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Development and Validation of E-SelfIMo: E-Learning Self-Directed Interactive Module in Earth Science

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Abstract

This study developed and validated E-learning Self-directed Interactive Modules (E-SelfIMo) for Earth Science. The study employed Research and Development method, using the Borg and Gall development procedure, in creating eight e-modules using Kotobee software, evaluating them by experts and students, and determining their effectiveness in terms of students' conceptual understanding. Experts agreed that E-SelfIMo met the DepEd standards for non-printed learning materials, and students attested to their high validity in content, format, and usefulness. Pretest and posttest results for the effectiveness of E-SelfIMo revealed that students exposed to the E-SelfIMo have progressed from "Near Mastery" to "Near Full Mastery" in the chosen Earth Science topics, showing more significant improvement in their conceptual understanding than the control group. This study concludes that E-SelfIMo supports interactive, active, and self-directed learning thereby, improving students' motivation, engagement, interest, and performance. The E-SelfIMo could be used with technology integration as a teaching and learning tool.

Keywords: self-directed learning, interactive e-modules, earth science, Kotobee, Philippines

1.0 Introduction

Technology integration is one of the many factors that set 21st-century education apart from other eras. Globalization and advancement in Science and Technology created a shift in the paradigm of learning which gives a critical role in integrating technology into the teaching and learning process. Integrating technology into the 21st-century learning paradigm changes education dynamics and puts learners as agents of change and their learning (Ma'rifatullah et al., 2021). The application of technology changes the classroom experience into a learner-focused experience, with learners taking more active roles in the learning process.

Technology enhances education as it makes delivering education easier. Education nowadays is not limited to the classroom and face-to-face setup and goes beyond the classroom walls as it gives learners access to unlimited information at their fingertips (Tarbutton, 2018). Technology transforms the classroom experience as students can take a more active role in their learning process through the help of technology, and teachers act more as guides or facilitators of learning. A study by Harris et al. (2016) suggests that with the technological shift in schools, students could access more lesson resources. This shift improves students' motivation and engagement, thereby also enhancing students' academic achievements. Malik (2018) also suggested that teachers should be able to integrate technology into their teaching to bring the students' maximum capacity, especially during this digital era, and to prepare them for

the workforce. For instance, technology allows educators and learners to use websites and other digital resources as primary resources and connect them to people to elevate their learning experience (Carpenter & Justice, 2017; Krutka & Carano, 2016).

Despite the advantages of integrating technology, Harris et al. (2016) noted that the digital divide and lack of technological accessibility among students, and insufficient funding in schools are the main barriers to integrating technology in schools and classrooms. Technology integration in schools usually means utilizing computers, which not all students have, and schools may have a limited supply. As the effectiveness of technology as a pedagogical tool and strategy depends on how educators use it, the digital competence and development of educators also remain challenges as requirements for digital competence change from time to time (Adomako et al., 2022; Scheepmaker et al., 2021; Caena & Redecker, 2019). Challenges in ensuring privacy and confidentiality, self-regulation, and creation and utilization of appropriate instructional technology are also present in the attempt to transition to blended learning and more thorough integration of technology in education (Turnbull et al., 2021; Rasheed et al., 2020). With the help of carefully selected instructional technology, students can develop skills that will help them in their future careers and as lifelong learners.

One of the challenges of 21st-century learning is developing and using technology to bring out the best results. Recent happenings, like the COVID-19 pandemic, made it more evident why technology integration is vital and irreplaceable in education (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020). Developing students' skills such as problem-solving, critical thinking, self-management, creative thinking, interpersonal ability or collaboration, and digital literacy is the focus of 21st-century learning (Joynes et al., 2019; Stehle & Peters-Burton, 2019; Wrahatnolo, 2018). It is essential to ensure that the technology they use in the classroom and even beyond the classroom walls could support their learning to develop these needed skills in their generation. It is essential to carefully select blended technologies for learning so students can engage with them and create meaningful learning experiences. This way, students become masters of information, media, and technology by making technology work for their benefit and being accountable for their learning (Lee, 2018).

