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Designing Interactive E-Learning Architecture: Leveraging SCORM Standards

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ABSTRACT : Learning Management Systems (LMS) play a pivotal role in contemporary education by providing diverse, customized learning materials to enhance online learning experiences, catering to e-learning and m-learning. One of the most crucial components of an LMS is the learning content or materials, which encompass text, multimedia, simulations, tests, discussions, collaborative tasks, concept mapping, and assessments, facilitating essential engagement and interaction for learners. Content development is crucial in enhancing learning experiences within LMS, enabling personalized learning, improving content quality, and supporting practical learning evaluation. Interactive e-learning models further enrich learning experiences by fostering engagement and facilitating the achievement of learning objectives through features such as simulations, games, discussions, and assessments. This study focuses on developing software architecture as interactive content based on the Shareable Content Object Reference Model (SCORM standard) to ensure seamless integration, compatibility, and efficient content management across various LMS platforms. This development aims to deliver consistent, efficient, and high-quality learning experiences for learners by enhancing the flexibility and user-friendliness of interactive content.

KEYWORDS : interactive content, e-learning, learning management system, m-learning, SCORM.

I. INTRODUCTION

LMS is a software platform for organizing, managing, and delivering online learning experiences. It enables educational institutions, organizations, or companies to efficiently create, deliver, and track courses or training and facilitate interaction between instructors and learners through features such as learning content, testing, discussions, and assessments [1]. LMS provides various learning materials, including text, multimedia, simulations, tests, discussions, collaborative projects, concept mapping, and assessments. These materials support online learning by delivering information, exercises, interactions, and evaluations necessary for learners. By offering a range of content types, LMS enables learners to engage effectively and enjoyably in learning while allowing instructors to monitor and assess learning progress more efficiently [2].LMS requires content development because content is crucial in providing effective and engaging learning experiences for users. By developing content tailored to learning needs, LMS can enhance learner engagement and motivation [3], provide personalized learning experiences based on individual learning styles, improve learning quality through clear and understandable information delivery, and support learning evaluation to effectively assess learner understanding and progress. Therefore, content development is essential in ensuring the success and effectiveness of LMS in supporting the learning process. LMS was critical in ensuring uninterrupted learning and student engagement [4].

Interactive e-learning models facilitate interaction between learners, learning content, instructors, and peers in a digital learning environment. This model helps to increase the motivation and activity of students, which leads to the implementation of an effective learning process [5]. By incorporating interactive features such as simulations, games, online discussions, and formative assessments, e-learning models enhance learner engagement and facilitate the achievement of learning objectives. Moreover, interactive e-learning models enable learning adaptation based on learners' needs and preferences, ensuring that learning objectives are achieved more effectively. Therefore, selecting an e-learning model appropriate to the established learning objectives is critical to designing a successful and meaningful learning experience.In this research, we will develop software architecture as interactive content based on SCORM [6]. Developing software architecture for SCORM-based content is crucial as SCORM is a widely used standard in e-learning. SCORM allows users to create learning content with a high level of reusability [7]. Architecture aligned with SCORM standards ensures that e-learning content can be accessed, managed, and tracked more efficiently across various LMS platforms. The development ensures that learning content functions well in various online learning environments and can be seamlessly integrated into existing learning management systems. Moreover, with SCORM-compliant architecture,

Content developers can ensure good compatibility and interoperability with various tools and systems, enhancing flexibility and user-friendliness for end-users. All of these contribute to delivering consistent, efficient, and high-quality learning experiences for learners.

