Chemistry students’ soft skills development through the integration of Think Pair Square (TPSq) using a socio critical and problem oriented approach in acid-based learning

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Abstract. The aim of this research was to develop the chemistry students’ soft skills through acid-based learning by integrating Think Pair Square (TPSq) using a socio critical and problem-oriented approach. The study involved 36, year 11, secondary school students. A qualitative research methodology using interviews, observations, a VLES questionnaire, and a reflective journal was employed to understand the process and to engage the participants. The issues of 1000mg vitamin C, “kangen water”, and infused water in relation to acid-base concept water was used to encourage students’ critical thinking in solving the problems. The results showed that students were engaged and motivated in meaningful chemistry learning experiences, while the teacher was challenged in the role of facilitator. The soft skills of collaboration and communication, and critical and creative thinking were stimulated during the process. The students learned to reflect on their own values during debate whilst solving the problems. Learning implications observed during the process showed that students’ soft skills developed during the learning process.

1. Introduction
The development of science and technology provides important challenges for Indonesia to develop citizens with the necessary competences to face 21st century challenges. Education in the 21st century needs to pay attention to soft skills that encourage students to think about their thinking (metacognition), to activate self-reflection and questioning [1]. The classroom learning experiences needs to be designed to develop students’ competencies in terms of collaboration, problem solving, self-control, critical thinking and communication [1]. Therefore, learning objectives should not only focusing on understanding concepts, but should include learning how to involve argument and critical thinking into the learning design [2, 3].

Chemistry is a branch of science that continues to develop through experiments on natural phenomena that occur in the environment [4]. Chemistry learning, in the 21st century, not only focuses on the concepts of chemistry, but must also be able to enable students to think critically and debate about chemical concepts used to solve problems that occur in everyday life [5,6]. Evidence indicates that students have difficulties in developing arguments and participating in argumentative discourses [7, 8]. One reason for this difficulty posits that teacher pedagogical skills are limited with regard to organizing activities that support the discourse of argumentation [7, 9, 10]. Most science classes do not involve activities that facilitate argumentation and critical thinking [9]. As a result, students in many
chemistry classes, have difficulty being active in the learning process and taking part in activities such as arguing, thinking critically about phenomena in everyday life, and communicating in the classroom. Therefore, an appropriate learning approach is needed to achieve learning objectives via these soft skills.

A socio-critical and problem-oriented approach is one learning approach that can link conceptual learning in the classroom with social problems that occur in society [5]. According to Christenson, et. al., chemical learning that is associated with everyday life will help students develop chemical concepts [6]. Socio-critical and problem-oriented chemistry-based learning can stimulate critical and creative thinking and argumentation [11]. A combination of science concepts and social-scientific problems is an effective way to engage students in active discussion and develop their ability to make decisions and think critically [10,12,13].

The aim of this research was to develop chemistry students’ soft skills through acid-based learning by integrating think pair square (TPSq) using a socio critical and problem-oriented approach. Learning was facilitated through discussion of scientific social issues using the think pair square (TPSq) method developed by Spencer Kangan [14]. According to Cottell and Millis, the TPSq technique gives students the opportunity to construct knowledge independently, correct understanding gained and improve understanding through a process of communication between members [15]. Students can increase motivation and get a plan for thinking; so there will be more ideas issued by students. In this study, TPSq was integrated with a socio-critical and problem-oriented approach in teaching acid-base concepts. The issues provided were related to current and critical issues in the Indonesia context.

2. Methodology

The study employed qualitative methods with data collected via interviews, reflective journals, classroom observations, and a VLES questionnaire. The study involved 36-year 11 secondary school students in Jakarta, Indonesia. The learning process stages of socio critical and problem-oriented with Think Pair Square (TPSq) is shown in the diagram below:

| Step | Description |
|------|-------------|
| 1 | Students are given the opportunity to think individually to solve problems in articles or give their opinions on issues in an article according to the views in the group namely "pro" or " contra" (Think) |
| 2 | Students are asked to discuss with their partners about solving problems in the article (Pair) |
| 3 | Students are then asked to join their group, discuss problem solving, complete group assignments given and make decisions that will be taken according to their "pro" or "conter" views (Square) |
| 4 | Each group conducts debates in front of the class (Class Discussion) |

Figure 1. stages of learning activities.

During the learning process, an analysis of students’ soft skills was conducted. The classroom observation and reflective journals were collected in learning process, meanwhile the interviews were conducted after the lesson. Data was coded by the different themes of students’ soft skill development then presented by data descriptions. Member checking was employed to clarify participants’ perspectives.

3. Results

Soft skills encountered during student learning showed the learning process provided students with more opportunities for discussion and interaction with other students [16]. Implications for the development of students' soft skills, and the assessment of teacher roles and learning methods were observed, followed by student responses through student interviews, and reflective student journals.
Figure 2. Graph of evaluates the implications of socio critical and problem-oriented learning.

Based on the figure above, the average score of each aspect above 4 means that students have perceptions that cooperation, empathy communication, critical thinking skills and reflection on social issues perceived, have been developed during the learning process. Furthermore, learning experiences were conducted by employing several teaching methods; laboratory experiments, discussion, debate and think pair square which can encourage students to be active during learning. Based on the VLES questionnaire, students perceived the teaching methods encouraged curiosity, developed conceptual understanding, and motivated them to critique given problems.

