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Interactive Digital Module in Teaching Chemistry for Science 10

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Abstract — This study aimed to develop an Interactive Digital Module (IDM) for teaching Chemistry to Science 10 students using Kotobee Reader as the platform. It focused on identifying the features of the IDM and assessing its validity in terms of content standards (content quality, instructional quality, assessment quality, and technical quality) and technical standards (functionality, reliability, usability, efficiency, and portability). The IDM was designed based on the Input – Process – Output (IPO) model and incorporated the Cognitive Theory of Multimedia Learning (CTML). The research used a descriptive design with Research and Development methodology, involving three groups of participants: Chemistry experts, Science 10 teachers, and IT experts. Two validation instruments were used: a content standard validation checklist adapted from DepEd LRMDS Evaluation Rating Sheet for Non-Print Materials, and a technical standard validation checklist adapted from ISO 9126. Data were analyzed using weighted mean, revealing that the IDM was highly valid in both content and technical standards. The study concluded that the IDM is a recommendable learning material that enhances student interest and perspective in Chemistry by incorporating multimedia learning. The success of the IDM in the educational context can be extended to nursing practice, particularly during health crises. Just as the IDM boosted students' interest and comprehension in Chemistry, similar digital modules can be developed for nursing education and training. Interactive digital tools can provide nurses with critical information, training on new protocols, and updates on emerging health threats in an engaging and accessible format. This approach can ensure that nurses are well-prepared and equipped with the latest knowledge and skills, ultimately improving patient care and outcomes during health emergencies.

Keywords* — *Cognitive Theory of Multimedia Learning, Content Standard, Interactive Digital Module, Kotobee Reader, Technical Standard

I. Introduction

One of the main goals of 21st century learning is the development of technology abilities as it adapts to the constantly changing educational landscape, emphasizing the 4Cs skills, such as communication, cooperation, and creativity. Curriculum should be supported by modern instructional pedagogies along with innovation and technological integration to address these competencies.

Interactive Digital Modules are tailored to engage students actively, catering to diverse learning styles and enhancing comprehension of complex subjects. Mayer's (2009) Cognitive Theory of Multimedia Learning posits that students learn more effectively when they can process information through both visual and auditory channels, which IDMs leverage by integrating various media formats. The potential of IDMs to transform education has been supported by numerous studies, which underscore their role in improving student engagement, comprehension, and retention of information.

The inadequacy of instructional resources and teaching aids that are in line with the DepEd-mandated learning outcomes is one of the many issues affecting the quality of Science education in the Philippines today. Due to lack of suitable learning tools, Science educators find it challenging to teach scientific, and technical concepts and principles. Rogayan and Dollete (2019) claimed that the dearth of Science education facilities is reflected in the low achievement levels of Filipino students in various examination, and the poor quality of their fundamental Science and Math education. Also, there is a lack of learning resources that are in line with the required competencies. The poor accomplishment levels of Filipino learners in various examinations are a reflection of the lack of Science education facilities, and the caliber of their education in Mathematics and Science fundamentals.

The Science literacy of learners in secondary schools is one of the areas of attention in the K to 12 curriculum. Learners should be able to demonstrate understanding of fundamental scientific ideas using investigative skills, as well as to apply scientific attitudes and values to solve societal, environmental, and educational problems, improve quality of life, and take part in discussions involving Science, technology, and the environment. Similarly, integrating Information Communication Technology is included in the enhanced curriculum. The Department of Education (DepEd) is working diligently to strategize how to give Filipino learners the best and highest-quality education possible, particularly in a flexible learning environment.

As regards to the condition of Chemistry education in the country, it can be challenging for learners to grasp many of the abstract concepts in Chemistry since it requires visualization at the sub-microscopic level of representation. Because of the topics presented in Chemistry lessons, learners frequently have a wide range of challenges understanding them. Since they must create their own ideas or thoughts, laboratories are a place to put their scientific expertise to use, considering that learners come in all shapes and sizes and learn in diverse manners. The ability of learners to study Chemistry should be fostered by the teachers' efficient teaching methods. Tatli and Ayas (2013) showed that virtual chemistry laboratories improved students' comprehension of chemical concepts and increased their interest in the subject. Ardac and Akaygun (2004) also reported that computer-based instructional materials significantly enhanced students' grasp of molecular structures and chemical reactions.

While these studies highlight the effectiveness of digital learning tools in enhancing science education, there remain gaps that this study aims to fill. Most existing research has focused on the broad application of digital tools in various scientific disciplines, with limited studies specifically targeting the development and validation of IDMs for Chemistry at the high school level. Additionally, there is a lack of comprehensive evaluation of IDMs based on both content and technical standards, which is crucial for ensuring their effectiveness and usability in real-world educational settings.

