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Redesigning Laboratories for Pre-service Chemistry Teachers: From Cookbook

Experiments to Inquiry-Based

Science, Environment, Technology, and Society Approach

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ABSTRACT

Because school laboratory activities obtained by pre-service[3] teachers tend to use cookbook experiments, this study focused on redesigning chemistry laboratory activities at the university level from cookbook experiments to inquiry-based Science, Environment, Technology, and Society (SETS) approach, and analyzing pre-service[3,8] chemistry[9] teachers[10] “[11] performances and[12] their[13] views[1] to[15] the[16] redesigned[17] laboratory[18] activities.[19] Through action research methodology, team teaching was conducted[20] with 20 PCTs by following „[11]Plan-Do-Study-Act“[21] (PDSA) Cycle model within „[11]The Course of Laboratory Practice in Basic Chemistry (CLP-BC)“[11,22]. Science process[23] skills[24] test[25] (SPST), performance observation[26] sheets[27] (POS), presentation observation sheets (PrOS), self-reflective journals (SRJ), and interviews were used[28] to evaluate the redesigned

process. The CLP-BC activities consisted of 16 meetings through two PSDA cycles. The redesigned chemistry laboratory activities included such topics as colligative properties of the solution;[29] chemical equilibrium on solubility;[30] acid-base titration;[31] solubility product;[32] and voltaic cells. The results indicated improvements at the PCTs[33] ‟[11] science process skills, performances in managing laboratory and discussion activities as well as their positive responses at their self-reflective journals.

Keywords: Cookbook experiments, inquiry, laboratory, pre-service[3] chemistry teachers, science-[7] environment-technology-society approach.

INTRODUCTION

The National Science Education Standards have emphasized three essential and interrelated learning objectives for all students studying science[7]: learning about the nature of science and scientists‟[11] studies; learning doing science[7] (that is, developing the abilities to design and conduct scientific investigations); and understanding scientific concepts and principles. Engaging students in inquiry learning facilitates all of three aspects; so that, the National Research Council (NRC) considers inquiry as an excellent content for science[7,34]

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learning[37] and learning methods (National Research Council, 1996).[38] Science students at all grades should have an opportunity to use scientific inquiry and develop scientific inquiry abilities to think and act in ways. These activities include asking questions, planning and conducting investigations, using appropriate tools and techniques to collect data, thinking critically and logically about the relationship between evidence and explanation, constructing and analyzing alternative explanations, and communicating scientific arguments (National Research Council, 2012). Thus, science/chemistry teachers have an important[39] role in preparing inquiry-based[40] learning environment for their students.

Chemistry laboratory activities are important[41] for chemistry learning because chemistry is an experimental science (Golinski, 1999). Chemistry laboratory practices enhance conceptual understanding of chemical principles and their applications in daily life because concepts help students to define and explain objects and events in their environments (Arends, 2012). Chemistry teachers should design and carry out chemical experiments by using science-related technology (Hidayah & Imaduddin, 2015). Many schools and universities have not fully implemented inquiry-based chemistry learning in practicum. Indeed, conventional chemistry practices lead to the use of guidelines provided by the lecturer or[11] "the cookbook experiments".[11,42] The[11] "cookbook experiments"[11] direct students to confirm what they have learned during instruction. Previous studies have shown that traditional/didactic instruction is not very successful in changing students‟ conceptions (Bodner, 1991; Gunstone & White, 1981; Luckie et al., 2013; Nakhleh, 1992; Smith & Metz, 1996; Ural, 2016). The didactic teaching style (i.e., "cookbook experiments") may be quite successful in instilling facts, rules, procedures, and algorithms of a specific science domain. However, it is insufficient to help students filter and build their ideas about science concepts because they are not encouraged to think them at a higher level or metacognition (Rickey, Teichert, & Tien, 2008; Zulfiani & Herlanti, 2018).

Many researchers have criticized the effectiveness of prescription-based practicum activities or "recipe following" or "cookbook" experiments (Brownell, Kloser, Fukami, & Shavelson, 2012; B. Feyzioğlu, 2009; E. Y. Feyzioğlu, 2012; Ural, 2016). The cookbook activities may somewhat show the possibility of "hands-on" activities, but they are rarely related to "minds-on" ones. When performing these tasks, students often forget the purpose of the activities and track steps mechanically without in-depth reflection or real involvement (Millar, 2010). Laboratory inquiry activities offer opportunities for pre-service teachers to examine how to present science learning to students (E. Lee, Brown, Luft, & Roehrig, 2007). The activities may also be used to explore scientific knowledge, challenge explanations, and provide opportunities to discuss any change in understanding (France & Haigh, 2009). Inquiry-based lab activities have the potential to develop students ‟ conceptual understanding (Hofstein & Lunetta, 2004; Wardani, Widodo, & Winarno, 2017). Nevertheless, many in- service and pre-service science teaching courses do not equip teachers with skills that are used as facilitators to guide inquiry. Teachers often lack enough information about such new learning models as inquiry-based learning and its implications for teaching and curriculum. So, many teachers have still preferred conventional teaching methods, which purpose to directly transfer knowledge to students (Hofstein & Lunetta, 2004; Li, 2016). Therefore, developing and implementing inquiry-based lesson plans should be included in teacher education programs.

As a part of the teacher preparation program, pre-service[3] teachers can manage laboratory activities through the process of planning a teaching sequence that is similar to their future teaching careers in the schools. When school-level students have great[49] roles in investigating, thinking, planning, practicing, and reflecting, inquiry can be implemented[50] as a teaching approach (Berg, Bergendahl, Lundberg, & Tibell, 2003) for pre-service[3] teachers at the university level. In this study, we attempted to redesign chemistry laboratory activities for

pre-service[3,51] chemistry teachers (PCTs) within the „[11]Course of Laboratory Practice in Basic Chemistry (CLP-BC)“[11,52]. The activity began with a laboratory activity using an experiment guide or cookbook, and then it was redesigned into an inquiry-based Science, Environment, Technology, and Society (SETS) activity.

SETS establishes the relationship between students[53] ‟[11] beliefs and the real world. This process will lead students to recognize possible problems they have. The created learning environment fosters students to collect data to solve their problems, consider alternative solutions, determine the best problem-solving ways and[54] practice them (Yager, 1990; Zhang & Asher, 2017). The relevant literature concludes that the level of chemistry achievement can be improved[55] through STSE-related-teaching approaches. Students, who experienced the STSE learning approach, showed significant increases in developing positive attitudes towards science,[7] creativity skills, scientific literacy,[56] social skills concerning the chemistry subject (Ahmed, 2018; M.-K. Lee & Erdogan, 2007; Yörük, Morgil,[57] & Seçken, 2010; Zahara & Atun, 2018). Within this framework, this study aimed at designing a 16-week program to improve the PCTs[58] ‟[11] science process skills and competencies of planning an inquiry-based experiment by shifting cookbook activities to inquiry-based SETS approach.

Inquiry as a Laboratory Activity for Pre-service[3] Chemistry Teachers

An alternative way to shift a traditional laboratory instruction is an investigation (or inquiry) approach (Domin, 1999). Inquiry-based teaching increases deeper and more meaningful understanding (National Research Council, 2000). Inquiry-based activities, which are inductive (DeBoer, 1991), have unspecified results and require students to make their work steps. As compared to traditional patterns, inquiry activities involve more student participation, and fewer guidelines, as well as giving more responsibility to students for choosing their working ways (Leonard, 1989). This approach makes students effective authorities for laboratory activities (Roth, 1995; Roth & Bowen, 1994) and improves their attitudes towards science learning (Merritt, Schneider, & Darlington, 1993). Inquiry-based laboratory activities are also able to enhance students'[11] abilities of formal operational thinking (Lawson & Snitgen, 1982).

The inquiry-based science activities that allow discussion, collaboration and[59] interaction between preservice[3] teachers are useful in developing their beliefs of inquiry-based science learning and enhancing their abilities to apply scientific inquiry processes. The overall findings have suggested that the inquiry-based activities, as an instruction method, should be preferred for preservice[3] teacher education (Çimer, 2007; Sağlam & Şahin, 2017; Tatar, 2012). Further, they have shown that inquiry-based learning increases students'[11] interest in student-[60] centered[61] investigations and facilitates conceptual understanding. Describing scientific phenomena through everyday language develops students‟[11] understanding and enables them to explain scientific phenomena by using scientific vocabulary and making connections with their conducted experiments (Bertsch, Kapelari, & Unterbruner, 2014). Engaging inquiry promotes students to actively involve in questions and answers, scientific inquiry, problem- solving, and experimental learning (Hayat & Rustaman, 2017). Thus, students can not only express their ideas and feelings in various ways but also enjoy their learning processes (Zubaidah, Fuad, Mahanal, & Suarsini, 2017).

