E-Learning General Chemistry Learning (Stoichiometry) Based on Computer Based Test

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Abstract. A lecturer should consider regarding how to leverage creative and effective learning material to reconstruct students' knowledge, skills, and creativity. With both the aid of learning media and a web-based learning paradigm, this study intends to demonstrate the viability, efficacy, and improvement of student learning outcomes in learning general chemistry solution materials. The ADDIE development model is that employed. Books and learning materials for general chemistry solutions using a web-based learning approach were produced as a result of this research and development, and they have been recognized as valid and successful in enhancing student academic outcomes. The change in student learning outcomes between using general chemistry learning resources and a web-based learning strategy before and after, with an average increase in learning outcomes of 25.633, provides proof of the improvement in student learning outcomes.

Keywords: Solution, Media, Web Based Learning Model.

1 Introduction

The 21st century's growth in modernity and globalization has had a significant impact on all disciplines, including education. There are more people now believe that formal education must transform as a result of the development of a global movement asking for new learning models for the 21st century. This transformation is critical to implementing new learning modalities required to address modern complicated global concerns. The changes in question are related to pedagogy, namely changes in acting from simple action to comprehensive action and the dominance of traditional teaching over technology-based education, rather than changes in curricular content [1].

Many things are required of a teacher or speaker in the twenty first century, particularly those that relate to abilities and skills. The teacher or lecturer's primary responsibility is to get

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students ready for the 21st century [2]. Improving students' learning capacities and assisting in their development to become persistent, active, independent learners are the main objectives of 21st century learning. The demands for professionalism of 21st century educators are not on the ability of educators to know and be proficient about everything, but rather educators have the expertise to learn alongside their students by becoming role models of trust, openness, and persistence to their students so that they can face the realities of 21st century digital life [3].

The 21st century, often known as the fourth industrial revolution, is the one in which science and technology have advanced at a rapid speed, necessitating the need for students to be flexible and keep up with these changes. The key to education in the twenty-first century is to support students in developing a solid knowledge base and comprehension so they can continue to learn throughout their lives. Consequently, a number of factors that are relevant in 21st century education must be taken into account by the educational system [4]. In order to accommodate the needs of the millennial generation and prepare students for 21st century life skills, 21st century learning must be technology-based. Science proficiency, metacognitive skills, the capacity for critical and creative thought, as well as the ability to collaborate or communicate, are requirements for students in the twenty-first century. This situation shows how expectations and reality are out of sync [5].

E-learning, which refers to a variety of software or programs that are available for learning media and can be accessed anytime, anywhere, is rapidly developing as a result of technological improvements [6]. E-learning is a well-liked method of distance learning that is essential in the field of education [7]. E-learning refers to learning that is offered through a computer via a CD-ROM, the internet, or an intranet. E-learning, often known as online learning, is the process of learning through computers and other types of media [8].

Utilizing electronic technology services, employing the benefits of computers, utilizing autonomous teaching materials, and using computers to store learning schedules, learning outcomes, and administrative affairs are the four features of e-learning [9]. E-learning has advantages as a supplement (extra), as a complement, and as a substitute in addition to the features listed above.

E-learning has been a choice and solution for adopting education in the digital age since the Covid-19 outbreak, that forces student to continue learning from home via the internet network. E-learning can increase student engagement since it forces them to be more independent learners. Additionally, e-learning can let students learn their own way so that the focus of education can change from being teacher-centered to being student-centered. [10].

Along with having the ability to influence the educational process, a teacher or lecturer also needs to be able to evaluate and assess the learning outcomes of their students. The capacity of educators to develop evaluation patterns, construct instruments, establish goals, evaluate the outcomes of student performance, and select the appropriate course of action for implementing evaluation and assessment results is proof of their understanding of evaluation techniques. As a result, in order to improve students' knowledge and learning outcomes, educators both teachers and lecturers, must be able to create the appropriate evaluation media. On the other hand, inaccurate measurements of learning outcomes and students' comprehension will occur if the assessment medium is not adequate.