In addressing this issue, the IDM in Teaching Chemistry for Science 10 could serve as an ICT-based interactive instructional learning material that can be used to improve the level of interest, motivation, and engagement of learners towards learning Chemistry. It can deliver lessons with the aid of *Kotobee Reader* as a platform having digital features like, virtual laboratory simulations, video animations, picture gallery, and widgets which could increase the level of learner's engagement and interest in learning Chemistry. It is a new avenue to enhance learner's inquiry skills and give them time for self-directed learning far from the traditional lecture teaching method.

II. Methodology

Locale of the Study

The study was conducted in selected schools in Ilocos Norte. Particularly, content standard evaluators are from a university, and from Department of Education Schools Divisions of Laoag City, Batac City and Ilocos Norte. On the other hand, the technical standard evaluators also come from a state university.

Research Design

The study employed a descriptive research design using Research and Development methodology in the development of interactive digital module. The creation of interactive digital module in teaching Chemistry for Science 10 was conducted following three stages namely: the planning stage, the development stage, and the validation stage as shown in Figure 2.

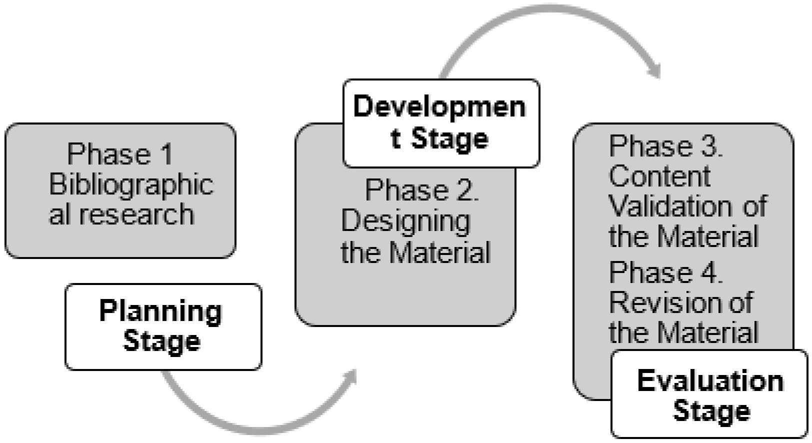

Figure 2. Schematic Diagram Showing the Steps in the Development of the Interactive Digital Module in Teaching Chemistry for Science 10.

Research Design

As shown in Figure 1, this study adopted the Input-Process-Output (IPO) Model to understand deeply the direction of the study. The K to 12 Most Essential Learning Competencies, and Cognitive Theory of Multimedia Learning were considered as the inputs of this study. These inputs serve as the foundation on the conceptualization and development of the material. These were examined and considered in the development process.

In the Process, the Designing, Writing, Developing and Validating Interactive Digital Module in Teaching Chemistry for Science 10 was based on the inputs. The IDM in Teaching Chemistry for Science 10 has eleven (11) parts: 1) Navigate, 2) Know Your Target, 3) Gear Up, 4) Concepts at a Glance, 5) Bring to Light, 6) Mailbag, 7) Work It Out, 8) In a Nutshell, 9) Spill the Skill ,10) Concept Check and 11) References. These were evaluated by the Chemistry experts, Science 10 teachers and IT experts.

Consequently, the Output of this study is the IDM in Teaching Chemistry for Science 10. The developed learning material sought to help learners develop and attain mastery and comprehension of the concepts resulting to the improvement of their academic performance in Chemistry.

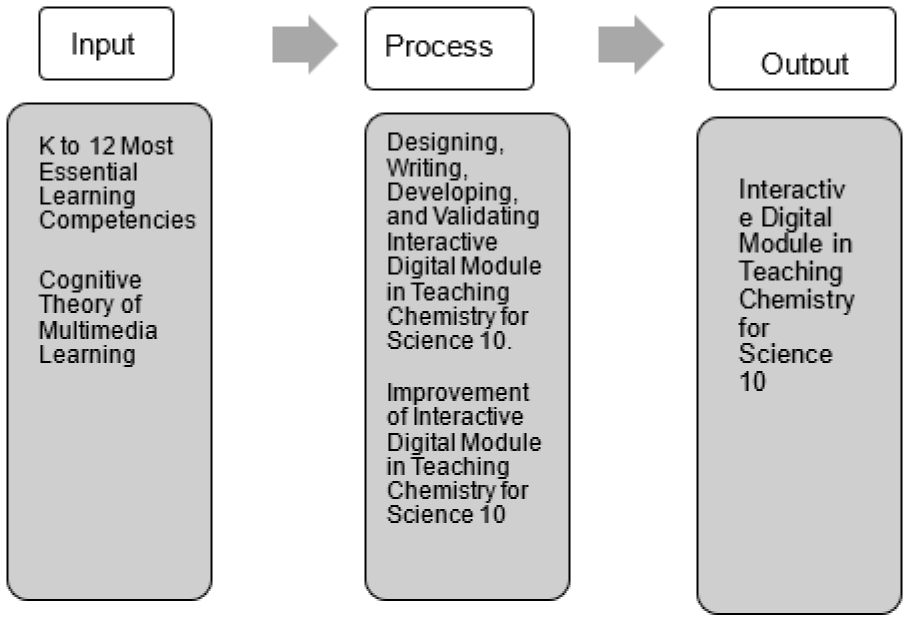

Figure 1. The Research Paradigm.