A prominent figure, Joseph Schwab, played a crucial role in inquiry-based curriculum development in the 1960s and 1970s. Schwab stated that student participation was so essential for practical activities to train science process skills such as asking questions, collecting data, and interpreting[62] results to appreciate questions (Schwab, 1960) (see Schwab‟s[11] scale of inquiry in science teaching for Table 1. (Mugaloglu & Saribas, 2010; Settlage & Southerland, 2007).

Table 1. Openness Levels of the Inquiry-based Teaching Approach

Level

Source of the Question

Ways to Gather Data

Interpreting Results

Level 0

Given

Given

Given

Level 1

Given

Given

Open

Level 2

Given

Open

Open

Level 3

Open

Open

Open

The type of inquiry can be distinguished as structured, guided, or open (Colburn, 2000; Hegarty-Hazel, 1986). The teacher has excellent control over questions, methods, and interpretations in Level 0, which is the lowest level of investigation. The teacher directly submits problems, procedures, and material content to students for the investigation process, but does not tell the expected results. Students find relationships between variables or generalize the collected data. This level of investigation is identified as a structured inquiry (Colburn, 2000) and known as cookbook activities. In fact,[63] cookbook activities generally cover more directions at observing and collecting data than structured investigation activities. Structured inquiry assignments are based[64] on the content-related curriculum (Zion & Mendelovici, 2012). In structured inquiry groups, lecturers also discuss possible experimental results and the best way to analyze the obtained data (Faulconer, 2016). Students produce the interpretation of results at level 1, while the teacher controls their asking questions and problem-solving procedures. The teacher only determines questions that need to be answered[65] at level 2, but students are free to use their methods to answer the questions and interpret the results. Levels[66] 1 and 2 are labeled[67] as a guided inquiry. Students control these three components at level 3. This level is interpreted[68] as an open inquiry (Colburn, 2000), which is the most sophisticated level of inquiry-based learning. Educators define this type of inquiry[69] as[70] the knowledge framework that allows students to choose various questions and approaches (Faulconer, 2016; Zion & Mendelovici, 2012). Thus, students are exposed[71] to sustainable decision-making procedures at every stage of the open inquiry.

This framework is useful for teachers to plan science activities for their students. Because students have more competencies in doing science[7], teachers will gradually allow them to control all procedures/processes. Scientific[72] experience type of a pre-service[3] teacher influences his or her beliefs about science teaching and learning (Duschl, 1983; Tatar, 2015). They may believe the significance of school students‟[11] direct experiences, but do not know how to translate them into class content. Having the opportunity to study new (and strict) content via prior knowledge and engaging social interaction may help pre-service[3] teachers to resolve this problem. Pre-service[3] teachers should make explicit connections amongst the inquiry process, their understanding of how people study science[7], and their teaching practices (Crawford, 2007; Sağlam & Şahin, 2017).

Based on the inquiry level in Table 1. this study led to design the inquiry-based laboratory activities for the PCTs at level 2 or guided inquiry. Laboratory activities were controlled [73] to adjust their competencies to school-level chemistry studies with several topics. Thus, several problems were deliberately designed [74] to investigate their methods and existing laboratory materials. Besides, the proposed problem challenged the PCTs to review the perspective of the SETS. The results were related to these four aspects, so the chemical content the PCTs had learned was directly associated with their real life.

Science, Environment, Technology, and Society (SETS) Approach in Chemistry Learning

Educational activists from science [7], technology, society and [75] the environment (STSE) have advocated the contextual literacy of ethics, individual and social responsibility (Aikenhead, 1994; Kumar & Chubin, 2000; Pedretti, 1999; Solomon, 1993). STSE programs

and [76] themes aim to interpret science [7] and technology as a socially embedded complex effort and promote the development of critical, scientific, and high-tech citizens, who can understand the STSE issues. The STSE or SETS makes students informed and responsible decision-makers (Pedretti, 2003). This study tried to elicit what the PCTs would be doing through the SETS -based inquiry laboratory activities and whether his or her scientific process skills would increase.

The purpose of the SETS learning is to enable students to understand science better, encourage them to improve their creative and critical thinking skills, and make boring and abstract topics more exciting and enjoyable (Aikenhead, 1994). Previous studies have revealed that the SETS implemented in chemistry learning has possessed a significant impact on learning outcomes (Imaduddin, 2013; Rahmah, Mulyani, & Masyikuri, 2017). Further, they have found a difference amongst critical thinking skills of students, who took the SETS-based guided inquiry, guided inquiry learning, and conventional learning (Jariyah, 2017; Nisak, Wartono, & Suwono, 2017). There is no doubt that learning[77] cannot be actualized[78] in an isolated environment from the world (Nakhleh, 1992). On the other hand, science topics have been taught[79] far from reality or the real world. Through the SETS connections, students aim to build their own[80] understanding of the SETS concept and integrate their life experiences into chemistry and human-made technological world. Students are expected[81] to build[82] and connect these SETS concepts[83] with each other[84] given[85] their continuous interactions (Aikenhead, 1994). The content of the Chemistry course intends to enable students to achieve adequate knowledge for[86] living in a modern technological environment. The SETS relationships should afford students to recognize their environmental and technological[87] conditions, understand their contribution to the community, and predict the possibility of damage that could occur. Therefore, research should be carried[88] out to prepare teachers and develop related equipment allowing students to establish the component connections of the SETS approach (Yörük et al., 2010). The literature has shown how the implementation of the SETS approach in teaching chemistry boosts[89] youngers[90] ‟[11] awareness, despite the[91] fact[92] that[93,94] some[95] obstacles[9] exist[97] in[98] scientific writing[99] and[100] dissemination[101 102] of the[103] results[104]. Overall, students[105] ‟ scientific literacy[106] levels and their commitments to the sustainable development of the local environment need to[107] be deepened[108] (Simões, Nazaré, & Trigo, 2016). Therefore, given a brief review of the relevant literature, this study focused on redesigning chemistry laboratory activities at the university level from the cookbook experiments to inquiry-based SETS pproach[109].

Research Questions

The following research questions guided the current study:

What is the process of redesigning laboratory activities for PCTs from the cookbook activities to inquiry-based SETS activities?

What are PCTs[110] performances and responses to the process of redesigning chemistry laboratory activities from the cookbook activities to inquiry-based SETS activities?

METHODOLOGY

Context

The Course of Laboratory Practice (CLP) for pre-service[3] chemistry teachers is a student- centered[111] [112], and involves several laboratory activities asking for active student engagement. Some chemistry teacher education programs include CLP-related courses, i.e., the „[11]Course of Laboratory Practice in Basic Chemistry (CLP-BC)‟[11,113]. The CLP-BC, which is commonly[114] taught[115] by teacher-centered[116] approach, contains a guidebook to re-practice[117] laboratory[118] activities in the school context and to deepen their subject-matter knowledge learned in the first year of the teacher education program. Cookbook experimental activities are adapted[119] to the school[120] science curriculum and the topics they will teach in their future teaching careers. Regular activities begin with a pre-test to measure their pre-existing knowledge of the chemical concepts that will be practiced and to prepare tools and materials following the instructional guidelines. The CLP-BC settings consist of a 16-week period[121] of laboratory activities and complete with a post-test. In this context, we redesigned the CLP-BC in which the PCTs experienced a shift from traditional lab activities into SETS-based inquiry activities[122]. That is, they tested and practiced two different types of[123] laboratory[124] activity[125] designs[126] and reflected their experiences of the differences between them.

