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Students' Practices of Scientific Investigation (PoSI) on the Learning of Food Test Materials Using an Explicit Instructional Approach

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Abstract: Carrying out assignments through scientific investigations is one of the most meaningful learning experiences for students. In addition, these activities can also have a positive influence on students' interest in learning science. In Indonesia, scientific investigation skills are a skill that students must possess. However, the fact is that there are still many students who have not mastered these skills properly. Therefore, this study aims to look at students' scientific investigation skills through Practices of Scientific Investigation (PoSI) using an explicit instructional approach. This study used the Quasy Experimental Research method, with a pretest-posttest control group design research design. The results obtained indicate that the five skills in PoSI seen in this study have not all been mastered perfectly by students, there are some skills that are still not possessed by students. Overall, the investigative skills (PoSI) of students in the treatment class showed better results when compared to students in the control class. The use of the explicit instructional approach applied in this study helps students carry out the five skills in the PoSI. The five skills in question are skills in making problem formulations, making hypotheses, designing experiments, analyzing experimental results, and making conclusions on experimental results. Habit is needed in developing some of the skills in the PoSI in students.

Keywords: Explicit instructional; Food test material; Practices of scientific investigation

Introduction

Working on assignments through scientific investigations is a meaningful learning experience for students with diverse abilities. It is known that, students do not find many difficulties when doing scientific investigation assignments (Cheng, 2008; Zourmpakis et al., 2022). It was further stated that the scientific investigation had a positive effect on students' interest in learning science through their involvement in scientific investigation tasks. Investigation-based learning can make students more active and successful in solving complex problems (Panjaburee & Srisawasdi, 2016), providing facilities for students to learn to collect information and process according to their knowledge, and implement it in the real world. Based on the results of this study it can be said that the skills of students who are provided through a learning process based on investigative or research activities are very important (Geng et al., 2019). In Indonesia, these skills are one of the skills that must be mastered by students.

Investigative skills tend to have similarities with research skills in their stages, both of which apply a number of things related to the scientific method. As explained by So (2003) in his writing which explains that what is meant by investigative skills are the skills of making questions, making hypotheses, finding and reading references, modifying investigative methods or designs well, conducting investigations, controlling variables, obtaining data, analyzing data, and present data (Fauzi et al., 2021). Research skills according to Willison (2012) are skills in finding information or data,

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managing the research process, analyzing and synthesizing data, and applying and communicating knowledge or research data (Khang et al., 2023).

The students' basic research skills in research project design, such as the ability to control variables, formulate problems and create hypotheses that students should have mastered, are still not mastered (Idris et al., 2022; Maison et al., 2020). It was further stated that there were several skills that had not been mastered by students, namely preparing work plans and determining the methods to be used for research or investigations, evaluating investigative data, organizing research data, and making arguments. However, in general students have been able to reach level two for research skills, except for a few students whose reasoning is concrete, they still fail to achieve the ability to organize research data and make arguments and citations. Students' investigative skills in the 21st century have been developed in Indonesian schools. These skills are needed in learning science, especially in Biology subjects. Humans are required to develop their potential and skills in the 21st century to respond to the challenges of globalization (Bedford et al., 2019).

Learning that can develop students' Science Process Skills is one way to do learning activities that involve students directly (Gunawan et al., 2019). It was further explained that experimental activities and other practicum activities were considered activities that were very supportive of students' knowledge and learning experiences in science. This is in line with Permendikbud Number 69 of 2013 concerning Characteristics of Biology Subjects for Senior High School (SMA/MA) which states that one of the learning objectives is to provide students with experience of the scientific method by practicing it through the stages of observation and experimentation. However, the results of research conducted by Kurniawati et al. (2016) state that there are still teachers who use the lecture method when teaching. This makes students tend to be passive in the learning process. The involvement of students in learning is not maximized by the teacher, so that the learning process only goes in one direction and students only act as recipients of information from the teacher.