Computer tests (CBT), that is, evaluation procedures or assessments using computer media and online-based managed by servers, are now used to conduct out evaluation processes that formerly relied on paper and pencil exams (PBT). As a result, evaluation processes or assessments must also change and adapt to the rapid advancement of information and technology in the 21st century [11]. A computer-based test, or CBT, is used to assess students' learning progress [12], using internet access, with a computer conducting the evaluation automatically [13], so, students don't need to use paper, pens, or pencil to respond to every inquiry [14], test results from students can be electronically stored, evaluated, and used in many different ways [15].

To deal with the drawbacks of paper-based learning assessment and realize paperless in the current digital era, the move from paper-based learning evaluation to computers must be made. This is because, among other benefits, CBT takes less time to complete and only requires students to remain still and respond to questions on the computer as opposed to using paper or pens [12], The test can be delivered at a time that is most convenient for the participants, less time will be required for test analysis and preparing written reports, logistical tasks like distributing and maintaining paper tests can be removed, and test takers can get rapid answers [16]. CBT is a great tool for educators to use when conducting diagnostic exams. For teachers, it is simpler to plan, carry out, and create academic policies for students [17].

It is necessary to construct e-learning on CBT-based General Chemistry instruction because of the current phenomena associated with the growth of modernization and globalization in the twenty-first century, and the Covid-19 pandemic, which still forces students to continue learning from home using an internet connection. It is envisaged that the development of CBT-based e-learning will help instructors and students study general chemistry, as well as assist instructors in administering diagnostic tests and establishing academic policies for students. This study's objective is to describe the viability (validity) and effectiveness of CBT-based online learning designed to improve students' learning outcomes for general chemistry lessons involving stoichiometric information.

2 Method

Developmental research, which employs the ADDIE development model, is the method utilized to address research challenges. The five steps of the ADDIE development paradigm are analysis, design, development, implementation, and evaluation [18]. The research process was carried out in stages, including: (a) analysis, which involved performing analysis to gather data on student needs and reading literature relating to the developing product; (b) Design, which is the phase in which objectives are determined and designs are made. Stoichiometry CBT-based e-learning materials will be developed; (c) Development is the stage of turning an idea into a finished product that is ready for use; (d) Implementation, which entails using the finished product e-learning General Chemistry study guides based on CBT stoichiometry and e) Evaluation, which entails conducting an assessment by assessing the efficiency of e-learning. General Chemistry and the impact of stoichiometry CBT material on student learning outcomes.

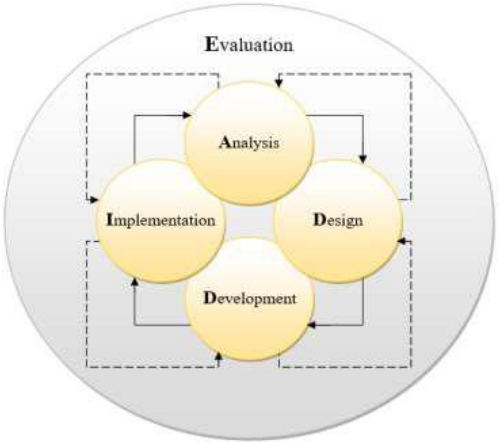

Fig. 1. ADDIE Development Model

The data was collected in both qualitative and quantitative formats. Following the expert validation sheet instrument, qualitative data was gathered from the evaluation, guidance, and input of media experts and subject matter experts. The achievement of student test results through CBT-based exams on stoichiometric content was converted into quantitative data. The SPSS program was used to evaluate the success and enhancement of student learning outcomes using a t-test with a paired sample t-test technique.

3 Results and Discussion

The project's outcome in its entirety is an e-learning program that teaches general chemistry stoichiometry for computer-based tests (CBT). With the intention of assisting lecturers and students in the learning process of General Chemistry on Stoichiometry, CBT-based e-learning is planned and developed. It is anticipated to support lecturers in carrying out diagnostic tests and in formulating academic policies for students. Expert validators who are subject matter experts in various fields assess the validity or viability of CBT-based e-learning. Students are asked to evaluate the outcomes after the items have been developed and put to use by experts.

3.1 Product's viability

Based on the viability of the generated Stoichiometry material and the viability of the media, the validators study and evaluate the viability (validity) of CBT-based e-learning in the General Chemistry course.