Phases of Research

Since this research characteristically focused on the development and improvement of[127] the[128] CLP-BC, it employed critical theory as a research paradigm. The critical theory concentrates on critics and/or[129] analysis of situations requiring improvement[130] (Kincheloe & McLaren, 2002). Action research, as a research methodology, pursues the critical theory paradigm and deals with problem-solving and project development (Atweh, Kemmis, & Weeks, 1998). This study with the PDSA (Plan, Do, Study, and Act) Cycle model generated a[131] collaborative team study for improving chemistry learning. (Langley et al., 2009). This study comprised of two PDSA cycles: (i) traditional laboratory activities, and (ii) improvement of these activities. Activity details on the PDSA Cycle are shown[132] in Figure 1.

Figure 1. The PDSA cycle for Redesigning Chemistry Laboratory Activities

Research Participants

The CLP-BC comprises of two parts, namely CLP-BC I and CLP-BC II. 20 participants were drawn[133] from the first-year pre-service[3] chemistry teachers, who had previously taken the CLP-BC I. These PCTs came from various regions in Indonesia and had a qualification variety of high school education.[134] The CLP-BC I was presented within a traditional laboratory[135] using a guidebook with practical objectives, theoretical basis,[136] practicum tools[137] and materials, and observation sheets, and evaluation of activities. They were divided into pairs for laboratory activities and completed the CLP-BC I at a 16-week semester.

Instruments and Data Analysis

The instruments consisted of paper and pencil tests, namely a science process skills test (SPST) integrating science process skills with chemistry topics and SETS aspects. The SPST incorporated „[11]observing, questioning, hypothesizing, predicting, investigating, interpreting, communicating‟[11] indicators (Harlen & Jelly, 1997). Because test validity uses the trustworthiness criteria (Guba & Lincoln, 1989), this study ensured them through credibility (member checking), transferability (thick description), dependability (emergence), and confirmability (audit trail data).[138] The SPST, which composed of seven questions with a maximum score of 100 points, covered the characteristics of the Basic Chemistry Practicum (i.e., level and material). Quantitative data were analyzed[13] descriptively.[140] Also, the achievement criteria before and after the treatment were analyzed[141] by calculating normalized[142] gain. The criteria for this N-gain consisted of low (0,0 ☜ < 3,0), medium (0,3 ☜ < 0,7), and high (0,7 ☜ < 1,0) level (Hake, 1998).

Other instruments, namely self-reflective journals (SRJ), performance observation[143] sheets (POS), and presentation observation sheets (PrOS), were adopted from previous studies[144] (Hidayah, 2014). The 24-item SRJ was a 4-point scale (maximum score=96) reflecting the[145] PCTs‟[11] views of science[146] process[147] skills[148] and[150] SETS aspects during[151] the[152] course[153]. Analysis[154] was made[155] through the average item scores of self-reflection categories: low (1,0 ≤ ≤ 2,0), medium (2,00 < ≤ 3,0), and high (3,00 < ≤ 4,00). The POS comprised of Yes- No Checklist and 30 lists spread over five aspects (i.e., practical preparation, the performance[156] of making solutions, the performance of practicum[157] processes[158], affective aspects[159], and performance of final stage). The analysis was done roughly by looking at the changes in average scores of the laboratory activities. In addition[160], unstructured interviews were conducted[161] to see students'[11] responses to the redesigned process[162]. Presentation observation sheets (PrOS) were scored[163] throughout „[11]interesting aspect of the presented material, participation in learning, activeness in discussions, students'[11] discussion abilities to convey their results, students'[11] skills in asking questions, and exposure to the SETS- integrated material‟[11,164]. The CLP-BC program and instruments are summarized[165] in Table 2.

Table 2. The CLP-BC program and instruments

Research Phases

Week

Focus

Instruments

"[11]Plan"[11] Phase

1

Pre-test and preparation of the cookbook experiments

SPST

"Do" Phase

2-7

The Cookbook Experiments

POS

"Study" Phase

8

Focus Group Discussion (FGD) for designing SETS- based inquiry approach between the lecturers and PCTs

"Act" and "Plan" Phase

9

Consultation on the design of inquiry practices and assistance in preparing practical tools and materials

"Do" Phase

10-14

The SETS-based inquiry activities

POS

15

Presentation of the results of the inquiry activities in practicum

PrOS

"Study" Phase

16

Post-test and evaluation

SPST, SRJ

RESULTS AND DISCUSSION

Design of the CLP-BC Program for Pre-service Chemistry Teachers

A strong movement towards inquiry learning, especially BSCS for biology and PSSC for physics (DeBoer, 1991), was developed in the 1960s. The inquiry-based projects in the 1960s revealed many explanations for their failure. Kohlberg and Gilligan believed that inquiry activities assumed formal operational thinking rather than trying to develop it (Kohlberg & Gilligan, 1971). Linn argued that the inquiry approach in the 1960s required

students[166] to simultaneously attend the concept of new subject matter, unknown laboratory equipment, and new[168] problem-solving tasks (Linn, 1980). Other critical studies showed that inquiry emphasized scientific processes in place of proper[169] science content (Friedl, 1991) and wrongly equated scientific inquiry[170] with the discovery of unsupervised students (Hegarty- Hazel, 1990). Lecturers, who teach pedagogical courses in teacher education programs, should consider that inquiry-based learning could not be an effective method to develop pre- service[171] teachers‟[11] critical thinking dispositions (Arsal, 2017). The implementation of inquiry- based[172] learning also showed its inability to improve their competencies of scientifically evaluating and designing scientific investigations (Arief & Utari, 2015). Teaching with minimal guidance is less effective and efficient as compared with the teaching approach that emphasizes student-centered learning. The provision of guidance[173] is increasingly not seen as a benefit when students already have prior knowledge providing[11] "internal"[11] guidance[174] (Kirschner, Sweller, & Clark, 2006). Inquiry learning is only successful in promoting student learning if students are ready or activities are designed correctly (Julien & Lexis, 2015; Kirschner et al., 2006). Therefore, the current study did not carry out suddenly the redesigning process. The first-year PCTs firstly experienced traditional laboratory activities to prepare and train their skills before the inquiry laboratory activities.

As can be seen from Table 3, the five laboratory activities were prepared[175] for mastering the PCTs[176] "[11] science content about the chemistry curriculum at the school level. Based on the second (Plan) phase at[177] the 9th week (see Table 2.), the SETS-based inquiry approach contained five themes. In each theme, a[179] problem, which was raised[180] regarding the SETS aspects, asked a group of the PCTs to conduct a further investigation through their laboratory activities.[178]

Table 3. The chemistry topic in the CLP-BC cookbook model

No

Topics

Purposes of laboratory activities

1

Colligative properties of the solution

Students can observe and know the difference in the boiling point of solvent with the electrolyte solution and non-electrolyte solution

Students can observe[181] and know[182] the difference in freezing point of solvent with the electrolyte solution and non-electrolyte solution

2

Chemical equilibrium

Students can observe[183] and know[184] reactions that can take place in two directions

Students can observe[185] and know[186] the occurrence of a shift in the equilibrium position of acetic acid with the addition of sodium acetate

Students can observe[187] and know[188] the occurrence[189] of a shift in[190] the equilibrium[191] position of acetic acid with the addition of ammonium chloride, NH4Cl

3

Acid-base titration

Students can observe[192] and know[193] the pH change of the solution from acid and base reactions

4

Solubility and Solubility Product

Students can determine the solubility of Ca(OH)2 in water and NaOH solution

Students can observe and know the effect of NaOH on the solubility of Ca (OH)2 and the results of the solubility of Ca(OH)2

5

Voltaic Cells

Students can observe and know the electrical energy produced by spontaneous redox reactions

Students can observe[194] and know[195] the electrical energy[196] produced from spontaneous[197] redox reactions using potato medium

Each group solved five problems, and the designs were not allowed to be the same as the other groups. Variations were made[198] by changing several laboratory variables, i.e., the type of material, tools, stages, or the overall work method (see Table 3 for the five problems proposed for the PCTs). The five problems[199] were prepared[200] by taking into account the topics in the previous [201] laboratory activities and linking them to the SETS aspect. [202] The PCTs were required to design practical activities and relate them to answer the questions posed on the problem. The communication between groups of the PCTs was important [203] to avoid the same practical [204] design on the variable aspect. As observed in Table 4, ten groups of the PCTs could design each of the five activities differently. Thus, the inquiry-based SETS approach included fifty variations of practical activities related to problem-solving. The variation [205] was driven [206] by the intensity of communication between groups in one class. The group of the PCTs designed activities [207] and scheduled problem-solving activities in practicum. The problem-solving duration lasted five working weeks, preceded by a design guidance process before the laboratory activity. This mentoring process took much time for pre-service [3] teachers and lecturers of the CLP-BC courses.

