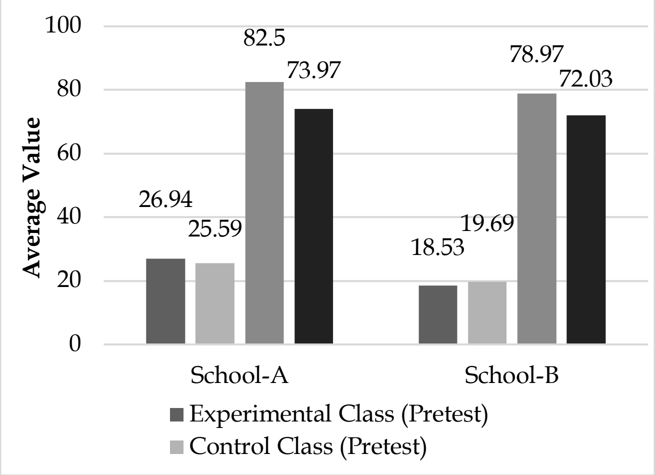

Figure 2. Pretest-Posttest Result

Figure 2 shows that the posttest results in both schools were higher than the pretest results. The average pretest score obtained is less than 30.00, while the posttest is more than 70.00, which means there is an increase in student knowledge after carrying out the learning process. It means that learning is an activity to gaining knowledge and understanding about something. The posttest average of the experimental class was higher than the control class in both schools. It indicated that learning using quantum learning was better than conventional learning. It also is seen from the difference in the N-Gain score shown in Figure 3. The N-Gain score of the experimental class is higher than the control class. The experiment class received a score of 0.76 while the control class of 0.65. It meant that the increase in knowledge at the experiment class was high while the control class was medium.

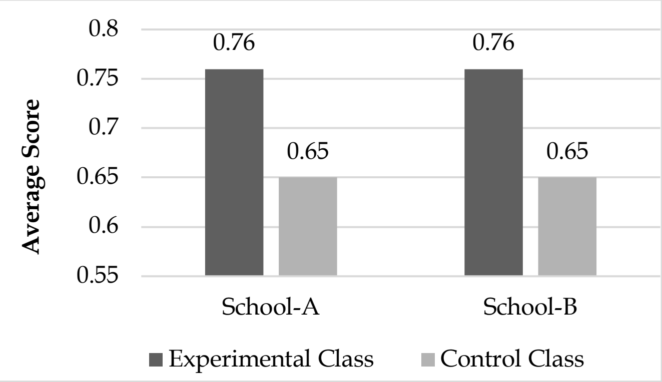

Figure 3. N-Gain Score

Students' attitudes and skills are observed during the learning process and assessed. Observation results showed in Figure 4 and Figure 5.

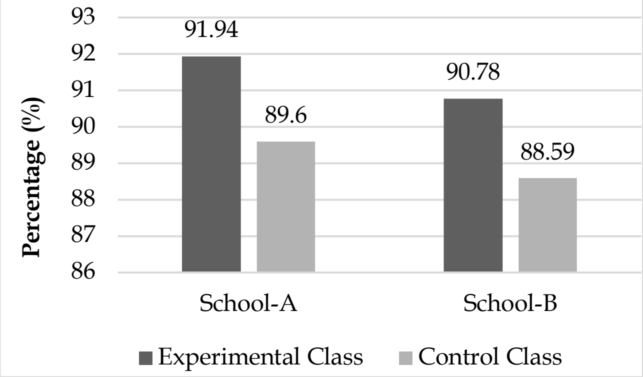

Figure 4. Observation Attitude Result

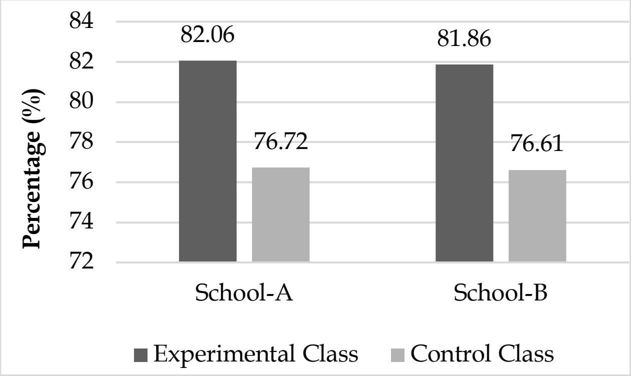

Figure 5. Observation Skills Result

Based on Figure 4 and Figure 5, the percentage of attitudes and skills in the experimental class was higher than that of the control class, both at School-A and School-B. These results indicate that quantum learning provides better results than conventional learning.

The learning outcomes obtained were analyzed using SPSS22 to determine the effectiveness of a quantum learning-based learning instrument. The test results showed in Table 5.

Table 5. Effectiveness Tests Result

School	Knowledge			Attitude			Skills		
	t/z-$_{\text{count}}$	t/z-$_{\text{table}}$	Decision	t-$_{\text{count}}$	t-$_{\text{table}}$	Decision	t-$_{\text{count}}$	t-$_{\text{table}}$	Decision
A	2.578	1.668	Accept H_1	2.136	1.668	Accept H_1	2.621	1.668	Accept H_1
B	2.406	1.64	Accept H_1	2.069	1.669	Accept H_1	3.146	1.669	Accept H_1

Based on table 5, the test results obtained t-$_{\text{count}}$ > t-$_{\text{table}}$ and z-$_{\text{count}}$ > z-$_{\text{table}}$ in both schools, both in the aspects of knowledge, attitudes, and skills. It meant that products were effective for improving learning outcomes. Several studies also indicate that the learning outcomes of students who use quantum learning-based learning instruments are better than those who don't use them (Amir, et al., 2019; Rusyadi, et al., 2013).

