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Web-CMS based as teaching materials to improve students' digital literacy

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Abstract: Technology advances and the profusion of information resources has the need to be accompanied by the students' digital literacy and critical thinking skills. Website is the example of technological advances that are still rarely used as Content Management System (CMS) in learning. The purpose of this research is to develop website-based teaching materials to increase students' digital literacy on material about cell. Research and development (R&D) conducted used ADDIE model. The development produces website-based teaching materials (Power Web Cell) which are later tested for the feasibility and the effectiveness in improving digital literacy of grade XI student on cell material. The product effectiveness test was caried out on 30 grade XI students who were selected using simple random sampling technique. The data was retrieved from digital literacy questionnaires measuring five areas. Hypothesis testing was conducted using paired sample t-test on pretest and posttest results. The results show that the developed Power Web Cell is feasible based on its feasibility tests' result and is effective in improving students' digital literacy. The content presented addresses more current issues and provides more interactive features, is recommended on developing website.

Keywords: digital literacy; teaching materials; website

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1. Introduction

Over the past two decades, technology has made rapid progress especially with the introduction of Internet (Nadiah et al., 2019). The world is in a new era where the rapid evolution of digital technologies such as the Internet of Things (IoT), Big Data (BD), Artificial Intelligence (AI) and mobile devices is driving major changes in various fields of life, including education (Savaneviciene et al., 2019). Advances in digital technology make education nowadays face many challenges. These challenges include: 1) the progress of digital technology is not in line with the advancement of educational theory; 2) Turbulent, uncertain, complex and ambiguous characteristics of society; 3) Generation that has extraordinary power of information, supported by global interconnectivity via the internet network (Bennett & Lemoine, 2014; Sumardi, 2020; UNICEF, 2017). Advances in digital technology, especially information technology affect very fast access to information, multiply learning resources because it offers search engines to provide the information and various communication and allows one to upload and download data or information from many different disciplinary fields (Iacovitti, 2022; Jalinus & Ambiyar, 2016; Szymkowiak et al., 2021).

The riches of digital information resources need to be accompanied by students' ability to manage and process secure and useful information. Students need to be equipped with skills that prevent them from acquiring various false information (Sabrina, 2019). One of them is the digital literacy skills. Digital literacy is defined as the ability to access, manage, understand, integrate, communicate, evaluate and create information securely and appropriately through digital technology that encompasses diverse competencies (Law et al., 2018). Digital literacy competence consists of five areas, namely information and data literacy; communication and collaboration; digital content creation; security and troubleshooting (Law et al., 2018; Vuorikari et al., 2022).

Digital literacy is an absolute learning necessity (Harjono, 2019; Murtadho et al., 2023; Peng & Yu, 2022). Digital Literacy is very essential in improving the quality of learning and owns practical value for completing a wide variety of tasks (Sánchez-Cruzado et al., 2021; Stevens et al., 2021; Sujana & Rachmatin, 2019). In this context, the digital literacy mastery allows students to develop cognitive, affective and psychomotor competencies through way better, faster, easier and more enjoyable learning process in a digital learning environment. Digital literacy has several elements such as critical thinking skills, creativity, constructing and evaluating information and the use of digital media effectively (Al-Qallaf & Al-Mutairi, 2016; Kaeophanuek et al., 2019).

Digital literacy of students can be developed by applying digital technology in learning. Website-based teaching materials can be used as an alternative to develop digital literacy. Websites are able to combine multimedia elements in the form of text, data, images, sound, animation, video and others into information that can be accessed by anyone (Smaldino et al., 2019). Website as teaching material will make the students easier to access the material and train them to find reliable sources. The use of website can accustom the students to be active in learning process so it is more meaningful. The website also allows teacher to create learning sites that contain learning content, learning activities, exercise and discussion rooms (Ninoriya, 2011). The implementation of information retrieval-based learning using website shows that students have significantly better learning attitudes, learning achievement and better critical thinking (Hwang et al., 2014). In addition, the implementation of online learning (e-learning) can improve students' digital literacy (Anggrasari, 2020; Prior et al., 2016; Tang & Chaw, 2016).