Table 4. The Problems for the CLP-BC with the inquiry-based SETS approach

No

Topics

Problems for the inquiry-based SETSactivities

1

Colligative properties of the solution

Suppose you work in a company that produces methyl alcohol, ethyl alcohol, and isopropyl alcohol. Production employees suddenly forget to label the barrel containing alcohol. The shipping department wants to know what type of alcohol will be sent [208] so they can put it in the appropriate truck. Your group is asked [209] to identify alcohol [210] in the barrel. The only available chemical known is tertiary

butyl alcohol. All alcohol in the plant dissolves tertiary butyl alcohol.

2

Chemical equilibrium on the

solubility

A homeowner is interested in buying water purifiers that are often offered[211] in several advertisements on TV, the internet, and other media. Before buying the tool, the homeowner takes the initiative to test whether he really[212] needs water purification or not. Therefore, he requests the services of a consumer advocate to check it. As a team works in consumer advocates, you are asked[213] to check[214] the hardness of the water owned by the homeowner. How do you check the water hardness level, including hard water or soft water? Also, advise homeowners about what should do!

3

Acid-base titration

Vinegar and olive oil are the main ingredients in most salad dressings. Acetic acid is available in vinegar. Vinegar is an aqueous solution that contains acetic acid as a solute. You are a member of the chemical analysis team. Your team is asked[216] to analyze the quality[217] of supplied vinegar in a company because the company has received complaints about the unsuitability of their dressings for
348 the[218] served salad.[215] Indeed, the condition of olive oil is not a problem. Your team is asked[219] to determine the concentration (molarity and percent mass) of acetic acid[220] in vinegar samples that the company has distributed to restaurants.

4

Solubility Product

Water in the pool generally contains a number of[221] dissolved calcium ions. The swimming pool is purified[222] with the addition of several chlorination agents. Calcium hypochlorite is commonly used.[223] Besides, calcium ions emerge from plaster lining the pond. Plaster[224] is a hydrate of calcium sulfate. A swimming pool company has recently contacted your group to address complaints from several customers. Customers have complained about plaster[225] in the pool that began to disappear after one year. The company wants to know how many plasters[226] that might be dissolved[227] before the pool water becomes a saturated solution of calcium sulfate. At first, the swimming pool includes soft water (non-hard water)

which does not contain calcium ions.

5

Voltaic Cells

Suppose your group is stranded somewhere in the sea and[228] you have to turn on the global positioning system (GPS). You do not have a replacement battery, but you have a bag full of coins. How much voltage can you make from this coin to make a battery?

Learning with the SETS approach overcomes misconceptions by considering the role of science[7] in society (Yörük et al., 2010). The main objective of the SETS-related chemistry is to present chemistry and technology as a methodology, which allows pre-service[3] teachers to

compare[229] benefits and losses in the presented problem-solving process. The presented[230] problems are part of the SETS components to find out the benefits[231] and applications in life to solve social problems[232] through chemistry and technology. Using this approach will increase scientific literacy[56] and student interest (Yörük et al., 2010). The problems[233] with the inquiry- based[234] SETS activities show chemistry-related professions as well as chemical positions, i.e., individual parts as citizens, communities, service users, or consumers. Allowing students to recognize the interaction(s) between SETS components will make abstract concepts more concrete.

In some cases, students may find inquiry laboratories time-consuming, and other laboratory works funny (Chatterjee, Williamson, McCann, & Peck, 2009; Luckie et al., 2012). For example; the PCTs stated the following quotation:

[11] "The first pleasant experience where we made the practical prescription, not from the lecturer or teacher." [11] [PCT 1]

Practical work can reveal the disparity between theory and practical experiments by constructing an understanding of the role played by experiments, while practical work is too costly and time-consuming (Castro & Morales, 2017; Ma & Nickerson, 2006). Other PCTs also showed enthusiasm through a statement suggesting that inquiry activities could construct their understanding of the chemistry concepts.

[11] "Such a meaningful experience because it trains independence in working in the laboratory. With independence, the things that are wrong and right can be seen up to the roots, although it is somewhat confusing." [11] [PCT 2]

The settings of inquiry activities in the redesigning process are presented [235] in Figure 2. The PCTs might not carry out them [236] in practicum before the stages were completed [237]. Before practical activities [238], problems were given to them to solve through practical activities [239]. They designed practical activities [240], identified equipment and material needs, and prepared the tools and materials themselves. Practical activities [241] were carried [242] out after the approval of the lecturer.

Figure 2. The Settings of the Inquiry Activities in Redesigning Process

Inquiry encouraged the PCTs to find the limits of their understanding of subject-matter knowledge, enabled them to build knowledge different from their pre-existing knowledge and[243] helped them understand the possibility of practical work in teaching. To develop their competencies, the PCTs might also gain an understanding of various aspects of pedagogical knowledge (Nivalainen, Asikainen, & Hirvonen, 2013). Through mentoring from the lecturers, the PCTs would understand the chemical concepts perceived as weak or still needed

improvement[244] [245], and their stages of understanding.[246] This understanding could be transferred[247] to problem-solving strategies of such topics as the colligative nature of the solution, chemical equilibrium on solubility, acid-base titration, solubility products, and voltaic cells.

Pre-service[3] Chemistry Teachers'[11] Performances and Responses

During the design process of the cookbook experiments into the inquiry-based SETS approach, how the PCTs managed laboratory activities could be directly observed.[248] Observations were conducted[249] within the aspects of preparing practical activities, making a practical solution, running the practice, affective issues in the laboratory, and their performances at the end of practical activities.[250] All of them were observed by Yes-No Checklist[251] in the POS. As seen from Table 5, the number of "[11]Yes"[11] response[252] was made[253] in integers. As compared the[254] number of "Yes"[11] response[11] with the maximal number of[255] "Yes"[11] response[11] for[256,257] each aspect, the number of the items was 37.

Table 5. The PCTs'[11] performances of laboratory activities

No.

Aspects

The average scores

(Cookbook Experiment)

The average scores of each inquiry-

based SETS activities

I

II

III

IV

V

1

Practical preparation

4/6

6/6

6/6

6/6

6/6

6/6

2

Performance of making

solutions

6/7

6/7

6/7

6/7

6/7

6/7

3

Performance of practical

processes

10/14

10/14

10/14

10/14

10/14

10/14

4

Affective issues

5/6

6/6

6/6

6/6

6/6

6/6

5

Performance of the final

stage

4/4

4/4

4/4

4/4

4/4

4/4

Total

29/37

32/37

32/37

32/37

32/37

32/37

As can be seen from Table 5, there were changes in the PCTs‟ [11] performances of the implementation of inquiry activities. The PCTs complemented all performance aspects. Inquiry learning seems to have provided them to experience the processes of preparing equipment and chemical materials, operating special tools for practical activities, and making reagents. They motivated them to learn the whole processes [258,259] in preparing practical laboratory activities. For instance; [260] the PCT [261] 3 stated that he had to buy directly one of the chemical materials that they did not find in the laboratory.
"[11] I was initially confused because I did not find oxalic acid to standardize NaOH solution in the laboratory. However, consulting with laboratory staff and lecturers, I just found out that the ingredients can be purchased [262] at Indrasari

stores, one of the chemical stores in Semarang city. I just visited the chemical store for the first time because I needed materials for the experiment I was going to do. Valuable experience because I will know where to buy chemicals when I become a teacher.[11] [PCT 3]

Also, when carrying out practical activities, the PCTs did not have much doubt because they really[263] understood what they were doing. It was different from the use of the cookbook format. The PCTs flipped their notes because they hesitated how to carry out practical work steps. An excerpt is in the following:

[11]"Designing practical laboratory activities myself, I became more aware of what to do. There is no need to open a work step record because everything has been memorized[264] [11]". [PCT 4]

Based on the five inquiry activities, the results were presented[265] through discussion activities. Two groups independently presented[266] each topic. Given their performances of the discussion session[267], the sharp differences occurred about such aspects as including media presentation, participation in learning, activeness in the discussion, the PCTs‟[11] abilities to convey the results of the discussion[268], questioning skills, and exposure related to SETS aspects (see Table 6).