Experts have long recognized self-directed learning (SDL) as an essential and effective learning approach. The more learners can freely and openly explore their learning opportunities, the more likely they will engage in creative activities and contribute to society (Bonk & Lee, 2017). Sanova et al. (2022), in their study about the relationship between digital literacy and self-directed learning, claim that using e-modules enables students to become more independent in their learning and improve their learning experience. These effects become more feasible if students have high digital literacy and use e-modules that are simple, easy to use, and encourage self-directed learning. Scheepmaker et al. (2021) also attested in their study that using interactive e-modules in science courses improves self-directed learning as learning tasks and assessments focus on developing critical thinking, scientific literacy, reflection, and communication skills. These studies show that integrating technology in the form of e-modules in learning helps develop and improve self-directed learning, improving students' learning experience and academic performance.

One way of integrating technology into learning is using electronic modules (e-modules). An e-module is a set of logically organized, nonprinted digital learning tool that students and teachers can use independently in the teaching and learning process (Trilestari & Almunawaroh, 2021). One commonly used type of e-modules is

interactive modules as a learning medium in online and blended learning activities. Once downloaded, interactive e-modules are still accessible even without using an internet quota, and they can be operated on a personal computer (PC), laptop, or smartphone— practically anywhere and anytime. Interactive e-modules have increasingly gained traction as a practical learning mode due to their flexibility and accessibility, especially during the COVID-19 pandemic (Crawford et al., 2020; Halim et al., 2020a; Halim et al., 2020b; Lockman & Schirmer, 2020). Interactive e-modules support students' learning and allow them to control their learning while becoming more engaged in the lessons. Interactive e-learning modules promote self-directed learning (SDL), allowing learners to take charge of their learning experience (Wen et al., 2022).

The readiness and integration of technology affects the global competitiveness of a county. Villeta et al. (2014) noted that the Philippines are one of the ASEAN countries that are highly competitive due to its technological readiness. This means that the Philippines has more access to technology which can be integrated into the teaching-learning process thus improving its quality of education. One evidence of its technological readiness is the use of technology-enhanced and computer-assisted programs in education. Kotobee is one of the many computer-assisted programs or software increasingly used to create and produce interactive eBooks for educational purposes in the Philippines, especially during the pandemic. It is a software-producing company based in the United Kingdom which allows the creation and hosting of eBooks online with a monthly subscription basis and works on MAC and PC (Kotobee, n.d.). Unlike other popular software, such as iBooks Author, that only run projects on specific devices, Kotobee authoring programs or software allows the creation of projects or eBooks in HTM and other formats, making it possible to view the project online on any device. This program was so effective in delivering needed competencies for learning modules that even the DepEd and UNICEF recognized the software as a resource in introducing the concept of Open Education Resources during the pandemic. In a memorandum, namely, OUA Memo 00-1020-0157 dated October 14, 2020, issued by the Office of the Undersecretary for Administration (OUA), Alain Del B. Pascua, master teachers, and other interested teachers are encouraged to attend Training Workshops for the DepEd-UNICEF OER/ eBook Development Project to produce eBooks using Kotobee reader that achieves DepEd's MELCs (Department of Education [DepEd], 2020). As DepEd and UNICEF had seen the potential of the Kotobee software in helping achieve their educational goals despite this pandemic, DepEd and Regional and Division offices throughout the country soon followed the same initiative. With Kotobee, teachers can create interactive eBooks enhanced with video, audio, 3D, book widgets, questions, and more to make learning more accessible and effective during the pandemic and in times when blended and online learning are the best options to deliver learning and focus on students' development (Kotobee, 2022).

Baring and Berame (2022), in their study about the effects of using interactive e-modules using Kotobee on the student's conceptual understanding, found out that using the Kotobee software has the main advantage when it comes to flexibility and accessibility as the e-modules using the software could be accessed online and offline and via different electronic devices. In addition, its engaging and interactive visual features make it more effective in improving students' comprehension. Hoai and Giang (2020), in their study about the benefits of using Kotobee software in teaching Chemistry in High Schools, also arrived at the same conclusion and added that the educator and learners could use Kotobee depending on their needs and available resources

and time. Other studies also attested that the use of e-learning materials or software like the Kotobee Software increases the autonomy to learn and development of relevant skills with the use of computer-assisted programs, web-based technology, and special features embedded in the software (Manalastas & De Leon, 2021; Abuhassna et al., 2020). Using software programs like Kotobee could address the need for innovative and responsive teaching and learning tool.

