Diversitas Journal
ISSN 2525-5215
Volume 9, Issue 1 (jan./mar. 2024) p. 0001 – 0017
https://diversitasjournal.com.br/diversitas_journal

Development of Virtual Science Interactive Learning Materials According to the ADDIE Model

Desenvolvimento de Materiais de Aprendizagem Interativos de Ciências Virtuais de Acordo com o Modelo ADDIE

ONG, Daniel Jr.[1]; ANCHETA, Oscar Jr.[2]

[1] 0000-0001-5615-9051; Don Mariano Marcos Memorial State University. San Fernando City, La Union, Philippines. dong@dmmmsu.edu.ph
[2] 0000-0001-5530-4288; Don Mariano Marcos Memorial State University. San Fernando City, La Union, Philippines. oancheta@dmmmsu.edu.ph

A B S T R A C T

Virtual instructional materials are in high demand amidst the pandemic. Many Filipino teachers were caught off guard and lacked adequate distance education tools. Though there were, the majority were dilapidated and obsolete. A logical approach, such as the ADDIE Model, is essential for developing instructional materials. Its process sequence is crucial since the design's effectiveness is measured by the results of evaluations and how the intended objectives are realized. This study aimed to develop virtual Science interactive learning materials for distance learning in accordance with the five steps of the ADDIE Model. A formal assessment was carried out on the developed materials to examine their validity in terms of Content Quality, Instructional Quality, Technical Quality, and Technical Error, and to evaluate their usability and interoperability.

R E S U M O

Os materiais instrucionais virtuais estão em alta demanda em meio à pandemia. Muitos professores filipinos foram apanhados desprevenidos e não dispunham de ferramentas adequadas de ensino à distância. Embora existissem, a maioria estava dilapidada e obsoleta. Uma abordagem lógica, como o Modelo ADDIE, é essencial para o desenvolvimento de materiais instrucionais. A sequência do seu processo é crucial, uma vez que a eficácia do design é medida pelos resultados das avaliações e pela forma como os objetivos pretendidos são alcançados. Este estudo teve como objetivo desenvolver materiais virtuais de aprendizagem interativos de Ciências para ensino a distância de acordo com as cinco etapas do Modelo ADDIE. Uma avaliação formal foi realizada nos materiais desenvolvidos para examinar sua validade em termos de qualidade de conteúdo, qualidade instrucional, qualidade técnica e erro técnico, e para avaliar sua usabilidade e interoperabilidade.

ARTICLE INFORMATION

Article process:
Submitted: 22/10/2023
Approved: 16/12/2023
Published: 10/01/2024

Keywords:
ADDIE, Developing Instructional Materials, Non-Print, Virtual Resources

Keywords:
ADDIE, Desenvolvimento de Materiais Instrucionais, Não Impressos, Recursos Virtuais

DOI: 10.48017/dj.v9i1.2825

Introduction

Virtual Science Interactive Learning Materials are being developed to address the problem of the Emerging Normal setup in the Philippine education system, where face-to-face contact is limited, and internet access is restricted. This initiative promotes inclusive teaching and learning for teachers and learners regardless of their proximity and socioeconomic background. Furthermore, adapting to 21st-century Science education in this digital age will equip younger students with the necessary skills and expertise to compete in future scientific professions (Osman & Chen, 2017).

The education sector has been greatly influenced by the shift towards non-face-to-face learning as a result of the pandemic. Technology has become a crucial component of the education system, enabling educational services to expand beyond the traditional classroom and into the digital realm. This has been particularly valuable during the pandemic, allowing educators to conduct virtual classes and ensure educational continuity.

Despite challenges such as poor communication and accessibility issues, investing in instructional technology is seen as a viable solution for promoting education and elevating academic outcomes. As Hillmayr et al. (2020) suggest, such investments may be key to overcoming the challenges.

In Philippine schools, the use of educational resources that support remote teaching and learning is encouraged, but there are challenges such as lack of learning resources and internet access for some learners and teachers. This shift to online instruction is meant to remediate mediocre and poor performances, but it also affects marginalized communities that may not have access to the necessary technology (Abadi et al., 2017; Hillmayr et al., 2020).

The introduction of non-face-to-face learning has been expedited due to the pandemic, and it is expected to continue to gain momentum in the post-pandemic era. Although this method has its benefits, it has unintentionally created a disparity in education, disproportionately affecting marginalized communities. In the New Normal, educational resources that can support remote learning are recommended by stakeholders. Online instruction is one way to achieve this, but not all learners and teachers have access to the internet or high-speed connections, hindering the effectiveness of this method. Furthermore, some educators still rely on traditional teaching methods, which have been proven ineffective in addressing learners' mediocre and poor performances (Haw et al., 2021).

The ADDIE model is a framework whose name depicts the five steps in the model: Analysis, Design, Development, Implementation, and Evaluation. It was initially developed in the 1970s by the Center for Educational Technology at Florida State University. The model has been widely used in instructional design and training development, both in academic and corporate settings (Heyberi-Tenekeci, 2019). Several studies have examined the effectiveness of the ADDIE model in various contexts, such as healthcare, business, and education. For instance, research has shown that the model can improve learners' engagement, performance,

and satisfaction (Cheung, 2016; Nichols Hess & Greer, 2016; Wagner, 2021). However, some scholars have criticized the ADDIE model for being too linear and rigid, as it may not account for the iterative and dynamic nature of the design process (Branch & Merill, 2011; Spatioti et al., 2022).