Table 6. The results of the Presentation Observation Sheet for Discussion Session

No

Topics

The average scores in each aspect

Total

A

B

C

D

E

F

1

Colligative properties of the

solution

3

3

3

3

3

3

18

2

Chemical equilibrium on

solubility

4

4

4

4

4

4

24

3

Acid-base titration

4

4

3

4

3

3

21

4

Solubility Product

3

4

4

3

4

3

21

5

Voltaic Cells

3

3

3

3

4

4

20

Note: A: Interesting aspects of the presented material, B: Participation in learning, C: Activeness in discussions, D: Students 'discussion abilities to convey the results, E: Students' skills in asking questions, F: Exposure to the SETS-integrated material.

As observed in Table 6, discussing how to check for water hardness (fourth topic) was the best scores for all aspects. The concept of Ca2+ solubility seems to have become attractive because of limestone soil conditions in some areas, Demak and Purwodadi Regency, Central Java Province. In the last decade, several authors have emphasized the importance of carrying out environmental projects based on scientific research, real problems and laboratory activities (Gayford, 2002; Kolstoe, 2002; Moseley, 2000). One of the strategies for implementing these issues may be the SETS approach (Zhang & Asher, 2017). Overall, a proper assessment of the project, a deepened students' scientific literacy, and their commitment(s) to the sustainable development of the local environment appear to be indicators of the achievement (Simões et al., 2016). The PCTs from Purwodadi told how she was interested in carrying out the practical laboratory activities to check the water hardness.

"I brought water from my house to check it myself in a chemical laboratory. I am curious about the results. It is nice to learn that I can be used to understand what is around me". [PCT 5]

As shown in Table 7, the PCTs[276] ‟[11] science process skills also showed an increase at a medium level (N-gain = 0.48). These skills contained observing, questioning, hypothesizing, predicting, investigating, interpreting, and communicating (Harlen & Jelly, 1997). Inquiry- based[277] SETS activities developed the PCTs[278] ‟[11] science process skills. Thirteen of the PCTs obtained N-gain value at the medium level.[279]

Table 7. Achievement criteria before and after learning based on SPST

No

Phase

Minimum

Maximum

Average

SD

Overall N-

gain

N-gain (n= 20)

Low

Medium

High

1

Pre-test

10

87.5

56.3

19.7

0.48

(medium level)

7

PCTs

13 PCTs

-

2

Post-test

56

95

77.1

9.8

As can be seen from Table 8, their self-reflective journals showed medium (13 students) and high (7 students) categories. The results of self-reflection also revealed their self-opinion of science process skills, and how inquiry activities affected their future teaching careers. The PCTs showed positive results in their self-reflective journals. Several statements of the SETS approach were also found [280] in interviews.

Table 8. The results of the PCTs‟ [11] self-reflective journals

Components	Results
Average (n = 20)	67.3
Standard Deviation	11.1
Minimum Score (Total Score = 96)	53
Maximum Score (Total Score = 96)	93
Low Category of Reflection	-
Medium Category of Reflection	13 PCTs
High Category of Reflection	7 PCTs

When the PCTs designed their experiments, they proposed explanations for the phenomena they observed. They discussed their understanding of its contents and faced various misconceptions that they or their colleagues had submitted. From the perspective of teacher knowledge, pre-service[3] teachers are aware of the fact that almost everyone has problems with their understanding, even in simple chemistry. Thus, they should pay attention to this misunderstanding when teaching later in school. Even if the role of a teacher is urgent in conceptual change, the interaction between peers is also an effective method of expressing and remedying misunderstandings (Nivalainen et al., 2013). Inquiry activities trained and improved their questioning and predicting skills. This stage seems to have occurred knowledge construction, as stated by PCT 6. "At[11] first, I was worried because it was not as usual. I then asked another friend, who was not in a group about the procedure she designed. From a casual conversation, I got many questions and ideas about designing lab work to solve problems".[11] [PCT 6]

Based on observations, several PCTs were almost frustrated because of the challenge of designing a practical laboratory activity based on the SETS problems. Students, who learn in the inquiry environment at an early stage, become impatient, but in the end, they understand what they are going through it and improve their learning. Finally, such a fosters them to begin enjoying it (Duran, McArthur, & Van Hook, 2004). In the CLP-BC, some PCTs showed their frustration and impatience levels through dependency in carrying out activities in the trial design process, preparation of tools and materials, and reporting results. Their final reflections showed a positive response to the redesigning process. The inquiry-based SETS approach needed to be further developed in other practical activities as stated by the PCT 7.
"This[11] practical activity shows that chemistry turns out to have a close relationship with the environment, technology, and society. I have just realized

how chemistry is used[281] to check the condition of the pool, the condition of the vinegar packaging, making the battery simple. Hopefully, another practicum can also be like this"[11]. [PCT 7]

Similar findings from inquiry learning experiences have shown that pre-service[3] teachers finally get a thorough appreciation of the benefits of teaching and learning science[7] through inquiry (Duran et al., 2004; Varma, Volkmann, & Hanuscin, 2009). Inquiry activities are effective in improving their science process skills (Özdemir & Işik, 2015; Sağlam & Şahin, 2017). The SETS approach also attracts attention and contributes to the improvement of science process skills (Zahara & Atun, 2018).

CONCLUSIONS

We have discussed the redesigned laboratory activities for the PCTs. The activity[282], which was initially the cookbook experiments, was redesigned concerning a inquiry-based[283] SETS activity. The redesigned chemical topics for laboratory activities included: (1) colligative properties of solution, (2) chemical equilibrium on solubility, (3) acid-base titration, (4) solubility product, and (5) voltaic cells.[284] The results showed that there were differences between the cookbook design and inquiry experiments in terms of learning stages, time allocation, skill and[285] motivation conditions in laboratory activities, as well as outcomes of laboratory activities.

Based on various findings during the redesigning process, there were enhancements of the PCTs‟[11] performances in regulating laboratory activities. Their performances[286] of the discussion activities about the results of independent practical laboratory activities also developed and showed good[287] results at[288] their science process skills, as well as their positive responses to the self-reflective journals.

The initial stage of the implementation of the inquiry activities may become reasonable and be achieved[289] with intensive mentoring activities in that they may have frustration and constraints at the early stage of inquiry-based learning. The duration for inquiry activities can be accomplished[290] through a peer tutoring system, and some delegated tutors from bright/hard-[291] working[292] students. Peer tutors may assist the processes of designing and preparing practical activities. Blended classes through online activities are also possible to overcome space and time constraints.

Furthermore, developing a higher-level inquiry or open inquiry for the PCTs is necessary. Seeing the results obtained at the guided inquiry has the potential to prepare the PCTs to attain the inquiry level. Also, the PCTs should be able to teach the inquiry-based SETS approach. A further design ought to include microteaching activities if pre-service[3] teachers follow the developmental design[293] of this activity and obtain complete knowledge related to pedagogical competencies.[294]

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1.	*for*	Inappropriate Colloquialisms	Delivery
2.	...	Misuse of Semicolons, Quotation Marks, etc.	Correctness
3.	*Pre-service; pre-service; preservice; Pre-Service*	Text Inconsistencies	Correctness
4.	the article	Determiner Use (a/an/the/this, etc.)	Correctness
5.	~~doi~~ → DOI	Misspelled Words	Correctness
6.	pre-service chemistry	Improper Formatting	Correctness
7.	*science; Science*	Text Inconsistencies	Correctness
8.	analyzing pre-service	Improper Formatting	Correctness
9.	pre-service chemistry	Improper Formatting	Correctness
10.	chemistry teachers	Improper Formatting	Correctness
11.	*"; „; "; students'; Teachers'; PCTs'; Students '; Students'; Chemists'*	Text Inconsistencies	Correctness
12.	performances and	Improper Formatting	Correctness
13.	~~and their~~ → and their	Improper Formatting	Correctness
14.	~~their views~~ → their views	Improper Formatting	Correctness
15.	~~views to~~ → views to	Improper Formatting	Correctness
16.	~~to the~~ → to the	Improper Formatting	Correctness
17.	~~the redesigned~~ → the redesigned	Improper Formatting	Correctness
18.	redesigned laboratory	Improper Formatting	Correctness
19.	*Because school laboratory activities obtained by pre-service teachers*	Hard-to-read text	Clarity