Biology learning, especially about cells, was chosen as the focus of research because cell material is closely related to various phenomena in living things and has transformative potential for digital learning. For decades it has been observed that the process of cell learning is not one of the easy one. Some of the commonly identified difficulties associated with cell are cell size, visualization of cell organelles and various process of cell (Vlaardingerbroek et al., 2014). Teachers can overcome these kinds of difficulties by not limiting learning resources only to textbook but also learning resources from the internet.

Based on this description, this research aims to develop website-based teaching materials as an innovation to increase students' digital literacy in cell material. The website being developed will present interesting 3D and interactive animations in which support students' understanding of cell material which visualizing abstract objects. Apart from being supported by 3D animation, this website also has other features such as quizzes, images, videos which are expected to improve understanding of cell concepts. Websites also provide access to a vast array of information on diverse subtopics, allowing students to explore and engage with content relevant to cell material. The role and urgency of this research is to find out how website-based teaching materials can stimulate students' digital literacy in cell material.

2. Materials and Methods

2.1 Research design

This study uses research and development methods (Research and Development). The product developed is a website-based teaching material to improve students' digital literacy skills on cell material. In general, the development steps using the ADDIE model are Analyze, Design, Development, Implementation and Evaluation (Branch, 2009).

2.1.1. Analysis

At the analysis phase, it aims to identify the need for teaching materials in learning. This phase includes conducting a needs analysis of students and teachers using questionnaires. The questionnaire contains perceptions regarding biology learning, supporting sources for biology learning, students' knowledge and their interaction with devices, and views regarding websites as teaching materials.

2.1.2. Design

The design stage is carried out to create teaching materials according to the needs of students and teachers. It takes several steps in design phase, consisting of: 1) selecting and analyzing material that will be included in teaching materials; 2) designing storyboards; 3) formulating content of teaching materials; and 4) creating research instruments.

2.1.3. Development

During the development phase, the website is created according to the storyboards. This stage is intended to produce a website which is then improved based on expert validation and trials by teachers and small group of students. The validation process involves four validators, namely material experts and media experts. It aims to obtain suggestions to determine the correctness of the content and websites' design. Once the website is declared valid, a trial of this website is carried out in small groups of students and teachers. The results of this trial are analyzed simultaneously for website improvements before implementation in large group.

2.1.4. Implementation

This implementation stage is the stage of testing website in large group students of XI grade. This activity involves a pretest and posttest. The pretest is used to determine students' basic knowledge and posttest to measure students' digital literacy. The test results obtained will be tested using tests such as normality and homogeneity test, paired-sample t test, and N-Gain.

2.1.5. Evaluation

At the final phase of ADDIE model, evaluation aims to improve website based on weaknesses discovered during the implementation stage. After improvements, the wesbite is suitable as a teaching material and ready to be disseminated.

2.2 Population and samples

Population and sample selection were carried out using stratified sample selection technique (multistage sampling) for all students of grade XI State High School in DKI Jakarta Province. In product effectiveness testing, simple random sampling techniques were carried out to reduce data bias. Based on the results of the simple random sampling technique, 30 units of grade XI high school students were obtained.

2.3 Data collection

Data collection techniques include observation, questionnaires and documentation. Observation is conducted at the research location on existing object and subject, in order to find problems, and determine the learning conditions. The identification of product feasibility uses measurements on the Likert scale. The data were obtained through distributing questionnaires to material experts and media experts. The data gained is quantitative (assessment) which is interpreted qualitatively then analyzed and used to revise the developed product.

2.4 Data analysis technique

Technical testing of product effectiveness to improve students' digital literacy on cell material was carried out using a one group pretest posttest research design. The instrument used in the effectiveness test was a digital literacy questionnaire adapted from Vuorikari et al. (2022). The digital literacy data obtained was the statistically analyzed through normality, homogeneity, hypothesis testing and N-gain test using SPSS. Additionally, questionnaires were distributed to determine students' responses to the product.