Alternative solutions seem needed to overcome these problems. Practices of Scientific Investigation (PoSI) with explicit and implicit instructional approaches is one of the solutions that can facilitate students to be able to develop several skills in PoSI, including making problem formulations, compiling hypotheses, planning research, analyzing research data, and concluding data results research (Oppenheimer et al., 2019; Vorholzer et al., 2020). Explicit and implicit instructional approaches are one part of scientific investigation (Nind, 2020). It was further argued that explicit and implicit instructional approaches could increase students' procedural knowledge and students' skills to engage in investigative practice in everyday scientific situations (Vorholzer et al., 2020).

Explicit and implicit instructional approaches are expected to be able to develop students' science skills, especially those related to PoSI (Madkins & de Royston, 2019). The difference between the explicit group and the implicit group is the provision of investigation directions (Fang et al., 2016). The explicit instructional approach is scientific practice instruction that is given clearly to students. As stated by Schwichow (in Vorholzer et al., 2020) that an explicit instructional approach must include more than just telling students about a rule. The meaning of the implicit instructional approach according to the Big Indonesian Dictionary (KBBI) is the opposite of the meaning of the explicit instructional approach. The implicit meaning in KBBI is something that is included (contained) in it (even though it is not stated clearly or openly); knotted in it; smooth contained; or something implied. In this approach, almost all activities involve students in scientific investigations in PoSI learning. Students are given the freedom to try and develop their skills, because in this approach students are not treated to instructions that clearly regulate and limit the learning process of "trying" students (Vorholzer et al., 2020).

Based on this explanation, it is known that this explicit and implicit instructional approach has its own advantages and disadvantages. The advantage over an explicit instructional approach is that it reduces the amount of time needed by students to find the concept they are looking for and the more experimental tasks are systematically structured along the PoSI concept (Vorholzer et al., 2020). The advantage of the implicit instructional approach is that it offers students more opportunities to learn to plan scientific investigations, how to formulate scientific questions and hypotheses and analyze and infer data. However, it does not discuss the concept clearly (Vorholzer et al., 2020).

Explicit and implicit instructional approaches in PoSI both require student activity, in which students are required to be involved in 5 processes of science practice, including making problem formulations, formulating hypotheses, planning research, analyzing research data, and concluding them. Through many student-centered activities, all students seem to have many opportunities, more time to explore and discuss concepts related to PoSI than specifically designed classroom management (Vorholzer et al., 2020). A study conducted by Kuhn et al. (2005) showed that children who received instructions at the beginning of each lesson had goal-oriented experiment plans and made more valid conclusions than children who practiced without instructions. Based on the results of previous research which showed that instructions or instructions had an effect on students' skills in experimenting until the conclusions of the experimental results were formed. This became the initial idea of the researchers to make the research conducted by Vorholzer et al. (2020)regarding the effect of explicit and implicit instructional approaches focused on comparing the effectiveness of explicit and implicit instructional approaches on scientific investigation skills as a reference for researchers. In this study, the researchers put more emphasis on how the influence of an explicit instructional approach on students' PoSI skills in food substance test material.

Method

The method used in this study is the Quasy Experimental Research method (Baydere et al., 2020; Gopalan et al., 2020). The design used is Static-group Comparison Design. This research was conducted in one of the high schools, involving two classes, students in the first class as the experimental group, while students in the second class as the control group. Students in the experimental group will carry out scientific investigation activities contained in PoSI with an explicit instructional approach. Meanwhile, students in the control group will carry out scientific investigation activities with the discovery learning model through an implicit instructional approach. Students' abilities are seen after the implementation of the two instructional approaches in the learning process or Practices of Scientific Investigation (PoSI).

First of all, students in the experimental group and the control group were given student worksheet which contained instructions in carrying out a series of scientific investigation processes through practicum testing of food substances. In the treatment group, the role of the teacher is to provide explicit direction and guidance to students so that students are able to complete the 5 tasks in PoSI which are manifested in the form of a report on experimental results. Before carrying out a food substance test, which is an experiment or a simple experiment, students are asked to do three tasks in PoSI, the three tasks are making a problem statement, making a hypothesis for the experiment, and designing a food substance test experiment to be carried out. The assignments they do are written in the student worksheet provided by the teacher. The same thing happened to students in the control group. They also carried out all three tasks prior to carrying out the food substance test. The difference with the experimental group is the form of instruction given by the teacher to students. The teacher gave explicit instructions to students in the experimental class, whereas in the treatment class, the teacher's instructions were given implicitly for the successful implementation of each task carried out by students.