“This debate was very effective to develop our curiosity about something and it was good for motivating me to study chemistry, and think pair square has given me the opportunity to think then share my thinking with my friends before starting the debate”
(Student 5, Student Interview, February 6th)

Teachers very rarely use the debate method which in my opinion this method is very appropriate in developing communication, cooperation and critical thinking skills
(Reflective Journal Student, January 30th)

Students opinions aligned with the aim of the socio-critical and problem-oriented approach to develop students' interest in the learning process by seeking knowledge that was relevant to the problems that occur in the community [17]. In addition, group discussions allowed individuals to develop more comprehensive solutions to the problems [18] and they provided opportunities for students to communicate [16, 19]. The teacher motivated all students to participate and express opinions during the learning process. The teacher encouraged students to think about the social issues provided and modeled how students could show appreciation for the opinions of other students during the learning process.

"During the learning process the teacher was able to make students think more deeply about debated social issues”
(Observation sheet, January 31th)

In this study, the teacher acts as a facilitator in accordance with the 2013 curriculum for learning that emphasizes student activity over teacher directed instruction.

3.1. Critical thinking

The learning experiences provided an opportunity for students to think broadly and deeply about social issues both as individuals and in groups, as described below.
“We are required to think more deeply about the topic being discussed. So rather than just sitting and listening to the teacher’s explanation, this activity is more challenging in learning, in addition to we are required to criticize the other groups’ opinions”
(Student 15, Student interview, January 23th)

Overall, socio-critical and problem-oriented learning can develop students' critical thinking skills through critiquing social issues. According to Duschl and College, a combination of chemical concepts and social-scientific problems is an effective way to involve students in discussions and develop students' ability to make decisions and develop critical thinking [10].

3.2. Empathy communication
Through the process of engaging in a socio-critical and problem-oriented approach, students developed empathy communication that was observed in group discussions, during poster/video presentations, and in debates. The implications of empathy communication include being able to accept the opinions and ideas of other students whilst paying attention to other students’ feelings.

Teacher : What do you feel when you debate in front of the class?
Student 5 : I am very happy because I can express my opinion and the results of the discussion and then hold on to get a group, and also, we can respect the opinions of our opponents even though it is against our group.
Student 10 : Me too, usually I never express opinions during learning. However, the debate made me motivated in giving my opinion.

The socio critical and problem-oriented learning, students discuss issues openly in different point of view such as social, moral and scientific concepts, these problems can be in line or conflict with student beliefs [20]. So that, in expressing opinions, students must also pay attention to other student’s feelings and respect their opinions.

3.3. Cooperation
Socio-critical and problem-oriented learning processes can help develop the ability to cooperate with other students when discussing social issues. Implications of student collaboration that were observed during the learning process students being careful in conveying ideas, giving opportunities to other students, discussing with other students, and cooperating with other students. Cooperative learning emphasizes student collaboration in learning [21]. Cooperative learning can optimize the role of students in interacting socially with other students and with teachers, communicating scientifically in a discussion activity, fostering teamwork, building a sense of responsibility, solving problems, and increasing understanding of chemical concepts [22]. The process helps students witness the development of cooperation during the learning process.

3.4. Reflection on social issues
Socio-critical and problem-oriented learning elevates social issues as the main topic of the lesson so that students learn the application of chemistry through social issues and become interested in studying chemistry that is beneficial to life.

Students are engaged in the learning experiences. students have explored the issues related to acid-base in their daily lives. Students learnt to give their opinions, and developed their critical thinking during the learning process
(Observer 1, Observation sheet, January 23th)

Integrating socio-critical and problem-oriented learning in chemistry stimulated students’ motivation to explore issues. Students became more critical about choosing products used in everyday life. This outcome aligned with the aims of socio-critical and problem-oriented learning which was to develop student interest in science and technology and to display understanding of the relevance of science in society during discussion and subsequent decision-making [12].
The development of students' soft skills during the learning experiences is relevant to the current Indonesian curricula focus on character education. Character education is an important aspect of the education process. According to Nucci et al., character education stimulates students’ basic values and behaviour development [23]. Developing soft skills is also relevant to the main objectives of a socio-critical and problem-oriented approach for fostering students’ attitudes in learning, and guiding students to achieve broader educational goals. The aim is to build readiness for life in a modern society based on science and technology [24]. The socio-critical and problem-oriented approach can develop students’ interest and skills [17].

The implementation of socio-critical and problem-oriented learning has several challenges, among others, some students are uninterested in the debate method used. They prefer to listen to learning material given directly by the teacher, other students think that learning associated with everyday life is not important and focusing on it reduces the time allocated to learning chemical concepts. These views are represented by the comment below:

*In my opinion, learning like this is less effective because its chemical concepts are less deeply studied. Besides, I feel lazy to find out more about the issues discussed such as infused water. I think infused water has nothing to do with chemistry lessons. I prefer learning which the concept of chemistry is explained directly by the teacher.*

(Student 18, Students Interview, January 23th)

Based on these challenges, the teacher may need to pay more attention to the understanding of the chemical concepts students have been taught well and be able to open up insights for the student that studying the relevance of chemistry on daily life is important because many phenomena in everyday life related to chemistry.

4. Conclusion
The integration of a socio-critical and problem-oriented approach in acid base learning was implemented. Students learnt to actively participate in their learning facilitated by the teacher. The results have shown that students developed critical thinking, empathy communication, and cooperation skills through reflection on social issues. The students had a positive attitude towards the variation in teaching methods and level of teacher support, especially during debates. However, the teacher faced some challenges by students who were less interested in the debate method used, preferring to listen learning material given directly by the teacher, and other students who considered that learning associated with everyday life is not important. Therefore, the teacher must pay more attention to the understanding of the chemical concepts students have been taught well and must be able to provide insights into the relevance of studying chemistry related to daily life.

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