The Department of Education (DepEd) in the Philippines recognizes the need for students to lead their learning experiences in a conducive environment. It supports the idea of e-learning materials such as e-modules and e-books as presented in Memorandum Order 105, series of 2009, suggesting that integrating technology is vital in meeting the needs of 21st-century learners. Moreover, DepEd Order number 39, series of 2016, entitled, Adoption of the Basic Education Research Agenda, encourages educators to study different teaching strategies, develop lesson plans, and create instructional materials under its research agenda Theme 1: Teaching and Learning, which fuels that use of e-learning materials, including e-modules in most universities and other educational institutions, to deliver learning (Baring & Berame, 2022). With this, e-modules could be designed and introduced to students as a digital learning media or resource which can empower students as independent learners (Jaenudin & Murwaningsih, 2017) and improve students' performance.

It can be harder to keep students involved when teaching Earth Science using the typical teaching-learning method because it is frequently thought of as a less demanding, boring, and low-profile subject. According to previous surveys and research, this is the perception since the subject frequently ignores inquiry-based learning and other student-centered learning strategies in favor of memorization and discussion without really allowing students to apply the concepts to their learning and experiences (Estacio & Cornejo, 2021; Orion, 2019; Greco & Almberg, 2018). E-learning can help students better understand complex ideas and procedures in Earth science. However, the efficiency of e-learning in Earth Science depends on the quality of the teaching materials and the students' capacity to interact with the content (Basar et al., 2021).

From this end, the researcher was motivated to develop an e-learning interactive and self-directed module (E-SelfIMo) for Earth Science. This study would serve as an avenue for improving the Science curriculum and innovative strategies for integrating technology into education, which teachers and students could use for the subject.

2.0 Methodology

Research Design

The study utilized the Research and Development (R&D) method (Gall et al., 2007) to develop e-modules in Earth Science using Kotobee software to facilitate self-directed and interactive learning. The R&D method is a procedure for developing a product that can be justified and evaluated for validity and efficacy (Juilando, 2019). Six stages were involved in creating the e-modules: data gathering, planning, product draft development, small-scale trials, product changes, and large-scale trials. The image below shows the model that was used to direct the development process.

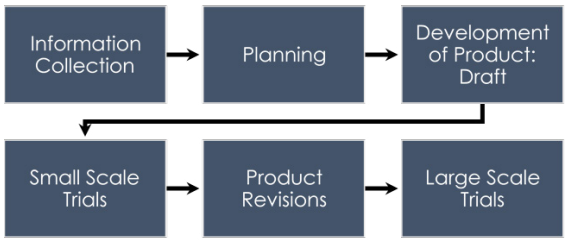

Figure 1. *Research and Development Model (Gall et al., 2007)*

Information was gathered in the initial stage to pinpoint educational gaps and create new models or innovations. (Gall et al., 2007). During the first stage of the project, the researcher gathered information by analyzing the needs, evaluating the literature, and identifying the problem. The researcher conducted the needs analysis to evaluate the modules and worksheets based on the K12 Most Essential Learning Competencies (MELCs) for Earth Science. Pertinent studies on e-learning self-directed and interactive modules were also reviewed, and the underlying causes of the problem were identified through preliminary observations of Earth Science classes and online interviews with teachers and students.

The 7 E's Learning model of instruction was used to build the Electronic Module during the planning phase. In the third stage, the initial product was developed using Kotobee software and evaluated by a team of experts. The validation process ensured that the E-SelfIMo adhered to DepEd guidelines, developed necessary skills and competencies, and met the criteria for use in the learning process.

The fourth stage is the small-scale trial. The researcher developed and pilot-tested a test questionnaire to determine its reliability among the students through a posttest with a pre-experimental research design in the form of a one-shot case study. The developed E-SelfIMo was also evaluated by the students at this stage.

The E-SelfIMo as the product of this research, along with the test questionnaires, was then revised based on the findings and suggestions from the students and comments and recommendations of the experts.