Data Gathering Procedure

In the conduct of this study, the researcher followed the standard operating procedures.

The researcher accomplished the forms required by the University Research Ethics Review Board (URERB). Then, the research's adviser checked the completeness of the required forms and filed in the URERB office. After a thorough review of all the ethical considerations and approval of URERB, the research was given a certification by the URERB committee to conduct the research study.

The researcher asked permission to the owner of the platform that was used by sending an electronic mail. Once the researcher received an approval from the owner of the platform, the researcher developed an IDM in Teaching Chemistry for Science 10, using *Kotobee Reader* as a platform. Meanwhile, the researcher also asked permission from the President of the chosen state university for the content validation of the developed IDM by three Chemistry experts who acted as evaluators of the content standards of the developed material, and three IT experts who evaluated the technical standards of the developed IDM.

The researcher also asked permission from the Schools Division Superintendents of Laoag City, Ilocos Norte, and City of Batac to allow the Science 10 teachers who are teaching Chemistry for at least three years to validate the content of the developed IDM afterwards.

Lastly, when the developed material has been validated, the researcher analyzed the data gathered. Suggested revisions were integrated in the developed learning material.

Statistical Treatment of Data

Weighted mean was used to analyze the ratings of the panel of evaluators on the content standards and technical standards of the IDM in Teaching Chemistry for Science 10.

The computed mean for the content standards was interpreted using the following range of interval point scores adapted from Pimentel (2019).

Range Interval	Descriptive Interpretation
3.51-4.00	Highly Valid (HV)
2.51-3.50	Valid (V)
1.51-2.50	Slightly Valid (SV)
1.00-1.50	Not Valid (NV)

Likewise, the computed mean for the technical standards was interpreted using the following range of interval point scores adapted from Acido (2020).

Range Interval	Descriptive Interpretation
4.51-5.00	Highly Valid (HV)
3.51-4.50	Valid (V)
2.51-3.50	Moderately Valid (MV)
1.51-2.50	Slightly Valid (SV)
1.00-1.50	Not Valid (NV)

III. Results and Discussion

The presentation, analysis, and interpretations of data relevant to the study are presented in this chapter. It discusses validity of IDM in terms of content standards as indicated by Chemistry experts and its validity in terms of technical standards as indicated by the IT experts.

Table 1 shows the different Chemistry contents in Science 10 together with the aligned learning competencies in each lesson.

Table 1. Chemistry Contents in Science 10.

Module No.	Module Title	Lesson Title	Learning Competencies
1	Behavior of Gases	Boyle's Law	Investigate the relationship between: [S9MT-IIj-20] volume and pressure at constant temperature of a gas;
		Charles' Law	volume and temperature at of a gas;
		Kinetic Molecular Theory	explains these relationships using the kinetic molecular theory
2	Biomolecules	Carbohydrates Proteins Lipids Nucleic Acids	Recognize the major categories of biomolecules such as carbohydrates, lipids, proteins, and nucleic acids. [S10MT-IVc-d-22]
3	Chemical Reactions	Conservation of Mass to Chemical Reactions Types of Chemical Reaction	Apply the principles of conservation of mass to chemical reactions. [S10MT-IVe-g-23]
4	Factors Affecting Rate of Chemical Reactions	Factors Affecting Rate of Chemical Reactions	Explain how the factors affecting rates of chemical reactions are applied in food preservation and materials production, control of fire, pollution, and corrosion. [S10MT-IVh-j-24]

It could be gleaned from the table that 11 of the Chemistry contents were all included in the IDM. Additionally, the developed material encompasses all the Chemistry contents in Science 10, such that the curriculum follows the spiral progression approach in delivering subjects across the entire secondary education of a learner. This means that the level of complexity and difficulty of the same concepts increases each year starting from grade school. With this, a needs assessment survey was not applied in this study as Chemistry contents in Science 10 is the most complex, and it is the last stage of Science concepts to be learned by learners in their Junior High School (JHS).

In addition, it is expected that education allows learners to learn concepts and skills appropriate to the developmental and cognitive stages and strengthen the knowledge retention, and mastery of concepts and skills using the spiral progression approach.