	tend to use cookbook experiments, this study focused on redesigning chemistry laboratory activities at the university level from cookbook experiments to inquiry-based Science, Environment, Technology, and Society (SETS) approach,...		
20.	*was conducted*	Passive Voice Misuse	Clarity
21.	the „Plan-Do-Study-Act“	Determiner Use (a/an/the/this, etc.)	Correctness
22.	~~“.~~ → .“	Misuse of Semicolons, Quotation Marks, etc.	Correctness
23.	Science process	Improper Formatting	Correctness
24.	~~process skills~~ → process skills	Improper Formatting	Correctness
25.	~~skills test~~ → skills test	Improper Formatting	Correctness
26.	performance observation	Improper Formatting	Correctness
27.	observation sheets	Improper Formatting	Correctness
28.	*were used*	Passive Voice Misuse	Clarity
29.	~~solution;~~ → solution,	Punctuation in Compound/Complex Sentences	Correctness
30.	~~solubility;~~ → solubility,	Punctuation in Compound/Complex Sentences	Correctness
31.	~~titration;~~ → titration,	Punctuation in Compound/Complex Sentences	Correctness
32.	~~product;~~ → product,	Punctuation in Compound/Complex Sentences	Correctness
33.	~~PCTs~~ → PCT's, PCTs'	Incorrect Noun Number	Correctness
34.	science.	Closing Punctuation	Correctness

35.	*for*	Inappropriate Colloquialisms	Delivery
36.	...	Misuse of Semicolons, Quotation Marks, etc.	Correctness
37.	~~learning~~ → Learning	Improper Formatting	Correctness
38.	*learning and learning methods (National Research Council, 1996).*	Incomplete Sentences	Correctness
39.	~~important~~ → essential	Word Choice	Engagement
40.	an inquiry-based	Determiner Use (a/an/the/this, etc.)	Correctness
41.	~~important~~ → essential	Word Choice	Engagement
42.	~~".~~ → ."	Misuse of Semicolons, Quotation Marks, etc.	Correctness
43.	of them	Wrong or Missing Prepositions	Correctness
44.	~~or~~ → of	Confused Words	Correctness
45.	the Ural	Determiner Use (a/an/the/this, etc.)	Correctness
46.	*be used*	Passive Voice Misuse	Clarity
47.	~~students~~ → students', student's	Incorrect Noun Number	Correctness
48.	~~in- servic~~ → in-service	Misspelled Words	Correctness
49.	~~great~~ → significant	Word Choice	Engagement
50.	*be implemented*	Passive Voice Misuse	Clarity
51.	~~pre-service~~ → Pre-service	Improper Formatting	Correctness
52.	~~“.~~ → .“	Misuse of Semicolons, Quotation Marks, etc.	Correctness

53.	~~students~~ → students', student's	Incorrect Noun Number	Correctness
54.	, and	Comma Misuse within Clauses	Correctness
55.	*be improved*	Passive Voice Misuse	Clarity
56.	*literacy; Literacy*	Text Inconsistencies	Correctness
57.	~~Morgil~~ → Morgul	Misspelled Words	Correctness
58.	~~PCTs~~ → PCT's, PCTs'	Incorrect Noun Number	Correctness
59.	, and	Comma Misuse within Clauses	Correctness
60.	the student	Determiner Use (a/an/the/this, etc.)	Correctness
61.	student-centered	Misspelled Words	Correctness
62.	. Interpreting	Hard-to-read text	Clarity
63.	~~In fact,~~ cookbook	Wordy Sentences	Clarity
64.	*are based*	Passive Voice Misuse	Clarity
65.	*be answered*	Passive Voice Misuse	Clarity
66.	~~Levels~~ → Grades, Groups	Word Choice	Engagement
67.	*are labeled*	Passive Voice Misuse	Clarity
68.	*is interpreted*	Passive Voice Misuse	Clarity
69.	~~inquiry~~ → investigation	Word Choice	Engagement
70.	as to	Wrong or Missing Prepositions	Correctness
71.	*are exposed*	Passive Voice Misuse	Clarity
72.	The scientific	Determiner Use (a/an/the/this, etc.)	Correctness

73.	*were controlled*	Passive Voice Misuse	Clarity
74.	*were deliberately designed*	Passive Voice Misuse	Clarity
75.	, and	Comma Misuse within Clauses	Correctness
76.	~~and~~ → And	Improper Formatting	Correctness
77.	~~learning~~ → knowledge, education	Word Choice	Engagement
78.	*be actualized*	Passive Voice Misuse	Clarity
79.	*been taught*	Passive Voice Misuse	Clarity
80.	~~own~~	Wordy Sentences	Clarity
81.	*are expected*	Passive Voice Misuse	Clarity
82.	~~build~~ → develop	Word Choice	Engagement
83.	~~concepts~~ → ideas	Word Choice	Engagement
84.	~~with each other~~	Wordy Sentences	Clarity
85.	, given	Punctuation in Compound/Complex Sentences	Correctness
86.	~~for~~ → of	Wrong or Missing Prepositions	Correctness
87.	~~technological~~ → technical	Word Choice	Engagement
88.	*be carried*	Passive Voice Misuse	Clarity
89.	chemistry boosts	Improper Formatting	Correctness
90.	boosts youngers	Improper Formatting	Correctness
91.	~~despite the~~ → despite the	Improper Formatting	Correctness
92.	~~the fact~~ → the fact	Improper Formatting	Correctness

93.	even though, although	Wordy Sentences	Clarity
94.	~~fact that~~ → fact that	Improper Formatting	Correctness
95.	~~that some~~ → that some	Improper Formatting	Correctness
96.	~~some obstacles~~ → some obstacles	Improper Formatting	Correctness
97.	obstacles exist	Improper Formatting	Correctness
98.	~~exist in~~ → exist in	Improper Formatting	Correctness
99.	scientific writing	Improper Formatting	Correctness
100.	~~writing and~~ → writing and	Improper Formatting	Correctness
101.	and dissemination	Improper Formatting	Correctness
102.	dissemination of	Improper Formatting	Correctness
103.	~~of the~~ → of the	Improper Formatting	Correctness
104.	~~the results~~ → the results	Improper Formatting	Correctness
105.	~~students~~ → students', student's	Incorrect Noun Number	Correctness
106.	scientific literacy	Improper Formatting	Correctness
107.	~~need to~~ → need to	Improper Formatting	Correctness
108.	*be deepened*	Passive Voice Misuse	Clarity
109.	~~pproach~~ → approach	Misspelled Words	Correctness
110.	~~PCTs~~ → PCT's, PCTs'	Incorrect Noun Number	Correctness
111.	student-centered	Misspelled Words	Correctness
112.	centered,	Comma Misuse within Clauses	Correctness

113.	~~".~~ → ."	Misuse of Semicolons, Quotation Marks, etc.	Correctness
114.	~~which is~~ → which is	Improper Formatting	Correctness
115.	~~is commonly~~ → is commonly	Improper Formatting	Correctness
116.	a teacher-centered	Determiner Use (a/an/the/this, etc.)	Correctness
117.	~~to re-practice~~ → to re-practice	Improper Formatting	Correctness
118.	re-practice laboratory	Improper Formatting	Correctness
119.	*are adapted*	Passive Voice Misuse	Clarity
120.	~~the school~~ → The school	Improper Formatting	Correctness
121.	~~a 16-week period~~ → 16 weeks	Wordy Sentences	Clarity
122.	inquiry activities	Improper Formatting	Correctness
123.	~~types of~~ → types of	Improper Formatting	Correctness
124.	~~of laboratory~~ → of laboratory	Improper Formatting	Correctness
125.	laboratory activity	Improper Formatting	Correctness
126.	activity designs	Improper Formatting	Correctness
127.	~~improvement of~~ → improvement of	Improper Formatting	Correctness
128.	~~of the~~ → of the	Improper Formatting	Correctness
129.	~~and/or~~ → and, or	Inappropriate Colloquialisms	Delivery
130.	~~improvement~~ → modification	Word Choice	Engagement
131.	~~generated a~~ → generated a	Improper Formatting	Correctness
132.	*are shown*	Passive Voice Misuse	Clarity