Quantum learning makes the learning process a meaningful activity (Suryani, 2013; Sujatmika, et al., 2018), because it motivates students to be active in it and relates discussion topics to everyday life like hydrocarbons and petroleum. There are many examples of hydrocarbons and petroleum in life, but the concept of matter is abstract. Dale explained that abstract concepts could be easier to understand if they begin with direct, concrete experiences (Zhang, et al., 2019). Quantum learning has a natural stage that relates matter to examples in life. That gives students the experience that what they are learning is around them and makes it easier to understand the material. Teaching is successful when it relates the experiences that students have with the material so students can develop their knowledge and abilities (Smidt, 2009), the material is stored longer in their memory (Hayani, et al., 2018), and have an impact on improving learning outcomes (Fitriani, et al., 2016).

The demonstration stage in quantum learning can help students to understand hydrocarbon material, such as on the topic of naming hydrocarbons. This topic is the primary concept in hydrocarbon materials and derivative materials. In them discusses the rules for naming hydrocarbons. Through demonstration activities, students try assembling hydrocarbon compounds and labeling them. It makes it easier for students to understand the rules for naming hydrocarbons, not just memorize them. Learning by doing provides more understanding so that learning becomes meaningful (Eshach, 2006), because meaningful learning ensure that learning activities learners participate in are effective and can be transformed into knowledge (Huang & Chiu, 2015). Demonstration activities encourage student interest and motivation, increase scientific knowledge content, provide insight into scientific reasoning, and develop positive scientific attitudes (Alneyadi, 2019). In contrast to the lecture method that only relies on the blackboard and verbal explanations, it makes students passive, frustrated, reduces learning effectiveness (Alemu, 2020), low interest in learning, and low curiosity (Wahyuni & Sulhadi, 2020).

Quantum learning can increase student learning motivation (Darkasyi, et al., 2014; Rodiyana, 2018) because it utilizes various elements such as the surrounding environment, seating arrangements, aroma, and music to create a pleasant learning environment (DePorter, et al., 2010). It is very much needed in the learning process (Hascher, 2013) because it makes students more creative and maximal in exploring their knowledge and can improve students' memory (Sujatmika, et al., 2018). Pleasant learning environment also makes students feel comfortable and happy to learn (Khalid, et al., 2016), so this can affect learning outcomes (Jhoni, et al., 2016).

A pleasant learning environment is not only determined from a physical perspective, but learning strategies can also provide an enjoyable learning environment. Quantum learning uses multi-methods, one of which is using games. That is one of the variations used at the repeat stage. The game that had integrated into the learning is crossword puzzles. Crossword puzzle games are one way to increase student interest and student learning outcomes through learning while playing (Alika & Radia, 2021). It makes quantum learning joyful. Games can reduce students' anxiety about the subject matter and allow them to act in the learning process (Yildiz, et al., 2018). Integrate games into learning not only increases social interaction among students but can also increase achievement motivation (Partovi & Razavi, 2019; Winatha & Setiawan, 2020), thinking skills, cognitive skills (Brom, et al., 2010), and student learning outcomes (Hidayatulloh, et al., 2020; Nainggolan, et al., 2020; Yildiz et al., 2018). The use of games can also contribute to predicting the development of students' knowledge (Zaki, et al., 2020).

Another important thing that makes quantum learning joyful is appreciating every effort made by students. That is the celebration stage. At this stage, the teacher and students celebrate every time the learning process is over to foster positive emotions in students. Appreciating emotionally and positively builds intimacy and warmth (Novita, 2015). However, appreciation can be given during the learning process when students express opinions, ask questions, or complete assignments. It can be expressed through body language, verbally, or given a simple gift. Praise or rewards contribute to student motivation (Sujiantari, 2016; Melinda & Susanto, 2018), improvements in classroom environments and attitudes (Gundersen & McKay, 2019), increasing student activity and learning achievement (Nurulhaq & Margana, 2013).

Generally, quantum learning can stimulate student thinking-activities so that it can improve understanding of concepts (Rodiyana, 2018) and student learning outcomes (Fayanto, et al., 2019; Jayantika, et al., 2019; Kalsum & Fadhila, 2018; Kusno & Purwanto, 2011; Masliani, 2018; Solikin & Abdullah, 2014; Ulandari & Surya, 2017). The implementation of quantum learning can increase student activity during the learning process (Fauzi & Muchlis, 2013; Jayantika, et al., 2019), both in the individual and also in group activities so that it affects skills. Quantum learning has a positive influence on improving students' social attitudes (Acat & Ay, 2014) and scientific attitudes (Widnyani, et l., 2016). This model emphasizes various interactions in the learning process through the learning steps. It indicates that quantum learning is a learning strategy that can be integrated into learning tools to improve student learning outcomes.

Conclusion

The quantum learning-based learning instrument on hydrocarbon and petroleum has been well developed. The product developed consisted of a syllabus, lesson plans, teaching materials, test questions, attitude observation sheets, and skills observation sheets. Quantum learning-based learning instruments on hydrocarbons and petroleum materials were valid and received responses from students and teachers is very good, so it was suitable for use. Quantum learning-based learning instruments on hydrocarbon and petroleum materials effectively improve student learning outcomes. The quantum learning-based learning instrument on hydrocarbon and petroleum has been well developed. The product developed consisted of a syllabus, lesson plans, teaching materials, test questions, attitude observation sheets, and skills observation sheets. Quantum learning-based learning instruments on hydrocarbons and petroleum materials were valid and received responses from students and teachers is very good, so it was suitable for use. Quantum learning-based learning instruments on hydrocarbon and petroleum materials effectively improve student learning outcomes.

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