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Development of Electronic Student Worksheets Based on Learning Cycle 7E (E-SW 7E) and Its Effect on the Students' Concept Understanding and Science Process Skills

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Abstract: This study aims to develop e-SW or e-LKPD products, test the feasibility of e-SW 7E products based on expert assessments, test the practicality of e-SW 7E products based on the assessment of chemistry teachers and peer reviewers, find out the responses of students in terms of readability and test the effectiveness of e-SW 7E products. The method in this research is R&D with a 4-D development model. The sampling technique used in this study used cluster random sampling techniques. Interviews, questionnaires, and question techniques carry out data collection techniques. The data analysis technique used is the assessment of theoretical validity by qualitative experts converted quantitatively using the Likert scale with a score range of 1-5, empirical validity analyzed using the Quest program, and manova test analysis using SPSS. The results of the study found that e-SW 7E based on learning cycle 7E feasible, practical student responses in terms of readability in the very good category resulted in an average of all aspects of 4.45 and a percentage of 82.5%. There was an effects on the understanding of concepts and skills of the science process by 34.5%.

Keywords: Electronic student worksheet; Learning cycle 7E; Science process skills; Understanding of concepts

Introduction

The Partnership for 21st-century Skills (P21, 2019) identifies that 21st-century learning skills (competencies of learners) (Sya'idah et al., 2020) are indispensable and needed in the era of globalization. In this era, science, technology, and information development is growing quite rapidly (Suardana et al., 2018). Along with the development of the 21st century, the use of technology is escalated quickly in the learning process, and innovation in learning devices is needed (Azizah et al., 2021). When students' learning media decreases, a that can be engaging to students' is needed, one of which is electronic-based learning media (Suryaningsih et al., 2021).

Observations were conducted in March 2023 at SMAN 2 Serang and SMAN 1 Malimping for limited trials and effectiveness tests. In these chemistry subject learning activities, teaching materials are classified as incomplete. Students do not have a handbook for learning and understanding the material; apart from that, online learning is still ongoing, which causes students not to get complete teaching materials because the teaching materials obtained are in the form of printed student worksheet, which makes it more difficult for students to understand teaching materials that support facilities in learning (Rahajeng, 2022). E-SW is presented in electronic form that can be stored on a computer system or internet cloud and accessed on the internet (Maulana et al., 2021, 2022) so that students can easily access it with smartphone devices owned by students (Pratama et al., 2021).

Many things, including the quality of teaching materials like e-SW, influence students' understanding

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of school learning materials. E-SW not only improves the understanding of concepts from students but can also improve science process skills. Science learning still does not optimize the development of the skills aspects of the science process. Science process skills and concept understanding are an entity in the chemistry learning process (Susi et al., 2020), the existence of science process skills are expected to support better student learning outcomes in terms of understanding concepts (Daud, 2018).The low skill in the science process of students' is caused by the rarity of teachers that uses relevant learning models and tends to be monotonous with relatively low science activities because teachers are more dominant in using traditional learning strategies. Teaching materials developed in e-SW, which contains learning model syntaxes in each learning phase, can increase the activeness of the learning process.

The learning cycle 7E model is based on the constructivism theory and was developed by Karplus in 1960 (Kusumawardani et al., 2020). The theory of constructivism explains that knowledge is constructed by the learner in their mind. One constructivist principle considers learning as the interaction between pre-existing knowledge and new knowledge, so previous knowledge plays an important role in later learning (Ghufrooni et al., 2019). Efforts to build knowledge students themselves will undoubtedly encounter difficulties, which encourages teachers to act as facilitators by assisting students in building their knowledge (Ahmadurifai, 2020).

Method

This research design uses the type of R&D (Research and Development) with 4-D development; 4-d has four stages: define, design, develop, and disseminate, developed (Thiagarajan, 1974).