Validity of the IDM in terms of Content Standards

In this section, the content standards of the IDM in Teaching Chemistry for Science 10 in terms of content quality, instructional quality, assessment quality and technical quality is discussed.

Table 2 shows the mean rating results of Chemistry experts on the content standards of the IDM in Teaching Chemistry for Science 10. Based on the table, the content quality of the IDM for all the modules gained a mean rating of 3.87, 3.83, 3.87, and 3.90, respectively, with a descriptive interpretation of *highly valid*, and the content contributes to enrichment, reinforcement, and mastery of the identified learning objectives.

The result entails that the content is in line with the topic and skills found in the DepEd Learning Competencies. Thus, the content of the interactive digital module is *valid.* This adheres to the study of Tarigan, Sipahutar and Harahap (2021) which claimed that seat works are given, following the progression of activities to gain mastery of the concepts in an interactive digital module.

Table 2. Mean rating results of Chemistry experts on the content standards of the IDM in teaching Chemistry for Science 10.

Content Standards of the Interactive Digital Module	Module 1	Module 2	Module 3	Module 4
Content Quality				
1. Content is consistent with topics/skills found in the DepEd Learning Competencies for the subject and grade/year level it was intended.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
2. Concepts developed contribute to enrichment, reinforcement, or mastery of the identified learning objectives.	4.00 (HV)	3.67 (HV)	3.67 (HV)	4.00 (HV)
3. Content is accurate.	4.00 (HV)	3.67 (HV)	3.33 (V)	3.67 (HV)
4. Content is up to date.	4.00 (HV)	4.00 (HV)	3.67 (HV)	4.00 (HV)
5. Content is logically developed and organized.	3.67 (HV)	3.67 (HV)	3.67 (HV)	3.67 (HV
6. Content is free from cultural, gender, racial, or ethnic bias.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
7. Content stimulates and promotes critical thinking.	3.67 (HV)	3.67 (HV)	3.33 (V)	3.67 (HV)
8. Content is relevant to real-life situations.	3.67 (HV)	4.00 (HV)	3.67 (HV)	4.00 (HV)

9. Language (including vocabulary) is appropriate to the target user level.	4.00 (HV)	4.00 (HV)	3.67 (HV)	4.00 (HV)
10. Content promotes positive values that support formative growth	3.67 (HV)	3.67 (HV)	4.00 (HV)	4.00 (HV)
Mean	**3.87 (HV)**	**3.83 (HV)**	**3.78 (HV)**	**3.90 (HV)**
Instructional Quality				
1. Purpose of the material is well defined.	4.00 (HV)	3.67 (HV)	4.00 (HV)	4.00 (HV)
2. Material achieves its defined purpose.	4.00 (HV)	3.67 (HV)	4.00 (HV)	4.00 (HV)
3. Learning objectives are clearly stated and measurable.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
4. Level of difficulty is appropriate for the intended target user.	4.00 (HV)	3.67 (HV)	4.00 (HV)	4.00 (HV)
5. Graphics / colors / sounds are used for appropriate instructional reasons	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
6. Material is enjoyable, stimulating, challenging, and engaging.	3.67 (HV)	3.67 (HV)	3.67 (HV)	3.67 (HV)
7. Material effectively stimulates creativity of target user.	3.33 (V)	3.67 (HV)	3.67 (HV)	3.33 (V)
8. Feedback on target user's responses is effectively employed	3.67 (HV)	3.67 (HV)	3.67 (HV)	4.00 (HV)
9. Target user can control the rate and sequence of presentation and review.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
10. Instruction is integrated with target user's previous experience.	3.67 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
Mean	**3.83 (HV)**	**3.80 (HV)**	**3.90 (HV)**	**3.90 (HV)**
Assessment Quality				
1. The questions test students' comprehension.	4.00 (HV)	4.00 (HV)	3.67 (HV)	4.00 (HV)
2. The assessment activities assess what the learners have learned.	4.00 (HV)	4.00 (HV)	3.67 (HV)	4.00 (HV)
3. The assessment tools measure mastery of the topic.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
Mean	4.00 (HV)	4.00 (HV)	3.78 (HV)	4.00 (HV)
Technical Quality				
1. Audio enhances understanding of the concept.	3.33 (V)	4.00 (HV)	4.00 (HV)	4.00 (HV)
2. Speech and narration (correct pacing, intonation, and pronunciation) is clear and can be easily understood.	3.67 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
3. There is complete synchronization of audio with the visuals, if any.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)