This study aimed to develop Virtual Science Interactive Learning Materials for distance learning in accordance with the five steps of the ADDIE Model. Investigating Transactional Distance the interaction of internal-Constructivist approaches on the lesson content (Hobbiss, 2018; Dagar & Yadav, 2016; Li et al., 2018; Lim et al., 2021; Kirsch et al., 2021) and external media-equivalence structure components (Suárez et al., 2018; Thomasian, 2021; Kariman, 2019; Stoltzfus & Libarkin, 2016; Osman & Chen, 2017). This is related to the purpose of the non-print resources as a tool for Distance Education and how they influenced learner autonomy (Martin-Beltrán et al., 2017; van Alten et al., 2020). Specifically, the development sought to determine the level of validity of the Virtual Science Interactive Learning Materials text in terms of Content Quality, Instructional Quality, Technical Quality; and Technical Errors; and evaluate the usability and interoperability of the Virtual Science Interactive Learning Materials.

Methodological Procedure

This study used the descriptive-development method using the ADDIE Model.

In the ***Analysis Phase***, the following were described prior to the development of the Virtual Science Interactive Learning Materials: (1) competency mastered by the students, (2) level of competence based on the Science Achievement Test results, and (3) Adequacy Rate and Status of non-print learning materials.

(1) There were four learning domains with targeted learning competencies to be addressed for Science 5 based on the analysis of the Achievement Test Results these topics are located in the Most Essential Learning Competencies (MELC), namely Matter for First Quarter, Living Things and Their Environment for the Second Quarter, Forces and Motion for the Third, and The Earth and Space for the Fourth Quarter.

(2) Analyses of the Science Achievement Test results for three school years, from SY 2017-2018 to SY 2019-2020, were done to determine the level of competence of the Grade 5 level in the Science subject. Based on the data, the posttest scores showed a significant increase from the pre-test results. However, a closer examination of Science competency levels revealed that the competencies were hardly reaching Closely Approximating Mastery or Mastery. The majority of students received Low Mastery to Average in most skills each year, with only a few reaching Moving Towards Mastery, Closely Approaching, and Mastery (see Table 1). Paying attention to these nuances is critical for strategic initiatives to improve student performance in the domain.

Table 1.

Learning Domain Mastered in the Science Subject

Learning Domain	Batch 1			Batch 2			Batch 3		
	Pretest (%)	*Posttest (%)*	*P-Value*	*Pretest (%)*	*Posttest (%)*	*P-Value*	*Pretest (%)*	*Posttest (%)*	*P-Value*
Matter	44.062 (AVR)	64.583 (AVR)	0.0002*	49.617 (AVR)	68.087 (MTM)	0.0000*	37.559 (AVR)	61.127 (AVR)	0.0000*
Living Things and Their Environment	48.125 (AVR)	70.833 (MTM)	0.0000*	65.792 (MTM)	76.503 (MTM)	0.0002*	47.887 (AVR)	70.423 (MTM)	0.0000*
Forces and Motion	42.604 (AVR)	63.229 (AVR)	0.0002*	40.437 (AVR)	59.344 (AVR)	0.0000*	35.493 (AVR)	64.789 (AVR)	0.0000*
Earth and Space	56.667 (AVR)	80.312 (MTM)	0.0000*	60.328 (AVR)	69.617 (MTM)	0.0049*	48.638 (AVR)	74.836 (MTM)	0.0000*
Weighted Average	**47.865 (AVR)**	**69.740 (MTM)**	**0.0000***	**54.043 (AVR)**	**68.388 (MTM)**	**0.0000***	**42.394 (AVR)**	**67.793 (MTM)**	**0.0000***

*Significant at 0.05

Legend:

96 – 100	Mastered (M)
86 – 95	Closely Approximating Mastery (CAM)
66 – 85	Moving Towards Mastery (MTM)
35 – 65	Average (AVR)
15 – 34	Low (L)
5 – 14	Very Low (VL)
0 – 4	Absolutely No Mastery (ANM)

Source: Own authorship.

(3) In determining the adequacy rate and status of non-print learning materials, a researcher-made questionnaire was developed and tested for validity and reliability. The overall response of the five expert evaluators with regard to the tool was Much Valid for it generated a Median of 4. Furthermore, regarding Content, Organization, and Objectivity criteria, the median was Much Valid (Md=4). On the other hand, the Appropriateness and Sensitivity were Very Much Valid (Md=5). In addition, the questionnaire was pilot-tested among 20 Science teachers. The calculated Cronbach alpha value of the questionnaire items is 0.736, implying Adequate Reliability. As a result, the test questions' internal validity (consistency) was Strong. This indicated that the questions were consistent and they were interrelated.

Table 2.