3. Results

This development resulted in the Power Web Cell website that can be accessed via mobile phones and laptops. This website is designed to be able to improve students' digital literacy.

3.1 Analysis

The needs analysis was conducted by distributing questionnaires to Biology teachers and the students who had already studied cell material. The total number of students who completed the questionnaire is 55 students. The result of the analysis of student needs can be seen in Figure 1.

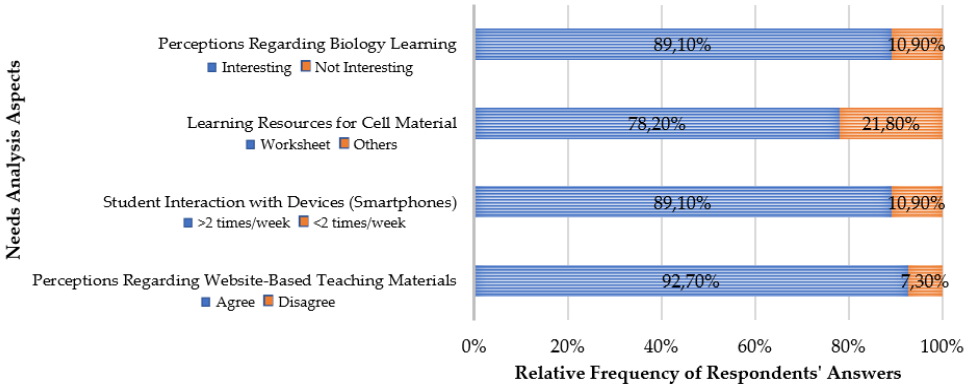


Figure 1. Diagram of analysis of student needs in Biology

Based on Figure 1, it is known that as many as 89,10% of students consider that learning Biology is interesting and only 10,90% think otherwise. About seventy eight percent of students are often given LKPD as a source of learning support, compared to other sources such as modules, textbooks, software or web-based teaching when learning Biology. Although, 89,10% of students revealed that they use devices >2 times/week as a medium in learning Biology. Therefore, 92,70% of students agree if website-based teaching materials that make them easy to learn Biology especially in cell material are developed.

These results are also supported by the outcome of the biology teacher questionnaire which states that teaching materials that are often used are textbooks, worksheet, modules and websites (Figure 2). Teachers feel that those teaching materials have not been effective in supporting biology learning due to the limitations of teaching materials such as material completeness, application of concepts, supporting images and flexibility. Therefore, teachers want interactive teaching materials by using digital technology containing material related to everyday life, other content such as images, animations and videos as well as material that is brief dan easy for students to understand

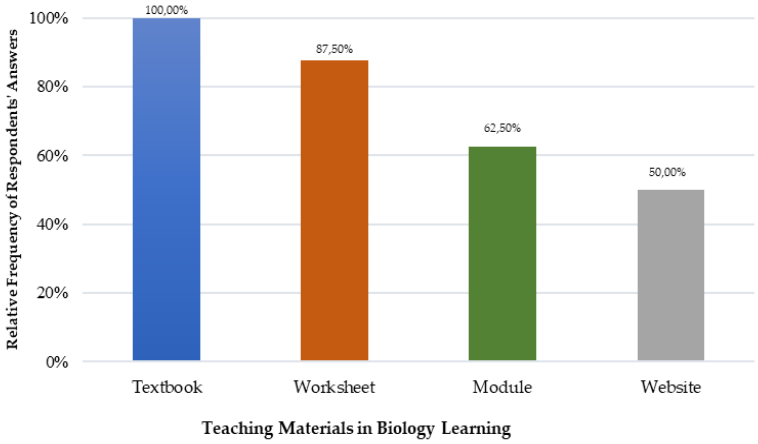


Figure 2. Teaching materials often used by teachers

3.2 Design

The design stage is a design phase made based on the results of the analysis of students' and biology teachers' needs. At this stage, the design of learning devices is carried out, which consist of making the sequence of learning objectives and teaching modules, preparing research instruments in the form of questionnaire on digital literacy and making storyboard.