II. METHOD

Interactive content is crucial for e-learning based on LMS because interactivity plays a key role in enhancing online learning engagement and effectiveness [8]. Here are several reasons why interactive content is essential in LMS-based e-learning. Interactive content, such as simulations, games, online discussions, and interactive exercises, can make learning more engaging and challenging for learners. This interactive content helps boost learner engagement and motivation to participate actively in the learning process. Interactive content allows learners to participate actively in learning, enhancing understanding and retention of learning materials. Learners can learn actively through exploration, experimentation, and reflection, which supports a more profound understanding. Interactive content enables adaptive learning based on learners' needs and preferences. By using interactive tools, learners can learn in ways that suit their learning styles, enabling more effective and personalized learning [9] Through active interaction with content, learners tend to have higher retention levels and achieve learning objectives more effectively. Interactive content allows learners to test their understanding, receive immediate feedback, and address their weaknesses directly. Interactive content is critical to enhancing the effectiveness and success of LMS-based e-learning by providing learners with a more engaging, effective, and relevant learning experience.

The development steps include identifying learning needs, conceptual architecture design, selecting technology and tools, prototyping, testing and evaluation, refinement, and implementation. With these steps, the resulting e-learning architecture is expected to enhance engagement and effectiveness of online learning, which aligns with SCORM standards, to meet modern learning needs. The primary step in this research is content development. We use CourseLab authoring tools for packaging content in SCORM format and use Visual Studio Code to write JavaScript programs or develop web-based applications. This architecture has three main components: LMS, SCORM files, and web-based applications. Figure 1 shows the development concept for the designed architecture.

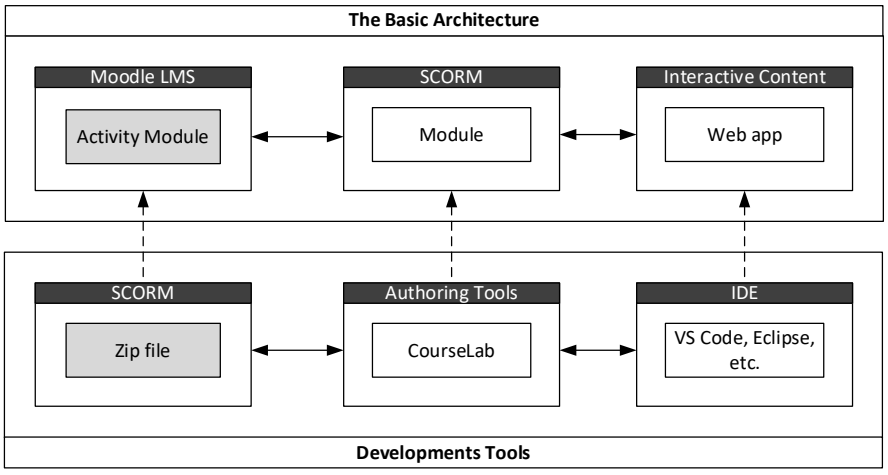

Figure 1. Basic architecture and Development Tools

III. RESULT

The process of developing interactive content with SCORM entails various stages, including delineating learning objectives, crafting interactive content using SCORM-compatible development tools, incorporating SCORM functionalities, conducting rigorous testing for functionality and compatibility, formatting content in compliance with SCORM standards, and integrating it into an LMS for monitoring usage and learning outcomes. Adherence to these steps ensures the creation of interactive content that meets SCORM standards and proves efficacious within e-learning contexts.The design result of the interactive content architecture based on SCORM is depicted in Figure 2. It comprises five essential components: LMS, SCORM, interactive content, school computer laboratory, and home (off-campus). We can develop unique content within the interactive web-based content section. This content is part of SCORM, whether included in an iframe or accessed directly through a web server. In this architecture, we used HTML, CSS, and interactive JavaScript libraries. In our

initial development phase, we extensively utilized libraries such as p5.js (p5.sound.js, p5.soundRec.js, dom.js), as well as ML5.js. The interactive learning approach in e-learning significantly impacts learner engagement and knowledge retention. This approach is achieved through interactive elements that require active participation, such as decision-making and problem-solving, which encourage learners to engage deeply with the learning content. Interactivity can be a valuable means to improve learning effectiveness in e-learning environments and promotes critical thinking skills, collaboration, active engagement, and self-efficacy [10].