The research was carried out for three weeks in March in the grade 11th of SMAN 2 Serang and SMAN 1 Malimping using a cluster random sampling technique. The research instruments used are instruments for understanding concepts in the form of posttests and questionnaires of science process skills. Data analysis techniques produce two types of data, namely qualitative data in the form of material expert validation results, media expert validation results, practicality sheet results, and readability questionnaire results, then quantitative data in the form of teacher practicality sheet results and product readability questionnaire results that will be rated using five categories according to the likert scale. The validity of the instrument test is carried out theoretically and empirically. People with expertise carry out theoretical validity following the instruments made. The assessment of theoretical validity by experts is qualitative. The qualitative data will be collected and then analyzed by converting the qualitative assessment results into quantitative using a Likert scale with a score range of 1-5. Next, the average of each assessed aspect is calculated using Equation 1.

$$\underline{X} = \frac{x}{n} \quad (1)$$

Information:
$\underline{X}$ = average score of each eligibility component
x = number of scores per eligibility component
n = number of appraisers

The ideal rating way to determine product quality is by comparing the average score of the overall aspects obtained that are shown in Table 1.

Table 1. Ideal Assessment Criteria

Score Range (i)	Category
$\underline{X} > \underline{X}_I + 1.8\ SB_i$	Very Good
$\underline{X} + 0.6\ SB\ i < \underline{X} \leq \underline{X}_i + 1.8\ SB_i$	Good
$\underline{X} - 0.6\ SB\ i < \leq + 0.6\ SB I_i\ \underline{X}_i$	Simply
$\underline{X} - 1.8\ SB\ i < \leq \underline{X} + 0.6\ SB\underline{X}_i i$	Less
$\underline{X} > I - 1.8\ SB_i$	Very Less

Empirical validity is carried out by piloting instruments tested for theoretical validity and then tested on class XII science students. The results of these trials were analyzed using the QUEST program. The price of MNSQ infit items is at an acceptance limit between ≥ 0.70 to ≤ 1.30 (Woollins, 1992). Instrument items are said to be reliable if the estimated reliability is 0.70. The categories of Cronbach's alpha values are shown in Table 2.

Table 2. Value Categories Cronbach's Alpha

Value of Reliability Coefficient	Category
> 0.81 – 1.00	Very High Reliability
> 0.61 – 0.80	High Reliability
0,4 – 0.60	Medium Reliability
< 0.40	Low Reliability

The data from product trials were analyzed with the Manova (multivariate of variance) test. The Manova test was conducted to answer three hypotheses and explore the connection between several dependent and independent variables with a prerequisite test of 9 assumptions (Sutrisno et al., 2018).

Result and Discussion

Learning cycle-based electronic students worksheet products was developed following the development stage of the Four-D (4D) R&D model developed by Thiangarajan (1974). The development stages used include the Define, Design, Develop, and Disseminate. The data on the results of each stage carried out are as follows:

Define Stage

The analysis at this stage includes five sub-stages. The first stage: the early-final analysis stage, is carried out field situation analysis to obtain information about the characteristics of students, problems that arise during the learning process, student learning needs and teaching strategies carried out by teachers, the results of interviews with chemistry teachers are obtained that the understanding of concepts and skills of students' science processes in chemistry learning has not been applied optimally due to the understanding of chemical material concepts in class XI in semester one there are too many where there are four chapters and eight KD with one week four hours for two meetings so that the material delivered to students' is not optimal enough while students are required to replace KD to continue the following material while for science process skills the lack of applying attractive learning models to the material learned and the lack of teaching materials. Students are less active in learning and lack enthusiasm for expressing opinions and asking questions. In contrast, the learning model needed by students can help students be more active when discussing so that they can exchange ideas with other friends. In practicum activities, students do not only carry out activity procedures without being given an apperception first.

The next stage is the analysis of learners. The interview results show that students are less active in the learning process and less enthusiastic in expressing opinions and asking questions. Therefore, electronics are developed so that they contain activities that can encourage students to be more active in learning process activities, enthusiastic in asking questions and expressing opinions, discussing with other friends, and interactive (Utami, 2021). The student analysis stage has been carried out; the next stage is the concept analysis stage, which determines the material to be delivered, namely the buffer solution material (Sariati et al., 2020). The task analysis stage at this stage identifies indicators of understanding concepts and science process skills that have been synthesized to be designed into question items and questionnaires, determining the core competencies and essential competencies that students will achieve from the buffer solution material. The last stage is the analysis of learning objectives, determining learning achievement indicators based on material analysis, buffer solutions, and curriculum analysis.