Adequacy Rate of Non-Print Learning Resources

Non-Print Learning Resources	Inventory Frequency (material)	Adequate (%)	Inadequate (%)	Not Available (%)
Digital Interactives (Online)	112	52.94	32.35	14.71
Digital Interactives (Non-Online)	109	52.94	29.41	17.65
eBook	33	35.29	35.29	29.41
Transparencies	6	11.76	26.47	61.76
Slides (Transparent Photo)	6	8.82	17.65	73.53
CD	32	5.88	35.29	58.82
VCD	18	2.94	20.59	76.47
DVD	14	0.00	29.41	70.59
VHS	11	0.00	26.47	73.53
Cassette	2	0.00	23.53	76.47

Source: Own authorship.

The analysis revealed that the digital interactive materials, both online and non-online, along with eBooks, were perceived as the three most adequate non-print learning materials by teacher-users (see Table 2). These resources were also the most frequently utilized for teaching and providing supplemental courses and activities (see Table 3). However, some non-print resources such as CDs, VCDs, DVDs, VHS tapes, transparencies, slides, and cassette tapes have become obsolete, dilapidated, and underutilized, with some still available in schools but not being used by teachers.

Table 3.

Status of Non-Print Learning Resources

Non-Print Learning Resources	Inventory Frequency (material)	Frequently Used (%)	Seldom Used (%)	Unused (%)	Dilapidated (%)	Obsolete (%)
Digital Interactives (Online)	112	44.12	35.29	11.76	8.82	0
Digital Interactives (Non-Online)	109	41.18	26.47	23.53	8.82	0
eBook	33	23.53	20.59	38.23	5.88	11.76
Transparencies	6	0	11.76	26.47	17.65	44.12
Slides (Transparent Photo)	6	0	0	14.71	17.65	67.65
CD	32	0	17.65	32.35	5.88	44.12
VCD	18	0	2.94	32.35	11.77	52.94
DVD	14	0	5.88	35.29	8.82	50
VHS	11	0	0	23.53	11.76	64.71
Cassette	2	0	2.94	26.47	17.65	52.94

Source: Own authorship.

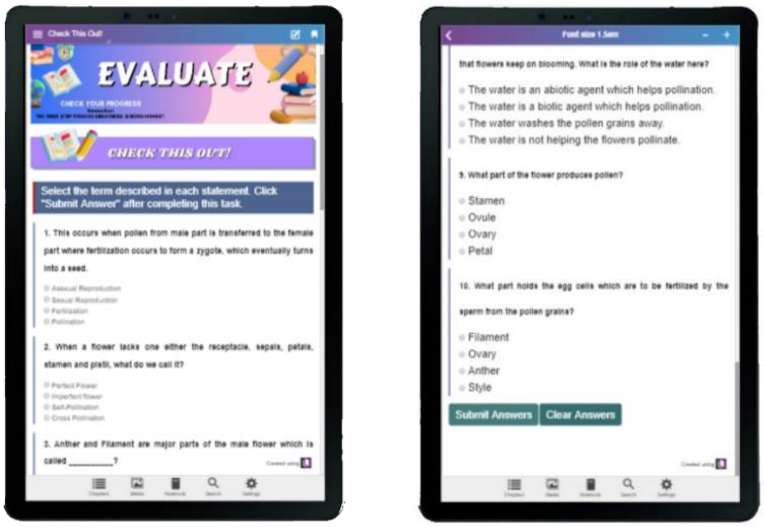
In the ***Design Phase***, structuring and designing of the instruction, learning strategies, assessment, and evaluation were included in this phase.

Virtual Science 5 (VS5) is a mobile learning package designed to address the challenges of remote learning, methodologies, and the distance learning environment. The design included internal-Constructivist approaches to the lesson content in the investigations of Hobbiss (2018), Dagar and Yadav (2016), Li et al. (2018), Lim et al. (2021), and Kirsch et al. (2021) in relation to Transactional Distance Theory. It was created as an electronic publishing (EPUB) platform to provide an innovative solution for students and teachers with low-bandwidth connections and can be accessed offline.

Its instruction design was created in the 5E paradigm, which included the stages: Engage, Explore, Explain, Elaborate, and Evaluate. Each lesson began with a Self-check Activity to assess prior knowledge. The Engage Phase introduced short activities to engage students and connect their prior knowledge to new concepts. The Explore phase involved hands-on activities to deepen understanding. In the Explain phase, students used interactive pop-up elements to explain what they had learned, while the Elaborate phase defined concepts and terminology. The Evaluation phase allowed students to demonstrate their comprehension by completing the prepared assessment tools (Figure 1).

Figure 1.

Assessment Feature of Virtual Science 5



Source: Own authorship.

VS5 lessons were developed with a constructivist foundation. The content was contextualized and rooted in reality, focused on the holistic construction of beliefs, and enabled lifelong learning (see Figure 2). Formative assessments were implemented to enable authentic learning through performance-based evaluations, and activities were adjusted to fit the realities of families and the available materials.

Figure 2.