The results of the needs analysis showed that 29,10% of students stated that cell material is one of the three materials that are considered difficult to learn and understand in grade XI. This is in accordance with the research of Amelia and Alberida (2022) which states that the factors causing the difficulty in learning cell material experienced by the students are due to abstract biology, difficulty in remembering, memorizing and understanding biological material that is too dense and numerous. In addition, in cell material the object is not directly observed and many parts must be remembered and understood precisely (Setiawati et al., 2019). Beside the material characteristic, teaching materials also affect students; understanding of the material presented (van Dulmen et al., 2023). There are 87,5% of teacher and 52,7% of students want images, animations and videos in teaching materials used in learning process.

The storyboard creation process is designed based on the result of the needs analysis. Storyboard is designed based on the results of the website which contains header menus and dropdown menus that will later be developed. The content displayed on the website is cell material text accompanied by supporting content such as videos, images, 3D animations and formative and summative test features. An engaging website can provide an effective and efficient learning experience for teachers and students as well as support the learning environment during and after class as it gives learners access to adequate contents (Lin & Jou, 2013).

3.3 Development

The product development phase begins when the storyboard is completed. The initial step taken in the development of website-based teaching materials (Power Web Cell) is editing the material that will be integrated into the website. The integrated material is adjusted to the learning outcomes and the sequence of learning objectives. The development of website-based teaching materials (Power Web Cell) continues with selecting hosting, making website domains and using html and php programming languages to create the appearance of the website. This display should pay attention to graphic elements such as background colors, text or images displayed and other visual expressions to create an aesthetic experience and more comfortable users when accessing the website (Dakić et al., 2016).

The homepage displays all information or content of the website. The Power Web Cell homepage uses a background in the form of cell illustration equipped with the website name, contact information such as email address, phone number and editor address, menu sub header that is connected to the material page. The homepage also displays learning outcomes, learning objectives and concept maps of cell material. At the bottom of the page, there are shortcuts and brief description of the cell sub material.

The materials integrated into the website are adapted from teacher handbooks, reference books on cells and credible website that discuss cells. Power Web Cell also contains content support features such as 3D animated models that can be clicked and operated by the students. This visualization can support students' understanding of cell structure and its organelles. This is supported by the research from Teplá et al. (2022) which states that the use of 3D models and animation in science subjects is perceived positively by the students because of the dynamic visualization. Besides, Power Web Cell also has other supporting content in the form of links that lead to other website that support the material and several videos which are directly connected to the YouTube application. This link is expected to facilitate students in accessing broader information related to cells. The usage

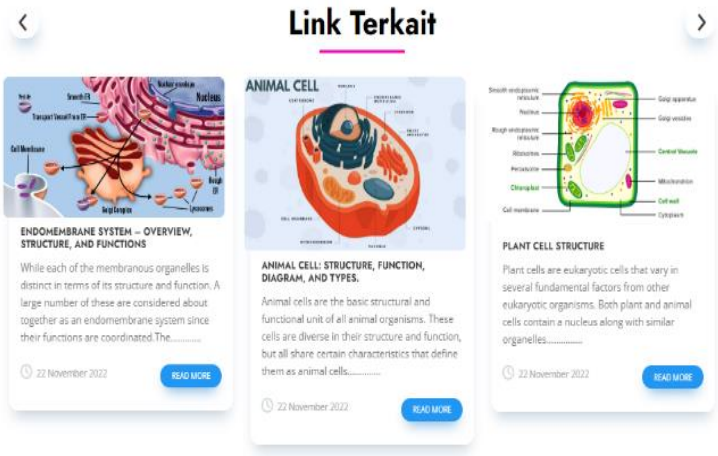
of technological support in the form of usable tools can improve learning, deepening and understanding of the material in class (El Hammoumi et al., 2022).