Design Stage

There are three sub-stages at the design stage: the preparation of test standards, criterion test construction, format selection, and initial design. The first stage is the preparation of instruments used as a reference to compile question points in e-SW 7E. The instrument used is a conceptual understanding question item to measure students'' understanding of concepts in the buffer solution material (Ginting et al., 2021). The second stage is the format selection stage based on technology use needs. It contains good learning media design by designing the appearance and content of the e-SW to be used, starting with the initial display, content, and cover. The last stage is the initial design, where at this stage, the initial product that has been designed will then be corrected by the supervisor to be revised following the suggestions that have been given so that the initial design of the e-SW 7E product is obtained.

Media is implemented after developing indicators of research instruments. E-SW is a media developed in this study with a wizer.me or https://app.wizer.me/learn/ domain, and there is a link code in the form of numbers adjusted to the contents of the LKPD (Rohmaya, 2022) for the next meeting. Wizer.me is an interactive online learning site that teachers and students can easily access. Equipped with features that can make it easier for teachers to make student worksheets and can directly provide assessments and evaluations in the form of suggestions and comments for student work.

Develop Stage

The development stage is the initial design of the E-SW product that has been validated by media experts and material experts with several aspects validated and then revised according to input and suggestions used to improve and improve the quality of the product developed (Rery et al., 2022) to produce e-SW 7E that is suitable for use by students. At this stage, question and questionnaire instruments are validated to measure students' understanding of concepts and science process skills.

Validation Test E-SW 7E Validation

Media experts and material experts validate e-SW products. Media experts provide assessment and input related to visual appearance, program engineering and performance, learning design, and materials. While material experts provide input related to aspects of substance, construction, and language.

Practicality Test of E-SW 7E by Teachers and Peers

The practicality test was measured using a questionnaire with indicators adjusted to aspects aspects (Aldi et al., 2022), including aspects of substance, appearance, software engineering, language, practicality, and distinctiveness, consisting of 19 questions. E-SW 7E, revised from input and suggestions by expert lecturers, then continued the assessment to educators. Practicality questionnaires were given to five chemistry educators or teachers after carrying out learning using e-SW 7E for practical dialysis chemistry teachers had filled out. The six aspects of the e-SW practicality questionnaire were calculated on average for each aspect resulting in an overall average score of 4.85. The average score is then analyzed by changing the qualitative assessment results into quantitative, which is then converted based on five categories: very good, good, sufficient, less, and significantly less, and the percentage obtained an overall average score of 97% in the very good category. It can be concluded that E-SW 7E is practically used in learning the chemistry of buffer solution materials. The results of the teacher assessment are shown in Table 3.

Table 3. Results of Product Assessment by Teachers

Aspects	Average	Percentage (%)	Category
Substance	4.88	97	Excellent
Display	4.84	96	Excellent
Software Engineering	5.00	100	Excellent
Language	4.63	92	Excellent
Practicality	4.80	96	Excellent
Peculiarities	5.00	100	Excellent
Overall average score	4.85	97	Excellent

The practicality questionnaire that the chemistry teacher has filled out is followed by an assessment by peer reviewers who are colleagues who both conduct development research consisting of three Postgraduate Students' of Yogyakarta State University chemistry education program in order to respond to E-SW 7E.

Table 4. Results of Product Assessment by Peer Reviewers

Aspects	Average	Percentage (%)	Category
Substance	4.45	89	Excellent
Construction	4.00	80	Good
Language	4.00	80	Good
Display	4.60	92	Excellent
Respond to Peer Reviewers	4.60	92	Excellent
Overall average score	4.05	87	Excellent

The questionnaire consists of eight questions with five aspects, including substance, construction, language, appearance, and peer reviewer responses, resulting in an average score of 4.05. The average score is then analyzed by changing the qualitative assessment results to quantitative with five categories, and the percentage of an overall average score of 87% is categorized as very good. It can be concluded that E-SW 7E is practically used in learning the chemistry of buffer solution. The results of the peer assessment are shown in Table 4.

Redability Test by Students'

E-SW is tested with a limited test to students first to test its readability to assist researchers in determining the parts that need to be improved and see the ease and difficulty of a product being read.