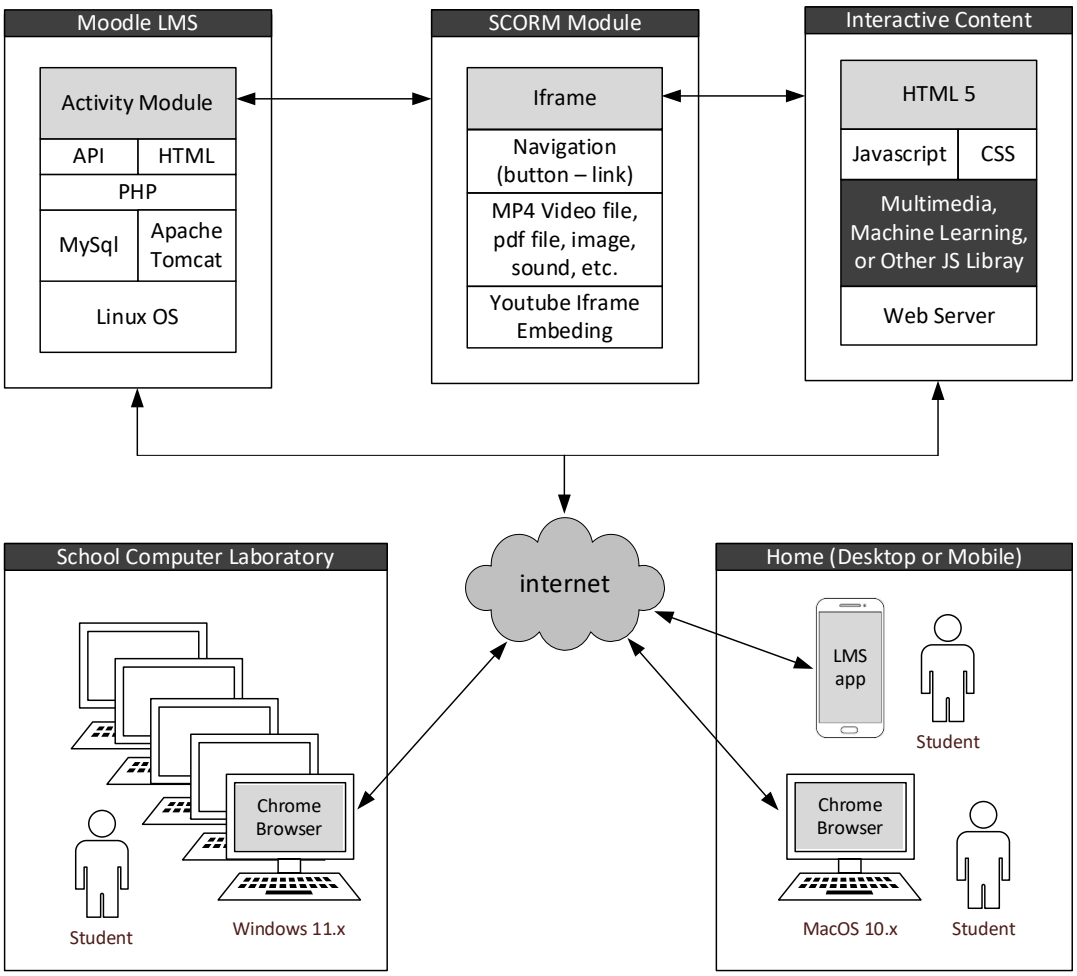

Figure 2. E--Learning Architecture with interactive content with SCORM based

IV. DISCUSSION

Technology integration into education has significantly transformed the learning landscape, giving rise to new paradigms [11], both stand-alone and internet based. Currently, the most popular form of technology-integrated learning is LMS-based e-learning. In general, e-learning tends to be passive, where students passively receive information through manuals or videos. However, e-learning technology enables the integration of interactive elements into virtual course rooms. Such content can transform learners from passive recipients to active participants. This improved interactivity involves learners in doing, thinking, and completing tasks, enhancing the effectiveness of the training process. The transformation of engaging learners in the digital space has been influenced by interactive e-learning content, which emphasizes active participation for an enriched learning experience. The post promises to provide insights into the anatomy of high-quality interactive e-learning, its creation process, and its significance for future educational efforts. Interactive content aims to help student enhance their understanding the content by exploring its elements. Interactive content impact on learner engagement and knowledge retention. SCORM plays a crucial role in e-learning by facilitating the creation and utilization of interoperable learning content across various LMS [12]. With SCORM, content developers can create reusable and adaptable learning materials tailored to learners' needs. Using SCORM enables tracking user interactions, such as learning progress and activity completion, and provides flexibility in developing various