At the product development stage, product validity was examined by two media experts and two material experts. The aspects assessed by material experts consist of four aspects namely material content, visual communication display, learning design and website utilization. While the aspects assessed by media experts consist of language, presentation, effects on learning and overall appearance.

The results of the material validity test obtained an average percentage of 82,6% with a very feasible predicate based on Yusuf (2016) interpretation table. These results can be interpreted that the material in Power Web Cell is in accordance with learning outcomes and learning objectives, the order of the material is appropriate and the language used is at the level of the students. The suitability and sequence in teaching material will help students and knowledge build understanding and knowledge of the studied material. This is supported by Arianti's research (Arianti, 2021) that coherent material can make it easier for the students to understand basic to complex material.

Table 1. Results of Power Web Cell development

No	Website section	Figure
1.	Home Page	
2.	Content	

No	Website section	Figure
3.	Sidebar and navigation	

In the media validity test, an average percentage of 85,5% was obtained with a very decent interpretation. This shows that Power Web Cell has quality in term of features, language, presentation, usability and appearance. However, the image, video and hyperlink presentation indicators only obtained a percentage of 75% with proper interpretation as a result from media expert validators. This can be assumed that happened because the presented images are not in HD quality yet and the videos do not have translation from foreign languages. Images and videos have important role within the website, which is to attract readers' attention and help them to et better information, hence attractive and good quality images and videos are needed (Jamsa et al., 2002). Nevertheless, the overall validation results show that Power Web Cell is stated very decent for further use in learning. Development results can be seen in Table 1.

3. 4 Implementation

The implementation phase is carried out after the product is declared suitable for use in learning. Power Web Cell was implemented on 30 grade XI high school students by referring to the sequence of learning objectives and teaching modules of 'Merdeka' curriculum. In the initial stage, students were asked to complete a 35-question pretest on digital literacy. The Application of Power Web Cell was carried out in seven meetings. At the end of the meetings, students were asked to take a posttest again.

Based on the results of the Power Web Cell implementation in learning, pretest and posttest results of students' digital literacy can be seen in Table 2. The results of the digital literacy pretest and posttest obtained an average score of 64.12 and 75.33, respectively. The average digital literacy posttest scores show an increase compared to the average pretest score taken previously. This is in line with research conducted by Aprilia et al. (2023), that website-based learning can improve students' digital literacy skills with an average value of 73,36%. Perdana et al. (2019) also mentioned that there is a significant difference in the level of digital literacy skills of students who used website compared to students who use direct learning.

Table 2. Pretest and posttest results for digital literacy

Data	*Digital Literacy*	
	Pretest	*Posttest*
Lowest Score	35.71	55.00
Highest Score	87.14	100.00
Mean	64.12	75.33
Normalized Gain	0.31	

The result of Normalized Gain calculation on digital literacy is 0,31. This value falls into the medium category which shows that the use of website-based teaching materials (Power Web Cell) is quite effective in improving students' digital literacy skills. At the end of the meeting, students were given a response questionnaire responding to the use of website-based teaching materials (Power Web Cell). The result obtained from the implementation process of teaching materials show that website-based teaching materials (Power Web Cell) are "Very Feasible" for use in learning.

Table 1. Digital literacy and critical thinking skills hypothesis test results

Test Type	Variable	Mean	Std. Deviation	Std. Error Mean	t	df	Sig.
Paired Sample T-Test	Digital Literacy	-11.215	8.768	1.601	-7.005	29	0.000*

*Notes: *statistically significant at 0.05 level. n=30*

Pretest and Posttest scores are analyzed for its distribution and variance. Analysis using Shapiro-Wilk showed that all data were normally distributed, including pretest (p=0.694) and posttest (p=0.501) for digital literacy ability variables. Furthermore, the homogeneity test result shows that the data on digital literacy ability is homogeneous (p=0.501). Both variables have met the prerequisite test so that both variables are further analyzed using paired sample t-test. The summary of paired sample t-test results (Table 3) shows a significant value of 0.000 less than 0.05 then H0 is rejected. This means that there is a significant difference in pretest and posttest scores of digital literacy skills using website-based teaching materials (Power Web Cell).

