Promoting vocational students' perception and achievement towards Chemistry: SPARE Learning Strategy for students majoring in Automotive Engineering

YusiArisandi[a,b], I WayanDasna[a*], SumariSumari[a],HabiddinHabiddin[a], SuhadiIbnu[a], Subandi[a]

[a]Graduate School, Department of Chemistry, UniversitasNegeri Malang, Malang, Indonesia

[b]BalaiBesarPengembanganPenjaminanMutuPendidikanVokasiBidangOtomotifdanElektronika (BBPPMPV BOE) Malang, Indonesia

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Abstract: Low Vocational High School students' perception and achievement towards Chemistry has been a critical issue. Various studies have been carried out to find a proper solution for such issue. In Indonesia, Vocational High School aims to produce skillful graduates who are ready-to-work in the relevant area. In Vocational High School, Chemistry is a supportive course which is commonly lack of students' interest. This study aimed to examine the improvement of vocational students' perception and achievement of Chemistry after the implementation of vocational expertise-based teaching strategy named SPARE (Stimulation, information Processing, Application, Reflection, and Evaluation). This study involved 129 vocational high school students majoring in Automotive Engineering with 63 students as the experiment group and 66 students as the control group. Independent Samples Test, Mann-Whitney U Test, and N-Gain scores were employed to analyze the data. This study revealed that SPARE effectively improved students' perception towards Chemistry and contributed significantly to increase their achievement. This study implies that implementing SPARE to other supportive courses at Vocational High School is a reasonable exercise.

Keywords: vocational high school, students' perception, automotive engineering

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1. Introduction

Vocational High School in Indonesia has its characteristics compared to Senior High School. The Vocational High School is intended to produce ready-to-work graduates, unlike Senior High School, which is mainly intended to prepare the students to continue their studies at the higher education level. The courses in vocational high school are divided into two broad categories: expertise courses and supportive courses. The expertise courses are intended to develop the students' competencies in their fields of expertise. In comparison, the supportive courses function as the basic knowledge of the topics related to the fields of expertise (Pendidikan dan Kebudayaan, 2018).In Automotive Engineering, Chemistry is one of the supportive courses. Some studies find out that Chemistry teaching in Vocational High School is less directly connected to the aspects in the expertise competence so that the interest, motivation, and learning achievement of Chemistry for Vocational High School students are low (Chairiah et al., 2016; Dinihari et al., 2020; Lia & Isnaeni, 2018; Refriwati, 2015; Widodo, 2017; Yuliastini et al., 2018). Vocational students tend to consider a non-skill subject like Chemistry useless and irrelevant to their professions at work. Most of them prefer subjects that are directly connected to their expertise competence (Dasna, 2012).

Studies conducted in Indonesia on Chemistry learning in Vocational High School show that the negative attitude towards Chemistry is triggered by Chemistry learning which less provides the application of Chemistry in the Automotive Engineering field (Dinihari et al., 2020; Lia & Isnaeni, 2018; Wiyarsi et al., 2017). Students are expected to independently transfer the knowledge of Chemistry into the context of Automotive Engineering. Unfortunately, most students cannot apply Chemistry to their expertise fields. Even they tend to consider Chemistry has no relevance towards their expertise fields. Therefore, Chemistry learning in vocational high school students should be directly connected to their expertise fields. For example, for those majoring in Automotive Engineering, the topics of redox and electrochemistry should be discussed in terms of how the concepts are applied in the automotive battery and motorcycle's spare parts corrosion and other relevant topics.

This study implements the automotive-based Chemistry learning presented using the SPARE (**S**timulation, Information **P**rocessing, **A**pplication, **R**eflection, and **E**valuation) learning strategy. Such strategy is conducted by connecting the Chemistry subject matters to one of the students' expertise competencies in Automotive Engineering and the Occupational Health and Safety and environmental issue (OHS-E). The knowledge of OHS-E is very important since the students do more practices in the workshop dealing with chemical substances. The incomplete combustion in fuel engines releases harmful gases such as Carbon Monoxide (CO), Hydrocarbons, Nitrogen Oxides

(NO_x),andParticulate Matter. Enander et al. (2004) state that thousands of professional technicians and vocational students have high risks of being exposed to metal particulates in the dust during the sanding process and methyl chloride vapour during the painting process. Consequently, implementing the SPARE learning strategy will provide Vocational High School students meaningful Chemistry learning that will support their expertise competencies.

