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DEVELOPMENT OF AN ELECTRONIC PORTFOLIO-BASED ASSESSMENT STRATEGY TO IMPROVE STUDENT'S HABITS OF MIND IN BUFFER SOLUTION MATERIAL

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Abstract

This study aims to develop an electronic portfolio-based assessment strategy to improve students' habits of mind on the buffer solution material. This study used the Research and Development 4D model which was carried out until stage 3 (Define, Design, and Development). The participants in this study were 10 students of class XI who had studied the material of buffer solution. The task developed in this electronic portfolio assessment consists of three tasks, namely a concept map of components and the working principle of a buffer solution, a lab simulation report for making a buffer solution with a certain pH, and a poster for the role of buffer solutions in living organisms. The results showed that the instrument was valid with a CVR value of 0.60 1.00 and reliable with a Cronbach Alpha value of 0.847 1,000. In the limited trial, task 1 had an N-Gain score of 0.66 (medium), task 2 had an N-Gain score of 0.49 (medium), and task 3 had an N-Gain score of 0.58 (medium). Overall, the average N-Gain score is 0.48 in the medium category. In the categories of self-regulation, critical thinking, and creative thinking, respectively, the average N-Gain score is 0.52; 0.43; and 0.51 in the medium category. Based on the results of a limited trial of the electronic portfolio-based assessment strategy that was developed it could improve students' habits of mind on the buffer solution material.

Keywords: Assessment strategy, Buffer solution, Electronic portfolio, Habits of mind.

1. Introduction

Assessment is a required component in learning activities because it can improve assessment and learning quality [1]. In the assessment, the portfolio is an alternative assessment that is used to obtain various information about the process and results of student development originating from documents or records of their experiences [2]. An electronic portfolio is a digital container that can store a variety of content including images, text, sound, and even video [3], as a collection of student work and notes about student learning progress which consists of two main aspects, including what has been done. Students learn and how successful they are in learning, as well as how students can think, ask questions, analyse, synthesize, produce, and be creative intellectually, emotionally, and socially with others [4].

The use of electronic portfolio assessment as an assessment for learning has the opportunity to form students' thinking habits or Habits of mind which are classified into three categories, namely self-regulation, critical thinking, and creative thinking [5-7]. Buffer solution is a very important material for class XI high school students. The buffer solution material does not only require mastery of concepts in the form of knowledge but also how to connect concepts that have been previously owned by students and will have an impact on students' habits of mind.

Many studies have been conducted on Electronic Portfolio Assessment. Some researchers [8] showed that the Electronic Portfolio Assessment is student-centred, Other researchers [9] showed that the use of the Moodle application as an e-portfolio platform could improve students' generic science skills in chemistry practicum. Other researchers [10] required the development of many unexplored features of the electronic portfolio. Other researchers showed that performance assessment can form Habits of mind.

In other literature, formative assessment can improve students' habits of mind. Other researchers [11] showed portfolio workbook as an effective method for student-centred learning of chemical engineering principles. However, there is no research linking the electronic portfolio-based assessment strategy with students' habits of mind, so this study aims to develop an electronic portfolio-based assessment strategy to improve students' habits of mind on the buffer solution material.

Based on our previous work [2, 12, 13], this study used the Research and Development 4D model which was carried out until stage 3 (Define, Design, and Development) [14]. Participants in this study amounted to 10 students of class XI. The three tasks developed are a concept map of the components and working principles of a buffer solution, a practical simulation report on making a buffer solution with a certain pH, and a poster on the role of buffer solutions in living organisms.

So far, there has been no research that discusses electronic portfolio-based assessment strategies to improve students' habits of mind on buffer solution material, so the novelty of this research is the electronic portfolio-based assessment strategy using the Edmodo platform, providing feedback to students in the assessment process, the use of an electronic portfolio-based assessment strategy can improve mastery of chemical concepts and can improve Habits of Mind with three categories, namely self-regulation, critical thinking, and creative thinking.

2. Theoretical Framework

2.1. Electronic portfolio assessment

In the assessment, the portfolio is an alternative assessment that is used to obtain various information about the process and results of student development originating from documents or records of their experiences [2]. Electronic Portfolio (e-portfolio) is a collection of works (documents), and student transcripts in electronic or digital format that can store a variety of content including images, text, sound, and even video [3] as a form of student progress records [3], as well as a collection of student work and notes on student learning progress which consists of two main things including what students have learned and how successful they are in learning, and how students can think, ask questions, analyse, synthesize, produce, and be creative intellectually, emotionally, and socially with others [4].