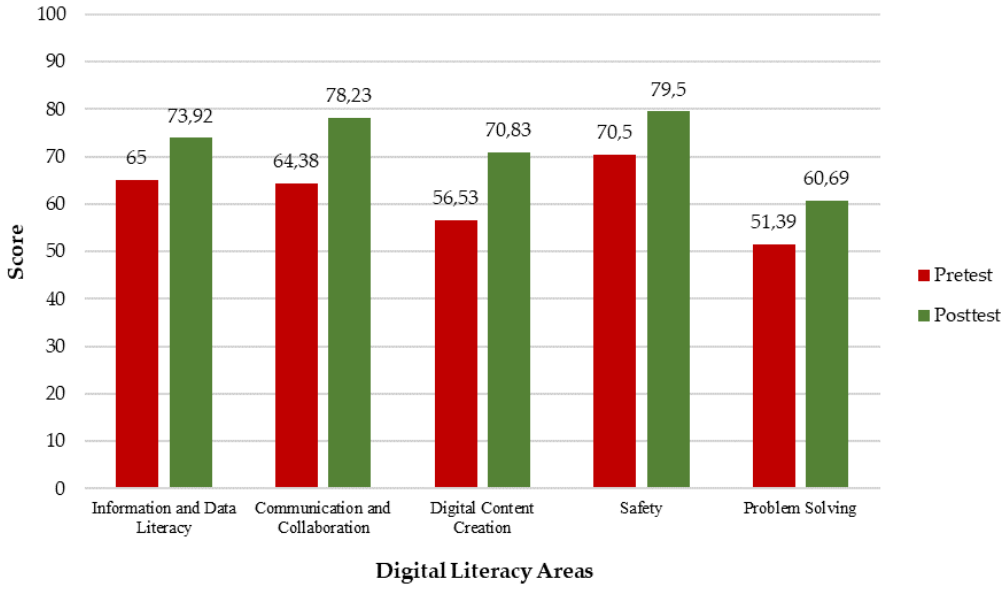


Figure 3. Pretest and posttest score in each digital literacy area

Based on Figure 3, the improvement of learners' digital literacy can be seen in all area, namely information and data literacy, communication and collaboration, digital content creation, security and problem solving. This increase shows that Power Web Cell as a website-based teaching material can accommodate student participants in developing digital literacy. The highest increase was seen in the digital content creation area with an initial value of 56.53 to 70.83, while the lowest was seen in the security area with a value difference of 9.0. Digital content creation is the area with the highest improvement because in the learning process, students created digital content in the form of presentation slides.

Security is the area with the lowest increase in score because students already understand the security in accessing information via the internet.

3. 4 Evaluation

The final stage of developing website-based teaching materials (Power Web Cell) is evaluation. This stage is a refinement of teaching materials that refers to the overall results of assessments from several experts and implementation phase. Based on the overall average results of the assessment, website-based teaching materials (Power Web Cell) received feasible category and received good comments from students. Even though this website is considered feasible for educational purposes, there are still areas for improvement such as, the display and connectivity of the website when opened with a certain internet provider. Integrating Power Web Cell into the curriculum can indeed serve as a valuable teaching material for grade XI students, enhancing their knowledge and digital literacy.

4. Discussion

The Power Web Cell that developed in this research are feasible and reasonably practical for fostering digital literacy among student. It provide valuable opportunities for students to develop digital literacy in a dynamic, interactive, and engaging learning environment. Educational digital resources developed by educators in schools can help students understand and educate them about digital literacy (Buchan et al., 2024).

The improvement of students' digital literacy is due to the implementation of Power Web Cell being integrated with habits that support digital literacy in learning process and the use of mobile devices. It has been discovered that the overall impact of mobile devices usage in learning is better than desktop computers usage. Mobile devices have various distinctive features such as real-time access to information, individualized interfaces, instant communication, feedback, and context sensitivity (Sung et al., 2016). Power Web Cell provides cell-related content in text form that can be read and understood by the students. In addition, the website also supports students in exploring information through the available links, thereby helping students to improve the area of information and data literacy. Websites that contain learning content are able to facilitate students' reading and writing skills even to access and use information affectively (Istikomah et al., 2021).