Samples of localized and contextualized information in the materials

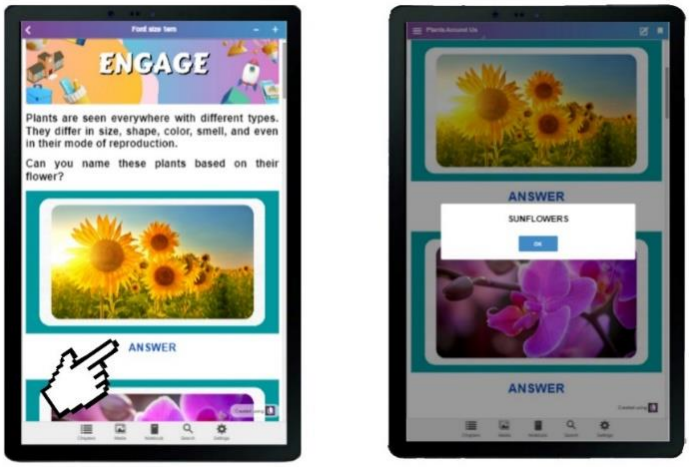
Source: Own authorship.

In the ***Development Phase***, this involved creating pop-up-based learning materials for virtual science education. It included searching and selecting appropriate data sources, creating content, illustrations, schemata, and graphs, typing and editing, and laying out the e-

textbook. The researchers considered external media-equivalence structure components as studied by Suárez et al. (2018), Thomasian (2021), Kariman (2019), Stoltzfus and Libarkin, (2016), and Osman and Chen (2017). Additionally, the phase involved structuring and writing dialogues. The dialogues in each lesson invited students to click on interactive pop-ups that integrated supplementary texts, audio, and photos to enhance the topics, much like a typical hyperlink (Figure 3).

Figure 3.

Interactive Pop-up-based feature of VS5



Source: Own authorship.

The VS5 lesson package was designed to be compatible with various devices, including Android and Apple IOS mobile phones, tablets, laptops, and desktop computers. However, an upgraded mobile or Windows system was required to fully experience the content, and an EPUB reader was necessary to view the files. The lessons were presented in EPUB format, which supported HTML for reflowable and interactive lessons.

Moreover, the VS5 project included interactive digital files of lessons, each less than 20MB in size, with condensed audio and video content to maintain quality. The project also featured auto-scored assessments with feedback and details about answers, including self-checks, quick checks, and formative tests. It includes an offline and online-ready practical guide for parents and guardians, accessible in PDF and Google Site format.

In the ***Implementation Phase***, the VS5 prototype was introduced to fifty (50) Grade 5 students within a month timeframe scheduled manner.

Lastly, in the ***Evaluation Phase***, formative assessments were carried out to attain the main objective of this research. The VS5 was assessed by five (5) professional evaluators: two subject matter experts, two learning design experts, and one learning media expert. The evaluation tool used was the DepEd Evaluation Rating Sheet for Non-print Materials under LRMDS Assessment and Evaluation of Locally Developed and Procured Materials (DepEd

Memorandum No. 441 s. 2019). Each category's score analysis was based on the minimum passing score.

Content Quality - at least 30 points out of a maximum of 40 points

Instructional Quality - at least 30 points out of a maximum of 40 points

Technical Quality - at least 39 points out of a maximum of 52 points

Technical Errors - at least 16 points out of a maximum of 16 points

Moreover, in the evaluation of VS5's usability and interoperability, usability was presented as a percentage, while interoperability was reported in text form. These were based on a trial conducted by expert evaluators.

Lastly, fifty (50) Grade 5 students were asked to provide feedback on the product prototype through a feedback form. A 4-point Likert scale level of agreement (4-Strongly Agree, 1-Strongly Disagree) among students' feedback was determined using the median.

Results and Discussion

Validity of the Virtual Science Interactive Learning Materials

The Validity Assessment of the Virtual Science Interactive Learning Materials, specifically the Virtual Science 5 (VS5), was determined through a scoring system. The criteria were scored, and each criterion's passing score determined the material's validity.

Content Quality

The VS5 demonstrated congruence with Science subject Learning Competencies and Grade 5 level based on the score of 39 out of 40 points for Content Quality. The material has adequate content and is free of bias, with factual, current, and logically produced information that reinforces defined learning objectives.

Based on the evaluation, the 5E model was structured well and easy to understand, stimulating critical thinking and real-world application. It considered technical language and strategies to clarify it, as well as positive value inclusions. The content aligns with Moore's Transactional Distance principles, prioritizing meaningful and constructive dialogue for improved comprehension. Several factors contributed to the effectiveness of VS5 content, including its accuracy, consistency with DepEd Learning Competencies for the corresponding grade level, and its ability to enrich, reinforce, or master identified learning objectives. When it comes to creating educational materials, it was ensured that material developers aligned the lessons with the curriculum for the specific subject and grade/year level they were intended for. This helped ensure that the content was relevant and useful for students and that it contributed to their mastery of the identified learning objectives.

In constructivist teaching methods, teachers act as a "guide on the side," allowing students to evaluate their own interpretations and understanding (Hobbiss, 2018). The 5E

Model is based on constructivist learning theory, which suggests that learners form knowledge and understanding based on their experiences. Through comprehension and reflection on activities, students can reconcile new knowledge with past ideas, thereby developing their independence and wisdom (Dagar & Yadav, 2016).

In addition to accuracy and consistency, materials that are easy to understand and follow can be more effective in helping students learn. Effective tools for teaching and learning must also be engaging can help to keep students interested and motivated to learn. To ensure effective learning, the contents should be structured to demonstrate the relevance of the topic to real-life situations and encourage critical thinking. Additionally, it is important to use appropriate language and vocabulary for the intended user level. While the reading material is critical, students' engagement with the content plays a vital role in their comprehension (Lim et al., 2021).