Students can use electronic portfolios in learning to archive their work, plan to improve their learning process and reflect on their learning experiences over time. Electronic portfolios can make assessment strategies more effective and efficient. Table 1 shows the differences between conventional and electronic portfolios [15].

Table 1. Differences between conventional and electronic portfolios.

No.	Conventional Portfolio	Electronic Portfolio
1	Requires physical evidence	Easier to be reviewed by the facilitator
2	Requires multiple reviewers to copy and distribute	Can be read and reviewed by several facilitators simultaneously
3	Must be physically transported	Can be accessed anytime and anywhere
4	Can be lost or more easily damaged	Safe, difficult, or impossible to lose or misplace
5	Does not allow interaction except when done in class	Allows interaction between students and teachers
6	Conventional Portfolio	Electronic Portfolio
7	Requires physical evidence	Easier to be reviewed by the facilitator
8	Requires multiple reviewers to copy and distribute	Can be read and reviewed by several facilitators simultaneously
9	Must be physically transported	Can be accessed anytime and anywhere
10	Can be lost or more easily damaged	Safe, difficult, or impossible to lose or misplace
11	Does not allow interaction except when done in class	Allows interaction between students and teachers

2.2. Habits of mind

Habits of mind as characteristics of what intelligent people do when they are faced with problems whose solutions cannot be easily identified [5, 16]. The application of habits of mind will help students to always use their time productively and hone their intelligence. Habits of mind are divided into three categories [6], namely:

(i) Self-regulation includes being aware of one's thoughts, planning effectively, being aware of and using the necessary sources of information, being sensitive to feedback, and evaluating the effectiveness of the action.
(ii) Critical thinking includes being accurate and seeking accuracy, being clear and seeking clarity, being open, refraining from being impulsive, being able

to position yourself when there is assurance, being sensitive, and knowing the abilities of his friends.

(iii) Creative thinking includes being able to engage in tasks even though the answers and solutions are not immediately apparent, making efforts to the maximum of their abilities and knowledge, creating, using, and improving evaluation standards that they make themselves, producing a new way of looking at situations that are different from the usual way that applies in general.

Habits of mind are important when the learning process takes place because it shows that learning is not only result-oriented but also implied in the learning process. The development of habits of mind can train students' thinking habits. Thus, it can produce good learning and also helps students to explore their knowledge further.

2.3. Buffer solution

A buffer solution is a solution that can maintain the pH value. When a small amount of strong acid or strong base is added to the buffer solution, very little change in pH occurs [17]. Figure 1 shows the change in the pH of the non-buffer solution, namely A shows the initial pH of 100 mL of dilute HCl solution and B shows the pH of the HCI solution after adding 1 mL of 1 M HCl solution (left) and 1 mL of 1 M NaOH solution (right) [17].

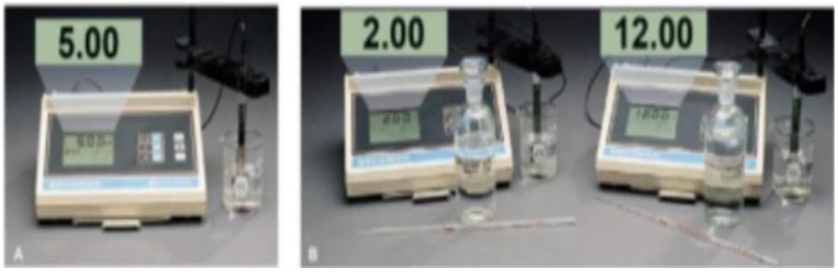

Fig. 1. pH of the non-buffer solution.

Figure 2 shows changes in the pH of the buffer solution, namely A shows the initial pH of 100 mL of dilute HCl solution and B shows the pH of the HCI solution after adding 1 mL of 1 M HCl solution (left) and 1 mL of 1 M NaOH solution (right) [17].

Fig. 2. pH of the buffer solution.

In simple terms, the workings of a buffer solution can be illustrated as shown in Fig. 3 [17]. A solution containing CH_3COOH and CH_3COONa is an example of a buffer solution. The acid component is CH_3COOH, while the base component is CH_3COO^-.