The sixth stage is the large-scale trial. The teacher introduced the revised materials to the target audience and the learning process started (Lasala, 2022; Morrison, 2019). Through Google Forms, all students took the pretest. A post-test was conducted after the intervention. The experimental group was introduced to the E-SelfIMo while the control group was advised to use the e-module in pdf format. Both module types have the same information; however, the E-SelfIMo includes multimedia such as images, videos, narration, and other interactive elements.

Participants

This study sought assistance from an eight-panel of experts who evaluated the developed E-SelfIMo. They were earth science teachers, master teachers in science, and content and media experts.

The study also used 25 randomly chosen Grade 12 SHS students in Sorsogon, Philippines as part of the small-scale trial to validate the developed E-SelfIMo and evaluate the test to be used in the large-scale trial. Fifty-nine (59) Grade 11 SHS Students enrolled in an Electronic Module Distance Learning (EMDL) class in one of the public high schools in Sorsogon, Philippines for the school year 2020-2021 served as the main respondents for the large-scale trial. The respondents who had the same teacher and underwent the same curriculum and teaching procedures were assigned to the control or experimental groups using the simple random sampling method.

Data Gathering

This study utilized the DepEd LRMDS guidelines for non-printed resources, covering content, instructional, technical, and accuracy, for the expert's evaluation. During the small-scale trial, this study adopted the student evaluation tool by Lasala, 2022; Madrazo & Dio, 2020, specifically along with content, format, and usefulness for the students' evaluation. Pretest was administered before the intervention. The intervention consisted of a six-week instructional time to finish all the topics based on the DepEd MELCs prescribed duration for each lesson module. Posttest was administered to both groups after the intervention to determine the changes in students' level of conceptual understanding. Also, students in the experimental group were requested to write in their journals their experiences learning with E-SelfIMo, followed

by subsequent unstructured online interviews. The data gathered were subjected to treatment and analysis for proper interpretation.

Data Analysis and Statistical Treatment

This study employed descriptive statistics and analysis for quantitative data. Descriptive statistical tools such as standard deviation, mean, and frequency percentage were used to describe the rating of experts and students for the developed E-SelfIMo. Percentage agreement was utilized to determine consistency among the evaluators. Descriptive interpretation was employed to analyze and interpret the results.

An unpaired T-test was used to determine if a significant difference between the pretest and posttest results of the experimental and control groups existed. Cohen's d value was also calculated to determine if the difference between the mean of the two student groups was statistically significant and to support the t-test results. The descriptive interpretation was employed in describing the results.

For the qualitative data obtained through interviews and journal logs, thematic analysis was employed to find patterns in data gathered to support findings from quantitative data (Nowell et al., 2017).

3.0 Results and Discussions

Development of E-SelfIMo

Using the Borg and Gall model as the framework, the researcher collected and analyzed information about learning resources for Earth Science education in the Philippines. Interviews with teachers and students from different schools in Sorsogon City revealed a significant gap in the learning process due to the inadequate learning resources available during the pandemic. The printed modules issued by the DepEd did not contain adequate information and often lacked various media types such as video, audio, and animation. The limited delivery and access to the modules also posed significant challenges to effective learning. The researcher adopted a need analysis questionnaire prescribed by the Office of Research and Development Services of Sorsogon State University to initiate the development of E-SelfiMo for Earth Science education using Kotobee software.

The researcher created eight e-learning self-directed interactive modules (E-SelfIMo) for Earth Science. These modules cover topics for the first quarter: characteristics of the earth (Module 1), earth's subsystems (Module 2), rocks and minerals (Modules 3 & 4), formation of fossil fuel (Module 5), geothermal and hydroelectric powerplant (Module 6), water resources and factors that affect them (Module 7), and soil degradation and conservation (Module 8). Each E-SelfIMo has a discussion and assessment section. The DepEd MELCs for Grade 11-Earth Science subject guided the researcher's development of the e-modules. Using E-SelfIMo, users could navigate between chapters, see and download e-module media, add notes using the Notebook function, search for specific words within the entire book or just a specific chapter, and change settings according to their preferences using the chapter button or icon. To help students having difficulty reading and speaking, the e-modules are also self-contained, standalone, adaptive, and user-friendly. Including these elements in e-modules can help students improve their literacy, create stimulating learning environments, and develop their creativity and practical thinking skills (Yulando et al., 2019). Widyana et al. (2022) and Istiqomah et al. (2021) suggested that text-to-speech features of e-modules could be an effective tool in language learning, just like the robot icon dubbed E-Blithe, which acts as the text-to-speech image for the developed E-SelfIMo.