The revised E-SW 7E product, based on suggestions and input from chemistry teachers and peers, is then tested for readability by students to determine students' responses to learning aspects and usage displays. The results of an overall average score of 4.45 with a percentage of 89% in the very good category. The results of readability responses by students are shown in Table 5.

Table 5. Readability Response Results by Students'

Aspects	Average	Percentage (%)	Category
Material	4.50	90	Excellent
Language	4.30	86	Excellent
Usege View	4.44	88	Excellent
Overall average score	4.45	89	Excellent

The Empirical Validity of Question Instruments and Questionnaires

Expertly validated and revised questionnaires were followed by empirical validation on cognitive questions (posttest) and science process skills. Empirical test validation involved 100 learners. Furthermore, the validation results are processed using Rasch model analysis with the QUEST program so that validity and reliability are known on each question number.

The posttest items on concept understanding as a whole are in the fit area because they are on the dotted line between 0.77 to 1.30. The dotted line plane with a vertical shape illustrates the position of the item acceptance limit score value with the INFIT MNSQ value. Based on the graph, from ten question items, it can be seen that the question items are within the item fit line with the Rasch model. It can be concluded that the posttest items of concept understanding are valid.

The analysis results show item reliability of 0.69 with a category that means the items are reliable. Infit Mean Square has a limit of 0.77 to 1.3. The data results show that the infit mean square value is 1.03, meaning that overall the items fit the Rasch model. The overall results are shown in Figure 1.

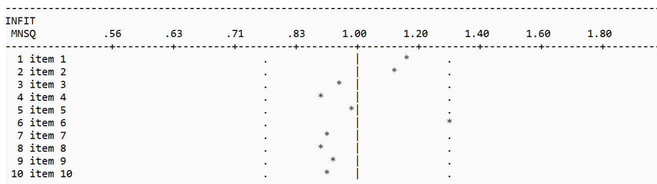

Figure 1. Infit mean square value

The science process skill items as a whole are in the fit area because they are within the dotted line between 0.77 to 1.30. The dotted line plane with a vertical shape illustrates the position of the item acceptance limit score value with the INFIT MNSQ value. It can be concluded that the items about understanding the concept are valid for nine items, because item one is outside the dotted line.

The analysis results show item reliability of 0.75 with a high category, which means that the items are reliable. Infit Mean Square has a limit of 0.77 to 1.3. The data results show that the infit mean square value is 1.03, meaning that overall the items fit the Rasch model. The overall results are shown in Figure 2.

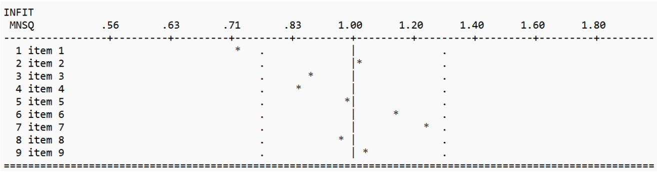

Figure 2. Infit mean square value

Disseminate Stage

The implementation of e-SW 7E is carried out in SMAN 2 Serang to determine the effectiveness of students' understanding of concepts and science process skills (Jumiati, 2021) after using E-SW 7E (Kustianingsih et al., 2021). Effectiveness tests were conducted to test the effectiveness of E-SW 7E products and their effects on understanding concepts and science process skills carried out in large-scale trials or effectiveness tests using a posttest-only control group design. There is one experimental class and one control class where the experimental class uses the E-SW 7E product, and the control class uses learning by following the learning applied by the teacher in the class.

The effectiveness test was carried out by simultaneously knowing the differences in cognitive and science process skills from each before and after using E-SW 7E on buffer solution material in high school. The data analysis used in this study was analyzed with a Mantova (multivariate variance) test. Multivariate statistical test analysis of the same subjects (One sample Hotelling's T2). Nine assumptions must be met to perform Hotelling's T-test. Based on the results of the boxplot outliers, univariates, and univariate for science process skills and concept understanding, there are no outliers. The multivariate normality test yielded a Sig. Value of conceptual understanding in the experimental class of 0.051 and a control class of 0.063, while the Sig. Value of science process skills in the experimental class was 0.169, and the control class was 0.341. It can be concluded that if the value of Sig. Obtained is more significant than 0.05, then the data is normally distributed.