Instructional Quality

The VS5 has been rated and scored based on its instructional quality, receiving a total of 37.4 points, surpassing the required 30 points out of 40 to satisfy this criterion. This indicated that the instructional objective of the resource was clearly defined and well-integrated into the material. Moreover, it revealed that the materials were appropriately designed and effectively served their intended purpose. The learning objectives and expected student performances were evident, with various teaching levels made available. The content was arranged in logical chunks and sequences, and the time spent engaging with the material was proportionate to the outcomes obtained.

The graphics, sound, and color were utilized neutrally in illustrations and visualizations, skilfully linking the figures and tables through modified dialogues. According to Transactional Distance Theory, courses with low transactional distance tend to benefit from interaction with an instructor through a loosely structured program that supports individual interactions (Martin-Beltrán et al., 2017). In more distant programs like what had arisen during the pandemic, however, where dialogue is limited, such as using printed modular approaches, learning materials were structured to incorporate all the necessary assistance, guidance, and recommendations developers can provide, albeit without the potential for dialogue with a teacher to reconfigure the learning situation (van Alten et al., 2020).

To address this, the researchers adopted a progressive structure that scaffolded the students' comprehension. The design, presentation, and display of information through VS5 encouraged user participation, and relevant, immediate, and logical feedback was provided. The instructions and questions were designed to eliminate confusion and provide precise knowledge, with each response prompt and helpful (Hobbiss, 2018). Access to numerous information and concept chunks was logical, and additional explanations of the interrelation

of the learning chunks and the many pathways were provided (Lim et al., 2021; Schöbel et al., 2021b).

Technical Quality

Virtual Science 5 multimedia exceeded the technical quality score with a total of 48 points out of a maximum of 52, indicating its potential to improve knowledge and comprehension. The material was visually appealing and easy to understand with clear voice-over, audio, video, and pictures that were in sync. The content used beneficial music and sound effects, pagination mechanisms, and restricted text on the screen. The Navigation page included clear directions and helpful user assistance resources, with suggestions to enhance the flow of pages with in-book hyperlinks. The content was developed with technical nuances and multimedia aspects that are crucial for cognition and learning.

In accordance with the Theory of Media-Equivalence, technical nuances, and multimedia aspects (Kariman, 2019) play a significant role, as they are essential to cognition and learning (Stoltzfus & Libarkin, 2016), despite being peripheral (Abadi et al., 2017).

Technical Errors

Virtual Science 5 scored the exact number of points needed to pass the criterion under the category of Technical Errors. This indicates that the presented information is correct and relevant, and any grammar mistakes, errors, out-of-date information, and visual flaws have been corrected to prevent misunderstandings or confusion.

Evaluation of Usability Characteristics

Multimedia Design

The Multimedia Design garnered 92.50 percent (92.50%) approval from the evaluators. This signifies that VS5's media elements were useful. Although there was room for improvement in terms of multimedia quality. However, using high-definition multimedia features needs more file storage, particularly for mobile phone users (Thomasian, 2021).

The layout's coherence has to be enhanced in order to accommodate the built-in functionality and all multimedia elements. Cognitive architecture and processing of information are fundamental in courses, most especially in difficult-to-understand lessons (Abadi et al., 2017), thus instructional designers should consider multimedia design to direct students' knowledge acquisition and attention. The limited capacity of the learners' working memory has significant consequences for education, including how instructional materials should be designed (Kariman, 2019).

Overall Interface

96.37 percent (93.37%) satisfaction across all categories indicated that the material's interface is aesthetically appealing and consistent, user-friendly, and offers adequate information and guidance for usage. Improvements in terms of simplicity and consistency across successive displays are also necessary. Strategically planning and designing the whole interface entails satisfying the learners in the virtual world they will traverse (Li et al., 2018; Kirsch et al., 2021). When a learner is unfamiliar with a topic, it might be difficult to appreciate its relativeness to them. As a result, instructional designers are encouraged to employ attentional signals to steer students' attention and mastery of the competency. According to Lim et al. (2021), these signals aid in information selection and the structuring and integration of multiple components.

Behavior of Controls & System Information

There was a 100 percent (100%) approval of evaluators on the usability of Behavior of Controls & System Information. This implies that the controls and functionalities in VS5 respond effectively to the user's instruction/direction. Menus, buttons, and other commonly used controls have comparable forms and aesthetics, and their designs are suitable for their intended usage. Moore (1997) outlined the importance of student-environment interaction or learners' seamless involvement with technology in providing more significant opportunities to focus on Learner-Content.

Thus, behavioral control over technology should not be an overwhelming task for students because self-paced learning encourages students to devote time to domains where they are weak (Nichols Hess et al., 2016). Thus, according to Osman and Chen (2017), designing interactive instructional tools that satisfy the demands of students while also addressing the boundaries of the teaching and learning environment is a critical component of effective teaching.