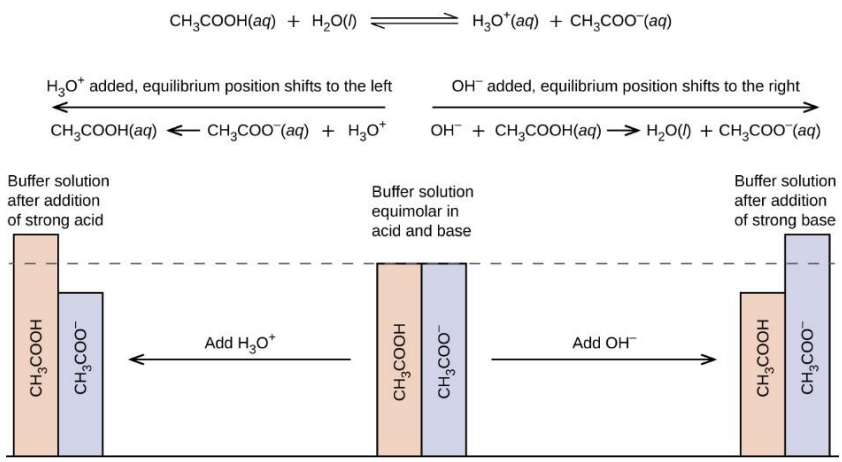

Fig. 3. The workings of a buffer solution.

Figure 3 shows the solution from the CH_3COONa salt. The CH_3COO^- ion is the conjugate base of CH_3COOH. How this buffer solution works depends on the equilibrium reaction, shown in the reaction equation (1).

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^- \quad (1)$$

If a small amount of a strong acid such as HCl is added to this solution, it will produce H_3O^+. Increasing the concentration of H_3O^+ causes the reaction to proceed to the left and re-establish equilibrium, shown in the reaction equation (2).

$$H_3O^+ + CH_3COO^- \rightarrow CH_3COOH + H_2O \quad (2)$$

When a strong base, NaOH, is added to the CH_3COOH and CH_3COONa buffer solutions, the OH^- ions will be neutralized by the acidic components in the buffer, shown in the reaction equation (3).

$$OH^- + CH_3COOH \rightarrow CH3COO^- + H_2O \quad (3)$$

3.Method

This study is a Research and Development (R&D) study with a 4D model [14]. This research procedure is only carried out until the third stage, namely:

(i) Define, at this stage, an analysis of the material to be used and also field surveys in high school and interviews with chemistry subject teachers in schools are carried out to find information about conditions, and facts in the field on the implementation of electronic portfolio assessments.

(ii) Design, at this stage the preparation of the initial instrument for the assessment of the electronic portfolio task is carried out. The tasks in this electronic portfolio are a concept map of components and the working principle of a buffer solution, a practical simulation report for making a buffer solution with a certain pH, and a poster on the role of buffer solutions in living organisms.

(iii) Development, at the development stage, the instrument quality is tested by testing its validity and reliability, as well as the implementation of the developed electronic portfolio assessment strategy.

Validity testing is done by asking for consideration from experts (expert judgment) as many as five validators. The results obtained from the considerations of the experts were then analysed using the Content Validity Ratio (*CVR*), with Eq. (4) as follows:

$$\text{CVR} = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \quad (4)$$

where n_e is the number of validators declared valid, and N is the number of validators

The results of the CVR are then compared with the minimum CVR value of One-tail significance of 0.05 [18] with the number of validators of as many as 5 people is 0.99. The reliability test used the inter-rater method with three raters and calculated the Cronbach Alpha value.

Data analysis habits of mind students using N-Gain obtained from student scores before and after giving the task. The increase in the task is calculated then categorized and interpreted according to the N-Gain criteria [19] with Eq. (5) as follows:

$$< g > = \frac{S_{after} - S_{before}}{S_{maks} - S_{before}} \quad (5)$$

where <*g*> is the normalized gain, S_{Before} is the score before giving feedback, S_{After} is the score after giving feedback, and *Smax* is the maximum score

4. Results and Discussion

The preparation of electronic portfolio instruments begins with basic competencies (KD) analysis and indicators. From the results of the KD analysis as well as indicators, three tasks are obtained that will be used in the developed electronic portfolio assessment instrument. Table 2 presents the tasks contained in this electronic portfolio.

Table 2. Tasks in the electronic portfolio.