Table 1. CBT-Based E-Learning Validation Results on Material Aspects

Component	Assessment Aspect	Validator (Mean Score)			Total Mean	Criteria
		I	II	III		
E-Learning	Viability of content	3.83	4.33	4.00	4.05	Valid
	Serving viability	3.90	4.33	4.22	4.15	Valid
	Language viability	4.10	4.40	4.40	4.30	Valid
	Graphic viability	4.20	4.22	4.20	4.21	Valid
	Mean Total Validation Results (E-Learning)				4.18	Valid
Computer Based Test (CBT)	Content (material)	4.50	5.00	4.50	4.67	Valid
	Construct	4.00	4.50	4.50	4.33	Valid
	Language	4.33	4.67	4.,33	4.44	Valid
	Time and hint	5.00	5.00	4.50	4.83	Valid
	Mean Total Validation Results (CBT)				4.57	Valid

Table 1, reveals what came out of the material's examination and evaluation by professional validators in the online general chemistry study guide based on CBT Stoichiometry. The general chemistry learning e-learning component obtained an overall average score of 4.18, and the content expert validation's findings were deemed valid. The CBT component had an average overall score of 4.57, which was considered acceptable. The main conclusion of the material expert validator's evaluation was that the online general chemistry learning resources based on CBT Stoichiometry are trustworthy or workable for use in education.

Table 2. Validated results of CBT-Based E-Learning on Media Aspects

Component	Assessment Aspect	Validator (Mean Score)			Total Mean	Criteria
		I	II	III		
E-Learning	Software engineering	4.40	4.50	4.40	4.43	Valid
	Interface view	4.22	4.33	4.22	4.26	Valid
	Verbal communication	3.88	4.38	4.25	4.17	Valid
	Mean Total Validation Results (E-Learning)				4.29	Valid
Computer Based Test (CBT)	Software engineering	4.40	4.40	4.00	4.27	Valid
	Interface view	3.78	4.44	4.33	4.18	Valid
	Verbal communication	4.13	4.38	4.25	4.25	Valid
	Mean Total Validation Results (CBT)				4.23	Valid

Table 2, exemplifies the outcomes of the evaluation and assessment of media expert validators in online general chemistry learning resources based on sroichiometry in computer-based evaluations (CBT). The material for General Chemistry Learning Sroichiometry obtained an average overall score of 4.29, and the media expert validation results were accepted as valid. The CBT component was declared valid if the average overall score was 4.23. In summary, the media expert validator's evaluation discovered that the general chemistry learning resources for online usage based on CBT Stoichiometry are trustworthy or useful for use in education.

3.2 Result of student learning

Tests are given both before and after using e-learning to see if students have accomplished their learning goals, and they are produced via a computer-based test (CBT). This stage was conducted with 30 students and completed in three (three) stages, including: (1) the

preliminary CBT test (pretest) before students were given assignments involving the e-learning that resulted; (2) the method of learning whereby students access and download e-learning materials utilizing a laptop, PC, or Android device; and (3) the concluding stage.

Table 3. Student Learning Outcomes

	N	Min	Max	Mean	Std. Deviation	Kolmogorov-Smirnov test	
						Statistic	Sig.
Pretest	30	43	73	59.13	7.371	0.678	0.748
Posttest	30	63	100	84.23	9.005	0.844	0.475

Table 3, The students' pretest scores are shown; the lowest score was 43 and the highest was 73. The mean was 59,13; the standard deviation was 7,371; the data had a normal distribution; the Kolmogorov-Smirnov test value was 0,678; and the p value was 0,744. Following online learning, the data had a normal distribution, the lowest score was 63, and the maximum score was 100. The Kolmogorov-Smirnov test value was 0,844 and the p-value was 0,475. The mean score for the students was 84.23, the standard deviation was 9.005, and the lowest and highest scores were respectively 63 and 100. Materials for stoichiometry in general chemistry.

3.3 Product effectiveness

The effectiveness of e-learning in general chemistry learning of the CBT-based Stoichiometry material, which was produced using a pretest-posttest technique, was evaluated to determine the rise in student learning results in finishing tests through the CBT application. With the use of the SPSS application, the test results were examined using a t-test or paired sample t-test procedure.