The electronic modules also included videos introducing the subject, clarifying ideas, and summarizing the lesson. The interactive pre- and post-tests before and after the lessons in the e-modules also provide an immediate feedback system. Each E-SelfIMo also comes with a word bank called Pictionary that provides further details

on various terms used to enhance the explanations of ideas on each page. Incorporating various media and features into e-modules can considerably improve learners' understanding of abstract concepts, increase the significance of the learning material, and address the need for more interactive and engaging digital materials in Earth Science (Yulando et al., 2019).

The findings show that the E-SelfIMO's distinctive media and content made the e-modules more engaging and interactive. For instance, the activity and video in Module 4 promoted critical thinking by providing open-ended questions and allowing them to analyze and solve problems using their knowledge and experiences. As students learn to think critically, their ability to learn independently and interaction even in online setting also improve (Nurdiyanti et al., 2021). Contextualization and personalization were utilized in Module 6's activity lesson to assist students to relate to the subject and making learning more relevant as well as to promote adaptive and flexible learning, which could increase the effectiveness of learning (Shuja et al., 2019).

Jurors' Evaluation of E-SelfIMo

To assess the E-SelfIMo's validity in terms of Content Quality, Instructional Quality, Technical Quality, and Accuracy, experts validated it using DepEd LRMDS guidelines. A jury of experts evaluated the E-modules to ensure consistency and reliability, and the researcher used frequency distribution and weighted mean scores to analyze and interpret the results. Kizlik (2014) asserted that evaluation is crucial for establishing the quality and value of learning modules. Table 1 summarizes the experts' assessment of the E-SelfieMo.

Table 1. *Jurors' summary of points of E-SelfieMo evaluations Criteria*

Criteria	Point to pass (DepEd, 2009)	Mean Scores of Juror's Evaluation								Ave. Score M1-M8
		M1	M2	M3	M4	M5	M6	M7	M8	
Content Quality	at least 30 of 40	38	38	39	39	39	39	39	39	38.75
Instructional Quality	at least 30 of 40	39	38	38	39	39	39	39	39	38.75
Technical Quality	at least 39 of 52	48	49	49	50	49	49	49	48	48.87
Accuracy	at least 16 of 16	16	16	16	16	16	16	16	16	16

Note: M-Module

The E-SelfIMo received passing points for all criteria set by the DepEd based on jurors' ratings. The learning modules created for E-SelfIMo have consistent content quality with the DepEd's MELCs for Grade 11 Earth Science and have satisfied the students' needs regarding scope, range, and depth of content and concepts. With a high rating for content quality, E-SelfIMo has the potential to help students build higher-order thinking skills, including critical thinking, creativity, inquiry, and problem-solving, and help them achieve their specific goals. Studies from the past support these results that using e-modules promotes students' independence and problem-solving skills, strengthening their capacity for critical thought (Madrazo & Dio, 2020; Dewi & Primayana, 2019; Rahmatika et al., 2021). The E-SelfIMo also enables students to independently convert old knowledge into new, more accurate knowledge, thereby increasing student learning results (Gilbert, 2016).

As for the Instructional Quality of the E-SelfIMo, findings show that the design of E-SelfIMo is tailored to fit its purpose, with clearly stated and measurable learning objectives anchored on the MELCs for Grade 11 Earth Science. According to Islamiyah (2015), an effective module must possess a systematic, consistent, coherent, and complete presentation. Proper arrangement of modules is

necessary for students to understand concepts more easily (Setyani et al., 2020).

Each E-SelfIMo is designed and developed from simple to complex concepts to let the learners determine the interrelationship of the concepts. The logical arrangement of lessons and assessments in E-SelfIMo is not the only reason for its high instructional quality but also the relevance of the different media used. As one of the jurors affirmed, "The E-SelfIMo is very engaging, plus it utilizes technology which is very innovative. It also assesses learning before and after learning the content, which is very important since modules like this promote self-paced learning. Likewise, the elaborate contents, including videos from various sources, make it easier for learners to understand." According to Mendoza, D. J. and Mendoza, D. I. (2018), using technology in making modules help students understand the material, thereby improving their learning outcomes. Good instructional quality guides students to quickly understand the concepts as they utilize all the features of e-modules like E-SelfIMo (van de Pol et al., 2015).