4. Music and sound effects are appropriate and effective for instructional purposes.	3.67(HV)	3.67 (HV)	3.67 (HV)	3.67 (HV)
5. Screen displays (text) are uncluttered, easy to read, and aesthetically pleasing.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
6. Visual presentations (non-text) are clear and easy to interpret	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
7. Visuals sustain interest and do not distract user's attention.	3.67 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
8. Visuals provide accurate representation of the concept discussed.	3.67 (HV)	3.67 (HV)	3.67 (HV)	4.00 (HV)
9. The user support materials (if any) are effective.	4.00 (HV)	3.67 (HV)	3.67 (HV)	3.67 (HV)
10. The design allows the target user to navigate freely through the material.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
11. The material can easily and independently be used.	4.00 (HV)	3.67 (HV)	4.00 (HV)	4.00 (HV)
12. The material will run using minimum system requirements.	4.00 (HV)	4.00 (HV)	4.00 (HV)	4.00 (HV)
13. The program is free from technical problems.	3.33 (V)	3.67 (HV)	4.00 (HV)	4.00 (HV)
Mean	**3.79 (HV)**	**3.87 (HV)**	**3.92 (HV)**	**3.95 (HV)**
Overall Mean	**3.87 (HV)**	**3.87 (HV)**	**3.85 (HV)**	**3.94 (HV)**

Legend:	**Range Interval**	**Descriptive Interpretation**
	3.51-4.00	Highly Valid (HV)
	2.51-3.50	Valid (V)
	1.51-2.50	Slightly Valid (SV)
	1.00-1.50	Not Valid (NV)

In terms of the instructional quality of the IDM, the evaluators indicated a mean rating of 3.83, 3.80, 3.90 and 3.90 of all the modules, respectively, with a descriptive interpretation of *highly valid*. This implies that there is a clarity and adequacy of instruction, and it could easily grasp by the users. Moreover, the finding is in consonance to the study of Acido (2020) which asserted that learning content with clear instructions avoid cognitive burden hence facilitating a good acquisition of self-paced learning, better retention of knowledge and improved performance.

In terms of technical quality of the IDM, the evaluators indicated a composite mean rating of 3.79, 3.87, 3.92 and 3.95, respectively, with a descriptive interpretation of *highly valid*. This entails that the technical performance or operation of the Interactive Digital Module achieved its purpose. The results of the study are aligned with the findings of Al Rawashdeh, Mohammed, Al Arab, and Alara (2021) who posited that interactive learning module is an effective tool as it provides unique learning styles and enhanced academic performances of learners.

Moreover, the result of the study shown in Table 1 with an overall mean rating of 3.87, 3.87, 3.85 and 3.94, respectively, having a descriptive interpretation of *highly valid*, further denotes that the IDM in Teaching Chemistry for Science 10 is *valid* in terms of content quality, instructional quality, assessment quality and technical quality.

As suggested by the validators, the researcher addressed all their comments and suggestions. The inconsistency of terms used in Module 2 Lesson 1 titled, "Carbohydrates" was also addressed to avoid misconception of the learners. The four modules were also made in one packaged and can be viewed as one material. A general introduction was also provided for the whole material.

Table 3 shows the mean rating results of Science 10 teachers on the content standards of the IDM in Teaching Chemistry for Science 10.

This is in consonance to the study of Mat and Mustakim (2021) which stated that e-module virtual learning is a vital channel to improve students' higher order thinking skills which allows the learners learn Chemistry independently, hence improving their knowledge.

Table 3. Mean rating results of Science 10 teachers on the content standards of the IDM in teaching Chemistry for Science 10.

Content Standards of the Interactive Digital Module	Module 1	Module 2	Module 3	Module 4
Content Quality				
1. Content is consistent with topics/skills found in the DepEd Learning Competencies for the subject and grade/year level it was intended.	3.92 (HV)	3.92 (HV)	3.93 (HV)	3.92 (HV)
2. Concepts developed contribute to enrichment, reinforcement, or mastery of the identified learning objectives.	3.93 (HV)	3.92 (HV)	3.94 (HV)	3.92 (HV)
3. Content is accurate.	3.92 (HV)	3.94 (HV)	3.94 (HV)	3.93 (HV)
4. Content is up to date.	3.92 (HV)	3.95 (HV)	3.94 (HV)	3.93 (HV)
5. Content is logically developed and organized.	3.92 (HV)	3.93 (HV)	3.92 (HV)	3.92 (HV)
6. Content is free from cultural, gender, racial, or ethnic bias.	3.90 (HV)	3.94 (HV)	3.93 (HV)	3.89 (HV)
7. Content stimulates and promotes critical thinking.	3.93 (HV)	3.92 (HV)	3.94 (HV)	3.93 (HV)
8. Content is relevant to real-life situations.	3.93 (HV)	3.94 (HV)	3.92 (HV)	3.93 (HV)
9. Language (including vocabulary) is appropriate to the target user level.	3.93 (HV)	3.93 (HV)	3.90 (HV)	3.95 (HV)
10. Content promotes positive values that support formative growth	3.93 (HV)	3.95 (HV)	3.92 (HV)	3.93 (HV)
Mean	**3.92 (HV)**	**3.93 (HV)**	**3.93 (HV)**	**3.92 (HV)**
Instructional Quality				
1. Purpose of the material is well defined.	3.93 (HV)	3.92 (HV)	3.92 (HV)	3.92 (HV)
2. Material achieves its defined purpose.	3.90 (HV)	3.93 (HV)	3.90 (HV)	3.94 (HV)
3. Learning objectives are clearly stated and measurable.	3.90 (HV)	3.93 (HV)	3.94 (HV)	3.93 (HV)