This Chemistry learning approach is expected to give contributions towards Chemistry learning in Vocational High School. For examples, it can increase the motivation to learn Chemistry, foster the students' positive perception towards Chemistry learning, and improve the students' learning achievement.The motivation and positive perception in science learning contribute to the students' learning achievement. The awareness of the relevance of subjects being learned can increase the students' motivation and positive perception in Chemistry learning (Bryan et al., 2011; Stuckey et al., 2013).Habiddin et al. (2020) uncovered that students' confidence affected their positive achievement on chemical kinetics.

The syntax in the SPARE learning strategy adopts the essence of the Student Team Achievement Division (STAD) cooperative learning model. Therefore, this model is expected to increase the students' motivation, perception, and learning achievement towards Chemistry as well as to increase the students' collaboration and teamwork skills. The relevant professional world for Vocational High School graduates usually needs good teamwork skill. SPARE learning strategy is designed into five stages: (1) **S**timulation (to brainstorm on the students' initial knowledge, deliver the importance of materials going to be learned, and relate them to the previous materials or the vocational ones). This stage aims to stimulate the students to be motivated to participate in the learning activity;(2) Information **P**rocessing (to organize the conceptual understanding through information processing in groups and connected to the vocational, and OHS-E). This stage aims to form the concept understanding based on series of information processing in groups; (3) **A**pplication (to apply the understanding and connect to the Socio-Scientific Issues (SSI) context, vocational, OHS-E). This stage aims to apply the conceptual understanding through a contextual discourse or problem in Automotive Engineering connected to OHS-E; (4) **R**eflection (to reflect the acquired understanding in the group learning activity by presenting the result of understanding/application added by consolidation or reinforcement done by the teacher). This stage aims to reflect the students' understanding and train the students to be able to communicate. When the students present the result of group discussion, the teacher will consolidate and give the reinforcement on the materials being learned; and (5) **E**valuation (to evaluate the learning achievement on the materials learned individually through a quiz, and its result contributes to the group's achievement, and eventually the group is appreciated).

The objectives of this study are: (1) to examine the difference in the vocational students' perception towards Chemistry between those experiencing SPARE and those experiencing conventional learning (direct instruction); and (2) to examine the difference in the vocational students' achievement in Chemistry between those experiencing SPARE and those experiencing conventional learning.

2. Methods

Research Design

This study was carried out using a quasi-experimental *pretest-posttest control group design*(Creswell, 2012; Creswell & Clark, 2007). Two Automotive Engineering classes with 63 students treated as the experiment group and 66 students treated as the control group participated in this study. The SPARE strategy was implemented in the experiment group, while the conventional one implemented in the control group. The conventional learning stated in this study covered lectures, question and answer sessions, and discussions, which is not oriented to vocational specific competencies and OHS-E.

Data Collection

For both groups (experiment and control), chemistry teaching was carried out in seven meetings covering Redox and Electrochemistry. Pretest and posttest were obtained to measure the difference in the students' understanding. Multiple-choice questions in the topics of Redox and Electrochemistry (25 questions each) were used for this purpose.

The students' perception in learning Chemistry was obtained by using a set of questionnaires consisting of 30 statements adopted from Kubiatko (2015) with 5 Likert scales ranging from 1 (strongly disagree), 2 (disagree), 3 (no opinion), 4 (agree) to 5 (strongly agree) were applied. The students' perception in learning Chemistry was classified into three levels: High (111-150), Moderate (71-110), and Low (≤ 30-70). The statements covered in the interview sheet were classified into five categories. They are:

1. The Interest in Chemistry (8 statements);
2. The Relevance of Chemistry (6 statements);
3. The Future Life and Chemistry (4 statements);
4. Chemistry and Vocational Learning (6 statements);

5. Chemistry Learning Strategy (6 statements).

The teaching instruments consist of the lesson plan, worksheet, and measurement tests, i.e. the students' perception questionnaire and interview guideline; and learning achievement test. All of the instruments were experienced content validity by three experts in the field. The achievement test was also validated empirically, with the reliability index of 0.863 falling in the high category.

Data Analysis

The Independent Sample Test was carried out to measure the difference in the students' perception towards Chemistry between the experiment and the control groups. Mann-Whitney U test was employed to determine the difference in the students' achievement between these two groups. N-Gain scores were also applied to determine the increase in the students' learning achievement. All the analysis were employed with the help of SPSS program.

Steps of SPARE Learning Strategy

The steps of the SPARE learning strategy in this study are shown in Table 1.