For the technical quality, the jury's verdict is that the developed E-SelfIMos are arranged systematically and that they support students' independent learning (Fausih & Danang, 2015, as cited in Rahmatsyah & Dwiningsih, 2021). The visuals (images, diagrams, animations, video) and audio are clear and easy to interpret. Interactive features of e-modules such as E-SelfIMo make it easy and fun to access and navigate. Furthermore, they cater to different learning styles and provide features for automatic feedback on assessments to improve learning outcomes (Heugh, 2013; Rahmatsyah & Dwiningsih, 2021). With the integration of technology in making the E-SelfIMo, students now have more resources to interact with and use for learning. Moreover, the researcher also ensures that the information and media used in the E-SelfIMo are correct, appropriate, and free from grammatical errors; thus, the ratings show perfect accuracy based on the jurors' evaluation.

For the inter-rater reliability test, table 2 below presents the summary of the ratings given by the jurors to E-SelfIMo.

Results show high reliability in the data because most raters have the same opinion about the validity and quality of the developed modules. However, there remain some changes or revisions to be made.

Students' Evaluation of E-SelfIMo

The researcher also conducted a small-scale trial to determine the reliability of the test questions provided during the intervention and the validity of the developed E-SelfIMo based on the students' validation in terms of content, format, and usefulness. The 25 Grade 12 students from one of the integrated national schools were randomly selected to evaluate the E-SelfIMo using the modified 5-point Likert scale adapted from the study of Madrazo and Dio (2020). Table 3 reveals that the students rated all e-modules very satisfactory (VS) based on the criteria.

Table 2. *Summary of the Jurors' Rating for the Modules per Category*

Criteria	Juror's Rating								% of Agreement
	J1	J2	J3	J4	J5	J6	J7	J8	
Content Quality	38	39	39	39	39	39	39	39	88%
Instructional Quality	39	39	39	39	39	38	39	39	88%
Technical Quality	49	49	49	50	49	49	49	49	88%
Accuracy	16	16	16	16	16	16	16	16	100%
Total									91%

Note: J-Juror

Table 3. *Student's summary of points of E-SelfIMo evaluations criteria*

Criteria	Mean Scores of Students' Evaluation								Overall
	M1	M2	M3	M4	M5	M6	M7	M8	
Content	4.5 (VS)	4.7(VS)	4.7 (VS)	4.5 (VS)	4.8 (VS)	4.7 (VS)	4.6 (VS)	4.6 (VS)	4.8
Format	4.5 (VS)	4.5 (VS)	4.5 (VS)	4.6 (VS)	4.7 (VS)	4.6 (VS)	4.6 (VS)	4.5 (VS)	4.6
Usefulness	4.5 (VS)	4.7 (VS)	4.5 (VS)	4.8 (VS)	4.8 (VS)	4.8 (VS)	4.7 (VS)	4.5 (VS)	4.7

Note: VS-Very satisfactory; M-Module

Students' evaluation (SE) along the Content of E-SelfIMo shows that it is well-organized and has the potential to stimulate and promote students' critical thinking skills (Belecina & Ocampo, 2018). The E-SelfIMo's content is media-rich and includes activities appropriate to the prescribed topics making them relevant, fascinating, and self-motivating (El-Sabagh, 2021; Rahmatsyah & Dwiningsih, 2021). The rating also implies that E-SelfIMo was able to achieve its purpose and objectives, promote understanding of concepts, and motivate students to engage in learning.

"This is the first time I have tested a material like this. The level of interactivity this method has to offer is fascinating! E-Modules like this are better than PDF files or plain text files that are widely used, which do not offer the following: more features, videos, interactive questions and mini-quizzes, and voice reading. These will indeed help students enjoy learning," one of the students affirmed. The content of E-SelfIMo allows the students to learn and explore at their own pace and makes them stay engaged (Abadi et al., 2017).