KD	Indicators	*Task*
3.12 Explain the working principle, pH calculations, and the role of buffer solutions in living organisms	3.12.1 Explain the meaning and components of a buffer solution. 3.12.2 Explain the working principle of an acidic buffer solution and an alkaline buffer solution. 3.12.3 Explain the role of buffer solutions in living organisms.	Concept map of components and working principle of buffer solution. Poster of the role of buffer solutions in the body of living things.
4.12 Making a buffer solution with a certain pH	4.12.1 Make a practicum report for making a buffer solution with a certain pH.	Report on the results of the practical simulation of making a buffer solution with a certain pH.

One of the feasibility of the developed instrument can be determined by testing the instrument based on content validity. An instrument has high validity when the instrument can measure the ability to be measured [2]. Based on the considerations and decisions of experts (expert judgment) as many as five people. This validity test uses a validation sheet in the form of a table containing indicators, tasks, assessed aspects, rubrics, the suitability of the indicators and tasks given, and the suitability of the tasks given, and the rubrics developed. Table 3 shows the CVR value of the content validity test results of the developed instrument.

Table 3. CVR value.

Indicators	Rated aspect	Suitability of Indicators and Tasks		Suitability of Tasks and Rubrics	
		CVR	**Validity**	**CVR**	**Validity**
Task 1 (Concept map of components and working principle of buffer solution)					
3.12.1	1.1 Concept hierarchy	1	Valid	1	Valid
3.12.2	1.2 Concept accuracy			1	Valid
	1.3 Conjunctions (Prepositions)			1	Valid
	1.4 Relationship between concepts			1	Valid
Task 2 (Report on the results of the practical simulation of making a buffer solution with a certain pH)					
4.12.1	2.1 Title and Purpose of Practicum	1	Valid	0.6	Invalid
	2.2 Theoretical Foundation			0.6	Invalid
	2.3 Tools and Materials			1	Valid
	2.4 Working Methods and Data			1	Valid
	2.5 Calculation			0.6	Invalid
	2.6 Discussion			1	Valid
	2.7 Conclusion			1	Valid
Task 3 (Concept map of components and working principle of buffer solution)					
3.12.3	3.1 Content/Text	1	Valid	1	Valid
	3.2 Design			1	Valid
	3.3 Pictures			1	Valid
	3.4 Material content			1	Valid

Based on the CVR value in Table 3 compared to the minimum CVR value, in Task 1 all aspects of the assessment have a CVR value of 1 or greater than the minimum CVR value. In task 2 there are three aspects of the assessment that have a CVR value of 0.6 or less than the minimum CVR value. In task 3 all aspects of the assessment have a CVR value of 1 or greater than the minimum CVR value. Therefore, improvements were made to the assessment rubric with a CVR value of 0.6 or not meeting the minimum CVR value based on suggestions from the validator and maintaining the assessment aspect with CVR 1. So based on the CVR results, it was concluded that the instrument was declared valid.

Determination of the reliability of the electronic portfolio instrument developed using the inter-rater method, which is to determine the consistency of different raters in assessing student work. The raters in this study amounted to 3 people. Inter-rater reliability was determined by calculating the Cronbach Alpha value using IBM SPSS 22. The results of the calculation of the Cronbach Alpha value and its categories are presented in Table 4.

Based on Table 4, the Cronbach Alpha value of the developed instrument is between 0.882 and 1.000. Most of the aspects are considered to have a very good reliability category, there are only two aspects that are considered to have a good reliability category according to the Cronbach Alpha criteria [20].

The results of the limited trial on task 1, namely the component concept map and the working principle of the buffer solution showed an increase in the average

score of students before and after being given feedback. The students' average scores and N-Gain scores are presented in Table 5.

Table 4. Cronbach Alpha value.

Indicators	Task	Rated aspect	Cronbach Alpha value	Reliability category
3.12.1	1. Concept map of components and working principle of buffer solution	1.1	0.903	SB
3.12.2		1.2	0.882	B
		1.3	0.966	SB
		1.4	0.945	SB
4.12.1	2. Report on the results of the practical simulation of making a buffer solution with a certain pH	2.1	1.000	SB
		2.2	1.000	SB
		2.3	0.882	B
		2.4	1.000	SB
		2.5	0.900	SB
		2.6	0.913	SB
		2.7	1.000	SB
		2.8	1.000	SB
3.12.3	3. Poster for the role of buffer solutions in living organisms	3.1	1.000	SB
		3.2	0.952	SB
		3.3	1.000	SB
		3.4	1.000	SB

*notes: SB= Very good, B= Good

Table 5. Task 1 N-gain scores.