Test homogeneity value Sig. Concept understanding 0.810 and science process skills 0. 557 It can be concluded that if the value of Sig. is more than 0.05, then the data variance, understanding, concepts, and skills of scientific processes are homogeneous or come from the same population. Matrix variances are homogeneous with testing. See Box's Test of Equality of Covariance Matrices (Box's M) aims to test the Manova assumption, which requires that the matrix of variance or covariance of the dependent variable is the same, Box's M value of 1.991 with Sig value 0.584 > 0.05 then Ho is accepted, and the data are declared eligible for the manova test. Furthermore, the absence of multicollinearity is indicated by a Pearson correlation value of 0.631 means that there is no multicollinearity based on the basic information of decision-making that if the Sig. Value is more than 0.05, then it correlates.

The effectiveness of E-SW 7E on each variable can be seen from the results of the test of between-subject effects significance values for concept understanding is smaller than 0.05, interpreting that there are differences in students" understanding of concepts after using e-SW with effect size values of 0.482 Furthermore, the significance value for science process skills (Salosso et al., 2018) is smaller than 0.05, interprets that there are differences in students science process skills after using E-SW 7E with an effect size value of 0.599. Furthermore, the influence of E-SW 7E can be further tested using the MANOVA test by resulting from the two bound variables, namely the understanding of the concepts and skills of the student science process (Sulistiyono, 2020) < 0.05, which means that there are differences in understanding the concepts and skills of the science process after using E-SW 7E so that E-SW 7E can be used in the learning process. The result of the test of between–subject effects are shown in Table 6.

Table 6. Result of Test of Between Subject Effects

Dependent Variable	Sig.	Partial Eta Squared
Understanding of Concepts	.000	.132
Process Science Skills	.000	.260

The understanding of concepts and science process skills was measured after (posttest) students' used E-SW 7E within six meetings. The results of the increase are known from the posttest scores on descriptive statistical tests by looking at the mean or average score, indicating that there is an increase in understanding of concepts and skills in the science process were tested with statistical tests with the help of the SPSS program. The result of the descriptive test is shown in Table 7.

Table 7. Result of Descriptive Test

Variable	Mean	Std. Deviation
Understanding of concepts	73.41	9.741
Science process skills	82.50	8.305

Resulting in an average understanding of concepts resulting in an average of 73.41 and science process skills 82.50 for concept understanding with a standard deviation of 9.741 and science process skills with a standard deviation of 8.305; in this case, there is a difference between understanding concepts and science process skills using E-SW 7E and students who do not use E-SW 7E.

Conclusion

Our findings provide an overview of worksheets based on learning cycle 7E and its effect on concept understanding and science process skills after studying buffer solutions using e-SW 7E. Student responses to e-SW 7E products in buffer solution material for grade XI high school students based on suggestions and inputs suitable for use in learning and based on the assessment of the readability of e-SW 7E by students with very good categories resulting in an overall average of 4.45 and a percentage of 89%. The understanding of concepts and science process skills of students who use e-SW 7E is better than students who do not use e-SW 7E in class XI high school buffer solution material based on descriptive test results that produce an average understanding of concepts of 73.41 and for science process skills of 82.50. Researchers recommend that e-SW 7E be developed on other chemicals at all grade levels in high school and using other variables.

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Author Contributions

The contributions of the authors to this study were as follows. Chaerunnisa Luvitasari Firdausi took the lead in writing the initial draft of the manuscript, Conceptualization, data curation, funding acquisition, methodology, visualization, writing–original draft, writing–review & editing, which was critically revised by all authors for important intellectual content. Kristian Handoyo Sugiyarto supervised the entire research process and provided valuable technical throughout the study. Yusup Maulana provided revisions and suggestions. Finally, all authors reviewed and approved the final version of the manuscript for submission.

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Conflicts of Interest

The authors declare that they have no conflicts of interest related to this study. Authors have no financial, personal, or professional affiliations that could be perceived as potential conflicts of interest that could influence the interpretation or presentation of the research findings. This ensures the integrity and impartiality of the study and the results reported in this article.

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