The next step is to conduct an experiment in the form of a food substance test. The two groups of students did this and recorded the results of their experiment in the provided student worksheet. The next task that must be carried out by them after obtaining the experimental data is to analyze the results. Students are given the freedom to use various sources to help them make an analysis of experimental results, both from Biology books, and from the internet. The teacher in the experimental class gave directions to students to carry out studies related to the chemical content contained in the food being tested, so that the analysis became more comprehensive and the study in-depth. After the two classes have analyzed the results of the experiment, then they have to complete the final task of scientific investigation, namely concluding the results of the experiment. In both classes they drew conclusions from the results of the food substance testing experiments and wrote them down on the student worksheet.

After the five scientific investigation tasks were completed by students in both groups, each of them was assigned to make a report on the results of the experiment and submit it to their teacher, who was in charge of being a teacher in the experimental and control classes was the researcher himself. After all student assignments were collected, the researcher assessed the results of their work, coded based on the assessment rubric previously made, and then analyzed it, so that results from research on scientific investigations (PoSI) using explicit and implicit instructional approaches could be obtained.

Result and Discussion

The five PoSI skills seen in this study do not appear to be fully mastered by students. This means that there are still several indicators in these skills that students cannot do. In the experimental class, the skills of formulating problems and making hypotheses can be performed by all students perfectly. But in the skill of designing experiments, only about half of the students in the class can do it perfectly. As for the skills of analyzing data to concluding data, there are still many students who have not been able to do it perfectly, some even cannot do it at all, and none (0%) of students can do it perfectly.

As for the control class, for the skills of formulating problems and making hypotheses there are still around 10% -15% of students who have not been able to do it at all. Furthermore, the results of students' skills in designing experiments were not much different from the experimental class, there were 59.40% of students in the class who could design experiments perfectly. In the skills of analyzing data to concluding data there are still many students who have not been able to do it, even almost all of them, and none (0%) of students can do it perfectly. The results of this study were slightly different from the results of research conducted by Wahyudi et al. (2013) which showed that students' skills in formulating hypotheses, designing experiments, and analyzing data obtained fairly good criteria. The following data shows a comparison of the number of students in the treatment class and the control class based on their ability to formulate problems (activity 1), make hypotheses (activity 2), design experiments (activity 3), analyze experimental data (activity 4), and conclude data the results of the experiment (activity 5) perfectly.

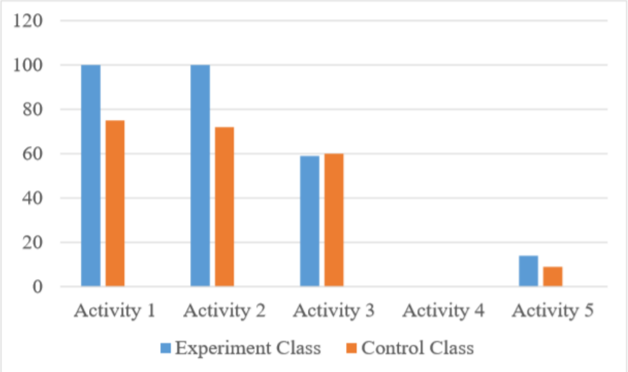

Figure 1. Comparison of the number of students in the experimental class and the control class who carry out PoSI activities perfect

Quantitative data previously obtained were supported by qualitative data obtained from interviews with several students in the treatment class. It is known that they find it helpful and easy to carry out activities in PoSI learning. This is in accordance with the results of the student response questionnaire analysis which shows that 77% of students in the class gave a positive response to learning with an explicit instructional approach. The results of interviews with several students in the control class who did PoSI learning without using an explicit instructional approach showed that students found it difficult to carry out activities instructed by the teacher, such as activities to formulate problems and create hypotheses. In this activity, there were still some students who were not able to do it perfectly. Even in the activities of designing experiments, analyzing data, to concluding data, as much as more than 50% of students have not been able to do it, as shown in Figure 1. According to Bjork (in Lazonder & Egberink, 2014) it is stated that the shortcomings of the implicit instructional approach applied to the control class is that it takes quite a long time and repeated experiments to get optimal results and to be as effective as the explicit approach applied to the treatment class.