The students also strongly agreed that the E-SelfIMo format was suitable for Grade 11 STEM students, implying that it has a clear font style and size, well-laid diagrams, illustrations, captions, and topics for easy reference. According to Camara (2016), a good module should be well-defined, short, interactive, accurately sequenced, written in clear language appropriate for the target learners, and utilized effectively for learning outcomes.

Findings further show that interactive E-SelfIMo is easily understood and user-friendly, with a built-in help mechanism and clear icons. E-SelfIMo's usability was positively evaluated by students and designed to be accessible to all learners, regardless of their access to technology and digital literacy level. It is straightforward and compatible to use on various devices. The module reduces digital inequality by facilitating offline learning, allowing students to download and explore it on various devices (Rahmatsyah & Dwiningsih, 2021; Aldama, 2020; Cuisia-Villanueva & Nuñez, 2021; Dhawan, 2020; Li & Qiu, 2018). One student declared, *"This E-modules [E-SelfiMo] succeeds in its purpose of being the accessible and interactive material that it is, and I believe that it will truly help students with their studies and bring value to their learning journey, and I genuinely want this type of module to be widely produced."* The flexibility and adaptability of E-SelfIMo are notable as some students may have limited technological access and resources, thus, making E-SelfIMo a good step towards improving learning delivery.

As shown in Table 4, the inter-rater reliability test has a strong agreement among student evaluators, with a percentage agreement value of 94.67%. Although some students had a slightly different opinion, most rated the e-modules as very satisfactory in all criteria. This high reliability of results supports the findings of this study.

To facilitate item analysis, an eighty-item competency assessment test was also given to the 25 Grade 12 students who evaluated the E-SelfIMo. For item analysis, the researcher evaluated and tallied the responses, measuring the index of difficulty and

discrimination. The discrimination index measures the number of students who correctly answered from the upper and lower 27% of students whereas the difficulty index compares the proportion of respondents who answered correctly (Kumar et al., 2021). Table 5 below illustrates how Padua and Santos' (1997) work was used as the foundation for evaluating the item analysis results for this study.

Table 4. *Summary of the Rating of Student Evaluation for the Developed E-SelfIMo*

Criteria	Rating					% Agreement
	Very Unsatisfactory	Unsatisfactory	Neutral	Satisfactory	Very Satisfactory	
Content	0	0	0	1	24	96%
Format	0	0	0	2	23	92%
Usefulness	0	0	0	1	24	96%
Total						94.67%

Table 5. *The index of difficulty and index of discrimination used in item analysis adopted from Padua and Santos (1997)*

Index of Difficulty	Index of Discrimination				
	Questionable (-1.00- -0.60)	Not Discriminating (-0.59- -0.21)	Moderately Discriminating (-0.20- 0.20)	Discriminating (0.21- 0.60)	Very Discriminating (0.61- 1.00)
Very Difficult (0.00-0.20)	Reject	Reject	Reject	Reject	Reject
Difficult (0.21 -0.40)	Reject	Reject	May Revise	Retain	Reject
Moderately Difficult (0.41-0.60)	Reject	Revise	Retain	Retain	Reject
Easy (0.61-0.80)	Reject	Reject	Revise	Retain	Reject
Very Easy (0.81- above)	Reject	Reject	Reject	Reject	Reject

After the item analysis, the researcher reduced the eighty-item test to fifty items with the index of difficulty and index of discrimination values of 0.76 and 0.22 which means that the final draft is of good quality. The researcher administered the final test draft to 30 Grade 12 students of one of the laboratory high schools here in the city of Sorsogon to determine its internal consistency using Kuder-Richardson Formula 20 adapted from the study of Dipon and Ricafort (2018). It also specified the duration to finish the test and the possible ambiguities in the test items.

Results using the KR20 of the 50-item test have a test statistic value of 0. 7153, indicating high reliability on the test's internal consistency. Zaiontz (2017) emphasized that a statistical significance not exceeding 0.90 denotes a heterogeneous test. Results confirm the questions' reliability and the different levels of questions indicated in the specifications table.

Product revision followed the small-scale trial integrating the feedback from the expert and

students and the reliability test results during the pilot testing. In the large-scale trial with 59 eleventh-grade students who had not learned about selected Earth Science topics, E-SelfIMos were used to assess the students' level of conceptual understanding. The experimental group was exposed to E-SelfIMos, while the control group was taught using the suggested strategy by DepEd. Table 6 below presents the pretest and post-test results of both groups of respondents.