types of learning content. As a widely accepted industry standard, SCORM ensures consistency and standards in developing, distributing, and managing e-learning content, providing an efficient and practical framework for educators and learners LMS can acquire various data from SCORM content, including user learning progress, quiz or test answers, interactive activities, evaluations, assessments, and learning history [13]. These data enable LMS to manage, analyses, and track user learning progress more effectively and provide helpful feedback to users or instructors.

P5 JavaScript Library : In this development, P5.js is a core JavaScript library for creating interactive content. This library easily creates art, graphics, and interactions in web environments. It is designed to simplify developers' process of producing visual art, animations, simulations, and interactive elements on web pages [14]. P5.js aims to democratize creative programming and digital art development, making it accessible to various audiences, including programming novices. Leveraging the canvas HTML5 element as a container for drawing graphics and interacting with visual elements, P5.js enables developers to generate images, animations, and graphics accessible across modern web browsers such as Google Chrome or Microsoft Edge. P5.js offers a wide range of functions and methods that are easy to use for drawing shapes, colors, and animations. We can create objects, change the background color, apply animation effects, and much more with just a few lines of code. P5.js supports user interaction through the mouse, keyboard, touch screen, and other input devices. You can respond to user input and create applications that interact with input devices effortlessly. In addition to graphics, P5.js also supports multimedia elements such as audio and video. We can play sounds, capture images from the webcam, and even create dynamic audio visualizations.

ML5 JavaScript Library : With the increasing demand for AI-based e-learning content, we have opted for the ML5 JavaScript library in this architecture. ML5.js is a JavaScript library designed to simplify the development of web applications that leverage Machine Learning (ML) and Artificial Intelligence (AI) technologies, specifically within the web environment [15]. It caters to web developers who may need to gain deep expertise in ML and AI but aspire to access these technologies more easily and quickly.

This library offers several features conducive to AI-based web development:

1. ML5.js aims to simplify and streamline web development by providing a more understandable interface compared to complex ML abstract models, enabling developers to begin using ML without an in-depth understanding of the underlying mathematics or algorithms.
2. ML5.js leverages TensorFlow.js, a powerful, popular, and widely used JavaScript-based ML library. This integration allows developers to utilize TensorFlow.js features more easily without mastering TensorFlow directly.
3. ML5.js includes various pre-trained ML models for tasks like image classification, object detection, sentiment analysis, and more.

These models can be seamlessly integrated into web projects without the need to train models from scratch. ML5.js supports image and audio processing, including image recognition, sound recognition, and audio processing, enabling the creation of applications that can listen to and interact with images and sounds. Furthermore, ML5.js boasts an active community with numerous tutorials, documentation, and open-source projects to assist developers in understanding and utilizing the library. It can be used across various platforms, including web browsers and Node.js, allowing developers to build ML-powered applications in diverse environments. Lastly, ML5.js has been utilized in various projects, from interactive art to machine learning applications. It is a valuable tool for web developers seeking to implement ML and AI within their web environments without requiring extensive knowledge. ML and AI have emerging role in web application development [16].

Other JavaScript Library: Many JavaScript libraries other than ML5.js and P5.js include Three.js for 3D graphics and virtual environments, Phaser.js as a game framework and interactive application, Tone.js for sound and music on the web, Blockly.js for visual learning and block-based programming, and Rita.js for natural language generation and processing. Developers can use these libraries to create creative, interactive e-learning content that supports effective learning in online environments.

Development : The structure of SCORM files follows the rules established in the SCORM standard. Generally, the SCORM file structure consists of several main components:

1. A manifest file, which is the most crucial part, contains metadata about the e-learning content, including descriptions, structures, and utilized resources.