Table 1. Steps of SPARE Learning Strategy

Stage	Steps
Stage I: *Stimulation*	1. The teacher explains the importance of the subject the students will learn and connects it to vocational subjects 2. The teacher divides the students into groups of 4-5 students by prioritizing heterogeneity based on academic achievement and gender
Stage II: *Information Processing*	1. Students construct the knowledge together in groups by discussing and answering the referral questions prepared by the teacher 2. Students get information about OHS-E connected to the subject 3. The teacher guides the learning in a group and ensures the students' understanding was correct
Stage III: *Application*	1. Students apply conceptual understanding through contextual cases and connect to the students' expertise 2. Students get information about OHS-E connected to the subject 3. The teacher guides the learning in group
Stage IV: *Reflection*	1. Group presentations (randomly) on the result of group discussion 2. Teacher guides and consolidates to give a deep understanding
Stage V: *Evaluation*	1. Students take the individual quiz, and its results contribute to the group score 2. The teacher gives an appreciation of the success of the group

3. Result and Discussion

3.1. The Difference in Students' Perception in Learning Chemistry

The students' perception was collected by using the questionnaire before and after the teaching intervention and strengthened by interviews with several students. As explained above, the students' perception of chemistry was described into five categories: The Interest in Chemistry; The Relevance of Chemistry; The Future Life and Chemistry; Chemistry and Vocational Learning; and Chemistry Learning Strategy. The students' perception is depicted in Table 2 below.

Table 2. The Students' Perception of Chemistry for Experiment and Control Groups

No	Statements	Experiment Group										Control Group									
		Initial Students' Perception (%)					Final Students' Perception (%)					Initial Students' Perception (%)					Final Students' Perception (%)				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
I	**THE INTEREST IN CHEMISTRY**																				
1	I like Chemistry more than other subjects	27	44	27	2	0	0	16	75	10	0	17	61	23	0	0	6	44	45	5	0
2	I need to learn Chemistry	2	16	41	38	3	0	0	19	70	11	0	6	42	50	2	0	5	14	76	6
3	I would like to have Chemistry lesson more frequently	10	57	32	2	0	0	11	71	16	2	14	50	33	3	0	6	30	52	12	0
4	I am bored during Chemistry lesson (-)	10	16	48	27	0	0	3	25	67	5	3	17	62	17	2	0	17	42	33	8
5	Chemistry is very interesting for me to learn	6	35	51	8	0	0	10	27	63	0	2	27	59	11	2	0	18	38	42	2
6	I think Chemistry is not important compared to other subjects (-)	6	13	52	27	2	0	2	10	59	30	0	11	67	23	0	0	9	39	47	5
7	I do not like Chemistry because it is useless for me (-)	3	14	40	40	3	0	0	19	68	13	0	9	61	29	2	0	5	35	52	9
8	I do not like Chemistry teacher (-)	0	3	33	49	14	0	0	13	52	35	3	9	20	52	17	0	5	24	42	29
II	**THE RELEVANCE OF CHEMISTRY**																				
9	Chemistry and Science are not familiar for me (-)	2	8	27	63	0	0	2	17	63	17	0	15	52	33	0	0	5	47	44	5
10	The development in learning Chemistry can improve our life	5	16	44	35	0	0	3	24	70	3	5	3	32	61	0	0	9	30	55	6
11	The knowledge on Chemistry can help us solve environmental problems	6	13	3	46	0	0	3	13	75	10	2	5	35	58	2	2	6	20	64	9
12	Natural science is an integral part of human's life	0	5	29	67	0	0	0	3	71	25	2	2	35	59	3	0	2	17	71	11
13	I think that the processes in nature are interesting	0	0	27	67	0	0	0	11	62	27	2	3	33	61	2	0	5	21	62	12
14	I think that my Chemistry teacher evaluates my achievement	2	6	62	30	0	0	2	21	65	13	3	6	45	45	0	0	8	27	58	8
III	**THE FUTURE LIFE AND CHEMISTRY**																				
15	The knowledge on Chemistry is not important for the future life (-)	0	13	32	51	5	0	0	10	62	29	0	8	45	47	0	0	3	33	58	6
16	The knowledge on Chemistry can help us solve problems in environment as well as in the future life	2	14	32	51	2	0	2	21	65	17	2	14	35	50	0	3	12	27	53	5