4. Level of difficulty is appropriate for the intended target user.	3.88 (HV)	3.90 (HV)	3.92 (HV)	3.93 (HV)
5. Graphics / colors / sounds are used for appropriate instructional reasons	3.90 (HV)	3.92 (HV)	3.90 (HV)	3.93 (HV)
6. Material is enjoyable, stimulating, challenging, and engaging.	3.93 (HV)	3.94 (HV)	3.92 (HV)	3.92 (HV)
7. Material effectively stimulates creativity of target user.	3.92 (HV)	3.93 (HV)	3.93 (HV)	3.92 (HV)
8. Feedback on target user's responses is effectively employed	3.50 (V)	3.54 (HV)	3.51 (HV)	3.56 (HV)
9. Target user can control the rate and sequence of presentation and review.	3.54 HV)	3.58 (HV)	3.57 (HV)	3.61 (HV)
10. Instruction is integrated with target user's previous experience.	3.76 (HV)	3.79 (HV)	3.75 (HV)	3.73 (HV)
Mean	**3.82 (HV)**	**3.84 (HV)**	**3.83 (HV)**	**3.84 (HV)**
Assessment Quality				
1. The questions test students' comprehension.	3.94 (HV)	3.93 (HV)	3.95 (HV)	3.93 (HV)
2. The assessment activities assess what the learners have learned.	3.92 (HV)	3.94 (HV)	3.93 (HV)	3.94 (HV)
3. The assessment tools measure mastery of the topic.	3.94 (HV)	3.92 (HV)	3.94 (HV)	3.93 (HV)
Mean	**3.93 (HV)**	**3.93 (HV)**	**3.94 (HV)**	**3.93 (HV)**
Technical Quality				
1. Audio enhances understanding of the concept.	3.92 (HV)	3.92 (HV)	3.95 (HV)	3.93 (HV)
2. Speech and narration (correct pacing, intonation, and pronunciation) is clear and can be easily understood.	3.90 (HV)	3.93 (HV)	3.92 (HV)	3.90 (HV)
3. There is complete synchronization of audio with the visuals, if any.	3.89 (HV)	3.90 (HV)	3.89 (HV)	3.92 (HV)
4. Music and sound effects are appropriate and effective for instructional purposes.	3.89 (HV)	3.94 (HV)	3.93 (HV)	3.92 (HV)
5. Screen displays (text) are uncluttered, easy to read, and aesthetically pleasing.	3.89 (HV)	3.93 (HV)	3.94 (HV)	3.92 (HV)
6. Visual presentations (non-text) are clear and easy to interpret	3.92 (HV)	3.95 (HV)	3.95 (HV)	3.95 (HV)
7. Visuals sustain interest and do not distract user's attention.	3.90 (HV)	3.94 (HV)	3.94 (HV)	3.94 (HV)
8. Visuals provide accurate representation of the concept discussed.	3.92 (HV)	3.95 (HV)	3.95 (HV)	3.94 (HV)
9. The user support materials (if any) are effective.	3.90 (HV)	3.93 (HV)	3.92 (HV)	3.95 (HV)
10. The design allows the target user to navigate freely through the material.	3.90 (HV)	3.92 (HV)	3.95 (HV)	3.93 (HV)
11. The material can easily and independently be used.	3.87 (HV)	3.94 (HV)	3.88 (HV)	3.90 (HV)
12. The material will run using minimum system requirements.	3.39 (V)	3.54 (HV)	3.42 (V)	3.44 (V)
13. The program is free from technical problems.	3.40 (V)	3.49 (V)	3.43 (V)	3.42 (V)

Mean	**3.82 (HV)**	**3.87 (HV)**	**3.85 (HV)**	**3.85 (HV)**
Overall Mean	**3.87 (HV)**	**3.89 (HV)**	**3.89 (HV)**	**3.89 (HV)**

Legend:	Range Interval	Descriptive Interpretation
	3.51-4.00	Highly Valid (HV)
	2.51-3.50	Valid (V)
	1.51-2.50	Slightly Valid (SV)
	1.00-1.50	Not Valid (NV)

In terms of the instructional quality of the IDM, the evaluators gave a mean rating of 3.82, 3.84,3.83, and 3.84, marked as *highly valid*. This entails that the instruction given were clear and adequate and this could be easily grasped by the users. Likewise, the illustrations, layout, and sequencing of directions are all appropriate thus, it facilitates better self-learning process among the students. This adheres to the study of Vidianti and Wijaya (2019) which claimed that learning materials that are arranged systematically, with clear instructions that are easily understood by learners according to their level of knowledge and thinking, can be learned independently.