A study conducted by Kuhn et al. (2005) showed that children who received instructions at the beginning of each lesson had more valid goal-oriented experiments and inferences than children who practiced without instructions. Based on the results of previous research, it showed that instructions or instructions had an effect on students' experimenting skills, until the conclusion of the experimental results was formed (Vorholzer et al., 2020). Compared to the results of research from Astuti et al. (2015), the results of this study are not much different from the results of that study. The results show that the guided experiment method proved to be more effective in improving students' research/experiment skills, compared to the modified free experiment method. This is illustrated by the success of students in the treatment class who received PoSI learning with an explicit instructional approach, all of them were able to carry out two activities to develop two PoSI skills perfectly. The research data shows that all students in the treatment class can formulate problems and make hypotheses perfectly. As for designing experiments, there are more than 50% of students who can do it perfectly. This proves that clear and complete guidance and instructions make it easy for students to carry out skills in experimenting or conducting scientific investigations.

These results are consistent with the results of research conducted by AbdElKholick et al. (in Ozgelen et al., 2013) which shows that in general, explicit and reflective approaches are more effective than implicit approaches in increasing students' views of the nature of science and inquiry. Also supported by Yacoubian et al. (2010) in the results of his research which suggested that implicit guided inquiry laboratory learning was not effective in increasing students' views about the nature of science and inquiry. Some of the results of these studies illustrate that in general the explicit approach is more effective than the implicit approach, especially in developing students' PoSI skills.

It is further explained regarding the results of this study on several student skills in PoSI. Beginning with the skill of formulating a problem. These skills have been made by almost all students, both in the control class and in the treatment class. This is evidenced by the number of students who got good grades in these skills which were obtained from the results of the assessment of practicum reports made by students from the two classes. All students in the treatment class were able to formulate the problem perfectly. As for students in the control class, there are still a small number of students who have not been able to formulate it perfectly. In fact, there are still students who cannot do it at all. Students who are categorized as imperfect in making problem formulations because the problem formulations in research reports made by students do not yet contain the variables to be studied. This is the same as the results of research by Ana et al. (2010) which shows that students are still less skilled in making problem formulations. The formulation of the problem is something that is important in research. As explained by Fang et al. (2016) that questions made by students can help strengthen students' understanding of the meaning of the steps of the investigation.

The skill of making a hypothesis is a skill that can be carried out by all students in the treatment class. All students in the class can make a hypothesis perfectly. As for the students in the control class, there were more than half the number of students, but there were still a few students who in making the hypothesis were not perfect, there were even some students who were unable to do it at all. The hypothesis is made by researchers to be used as a rational estimate of the research topic being worked on. After the research data is obtained, analyzed and interpreted, new researchers can conclude that the research conducted supports or rejects the hypotheses that have been made.

Hypothesis is an explanation that needs to be tested for truth by gathering more evidence to solve a problem. Making a hypothesis is felt for a long time by students because in the literature search section which will be used as the basis for making hypotheses, students are still having difficulties. This is because students have not been able to search for literature and cite sources that are in accordance with the instructions from the teacher correctly so that the hypotheses made are less convincing to the reader. Often, in class, students only get explanations from the teacher without being taught to look for them on their own. This lack of learning experience makes students have difficulty in making hypotheses. The results of this study are not much different from the results of research conducted by Pratiwi et al. (2014) which as a whole it can be concluded that most students have been able to formulate hypotheses that allow them to be tested.

Experiment design skills are skills that can be performed perfectly by more than half of the students in the treatment (58.6%) and control (59.4%) classes. This means that both classes are dominated by students who can design experiments perfectly. However, there are still some students who are not perfect in designing experiments in both classes. In the treatment class there were no more students who made imperfect experimental designs. As for students in the control class there were still some students who made imperfect experimental designs. Students can design experiments, but are still imperfect. An experimental design that is said to be imperfect is an experimental design whose work steps are not in accordance with the research objectives. In addition, the experimental design which is said to be imperfect is the selection of tools and materials that are disproportionate and not in accordance with the research needs. Another thing that is included in the skill of designing an experiment is the ability to determine the tools and materials, sources used, and determine the steps of research work. This is supported by an explanation from Lederman et al. (2014) which says that students need to understand the importance of alignment between research problem formulation and research methods. It was further explained that in general students must understand that the formulation of the problem and research methods must be appropriate to answer the research questions posed.