Table 4. Product Effectiveness Test Results (t-test)

		Paired Differences		t	df	Sig. (2-tailed)
		Mean	Std. Deviation			
Pair 1	Posttest – pretest	25.100	6.784	20.265	29	0.000

Table 4, presents the outcomes of a t-test utilizing a paired sample t-test approach used to evaluate the efficacy of general chemistry e-learning based on CBT. With a difference in average scores (posttest-pretest) of 25,100, the analysis's findings indicated that the implementation of the resulting CBT-based online General Chemistry learning was successful in enhancing student learning outcomes. The results of the analysis offered up a tcount value of 20,265 and a probability (sig.) of 0,000< 0,05.

An e-learning application for learning general chemistry that is based on CBT and takes into consideration the media and material elements is the end product of this research and development. E-learning for general chemistry is created using CBT. Experts and practitioners have reviewed the CBT-based General Chemistry e-learning, and the results have been found to be reliable and useful for educational purposes. The validity of the CBT-based General Chemistry learning e-learning is qualitatively fulfilled based on the evaluations of the material

expert validators and media expert validators, which are generally indicated in the valid category.

Advantageous for enhancing student learning results is the use of CBT-based general chemistry e-learning. Based on the rise in students' capacity to pass CBT assessments, the effectiveness of e-learning General Chemistry based on CBT is statistically validated. The resulting CBT-based General Chemistry e-learning received highly favorable student feedback.

The results of this study and development have consequences for lecturers in that it is possible to create creative learning, and one of them is CBT-based e-learning, in order to improve the capability and success of results of student learning. Students' comprehension, competence, and capacities can be improved using this CBT-based General Chemistry e-learning.

4 Conclusion

Through the ADDIE development model, books and online courses for general chemistry learning on computer-based tests (CBT) stoichiometry were produced as a result of this research and development. It has been deemed credible (possible) and successful in raising student learning results. The assessment of the validators of the material experts and media experts is the basis for qualitatively meeting validity, who commonly appear in the acceptable category (viability). Based on the use of computer-based tests (CBT) for general chemistry learning, the results of statistical hypothesis testing with a probability level of < 0,05 corroborate the effectiveness. The enhancement of learning outcomes for students, both before and after utilizing the general chemistry e-learning program based on CBT-based stoichiometry, serves as proof of the improvement in student learning outcomes. The average gain in results of student learning or the difference between the pretest and posttest is 25,100.

The results from this research and development are anticipated to serve as an example for users, development researchers, and other lecturers as they work to build CBT-based online learning in other areas.

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References

[1] Afandi, Junanto, T., and Afriani, R.: Implementasi Digital-Age Literacy dalam Pendidikan Abad 21 di Indonesia, in *Seminar Nasional Pendidikan Sains*, pp. 113–120 (2016).

[2] Panggabean, F.T.M., Pardede, P.O., Sitorus, R.M.D., Situmorang, Y.K., Naibaho, E.S., and Simanjuntak, J.S.: Application of 21st Century Learning Skills Oriented Digital-Age Literacy to Improve Student Literacy HOTS in Science Learning in Class IX SMP, *J. Mantik*, vol. 5, no. 36, pp. 1922–1930 (2021).

[3] Prayogi, R. D., and Estetika, R.: Kecakapan Abad 21 : Kompetensi Digital Pendidik Masa Depan, *J. Manaj. Pendidik.*, vol. 14, no. 2, pp. 144–151 (2019).

[4] Panggabean, F.T.M., Silitonga, P.M., and Sinaga, M.: Development of CBT Integrated E-Module to Improve Student Literacy HOTS, *Int. J. Comput. Appl. Technol. Res.*, vol. 11, no. 05, pp. 160–164 (2022) doi: 10.7753/IJCATR1105.1002.

[5] Sugiyarti, L., Arif, A., and Mursalin.: Pembelajaran Abad 21 di SD, in *Prosiding Seminar dan Diskusi Nasional Pendidikan Dasar*, pp. 439–444 (2018).