17	After finishing my study, I would like to work and apply my knowledge on Chemistry	3	24	63	10	0	0	2	30	65	3	2	14	59	26	0	3	9	47	38	3
18	Chemistry is not important for daily life (-)	3	8	49	33	6	0	0	16	59	25	0	8	44	47	2	0	5	35	47	14
IV	**CHEMISTRY AND VOCATIONAL LEARNING**																				
19	Chemistry is useful to support the vocational subjects	6	32	43	19	0	0	0	2	71	27	3	18	48	30	0	2	17	24	58	0
20	Chemistry taught by the teacher meets the needs of my expertise program	8	25	57	10	0	0	0	5	62	33	0	33	53	14	0	0	15	33	50	2
21	Chemistry has nothing to do with vocational subjects in my expertise program (-)	8	32	51	24	0	0	0	3	56	41	0	18	67	15	0	0	9	52	35	5
22	I am more aware of the importance of applying OHS and environment in vocational practices at school	3	30	51	16	0	0	0	16	57	27	0	33	52	15	0	2	12	52	35	0
23	I can understand the risks of using chemical substances during the vocational practices by learning Chemistry	3	22	51	16	0	0	0	3	62	35	0	50	36	14	0	0	15	41	42	2
24	The application of OHS and environment in vocational practices is not directly connected to Chemistry (-)	2	19	68	11	0	0	0	24	51	25	0	36	59	5	0	0	21	48	29	2
V	**CHEMISTRY LEARNING STRATEGY**																				
25	I can understand Chemistry subject from the learning strategy used by the teacher	3	21	49	27	0	0	0	13	78	10	9	14	44	33	0	3	8	30	59	0
26	Chemistry given with fun strategy makes me want to learn Chemistry more	0	35	51	14	0	0	3	19	67	11	9	41	45	5	0	2	12	45	38	5
27	I can interact with other friends and help each other in understanding the content in the group	3	16	46	35	0	0	0	8	79	13	2	20	36	42	0	0	9	26	61	5
28	Group learning is troublesome and not interesting for me (-)	2	14	51	33	0	0	0	19	67	14	3	14	65	18	0	2	6	48	36	8
29	I prefer learning Chemistry by listening to the teacher instead of being active in the class (-)	2	25	46	27	0	0	5	19	63	13	3	21	52	24	0	0	9	44	44	3
30	I can develop social interaction and communication skills in learning Chemistry	0	25	44	29	2	0	2	29	63	6	2	9	55	33	2	0	5	42	52	2

Based on Table 2, in the experiment group, there is an increase in the students' positive perception towards Chemistry learning in every aspect, especially in the fourth aspect that is Chemistry and Vocational Learning. It shows that the students' perception towards Chemistry learning has significantly increased through the learning using the SPARE learning strategy. The most significant increase was observed in the link between vocational and Chemistry subject matters that meet the needs of Automotive Engineering expertise competence and the relationship between Chemistry and the knowledge and application of OHS-E.

On the other hand, the students' perception in the control group only has a minor increase in every aspect. Even in the fourth aspect that is Chemistry and Vocational Learning, there is no significant increase in the students' perception as it is in the experiment group. It shows that conventional Chemistry learning does not increase the students' positive perception significantly.

The data on the level of students' perception towards Chemistry learning are shown in scoring ranges covering three criteria which are: High (111-150); Moderate (71-110); and Low (≤ 30-70). The following Table 3 presents the data of the criteria of students' perception in percentage in both the experiment and the control groups.

Table 3. The result of students' perception

Group	**Criteria of Students' Perception**	**Initial (%)**	**Final (%)**
Experiment	High	0	10
	Moderate	76	90
	Low	20	0
Control	High	0	0
	Moderate	88	98
	Low	12	2

Table 3 shows that no student perceives low criterion after the treatment in the experiment group. Even there are 10% of students who have the perception of high criterion. Some students still perceive low criterion in the control group, and none of them perceives high criterion. The average score of the students' perception towards Chemistry learning is shown in Table 4.

Table 4. The average score of the students' perception towards Chemistry learning

Group	**N**	**Initial Students' Perception**		**Final Students' Perception**	
		$\overline{X}$	**Category**	$\overline{X}$	**Category**
Experiment	63	91	Moderate	118	High
Control	66	92	Moderate	103	Moderate

Table 4 shows the increase in students' perception in the experiment group, from moderate to high. Meanwhile, there is an increase in students' perception score for the control group, but it is still in the range of moderate category.

The Independent Sample Test confirmed the difference in the students' perception between the experiment and the control groups with the Sig. (2-tailed) value of 0.000 (<0.05). As a result, the Chemistry learning in Vocational High School that uses the SPARE strategy brings higher impact towards the increase in students' perception of chemistry.