Rated aspect	Average		N-Gain	Category
	Before *feedback*	**After *feedback***		
1.1	1.8	3.3	0.68	Medium
1.2	2.2	3.2	0.56	Medium
1.3	1.9	3.5	0.76	High
1.4	1.9	3.2	0.62	Medium
Average	**1.95**	**3.3**	**0.66**	**Medium**

Based on the N-Gain value in Table 5, the increase in students occurred in the medium to high category according to the N-Gain category [19]. Errors that occur in the results of the initial work have been corrected by students. This can be seen from the average score after giving feedback which has increased.

In task 2, which is a practical simulation report on making a buffer solution with a certain pH, the test results show an increase in the average score of students before and after being given feedback. The students' average scores and N-Gain scores are presented in Table 6.

Based on Table 6, aspects 2.1 and 2.2 have a high increase because the practicum simulation reports carried out by students after giving feedback on these aspects showed significant improvement results. Meanwhile, for aspects with moderate improvement, the results of student improvements showed significant

results. In aspects that are assessed with low improvement, students' improvement in these aspects tends to be less significant.

Table 6. Task 2 N-gain scores.

Rated aspect	Average		*N-Gain*	Category
	Before *feedback*	**After *feedback***		
2.1	3	3.8	0.80	High
2.2	1.80	3.40	0.73	High
2.3	2.80	3.20	0.33	Medium
2.4	2.60	3.40	0.57	Medium
2.5	3	3.2	0.25	Low
2.6	2.4	2.8	0.25	Low
2.7	3.2	3.6	0.5	Medium
2.8	3	3.4	0.4	Medium
Average	**2.73**	**3.35**	**0.49**	**Medium**

In task 3, namely making posters of the role of buffer solutions in the bodies of living things, the test results showed an increase in the average score of students before and after being given feedback. The students' average scores and N-Gain scores are presented in Table 7.

Table 7. Task 3 N-gain scores.

Rated aspects	Average		*N-Gain*	Category
	Before *feedback*	**After *feedback***		
3.1	2.4	3.2	0,50	Medium
3.2	2.8	3.4	0,50	Medium
3.3	2	3.3	0,65	Medium
3.4	2.1	3.3	0,63	Medium
Average	**2.33**	**3.30**	**0,58**	**Medium**

Based on Table 7, all aspects assessed in task 3 experienced an increase in the average score. After the N-Gain value is calculated, the increase in all aspects is in the moderate category.

The results of the analysis in the Habits of Mind category show an increase, this is known through the average score obtained by students in each Habit of Mind category which is presented in Table 8.

Table 8. Habits of Mind N-Gain scores

Habits of Mind category	Average		*N-Gain*	Category
	Pre	Post		
Self-regulation	2.84	3.44	0.52	Medium
Critical thinking	2.83	3.33	0.43	Medium
Creative thinking	2.58	3.3	0.51	Medium
Average	**2.75**	**3.36**	**0.48**	**Medium**

Based on Table 8, this electronic portfolio assessment provides the highest increase in the self-regulation category with an N-Gain value of 0.52. Then followed by the creative thinking category with an N-Gain value of 0.51 and the critical thinking category with an N-Gain value of 0.48. This is because the electronic portfolio assessment through the assignment of tasks and feedback affects self-regulation. Then, after students realize and improve their self-regulation skills, students can develop their creative thinking and critical thinking skills.

This study can give additional information regarding self-regulation [5], critical thinking, and creative thinking, in which these have been reported in previous studies [21-33].

5. Conclusion

The purpose of this study was to develop an electronic portfolio-based assessment strategy to improve students' habits of mind on the buffer solution material. Based on the results of the research conducted, the electronic portfolio assessment instrument developed based on the validity test met the valid requirements with a CVR value of 0.60 – 1.00 and reliable with a Cronbach Alpha value of 0.882 – 1.000. The results of the limited trial on each task showed an increase in the average score before and after giving feedback, task 1 had an N-Gain score of 0.66 (medium), task 2 had an N-Gain score of 0.49 (medium), and task 3 has an N-Gain score of 0.58 (medium). Overall, the average N-Gain score is 0.48 in the medium category. In the categories of self-regulation, critical thinking, and creative thinking, respectively, the average N-Gain score is 0.52; 0.43; and 0.51 in the medium category. Thus, the results obtained that the electronic portfolio-based assessment strategy developed can improve students' habits of mind on the buffer solution material.

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