Customizability/Support for User Preferences

The majority of the criteria offered received 97.14 percent (97.14%) acceptance from the evaluators. This implies that the functionalities of VS5 are usable and can be customized according to the specified pace desired by the users. The designers also considered the durability and good quality of the physical design, which is intended to create ideal learning experiences for all learners. Although VS5 is accessible to desktop and laptop computers that primarily require mouse devices, this was designed to satisfy the touch screen advantages of today's mobile technology while also increasing user enjoyment. Increased enjoyment of learning is more apparent with the customizability and assistance provided to learners because students change from the passive role of acquiring knowledge to the more active one of being seekers of knowledge (Nuncio et al., 2020).

Data Entry by User

The evaluators gave VS5 96.37 percent approval. This implies that the VS5's data entry fields and forms encourage user interaction, resulting in clear, guided navigation and a lower incidence of erroneous/missing data entries. A well-planned structural e-design and logical framework was required for good course organization and navigation. While there is no "perfect" approach to designing a course, there are other areas where the VS5 might be improved, such as the explicitness of when data should be entered and directions on the length of time necessary to submit the data. Instructional Designers, teachers, and facilitators must be thoughtful in their decisions and carry useful instruction throughout the whole course structure (Schöbel et al., 2021b). However, to reduce student dissatisfaction with interactive systems, teachers should be clear and transparent about their expectations, and offer opportunities for students to receive assistance (Suárez et al., 2018; van Alten et al., 2020).

Hyperlinks

The evaluators have unanimous approval of the usability of Hyperlinks. This demonstrated that the Hyperlink text contains relevant and helpful information on where the learners were directed by the hyperlinks. Furthermore, the hyperlinks are consistent and constructed in accordance with acceptable link formatting conventions. Since the hyperlink has been lauded for its potential to 'connect people and information,' linking to other multimedia as well as other references can aid enhance engagement and counter the cognitive distraction that hyperlinks can cause (Martin-Beltrán et al., 2017). Furthermore, including other valuable and relevant resources. According to Nichols Hess and Greer (2016), hyperlinks can expose learners to new information and show them different ways of thinking and learning.

Evaluation of Interoperability: Technical Format

The standards under the Technical Evaluation Guidelines and Checklist (for Digital Offline Resources) are generally satisfied by the VS5 based on the Evaluation of Interoperability.

Support Browsers and Platforms

The Virtual Science 5 in Electronic Publication (EPUB) format was equally effective in different browsers such as Mozilla Firefox 2 & 3 and Microsoft Internet Explorer 6.0 in Microsoft Windows 2000, Mozilla Firefox for 2, Microsoft Internet Explorer 7.0 in Microsoft Windows XP, Apple Safari 2.0 on Apple OS X, and their updated versions. Moreover, the material is equally effective in operating systems/ platforms such as Windows (Vista, XP) and Mac (up to 10.5), likewise with Android systems and Apple IOS mobile phones. Linux, on the other hand, is an open-source operating system similar to Windows, Mac, and Android, although it is not largely commercially accessible in the locality.

International Web Application Standards

The Virtual Science 5 conformed to all international web application standards requirements. Particularly in the Markup language, which means that the VS5 has an XHTML 1.1 document type that is a fully functional document type with rich semantics. Conformance to style sheets also means that the material has several different units for expressing a length. Many of the CSS properties take "length" values, such as width, margin, padding, font size, etc. which are useful in making the overall interface aesthetically appealing and design consistent. Conformant to Portable Document Format (PDF) docs of Adobe and Rich Text Format (RTF) by Microsoft Word means that VS5 can contain links and buttons, form fields, audio, video, and business logic. The PDF and RTF formats are useful since they are ubiquitous, which means they can be read by practically all word processors (Thomasian, 2021).

It was also determined that the VS5 conformed with the movie/video, and audio elements. This indicated the materials were able to play audio using the coding format for digital audio such as MP3. The evaluators have seen no conformity with MP2 since this is the standard for sound playback in digital television and radio and not for the Virtual Interactive material developed.

VS5 likewise was conformant with movie/video formats such as AVI and SWF. These are the standard video formats for Windows machines and Adobe programs respectively. VS5 also contained hyperlinked FLV video files that are powered by Adobe Systems for online video on such websites as YouTube, Vimeo, and many other streaming resources.

Software add-ons or Plugins were installed on VS5, enhancing its scripting capabilities. The VS5 was conformant with JavaScript, the programming language for the web. This indicated that the VS5 can be updated and changed through both HTML and CSS. Likewise, JavaScript can calculate, manipulate, and validate data. Lastly, SWF conformity indicated that the Adobe program VS5 can hold interactive text and graphics through this plugin.

Standalone Files

VS5 conformed in all portable formatting files. This means that the virtual learning material can be sent in Open Office, and Microsoft Office, with no standard formatting (TXT file), Portable Document Format, and Rich Text Format. Since Virtual learning is part of e-learning according to Crompton (2017) development of the material should focus on the mobility of the technology. Learning through hardware devices with their corresponding software according to Nuncio et al. (2020) should be convenient for use by learners and characterized by portability, comfort, satisfaction, and unobtrusiveness.