133.	*were drawn*	Passive Voice Misuse	Clarity
134.	*The CLP-BC comprises of two parts, namely CLP-BC I and CLP-BC II. 20 participants were drawn from the first-year pre-service chemistry teachers, who had previously taken the CLP-BC I. These PCTs came from various regions in Indonesia and had a qualification variety of high school education.*	Hard-to-read text	Clarity
135.	traditional laboratory	Improper Formatting	Correctness
136.	theoretical basis	Improper Formatting	Correctness
137.	practicum tools	Improper Formatting	Correctness
138.	*Because test validity uses the trustworthiness criteria (Guba & Lincoln, 1989), this study ensured them through credibility (member checking), transferability (thick description), dependability (emergence), and confirmability (audit trail data).*	Hard-to-read text	Clarity
139.	~~were analyzed~~ → were analyzed	Improper Formatting	Correctness
140.	analyzed descriptively	Improper Formatting	Correctness
141.	*were analyzed*	Passive Voice Misuse	Clarity
142.	the normalized	Determiner Use (a/an/the/this, etc.)	Correctness
143.	performance observation	Improper Formatting	Correctness
144.	previous studies	Improper Formatting	Correctness
145.	~~reflecting the~~ → reflecting the	Improper Formatting	Correctness
146.	~~views of~~ → views of	Improper Formatting	Correctness

147.	~~of science~~ → of science	Improper Formatting	Correctness
148.	science process	Improper Formatting	Correctness
149.	~~process skills~~ → process skills	Improper Formatting	Correctness
150.	~~skills and~~ → skills and	Improper Formatting	Correctness
151.	~~aspects during~~ → aspects during	Improper Formatting	Correctness
152.	~~during the~~ → during the	Improper Formatting	Correctness
153.	~~the course~~ → the course	Improper Formatting	Correctness
154.	The analysis	Determiner Use (a/an/the/this, etc.)	Correctness
155.	*was made*	Passive Voice Misuse	Clarity
156.	the performance	Improper Formatting	Correctness
157.	~~of practicum~~ → of practicum	Improper Formatting	Correctness
158.	practicum processes	Improper Formatting	Correctness
159.	affective aspects	Improper Formatting	Correctness
160.	~~In addition~~ → Also, Besides	Wordy Sentences	Clarity
161.	*were conducted*	Passive Voice Misuse	Clarity
162.	redesigned process	Improper Formatting	Correctness
163.	*were scored*	Passive Voice Misuse	Clarity
164.	~~".~~ → ."	Misuse of Semicolons, Quotation Marks, etc.	Correctness
165.	*are summarized*	Passive Voice Misuse	Clarity
166.	~~students~~ → Students	Improper Formatting	Correctness

167.	~~unknown~~ → new	Word Choice	Engagement
168.	~~new~~ → unique	Word Choice	Engagement
169.	~~proper~~ → appropriate, good	Word Choice	Engagement
170.	~~inquiry~~ → investigations	Word Choice	Engagement
171.	~~pre- servic~~ → pre-service	Misspelled Words	Correctness
172.	~~inquiry- base~~ → inquiry-based	Misspelled Words	Correctness
173.	~~guidance~~ → advice	Word Choice	Engagement
174.	~~guidance~~ → advice	Word Choice	Engagement
175.	*were prepared*	Passive Voice Misuse	Clarity
176.	~~PCTs~~ → PCT's, PCTs'	Incorrect Noun Number	Correctness
177.	~~at~~ → in	Wrong or Missing Prepositions	Correctness
178.	*In each theme, a problem, which was raised regarding the SETS aspects, asked a group of the PCTs to conduct a further investigation through their laboratory activities.*	Wordy Sentences	Clarity
179.	~~theme~~ → piece, article	Word Choice	Engagement
180.	*was raised*	Passive Voice Misuse	Clarity
181.	~~observe~~ → attend, follow	Word Choice	Engagement
182.	~~know~~ → see	Word Choice	Engagement
183.	~~observe~~ → attend, follow	Word Choice	Engagement
184.	~~know~~ → understand	Word Choice	Engagement
185.	~~observe~~ → attend, follow	Word Choice	Engagement

186.	~~know~~ → see	Word Choice	Engagement
187.	~~observe~~ → attend, follow	Word Choice	Engagement
188.	~~know~~ → see	Word Choice	Engagement
189.	~~occurrence~~ → event	Word Choice	Engagement
190.	~~shift in~~ → change in, change of	Word Choice	Engagement
191.	the equilibrium	Determiner Use (a/an/the/this, etc.)	Correctness
192.	~~observe~~ → attend, follow	Word Choice	Engagement
193.	~~know~~ → learn, understand	Word Choice	Engagement
194.	~~observe~~ → attend, follow	Word Choice	Engagement
195.	~~know~~ → learn, understand	Word Choice	Engagement
196.	~~energy~~ → power	Word Choice	Engagement
197.	~~spontaneous~~ → automatic, unexpected	Word Choice	Engagement
198.	*were made*	Passive Voice Misuse	Clarity
199.	~~problems~~ → issues	Word Choice	Engagement
200.	*were prepared*	Passive Voice Misuse	Clarity
201.	~~the previous~~ → The previous	Improper Formatting	Correctness
202.	*the previous laboratory activities and linking them to the SETS aspect.*	Incomplete Sentences	Correctness
203.	~~important~~ → essential	Word Choice	Engagement
204.	~~practical~~ → experimental, functional	Word Choice	Engagement
205.	~~variation~~ → interpretation	Word Choice	Engagement

206.	*was driven*	Passive Voice Misuse	Clarity
207.	~~activities~~ → exercises	Word Choice	Engagement
208.	*be sent*	Passive Voice Misuse	Clarity
209.	*is asked*	Passive Voice Misuse	Clarity
210.	~~alcohol~~ → drink	Word Choice	Engagement
211.	*are often offered*	Passive Voice Misuse	Clarity
212.	~~really~~	Wordy Sentences	Clarity
213.	*are asked*	Passive Voice Misuse	Clarity
214.	~~check~~ → review	Word Choice	Engagement
215.	*Your team is asked to analyze the quality of supplied vinegar in a company because the company has received complaints about the unsuitability of their dressings for the served salad.*	Wordy Sentences	Clarity
216.	*is asked*	Passive Voice Misuse	Clarity
217.	*quality; Quality*	Text Inconsistencies	Correctness
218.	~~for the~~ → for the	Improper Formatting	Correctness
219.	*is asked*	Passive Voice Misuse	Clarity
220.	the acid	Determiner Use (a/an/the/this, etc.)	Correctness
221.	~~a number of~~ → several, some, many	Wordy Sentences	Clarity
222.	*is purified*	Passive Voice Misuse	Clarity
223.	*is commonly used*	Passive Voice Misuse	Clarity

224.	~~Plaster~~ → Application, Dressing	Word Choice	Engagement
225.	~~plaster~~ → application	Word Choice	Engagement
226.	~~plasters~~ → applications, bandages, dressings	Word Choice	Engagement
227.	*be dissolved*	Passive Voice Misuse	Clarity
228.	, and	Punctuation in Compound/Complex Sentences	Correctness
229.	~~compare~~ → Compare	Improper Formatting	Correctness
230.	~~presented~~ → given, proposed	Word Choice	Engagement
231.	~~benefits~~ → services, advantages	Word Choice	Engagement
232.	~~problems~~ → issues	Word Choice	Engagement
233.	~~problems~~ → issues	Word Choice	Engagement
234.	~~inquiry- base~~ → inquiry-based	Misspelled Words	Correctness
235.	*are presented*	Passive Voice Misuse	Clarity
236.	~~carry out them~~ → carry them out	Misplaced Words or Phrases	Correctness
237.	*were completed*	Passive Voice Misuse	Clarity
238.	~~activities~~ → exercises	Word Choice	Engagement
239.	~~activities~~ → exercises	Word Choice	Engagement
240.	~~activities~~ → exercises	Word Choice	Engagement
241.	~~activities~~ → exercises	Word Choice	Engagement
242.	*were carried*	Passive Voice Misuse	Clarity
243.	, and	Comma Misuse within Clauses	Correctness