Learning activities are designed to support the improvement of digital literacy in the areas of students' communication and collaboration through discussion and group work. Power Web Cell is also used as one of the student learning resources in creating digital content in the form of presentation slides that discuss cell. Students can take pictures and information from the website. Restricting internet access on interesting and easily accessible reading material sources can encourage reading independence and affect student learning outcomes. By using the platform provided by the teacher, students can protect themselves from exposure to hoaxes, scams, pornography and other content that is not related to learning materials. The website also teaches students to be careful in entering passwords to maintain the security of their accounts.

Power Web Cell has the advantages of being interactive, easy to use and flexible. The interactivity form of Power Web Cell is the existence of hyperlinks that connect to other sources for easy access to information, have 3D animation content and video related to cell material. Interactive teaching materials will encourage students' involvement in the learning process so that it can encourage changes in emotional behavior and cognitive abilities (Fredricks et al., 2004).

The development of Power Web Cell is structured into various segments of material, aiming to enhance students' retention and comprehension. It refers to the theory of Cognitive Load Theory (CLT) and Cognitive Theory of Multimedia Learning (CTML) which states that a person can learn, think and solve problems because of the relationship between working memory and long-term memory. Power Web Cell contains multimedia that can reduce sources of cognitive load so that effective learning can be achieved (Sweller, 2011). Extrinsic cognitive load can be reduced by applying the principle of

coherence, redundancy, signaling, temporal contiguity and spatial contiguity. In Power Web Cell, it is indicated by the presence of stimulus sentences, interesting images, highlight in titles and videos. Intrinsic load can be reduced by applying the principles of segmenting and modality, in Power Web Cell shown by the division of cell material in the menu subheader, instruction for using the website and 3D animation. Meanwhile germane cognitive load can be developed by applying the principle of personalization where the students can access Power Web Cell easily and there are formative and summative test that can be done directly by students (Sweller, 2011; Mayer, 2017). Information (images, video and text) in Power Web Cell which designed according to these principles will be fully processed by working memory and transferred to long-term memory, resulting in more effective learning (Sweller, 2011).

Power Web Cell represents a convergence of CLT-CTML principles and digital literacy objectives in education. By strategically aligning its design with CLT-CTML, Power Web Cell aims to optimize learning experiences for students. This is in line with research by Skulmowski and Xu (2022), by understanding the cognitive demands posed by learning materials, teachers can design learning experiences which optimize cognitive load management and encourage more effective learning outcomes. Moreover, it serves as a platform for students to develop essential digital literacy, including information and data literacy, problem solving, and technological proficiency. The integrated science instructional materials were effective in the scientific approach to improving the aspects of knowledge and digital literacy (Asrizal et al., 2018). Bergdahl et al. (2020) propose that students' involvement in (technology-enhanced) learning correlates with their proficiency in digital skills. Advancements in technology and sophisticated tools will facilitate more efficient learning for students, enabling them to monitor their progress effectively and digitally literate (Haleem et al., 2022; Szymkowiak et al., 2021).

5. Conclusions

Power Web Cell has been developed into teaching materials through a research and development process using the ADDIE model. This website received an assessment with a very feasible interpretation to be used as a biology learning resources on cell material. The application of Power Web Cell is effective in improving digital literacy skills in cell material based on the results of the questionnaires given to students.

Power Web Cell has the advantages of being effective, easy to use and flexible. The form of Power Web Cell interactivity is that there are hyperlinks connected to other sources for easy access to information, has 3D animation content and videos related to cell material. Power Web Cell can be used as a resource to support the learning process both at school and outside of school. Power Web Cell is able to help students comprehend cell material and improve digital literacy skills in biology subject. The development on further research, it is recommended that the content presented addresses more current issues, improves the quality of test instruments and provides more interactive features.

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