On the other hand, the assessment quality of the IDM gained a mean rating of 3.93, 3.93, 3.94 and 3.93 respectively with a descriptive interpretation of *highly valid*. This implies that the IDM provides sufficient and differentiated assessment strategies. The result of the study is in consonance with the study of Bardhan, Dey and Mohanty (2020) which asserted that digital assessment tools will not only grab the attention of the learners but also motivates them. Integrating technology in assessment are inculcation positive energy among learners as they explore new concepts which adds more pinch of fun in the classroom.

In terms of technical quality of the IDM, the evaluators indicated a mean rating of 3.82, 3.87, 3.85, and 3.85, respectively, with a descriptive interpretation of *highly valid*. This suggests that the technical performance or operation of the IDM achieved its purpose. This is in consonance to the work of Tarigan, Sipahutar and Harahap (2021) which stated that designing classroom activities with interactive features will help the students comprehend the lesson well.

Moreover, the result of the study shown in Table 3 with an overall mean rating of 3.87,3.89, 3.89, and 3.89, respectively, is marked as *highly valid*. This further denotes that the IDM in Teaching Chemistry for Science 10 is valid in terms of content quality, instructional quality, assessment quality and technical quality.

The researcher addressed all the comments and suggestions of the validators by providing clear and adequate instructions in all the activities found in the modules. The activities in the IDM were all reconstructed from hands on laboratory activity into virtual activities which include virtual laboratory activities, using Phet simulation, and video clips, gamified activities like crossword puzzle, pair matching, and memory game using widgets since the developed material is an interactive one. More examples and visual representation were also added in the *Mailbag* portion of the module for the learners to easily understand the lesson. Lastly, some of the activities were reduced to avoid information congestion, and to retain mastery of concepts on the part of the learners.

Validity of IDM in terms of Technical Standards

In this section, the technical standards of the IDM in Teaching Chemistry for Science 10 in terms of functionality, reliability, usability, efficiency and portability, is discussed.

Table 4 shows the mean ratings of IT experts on the technical standards of the IDM in Teaching Chemistry for Science 10. In terms of functionality, the IDM gained a mean rating of 4.89, 5.00, 4.89 and 5.00 with a descriptive interpretation of *highly valid*. This means that the software operates the required task and functions accurately and it interacts with other components or systems.

Table 4. Mean rating results of IT experts on the technical standards of the IDM in teaching Chemistry for Science 10.

Technical Standards of the Interactive Digital Module	Module 1	Module 2	Module 3	Module 4
A. Functionality				
1. The software performs the required task.	5.00 (HV)	5.00 (HV)	5.00 (HV)	5.00 (HV)
2. The software functions accurately.	5.00 (HV)	5.00 (HV)	5.00 (HV)	5.00 (HV)
3. The software components interact with other components or systems.	4.67 (HV)	5.00 (HV)	4.67(HV)	5.00 (HV)
Mean	4.89 (HV)	5.00 (HV)	4.89 (HV)	5.00 (HV)
B. Reliability				
1. The software can withstand component or environmental failure.	4.67 (HV)	3.67 (V)	5.00 (HV)	5.00 (HV)
2. The failed system can go back to its full operation, including data and network connections.	4.00 (V)	3.67 (V)	4.33 (V)	4.67 (HV)
Mean	4.33 (V)	3.67 (V)	4.67 (HV)	4.83 (HV)
C. Usability				
1. The system is easy to learn.	4.67 (HV)	4.67 (HV)	4.67 (HV)	4.67 (HV)
2. The system is easy to use and operate.	4.67 (HV)	4.67 (HV)	4.33 (V)	4.33 (V)
3. The interface looks good.	5.00 (HV)	5.00 (HV)	5.00 (HV)	5.00 (HV)
Mean	4.78 (HV)	4.78 (HV)	4.67 (HV)	4.67 (HV)
D. Efficiency				
1. The system responds quickly.	3.67 (V)	3.67 (V)	4.67 (HV)	5.00 (HV)
2. The system requires small amount of disk space and memory.	3.67 (V)	3.67 (V)	4.67 (HV)	5.00 (HV)
Mean	3.67 (V)	3.67 (V)	4.67 (HV)	5.00 (HV)
E. Portability				
1. The system adapts changes in specifications or operating environments.	4.67 (HV)	4.33 (V)	4.67 (HV)	5.00 (HV)