244.	~~improvement~~ → Improvement	Improper Formatting	Correctness
245.	improvement,	Punctuation in Compound/Complex Sentences	Correctness
246.	*improvement, and their stages of understanding.*	Incomplete Sentences	Correctness
247.	*be transferred*	Passive Voice Misuse	Clarity
248.	*be directly observed*	Passive Voice Misuse	Clarity
249.	*were conducted*	Passive Voice Misuse	Clarity
250.	~~activities~~ → exercises	Word Choice	Engagement
251.	Yes-No Checklist observed all of them	Passive Voice Misuse	Clarity
252.	~~response~~ → responses	Incorrect Noun Number	Correctness
253.	*was made*	Passive Voice Misuse	Clarity
254.	to the	Wrong or Missing Prepositions	Correctness
255.	~~response~~ → responses	Incorrect Noun Number	Correctness
256.	~~response~~ → answer	Word Choice	Engagement
257.	~~response~~ → responses	Incorrect Noun Number	Correctness
258.	~~processes~~ → operations, procedures, methods, strategies	Word Choice	Engagement
259.	~~processes~~ → process	Incorrect Noun Number	Correctness
260.	~~instance;~~ → instance,	Punctuation in Compound/Complex Sentences	Correctness
261.	~~the~~ PCT	Determiner Use (a/an/the/this, etc.)	Correctness

262.	*be purchased*	Passive Voice Misuse	Clarity
263.	~~really~~	Wordy Sentences	Clarity
264.	*been memorized*	Passive Voice Misuse	Clarity
265.	*were presented*	Passive Voice Misuse	Clarity
266.	~~presented~~ → submitted	Word Choice	Engagement
267.	*Given their performances of the discussion session*	Misplaced Words or Phrases	Correctness
268.	~~discussion~~ → debate	Word Choice	Engagement
269.	Note:	Misuse of Semicolons, Quotation Marks, etc.	Correctness
270.	~~the results~~ → the results	Improper Formatting	Correctness
271.	~~scores~~ → score	Incorrect Noun Number	Correctness
272.	~~have become~~ → have become	Improper Formatting	Correctness
273.	become attractive	Improper Formatting	Correctness
274.	~~real problems~~ → real problems	Improper Formatting	Correctness
275.	, and	Comma Misuse within Clauses	Correctness
276.	~~PCTs~~ → PCT's, PCTs'	Incorrect Noun Number	Correctness
277.	~~Inquiry- base~~ → Inquiry-based	Misspelled Words	Correctness
278.	~~PCTs~~ → PCT's, PCTs'	Incorrect Noun Number	Correctness
279.	*These skills contained observing, questioning, hypothesizing, predicting, investigating, interpreting, and communicating (Harlen & Jelly, 1997). Inquiry- based*	Monotonous Sentences	Engagement

	SETS activities developed the PCTs " science process skills. Thirteen of the PCTs obtained N-gain value at the medium level.		
280.	*were also found*	Passive Voice Misuse	Clarity
281.	*is used*	Passive Voice Misuse	Clarity
282.	~~activity~~ → move, movement, action, training	Word Choice	Engagement
283.	an inquiry-based	Determiner Use (a/an/the/this, etc.)	Correctness
284.		Intricate Text	Clarity
285.	, and	Comma Misuse within Clauses	Correctness
286.	~~performances~~ → accounts, versions, interpretations, renditions	Word Choice	Engagement
287.	~~good~~ → promising	Word Choice	Engagement
288.	~~at~~ → in	Wrong or Missing Prepositions	Correctness
289.	*be achieved*	Passive Voice Misuse	Clarity
290.	*be accomplished*	Passive Voice Misuse	Clarity
291.	~~hard~~ → challenging	Word Choice	Engagement
292.	~~hard- workin~~ → hard-working	Misspelled Words	Correctness
293.	~~design~~ → system, plan, structure, strategy	Word Choice	Engagement
294.	*A further design ought to include microteaching activities if pre-service teachers follow the developmental design of this activity and obtain complete knowledge*	Hard-to-read text	Clarity

	related to pedagogical competencies.		
295.	Acknowledgments	Mixed Dialects of English	Correctness
296.	acknowledgments	Mixed Dialects of English	Correctness
297.	*are conveyed*	Passive Voice Misuse	Clarity
298.	~~inquiry based~~ → inquiry-based	Misspelled Words	Correctness
299.	~~based primary~~ → based primary	Improper Formatting	Correctness
300.	primary science	Improper Formatting	Correctness
301.	~~influence of~~ → influence of	Improper Formatting	Correctness
302.	~~of inquiry~~ → of inquiry	Improper Formatting	Correctness
303.	~~inquiry~~ → search, investigation, question	Word Choice	Engagement
304.	~~inquiry base~~ → inquiry-based	Misspelled Words	Correctness
305.	~~inquiry based~~ → inquiry based	Improper Formatting	Correctness
306.	~~based lessons~~ → based lessons	Improper Formatting	Correctness
307.	~~lessons on~~ → lessons on	Improper Formatting	Correctness
308.	~~on interest~~ → on interest	Improper Formatting	Correctness
309.	~~interest and~~ → interest and	Improper Formatting	Correctness
310.	~~and conceptual~~ → and conceptual	Improper Formatting	Correctness
311.	~~students~~ → student's, students'	Incorrect Noun Number	Correctness
312.	~~Diambil~~ → diambil	Confused Words	Correctness
313.	~~dari~~ → Dari	Misspelled Words	Correctness

314.	~~inquiry- base~~ → inquiry-based	Misspelled Words	Correctness
315.	The breeding, or A breeding	Determiner Use (a/an/the/this, etc.)	Correctness
316.	~~an~~ apprehension	Determiner Use (a/an/the/this, etc.)	Correctness
317.	~~a case~~ → A case	Improper Formatting	Correctness
318.	*hal*	Unknown Words	Correctness
319.	~~for~~ → of	Wrong or Missing Prepositions	Correctness
320.	~~Pres~~ → Press	Confused Words	Correctness
321.	the Biotechnology	Determiner Use (a/an/the/this, etc.)	Correctness
322.	~~council~~ → Council	Misspelled Words	Correctness
323.	~~education~~ → educational	Confused Words	Correctness
324.	inquiry-oriented	Misspelled Words	Correctness
325.	, and	Comma Misuse within Clauses	Correctness
326.	*hal*	Unknown Words	Correctness
327.	*Why Minimal Guidance During Instruction Does Not Work.*	Incomplete Sentences	Correctness
328.	~~Science~~ → science	Confused Words	Correctness
329.	~~certain~~ → specific	Word Choice	Engagement
330.	~~Diambil~~ → Dianabol	Misspelled Words	Correctness
331.	*dari*	Unknown Words	Correctness
332.	~~inquiry based~~ → inquiry-based	Misspelled Words	Correctness

333.	~~Commite~~ → Committee	Misspelled Words	Correctness
334.	~~centres~~ → centers	Mixed Dialects of English	Correctness
335.	, and	Comma Misuse within Clauses	Correctness
336.	*hal*	Unknown Words	Correctness
337.	~~introductin~~ → introduction	Misspelled Words	Correctness
338.	~~culture~~ → Culture	Misspelled Words	Correctness
339.	~~a STSE~~ → an STSE	Determiner Use (a/an/the/this, etc.)	Correctness
340.	~~through~~ → Through	Improper Formatting	Correctness
341.	, and	Comma Misuse within Clauses	Correctness
342.	The Ural	Determiner Use (a/an/the/this, etc.)	Correctness
343.	, and	Comma Misuse within Clauses	Correctness
344.	Science ,	Improper Formatting	Correctness
345.	Technology ,	Improper Formatting	Correctness
346.	, and	Comma Misuse within Clauses	Correctness
347.	~~Internasional~~ → International	Confused Words	Correctness
348.	*team is asked to determine the concentration (molarity and perc*	Investigation 2 How much acetic acid is in vinegar? http://www.rsc.org/suppdata/c6/rp/c6rp00093b/c6rp00093b1.pdf	Originality
349.	*esults showed that there were differences between the*	The results showed that there were differences between ... https://www.coursehero.com/file/p1vngtr/The-results-showed-	Originality

		that-there-were-differences-between-male-and-female-related/	
350.	*iting from an open-ended experiment? A comparison of attitudes to, and outcomes of, an expository versus an open-inquiry version of the same experiment. International Journal of Science Education, 25(3*	Benefiting from an open-ended experiment? A comparison of ... https://www.tandfonline.com/doi/abs/10.1080/09500690210145738	Originality
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