Production Software and Size

VS5 conformed with the production software and has generally less than 20 MB size per VS5 lesson file. Conformant to support interoperable media types such as Web 2.0 and

Extensible Markup Language (XML) indicated that the VS5 preserves the structure and formatting of a digital document regardless of whether traditional PC-based software applications or modern mobile technologies are used to read it. This is important for the next-generation Internet and non-internet technologies so as to create learning tools that behave dynamically (Li et al., 2018).

Student Feedback

Generally, the students, who tested the VS5 material prototype, strongly agreed that the VS5 was aligned with the principle of instructional material design from the learning objective, to process up to the assessment of learning. According to Szopiski and Bachnik (2022), Distance education should support both students and teachers in determining the ideal style of learning, which could be accomplished by regularly assessing learners.

Generally, the students strongly agreed that the online and offline functionalities of Virtual Science 5, aided them in their studies. The multimedia contents were highly beneficial because they were related to the lessons, and the interactive pop-up features were surprisingly engaging. On the other hand, the installation process has been a challenging phase because the initial handbook is in offline PDF format based on the comments and suggestions. Through this experience, the VS5 has later been developed with an online interactive instructional using Google Sites.

Communication and information transfer capabilities enabled by e-learning and mobile learning are increasingly transforming the way people work and learn (Osman & Chen, 2017). However, Stoltzfus and Libarkin, (2016) emphasized that instructional innovation such as the development of virtual Science interactive materials is heavily dependent on social acceptance. The end-to-end process of developing a systematic and well-planned instructional design according to the Theory of Media-Equivalence is still reliant on the learners: how they can absorb the material content, their satisfaction with the mobility of their learning, and how the material's structure and other technical features help them become autonomous learners.

Conclusion

Based on the preceding section, this research concluded that non-print materials, such as cassette tapes, VHSs, DVDs, VCDs, CDs, slides (transparent photos), and transparencies, have a low adequacy rate. This is due to their obsoleteness, dilapidation, and inconvenience when utilized in distance learning. Furthermore, since Grade 5 students' competency level in Science is below the Close to Approximating Mastery or even Mastery level and in the average performance, addressing Grade 5 Science competencies, low adequacy rate, and other distance education challenges require strategic academic solutions.

Utilizing a logical approach like the ADDIE Model is crucial to creating effective instructional materials. By following a sequential process, researchers were able to develop

Virtual Science 5, an interactive learning material that engages learners in a virtual classroom setting. Despite criticism from Branch and Merill (2011) and Spatioti et al. (2022) regarding the ADDIE model's linearity and rigidity, it has proven to be an indispensable tool for instructional design. The Virtual Science 5 conformed to Validity Indicators - specifically the Content Quality, Instructional Quality, and Technical Quality Standards - was tested for Technical Errors. Additionally, the VS5 met Usability Characteristics, particularly in Multimedia design, Overall interface, Behavior of Controls & System Information, Customizability/Support for User Preferences, Data Entry by User, and Hyperlinks. Furthermore, the VS5 met interoperability evaluations.

REFERENCES

Abadi, M., Cahya, E., & Jupri, A. (2017). The development of interactive mathematics learning material based on local wisdom. *Journal of Physics*, 895, 012086. https://doi.org/10.1088/1742-6596/895/1/012086

Branch, R. & Merrill, M.D. (2011). Characteristics of instructional design models. *In Trends and Issues in Instructional Design and Technology*; Reiser, R.A., Dempsey, J.V., Eds.; Merrill-Prentice Hall: Upper Saddle River, NJ, USA, 2011; pp. 8–16

Cheung, L. (2016). Using the ADDIE model of instructional design to teach chest radiograph interpretation. *Journal of Biomedical Education*, 2016, 1–6. https://doi.org/10.1155/2016/9502572

Crompton, H. (2017). Moving toward a mobile learning landscape: presenting a mlearning integration framework. *Interactive Technology and Smart Education*, 14(2), 97–109. https://doi.org/10.1108/itse-02-2017-0018

Dagar, V. & Yadav, A. (2016). Constructivism: A Paradigm for Teaching and Learning. *Arts and Social Sciences Journal*, 7(4). https://doi.org/10.4172/2151-6200.1000200

Department of Education Memorandum No. 441 s. 2019. (2019). Guidelines and Processes for LRMDS Assessment and Evaluation of Locally Developed and Procured Materials. Department of Education. Republic of the Philippines.

Haw, J. Y., King, R. B., & Trinidad, J. E. R. (2021). Need supportive teaching is associated with greater reading achievement: What the Philippines can learn from PISA 2018. *International Journal of Educational Research*, 110, 101864. https://doi.org/10.1016/j.ijer.2021.101864

Heyberi-Tenekeci, E. (2019). Optimal Use of Virtual Learning Environments (Moodle) in Healthcare and Adult Learning through the Essential Understanding of the Who, What and How of E-learning – Use of ADDIE Model. *European Journal of Science and Technology*.