Based on the results of this study it is known that students' skills in analyzing experimental data vary. Many students in the treatment class were unable to analyze the results of the experiment, only a few students were able to do so, even though the results of the analysis were less than perfect. This means that they have not been able to make data analysis properly and correctly. In fact, the data shows that there is not a single student in the two classes who can do it perfectly. This means that 0% of students who can analyze data perfectly in both classes. The data from this study indicate that the skill of analyzing experimental data is a skill that is relatively difficult for students, it can be seen from the data showing that students from the treatment class and the control class do not have a single student who can analyze data perfectly. Even in the control class, almost all students could not analyze the experimental results perfectly. Although there are still some students who are able to do it, but not perfect.

The data analysis carried out by the students was said to be imperfect because what the students wrote was the result of the experiment which was rewritten in narrative form, not an explanation of the results of the analysis of the experiment results. Yet according to Berland et al. (2009), analyzing data is one of the skills in explaining a phenomenon scientifically based on data. It was further stated that science education experts usually regard this scientific explanation as an attempt to provide an explanation for a specific natural phenomenon, about what happened and why it happened. The analysis as a way of examining something by presenting all the basic elements related to the elements in question. An important flow in data analysis is the presentation of data. Presenting data is presenting a set of structured information that gives the possibility of drawing conclusions and taking action. Many students have not been able to relate their experimental results to existing theories, so the discussion in their analysis is less comprehensive. The results of the interviews showed that students needed a long time to do this task. Experience doing data analysis is valuable.

The results of this study also show data about students' skills in concluding experimental data. The results show that the skills of students in the treatment class in concluding data are better than students in the control class. Although the number of students wasn't large enough, however, there were still students who were able to deduce it perfectly. When compared with the previous skill, namely the skill of analyzing data, students are better at concluding data. Students in the treatment class concluded data based on data obtained from the results of the food substance test experiment that had been carried out previously. Students make conclusions from the results of the experiment. Conclusions are made to answer the formulation of the problem which is made as a direction for the purpose of the experiment or research being carried out. This is known from the reports made by students which are supported by the results of the student response questionnaire analysis. The ability to describe in writing the data presented in tabular form, it is also necessary to be able to describe what is implied by expressing his own opinion according to the existing data or possible predictions in the data.

The results of the interviews show that students who receive PoSI learning with an explicit instructional approach find it helpful to have clear directions from the teacher so that they know what they have to make to produce good and correct conclusions. The results of previous research indicate that students' ability to conclude data on the results of practicum activities is very dependent on the level of students' understanding of the objectives of the activity. Therefore, the conclusion of the practicum will be appropriate if the objectives have been understood (Wasilah, 2012). The results of a previous study conducted by Juniati et al. (2009) showed that skills in concluding experimental results were well developed, but the percentage was still small. According to Juniati et al. (2009) this increase occurred because students' knowledge increased because students became actors and played an active role in the teaching and learning process.

Conclusion

The results of this study indicate that over all the PoSI skills of students in the treatment class are better than students in the control class. The use of an explicit instructional approach assists students in carrying out several PoSI skills, including the skills of formulating problems, making hypotheses, planning experiments, analyzing data and concluding data. The instructions given by the teacher help make it easier for students to carry out several activities that practice their PoSI skills. their unfamiliarity in carrying out several activities to practice PoSI skills, made them find it difficult to do so, especially in the process of designing experiments and analyzing experimental results. Therefore, habituation is needed in developing some of the student's PoSI skills. Based on the implications and findings presented in the analysis of students' PoSI skills in learning food substance testing materials using an explicit instructional approach, the recommendation that can be given is the need for further research on the development of 21st century research skills through different learning models. Furthermore, there is a need for research on the development of PoSI skills using explicit and implicit instructional approaches in other materials, and there is a need for research that compares the development of students' PoSI skills using explicit and implicit instructional approaches in quite a long time and repetitive activities.

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The authors declare no conflict of interest.

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