[6] Panggabean, F.T.M., Purba, J., and Sinaga, M.: Pengembangan Pembelajaran Daring Terintegrasi Media Untuk Mengukur HOTS Mahasiswa Pada Mata Kuliah Kimia Organik, *J. Inov. Pembelajaran Kim. (Journal Innov. Chem. Educ.*, vol. 3, no. 1, pp. 11–21 (2021).

[7] Guntoro, Costaner, L., and Sutejo.: Pelatihan Sistem Pembelajaran E-Learning pada Sekolah Menengah Kejuruan Dwi Sejahtera Pekanbaru, *Din. – J. Pengabdi. Kpd. Masy.*, vol. 1, no. 1, pp. 39–45 (2017).

[8] Pudyastuti, A.T., and Budiningsih, C. A.: Efektivitas Pembelajaran E-Learning pada Guru PAUD Selama Pandemic Covid-19, *J. Obs. J. Pendidik. Anak Usia Dini*, vol. 5, no. 2, pp. 1667–1675 (2021) doi: 10.31004/obsesi.v5i2.873.

[9] Supratman, E., and Purwaningtias, F.: Pengembangan Media Pembelajaran E-Learning Berbasis Schoology, *J. Inform. J. Pengemb. IT*, vol. 03, no. 03, pp. 310–315 (2018) doi: 10.30591/jpit.v3i3.958.

[10] Wahyudi, I.: Pengembangan Program Pembelajaran Fisika SMA Berbasis E-Learning dengan Schoology, *J. Ilm. Pendidik. Fis. Al-BiRuNi*, vol. 6, no. 2, pp. 187–199 (2017) doi: 10.24042/jipfalbiruni.v6i2.1850.

[11] Agustinasari, Susilawati, E., and Fitriati, I.: Peningkatan Kemampuan Guru SMAN 2 WOHA dalam Melakukan Evaluasi Pembelajaran Menggunakan CBT, *J. Masy. Mandiri*, vol. 4, no. 2, pp. 273–280 (2020).

[12] Fitriati, I., and Irawati, I.: Implementasi Computer Based Test English Computer (CBT-EC) Untuk Efesiensi Evaluasi Bahasa Inggris Komputer di STKIP Taman Siswa Bima, *J. Ilmu Sos. dan Pendidik.*, vol. 2, no. 2, pp. 204–210 (2018).

[13] Putri, U.M., and Rahayu, S.: Aplikasi Computer Based Test (CBT) Sebagai Alternatif Evaluasi Hasil Pembelajaran Siswa, *J. Sist. Inf.*, vol. 4, no. 2, pp. 153–164 (2018).

[14] Ardiansyah, M.: Analisis Penilaian Tengah Semester Menggunakan Sistem CBT Pada Mata Pelajaran Matematika di SMK Islam Perti Jakarta, *Res. Dev. J. Educ.*, vol. 7, no. 1, pp. 29–38 (2021).

[15] Annisak, W., Astalini, and Pathoni, H.: Desain Pengemasan Tes Diagnostik Miskonsepsi Berbasis CBT (Computer Based Test), *J. EduFisika*, vol. 02, no. 01, pp. 1–12 (2017).

[16] Supranoto, H.: Penggunaan Soal HOTS Ekonomi Berbasis CBT untuk Meningkatkan Hasil Belajar Siswa Kelas XII SMAN 2 Ulubelu, *J. Pengemb. Profesi Pendidik Indones.*, vol. 1, no. 1, pp. 1–9 (2021).

[17] Rosida, I., and Susatyo, E.B.: Analisis Pemahaman Konsep pada Pembelajaran Larutan Penyangga Model Discovery Learning Menggunakan Tes CBT, *Chem. Educ.*, vol. 10, no. 2, pp. 62–69 (2021).

[18] Purba, J., Panggabean, F.T.M., and Widarma, A.: Development of Online General Chemistry Teaching Materials Integrated with HOTS-Based Media Using the ADDIE Model, *Int. J. Comput. Appl. Technol. Res.*, vol. 11, no. 05, pp. 155–159 (2022) doi: 10.7753/IJCATR1105.1001.