2. The software used is easy to install.	5.00 HV)	5.00 (HV)	5.00 (HV)	5.00 (HV)
3. The system is easy to plug and play.	5.00 HV)	4.67 (HV)	4.67 (HV)	5.00 (HV)
Mean	4.89 HV)	4.67 (HV)	4.78 (HV)	5.00 (HV)
Overall Mean	4.71 HV)	4.76 (HV)	4.73 (HV)	5.00 (HV)

Legend:	Range Interval	Descriptive Interpretation
	4.51-5.00	Highly Valid (HV)
	3.51-4.50	Valid (V)
	2.51-3.50	Moderately Valid (MV)
	1.51-2.50	Slightly Valid (SV)
	1.00-1.50	Not Valid (NV)

In terms of reliability, the evaluators indicated a mean rating of 4.33 and 3.67 for Module 1 and Module 2, respectively, with a descriptive interpretation of *valid*. This means that the low mean rating implies that the material is greatly affected by the type of operating system of the device used to function well. However, modules 3 and 4 are given a mean rating of 4.67 and 4.83, respectively, with a descriptive interpretation of *highly valid*. This further denotes that the software can resist environmental failure and it can go back to its full performance. It can be gleaned from the result that the developed material could deal with technical bugs adequately.

Likewise, the usability of the software gained a mean rating of 4.78, 4.78, 4.67, and 4.67 respectively, described as *highly valid*. This means that the developed IDM is easy to use and learn. It is easy to explore without too much assistance.

Aside from usability, the efficiency of the IDM received a mean rating of 3.67 for modules 1 and 2, marked as *valid*. This aspect is concerned with the system resources used when giving the necessary functionality, and the material achieved the said requirement. On the other hand, modules 3 and 4 were given a mean rating of 4.67 and 5.00, respectively, with a descriptive interpretation of *highly valid*. This entails that the system responds quickly, and it requires small amount of disk space and memory.

In terms of portability, the developed material gained a mean rating of 4.89 4.67, 4.78 and 5.00, respectively, with a descriptive interpretation of *highly valid*. This means that the software is easy to plug and play and it is easy to install as it adapts changes in specifications.

Furthermore, Table 4 shows an overall mean rating of 4.71, 4.76, 4.73, and 5.00, respectively with a descriptive interpretation of *highly valid*. This denotes that the IDM in Teaching Chemistry for Science 10 is valid in terms of functionality, reliability, usability, efficiency, and portability. The result of the study supports the findings of Aljraiwi (2017) which claimed that educational applications or software help teachers facilitate learners' contributions in the learning process, thus, boosting their motivation, and enhancing their academic performance.

The results and remarks from the evaluators show that the developed material is effective in Teaching Chemistry for Science Grade 10. The remarks of the IT experts are notable on the proposition of Acido (2020) that teachers should design a suitable educational application or software to support the delivery of learning, skills and knowledge in a holistic approach without any limitations.

Based on the results illustrated in the three tables, it can be gleaned that the developed IDM in Teaching Chemistry for Science 10 is valid in terms of content standards and technical standards. This implies that all the contents found in the IDM are all aligned with competencies found in the K to 12 Science Curriculum as prescribed by DepEd. Additionally, the developed material is user-friendly because clear instructions are provided on what to accomplish by the learners, assessment is enjoyable and interactive as it boosts learner's interest and motivation, and learners are given the chance to appreciate the world of Chemistry through its interactive and relevant learning activities for an effective learning. The developed IDM can be accessed both online and offline which make it convenient for the learners, because it can be used in different teaching strategies, like remote learning. The application used to view the developed learning material is well organized as it helps to deliver the lesson effectively and efficiently.

IV. Conclusion

The study concluded that the developed Interactive Digital Module (IDM) for Teaching Chemistry to Science 10 students is a valid and effective learning material, as confirmed by various evaluators. The IDM features eleven components, including animations, videos, virtual lab simulations, and widgets, which help in assessing mastery of Chemistry concepts and provide comprehensive instructions for both facilitators and learners. The IDM was found to be highly valid in terms of content and technical standards, supporting the Cognitive Theory of Multimedia Learning. This theory suggests that learners understand information better when it is presented through various multimedia formats. The study recommends the use of the IDM to enhance academic performance and suggests that Chemistry teachers collaborate with IT experts to design more computer-based instructional tools. It also urges school administrators to encourage the development of interactive materials and professional development programs for teachers. The results may guide curriculum developers in creating interactive learning materials and drafting technology-use policies. The study further recommends testing the IDM in actual classroom settings and comparing the performance of learners using IDM with those using conventional instructional materials.

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