Effectiveness of the development of the inquiry-based learning model to improve students' psychomotor achievement

R A Siregar
Institut Pendidikan Tapanuli Selatan, Jl. Sutan Moh. Arif, Batang Ayumi Jae, Sumatera Utara 22733 Indonesia
E-mail: rabiyatuladawiyah8620@yahoo.co.id

Abstract. Students often consider chemistry as a difficult subject. Therefore, an engaging learning model is important in chemistry learning. This study aimed to produce an effective learning model to improve students' psychomotor achievement. This study used research and development using ADDIE model. The research was conducted in two senior high schools in Padang Sidempuan, North Sumatera. The participants were divided into an experimental class and a control class. The effectiveness of the learning model was investigated by assessing students' learning achievement, especially on the psychomotor aspect. The result showed that the inquiry-based learning model was effective. This result implies that the model can be used to improve students' psychomotor achievement.

1. Introduction
Chemistry studies specific phenomena that occur in substances and everything related to substances, namely the composition, structure and properties, transformation, dynamics and energetics of substances. Chemical materials are macroscopic, microscopic and symbolic. Judging from its content, learning chemistry involves skill and reasoning. There are two things related to the process of learning chemistry that cannot be separated, that is chemistry as a product and chemistry as a process (scientific work). Therefore, the learning process of chemistry should pay attention to the characteristics of chemistry as a process and product.

The goal of chemistry learning in high school is for students to gain experience in applying scientific method through experiments where students perform hypothesis testing by doing experiments, data retrieval, processing and interpreting data, and communicating experimental results orally and in writing. Students gain experience of scientific method by using inquiry-assisted learning model that includes presenting questions or problems, making hypotheses, designing experiments, experimenting to obtain information, collecting and analyzing data, and concluding. These syntaxes are only suitable for studying macroscopic chemistry with laboratory activities, but not suitable for microscopic and symbolic chemistry [1].

The learning process in the 2013 curriculum for all levels is implemented using a scientific approach which includes observing, questioning, trying/gathering information, reasoning and communicating. Scientific approach is a learning approach that adopts the steps of scientists in constructing knowledge through scientific method. This is in line with one of the goals of chemistry learning in high school which is to gain experience in applying scientific method through experiments.
where learners perform hypothesis testing by doing experiments, retrieving data, processing and interpreting data, and communicating experimental results orally and in writing.

Not every high school in Padang Sidempuan has adequate laboratory. Initial observation found that 50% of state high schools in Padang Sidempuan do not have their own chemical laboratory. This situation causes difficulties in performing chemically-related activities. The schools that do have lab equipment and chemicals have not made good use of them. This information was obtained from a survey conducted on 6 to 20 April 2015. The survey reveals that 50.00% of high school chemistry teachers in Padang Sidempuan carry out chemical practicum activities only 1 to 2 times in a year. This finding is supported by a research conducted by Festiyed [2] who found that about 19% of high school chemistry teachers made use of the laboratory more than 6 times in a semester, while 47% have not used laboratory. Learning chemistry outside of laboratories can affect students’ scientific attitude, problem solving skills, scientific investigations and scientific acquisition skills [3].

The importance of conceptual understanding in the teaching and learning process greatly influences attitudes, decisions and ways of solving problems. Previous studies describe some problems in learning chemistry: students’ skills in laboratory activities are still low, students’ thinking ability is still low which causes low learning achievement, students have difficulty in explaining chemical terms, difficulty in understanding chemical concepts, and difficulty in solving problems related to calculation [4,5]. Other studies suggest that the causes of these difficulties are: poor understanding of prerequisite concept, teacher-oriented learning, the learning process focus more on memorization of information due to time constraints, and the teaching materials do not fit the characteristics of students [6,7].

Another problem is the teaching approach. Most teachers start teaching by explaining a topic, followed by giving questions and answers, and then end it with exercise. This monotonous routine does not encourage scientific attitude. In addition to that, in terms of assessment of learning achievement, teachers usually focus only on the cognitive domain. They often forget about psychomotor domain in conducting practicum activities. In order to improve students’ chemical learning activities, it is necessary to develop a learning model that can collaborate learning approaches and models. The learning model developed is the inquiry-based learning model.

The use of inquiry-based learning model is expected to improve students’ learning achievement in the psychomotor and affective aspects. Students are invited to actively conduct experiments or investigations and construct their understanding of a topic. This model can train students to observe macroscopic, microscopic and symbolic chemicals through practicum activities.

Inquiry-based learning is a learning model that provides adequate instructions for students through complete procedures and directive questions during the process of inquiry [8]. Teacher asks many questions during learning process to guide students to come to a conclusion on their own. The type of inquiry that is suitable for high school level is guided inquiry, since guided inquiry provides more directions for students who are not ready to solve problems with inquiry without assistance due to lack of experience and knowledge or have not reached the level of abstract cognitive development [9]. Through guided inquiry, a teacher can provide guidance and direction to students to conduct investigations. The formulation of the hypothesis is based on the information that the students obtain through listening to information from books and the internet.

Inquiry-based learning model is very helpful for teachers in implementing the 2013 curriculum because it uses scientific method. Therefore, this study aimed to develop an inquiry-based learning model to improve students’ psychomotor achievement in chemistry.

2. Method
This study applied Research and Development (R&D). The product was an inquiry-based learning model that was designed to improve students’ psychomotor achievement in chemistry. The study was conducted at senior high schools in Padang Sidempuan, North Sumatera, Indonesia. The ADDIE model was used in the development of the product. ADDIE stands for analysis, design, development, implement and evaluation. This paper focuses on the results of the evaluation phase.
The population in this study included all public high schools in Padang Sidempuan, North Sumatra consisting of 8 schools. The test subjects were chemistry teachers who taught in grade XI and the students. Selection of the test subjects was based on the criteria of schools’ accreditation. Three high schools were chosen to participate in the study, they were SMA Negeri 2 Padang Sidempuan as high category, SMA Negeri 5 Padang Sidempuan as medium category and SMA Negeri 7 Padang Sidempuan as low category.