Several factors may cause an increase in the students' perception after experiencing SPARE learning. One factor is the stimulation given by the teacher to brainstorm the students' initial knowledge and persuade them to be interested in learning the subjects connected to the vocational materials. The leading questions provided in the students' job sheet to form their conceptual understanding was also connected to the vocational and OHS-E. The reading materials in the forms of articles used as the students' discussion materials and the provided pictures are also connected to the materials in the automotive field. It contributes well to the increase in the students' perception of Chemistry learning. For example, in the third meeting of Redox reaction based on the removal and addition of electrons, the topic delivered is connected to basic Automotive Engineering about Automotive Battery Maintenance. The process of oxidation and reduction is directly illustrated in the actual reaction while using and charging the battery. In the application stage, the given problem is about the use of fuel cell. The information on OHS-E is given to students while working with an automotive battery and its hazardous waste. The information on OHS-E dealing with fuel cell will make the students understand the advantages and disadvantages of using the fuel cell. Vocational students will appreciate the Chemistry learning better if it brings benefits to support their expertise competencies and facilitate their careers (Sheldrake et al., 2017). These results demonstrate that Chemistry teachingconnected to their specific competencies will increase their positive perception towards Chemistry. It confirms the statements from Aikenhead (2003), Autida (2012), Holbrook (2005), and Stuckey & Eilks (2014) that choosing relevant and contextual-based topics will increase the students' motivation and perception towards science learning.

The following interview quotes strengthen the supposition that SPARE learning increases the students' positive perception towards Chemistry. Several students stated that they need Chemistry lesson to support the vocational subject matters due to the following reasons:

- *"our activity in workshop deals with chemical substances, and now we know better about their potential dangers while using them."*
- *"the engine operations deal with Chemistry, for examples, in using the electric battery or during the fuel combustion process."*
- *"Chemistry is useful for both vocational learning and daily life; we deal with chemical substances in our daily life, such as when we use gases in welding."*

From the perspective of OHS-E, the SPARE learning makes the students understand the importance of applying OHS-E as presented in the following interview quotes:

- *"from Chemistry class, we get the information on the risks, how we use, and how to implement OHS-E when we deal with chemical substances."*
- *"We understand better how to implement OHS-E, and we will be more careful than before."*
- *"We are aware of the danger of battery's water waste and its negative effects on our health. We can prevent or avoid the risks when we can manage the waste well."*

The interview quotes above show that the students' perception towards Chemistry is better after they experience SPARE learning.

3.2. The Difference in Students' Learning Achievement

The students' learning achievement on Redox and Electrochemistry topics in this study was obtained from the pretest and posttest scores. Due to the parametric test's unfit requirement, a non-parametric Mann-Whitney U test was employed to measure the difference in the students' achievement between the two groups (experiment and control groups). The Mann-Whitney U Test to measure the difference in the students' initial ability demonstrated a Sig. (2-tailed) of 0.555 and 0.483 for Redox and Electrochemistry topics, respectively. It implies that there was no significant difference in the initial ability of both the experiment and the control groups, leading to a conclusion that the difference in the posttest scores between the two groups is due to the intervention (SPARE strategy versus conventional strategy). The average scores of final students' learning achievement for both groups are presented in Table 5.

Table 5. The average score results of students' learning achievement

Group	N	$\bar{X}$ Posttest	N-Gain
A. Redox			
Experiment	63	76	0.7
Control	66	71	0.6
B. Electrochemistry			
Experiment	63	75	0.7
Control	66	70	0.6

Table 5 shows that the experiment group's average posttest scores were higher than those of the control group, both on Redox and Electrochemistry topics. N-Gain scores of the experiment group were also higher than those of the control group.

The Mann-Whitney U Test statistical test confirmed the difference implying that the SPARE strategy improved vocational students' achievement in Chemistry. The improvement in the students' perception of Chemistry may contribute to the improvement in their achievement. Nazhifah & Copriady (2015) report that the student's perception of Chemistry positively correlates with the increase in the students' learning achievement. The students will gain better result in the Chemistry lesson if they perceive well towards it. The learning connected to vocational materials is relevant to Chemistry learning and a meaningful learning approach that can increase the students' cognitive learning outcome (Holbrook, 2005; Wiyarsi et al., 2017). Chemistry learning using the SPARE strategy connected to vocational and OHS-E is a contextuallearning approach that connects real-life to the scientific content of Chemistry. Using personallyrelevant context had mostly positive effects on the students' motivation and interest (Jürgen Menthe, 2014). Ültay & Çalık (2012) noted that context-based Chemistry lessons are more effective in developing positive attitudes towards Chemistry. Students who have positive attitudes towards Chemistry and engage in science learning will pursue goals such as gaining good learning outcome and learning science related to careers (Bryan et al., 2011; Palmer, 2009).

8. Conclusion

This study revealed a significant difference in vocational students' perception and achievementtowards Chemistry between the experiment and the control groups. The results confirm that the SPARE learning strategy effectively improved the students' perception towardsChemistry and contributed significantly to increasingthe students' learning achievement. This study implies that implementing SPARE to other supportive courses at Vocational High School is a reasonable exercise.

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