Hillmayr, D., Ziernwald, L., Reinhold, F., Hofer, S. & Reiss, K. (2020). The potential of digital tools to enhance mathematics and Science learning in secondary schools: A context-specific meta-analysis, *Computers & Education*, Volume 153, 2020, 103897, ISSN 0360-1315, https://doi.org/10.1016/j.compedu.2020.103897

Hobbiss, M. (2018). Constructivism is a theory of learning, not a theory of pedagogy. NeuroScience explains why this is important. https://npjscilearncommunity.nature.com/users/33200-mike-

hobbiss/posts/41828-constructivism-is-a-theory-of-learning-not-a-theory-of-pedagogy-neuroScience-explains-why-this-is-important

Kariman, D. (2019). Effectiveness Of Guided Discovery-Based Module: A Case Study in Padang City, Indonesia. ISSN 2087-8885 E-ISSN 2407-0610 *Journal on Mathematics Education* Volume 10, No. 2, pp. 239-250

Kirsch, C., Engel De Abreu, P. M., Neumann, S., & Wealer, C. (2021). Practices and experiences of distant education during the COVID-19 pandemic: The perspectives of six- to sixteen-year-olds from three high-income countries. *International Journal of Educational Research Open*, 2, 100049. https://doi.org/10.1016/j.ijedro.2021.100049

Li, S., Yamaguchi, S., & Takada, J. (2018). The influence of interactive learning materials on Self-Regulated learning and learning satisfaction of primary school teachers in Mongolia. *Sustainability*, 10(4), 1093. https://doi.org/10.3390/su10041093

Lim, J., Whitehead, G. E., & Choi, Y. (2021). Interactive e-book reading vs. paper-based reading: Comparing the effects of different mediums on middle school students' reading comprehension. *System*, 97, 102434. https://doi.org/10.1016/j.system.2020.102434

Martin-Beltrán, M., Tigert, J. M., Peercy, M. M., & Silverman, R. D. (2017). Using digital texts vs. paper texts to read together: Insights into engagement and mediation of literacy practices among linguistically diverse students. *International Journal of Educational Research*, 82, 135–146. https://doi.org/10.1016/j.ijer.2017.01.009

Moore, M. G. (1997). Theory of transactional distance. *Theoretical principles of distance education*, 1, 22-38

Nichols Hess, A., & Greer, K. (2016). Designing for Engagement: Using the ADDIE Model to Integrate High-Impact Practices into an Online Information Literacy Course. *Comminfolit*, 10(2), 264. https://doi.org/10.15760/comminfolit.2016.10.2.27

Nuncio, R. V., Arcinas, M. M., Lucas, R. I. G., Alontaga, J. V. Q., Neri, S. G. T., & Carpena, J. M. (2020). An E-learning outreach program for public schools: Findings and lessons learned based on a pilot program in Makati City and Cabuyao City, Laguna, Philippines. *Evaluation and Program Planning*, 82, 101846. https://doi.org/10.1016/j.evalprogplan.2020.101846

Osman, K. & Chen, C.W.C (2017). Teaching and Learning Primary Science for Marginalised Children. https://doi.org/10.5772/intechopen.68577

Schöbel, S., Saqr, M., & Janson, A. (2021b). Two decades of game concepts in digital learning environments – A bibliometric study and research agenda. *Computers & Education*, 173, 104296. https://doi.org/10.1016/j.compedu.2021.104296

Spatioti, A., Kazanidis, I. & Pange, J. (2022). A Comparative Study of the ADDIE Instructional Design Model in Distance Education. *Information*. 13. 402. 10.3390/info13090402.

Stoltzfus, J. R. & Libarkin, J. (2016). Does the Room Matter? Active Learning in Traditional and Enhanced Lecture Spaces *CBE Life Sci Educ*. 2016 Winter; 15(4): ar68. doi: 10.1187/cbe.16-03-0126

Suárez, A., Specht, M., Prinsen, F., Kalz, M., & Ternier, S. (2018). A review of the types of mobile activities in mobile inquiry-based learning, *Computers & Education*. https://doi.org/10.1016/j.compedu.2017.11.004

Thomasian, A. (2021). Storage Systems: Organization, Performance, Coding, Reliability, and Their Data Processing (1st ed.). Morgan Kaufmann. https://doi.org/10.1016/B978-0-32-390796-5.00002-4

van Alten, D. C., Phielix, C., Janssen, J., & Kester, L. (2020). Self-regulated learning support in flipped learning videos enhances learning outcomes. *Computers & Education*, 158, 104000. https://doi.org/10.1016/j.compedu.2020.104000

Wagner, E. D. (2021). Becoming a Learning Designer. In J. K. McDonald & R. E. West (Eds.), *Design for Learning: Principles, Processes, and Praxis*. EdTech Books. https://edtechbooks.org/id/learning_designer

van Alten, D. C., Phielix, C., Janssen, J., & Kester, L. (2020). Self-regulated learning support in flipped learning videos enhances learning outcomes. Computers & Education, 158, 104000. https://doi.org/10.1016/j.compedu.2020.104000

Wagner, E. D. (2021). Becoming a Learning Designer. In J. K. McDonald & R. E. West (Eds.), *Design for Learning: Principles, Processes, and Praxis*. EdTech Books. https://edtechbooks.org/id/learning_designer

Wibawa, A.T., Ashrianto, P.D., & Pambudi, S.T. (2021). Implementation of ADDIE Model in Improving the Ability of Lecturers to Write Scientific Articles in Accredited Journals. *RSF Conference Series: Business, Management and Social Sciences*. https://doi.org/10.31098/bmss.v1i4.353