The effectiveness of the product was assessed by investigating students’ psychomotor achievement. Friedman test was used to assess students’ achievement. Data analysis used a normalized gain test. The hypothesis proposed was \( P \neq 0.05 \), meaning there was an improvement of psychomotor learning achievements with practicum activities in every meeting.

3. Result and discussion
This section discusses the results of the development of the inquiry-based learning model. The model used computer laboratory and simulation to improve students’ learning achievement. The development model was the ADDIE model which included five steps: Analysis, Design, Development, Implementation and Evaluation. The analysis phases covered analysis of curriculum and students’ characteristics. The result of the analysis phase showed that almost all chemistry lessons for grade XI could be done through lab work activities, except for Hydrocarbon and Petroleum. The analysis of students’ characteristics showed that there was a need to improve the students’ interests in learning chemistry. A teacher needs to facilitate students to develop their thinking skills through their interactions with the teacher, with themselves and with the environment. After the implementation of the inquiry-based learning model, there was an improvement of students’ psychomotor achievement with an average value of 0.35 as shown in figure 1.

![Figure 1. Students’ psychomotor achievement.](image)

Figure 1 shows that there was improvement in students’ psychomotor achievement for every meeting. The assessment of the students’ psychomotor achievement was done by using performance appraisal. The assessment covered the ability to prepare lab work, activities during the lab work, and the ability to deliver experiment results.

The significance of the students’ psychomotor achievement for each meeting through practicum activities was analyzed using Friedman test. The value was 0.000. If this result was compared, then it was obtained that \( P \neq 0.05 \). Therefore, it could be concluded that there was a difference between the control group and the experiment group. Therefore, it could be stated that there was an improvement in students’ psychomotor achievement using the inquiry-based model.

This result is supported by the results of research conducted by Naaman and Barne [9] who found that laboratory activities could facilitate students’ psychomotor achievement. Furthermore, Hofstein, Shore and Kipnis [10] stated that the activities in the laboratory could provide an opportunity for students to learn in an authentic environment and build their knowledge of chemical-related
phenomena. In addition, by conducting experiments in the laboratory students were able to practice inquiry skills such as posing questions, formulating hypotheses, and conducting further investigations of questions that have been asked.

The use of appropriate learning model in each learning was expected to produce a fun learning process and could improve students’ competence or achievement. A teacher must be able to choose the appropriate learning model for their students. The application of the inquiry-based learning model had good impact on students’ psychomotor domain. It could be seen that the value of the process of conducting practicum activities in collecting data was the highest value. The reason for this was because the students were highly motivated in conducting the experiment or practicum. Usually the students only listened to their teacher’s explanation and then asked to answer the questions that the teacher gave. Now they had practicum activities. The chance to fulfill their self-actualization needs made the students to be in high spirit to learn and they were happy doing the tasks assigned by the teacher. One way to meet students’ self-actualization needs was by creating meaningful learning associated with the students’ real life and involving the students in the activity of knowledge discovery.

As for the students’ ability in presenting experiment result, the score was lower. The reason was because the students paid less attention to the questions that had been answered when analyzing the data. Furthermore, the students did not work collaboratively in making conclusions; they relied on their clever friends.

The components of the inquiry-based learning model which was developed in this research consisted of syntax, social system, principles, support system, and the instructional impact. The syntax consisted of: 1) presenting a phenomenon/problem; 2) formulating the problem; 3) proposing hypothesis; 4) collecting data; 5) testing the hypothesis; 6) elaborating knowledge relating to aspects (macroscopic, microscopic and symbolic); and 7) concluding. This syntax integrated scientific approach (observing, asking, collecting data/information, reasoning and communicating). The social system in the implementation of the inquiry-based learning model was that the teacher acted as a mentor and facilitator who helped the students to construct their understanding of chemistry to promote the students’ sense of responsibility both individually and in groups. The principle reaction that emerged in the inquiry-based learning model was the teacher acted as a guide in the learning group in the discussion and practical activities that helped each other. The teacher acted as a facilitator who supported every learning activities and motivated the students to be able to construct information through learning activities using scientific measures. The support system in inquiry-based learning model developed in the form of inquiry-based learning model book, teacher book of inquiry-based learning model and student book of inquiry-based learning model. The instructional impact of the application of inquiry-based learning model was the success of student learning related to the improvement of cognitive, psychomotor and affective areas. The accomplishment of the application of inquiry-based learning model was the students’ increasing interest in researching, self-confidence, openness, reading ability, learning motivation and cooperative spirit.

Overall achievement of student learning in the psychomotor domain was increased. This result was reinforced by Friedman's test analysis of 0.000. The value of significance was ≤ 0.05 then it could be said that there was a difference in students’ psychomotor achievement between the students who were taught using inquiry-based learning model and the control group.

In learning with inquiry-based learning model, the students were required to conduct scientific investigation through formulating problem, making hypotheses, collecting data through experiments, analyzing data and concluding. All these activities required the students to play an active role in their learning process. This is in accordance with the theory constructivism which suggests that a good learning is a learning that actively involves the students in knowledge construction.

The impact of this activity was that the students were specifically required to be able to construct their own knowledge, attitudes and ability, and to use all their senses to seek or find answers to a question. The students was responsible directly to solve problems that the teacher provided. There was
also an improvement in the students’ performance and learning achievement especially in the psychomotor domain.

4. Conclusion
It was concluded that the inquiry-based learning model that had been developed was effective in improving students’ psychomotor achievement.

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