Table 6. *Unpaired t-test results for pre-test and post-test of students in the Control and Experimental Group*

Topics	No. of Items	No. of Points	PRE-TEST						POST-TEST						Effect Size
			Control Group (N-29)			Experimental Group (N-30)			Control Group (N-29)			Experimental Group (N-30)			
			Weighted Mean	PL (%)	Interpretation	Weighted Mean	PL (%)	Interpretation	Weighted Mean	PL (%)	Interpretation	Weighted Mean	PL (%)	Interpretation	
Earth Characteristics and Subsystem	10	30	18.3	61	NM	18.2	60.70	NM	21.9	73.0	NM	26.5	88.3	NFM	1.07
Rocks and Minerals	10	30	15.8	53	NM	15.6	52.00	NM	21.44	71.3	NM	26.3	87.8	NFM	0.40
Energy Resource: Fossil Fuels	7	21	12.9	62	NM	13.1	62.20	NM	16.1	76.7	M	18.1	86.2	NFM	0.63
Energy Resource: Geothermal and Hydrothermal	16	48	23.2	48	LM	22.1	46.02	LM	34.70	72.3	NM	40.4	84.2	NFM	0.38
Waste Generation and Management	7	21	13.2	63	NM	12.5	59.52	NM	16.70	79.5	M	18.5	88.1	NFM	
Overall Mean	**50**	**150**	**83.4**	**57**	**NM**	**82.3**	**56.10**	**NM**	**110.9**	**75.0**	**NM**	**130**	**86.9**	**NFM**	**1.25**
SD			**18.19**			**15.00**			**8.84**			**7.49**			
p-value			**0.402**									**0.00**			

*Note: ***Significant at 0.05 level*

PL= performance level; LM= low mastery; NM= Near Mastery; M=Mastery; NFM=Near Full; Mastery

Before the intervention, both groups had a similar level of conceptual understanding, as indicated by their similar weighted means. The E-SelfIMos acted as a learning resource to improve the students' conceptual understanding. The post-test results showed that the experimental group significantly improved their conceptual understanding, going from "Near Mastery" to "Near Full Mastery." In contrast, the control group remained at the same level. The computed p-value (0.00) and Cohen's d-value (1.25) support these findings, indicating that using E-SelfIMo significantly impacted the respondents' performance. Using E-SelfIMo positively impacts students' learning outcomes in Earth Science since it encourages active and self-directed learning and increases students' motivation and fun studying the Earth Science topics, thus, improving their performance (Logan

et al., 2021). These data validate the findings of previous studies about the effects of interactive e-modules claiming that using interactive e-modules increases students' learning output as they become more independent, engaged, creative, and active in learning (Agustina & Rosalia, 2022; Hendriyani & Effendi, 2020).

This study uses E-SelfIMo positively, but it also presents various limitations. The results may only be generalized to some subjects since these E-SelfIMo are only for Earth Science. Furthermore, the validation of the developed E-SelfIMo focused only on its acceptability and quality as perceived by the expert and student respondents and the effectiveness of the E-SelfIMo in improving students' conceptual understanding. Nonetheless, these resoources are a good reference as to the potential of E-SelfIMo as a learning and teaching resource.

4.0 Conclusions

It has been concluded that developing E-SelfIMo for Earth Science using the Kotobee software answers the need for research-based, appropriate, and effective technology integration in education. The flexibility and accessibility of the developed E-SelfIMos and its various features make them more interactive and conducive to self-directed learning. Through the evaluation process, the E-SelfIMo received positive expert ratings for all criteria set by DepEd, indicating its high validity in terms of Content Quality, Instructional Quality, Technical Quality, and Accuracy. E-SelfIMo has strong potential as a pedagogical tool and an excellent example of utilizing technology based on the needs of the learners and the demands of time. The E-SelfIMo has the potential to enhance students' learning outcomes and promote self-paced and independent learning. The evaluation of students also showed that the E-SelfIMo was a reliable and valid tool for learning as its content, format, and usability are focused on enhancing student's learning experience and academic performance. The developed E-SelfIMo has features to support active, interactive, and self-directed learning and exemplifies an effective way to integrate technology into education.

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