2. Some content files contain the actual learning materials, such as text, images, videos, and interactions. These files are organized in a hierarchy defined in the manifest.
3. JavaScript files are used to control content behaviour and manage user interactions.
4. Other files support additional functionalities such as reporting learning outcomes and interacting with the LMS.

The overall structure of SCORM files enables interoperability and portability of e-learning content across various LMS platforms that support the SCORM standard [17]. These files are packaged in a zip format containing all the necessary files and folders for the e-learning content.

Here are the essential terms in SCORM:

1. Package: The smallest unit of e-learning content packaged in a specific format (e.g., zip file).
2. Lesson: A more significant part of e-learning content that covers multiple topics or learning modules.
3. Module: Individual sections within a lesson that contains specific learning material.
4. Asset: Resources used in learning, such as images, videos, or audio files.
5. Metadata: Information about e-learning content, including title, description, author, version, and language.

User interaction with e-learning content can be guided by scripts and rules established in the SCORM standard. If using CourseLab authoring tools, scripts and rules can be included in module.js. The developed JavaScript functions encompass various aspects such as navigation, activity completion, assessment, and library usage. Through predefined scripts within the SCORM package, users can receive clear guidance on interacting with the content, including steps to navigate materials, complete activities, and answer evaluation questions. The rules established within SCORM ensure consistency in the learning experience, allowing users to focus on the learning process without needing clarification on interaction procedures.

Implementation : We have developed several interactive learning modules. We selected several subjects with themes that we find fascinating as development projects. These subjects include mathematics for elementary school, physics for junior high school, English for high school, and introduction to artificial intelligence for elementary school students. In the first development, we used the System Usability Scale (SUS) for evaluation. SUS is suitable for testing applications because it is a simple, fast, and effective tool for measuring users' perceptions of the usability of a system or application [18]. Using the SUS questionnaire, which consists of 10 questions, we can quickly gain an overview of how well users can use the application. The results of the SUS testing can provide valuable insights into the strengths and weaknesses of the application, as well as areas that need improvement. In addition, SUS has been widely used in various application testing contexts, making it easier to compare applications and collect consistent data for usability analysis. Table 1 shows the first content or interactive e-learning as SCORM modules with the SUS score.

Table 1. The first content development and SUS Score

Theme	Objective(s)	Library	Interactive elements	Platform	SUS Score
Geometry: circle, square, and triangle.	Students can estimate the circumference and area of a flat field.	P5.js	Students can draw on the canvas, match the drawing to shape and size, and calculate the circumference or area.	e-Learning	82.5
Learning geometry with coding	Students understand concepts faster.	P5.js	Students can write programs to draw line, quadrangle, triangle, or circle shapes within the canvas	e-Learning	67.5
AI for kids	Students understand the basic concept of AI	P5.js, P5.speechRec.js, P5.sound.js, and ML5.js	Student can generate data set, training the data, and prediction the testing data. Student will work with mouse and camera.	e-Learning	75
English pronunciation	Students can pronounce fluently a word or sentence.	P5.js, P5.speechRec.js, P5.sound.js	Students can choose a practice theme and then practice listening and saying words/sentences independently.	m-Learning	80

English writing skill	Students can write sentences with correct grammar	P5.js, rita.js, grammar API	Students can write sentences in a text editor, check sentence structure, and correct.	e-Learning	-

Devices may utilize browsers or applications for access. Accessing e-learning content through browsers operates seamlessly on Windows and macOS operating systems. However, when accessing e-learning content through applications such as Moodle App, contents involving microphone access may encounter functionality issues. In m-learning access, browser-based access performs well in Android environments, whereas in iOS environments, microphone access may not function optimally due to JavaScript library constraints. Similarly, when accessing m-learning content through applications, all microphone accesses may not function optimally in Android and iOS environments.

Future Challenge : Developing SCORM-compliant e-learning content may encounter challenges such as integrating interactive and responsive content, ensuring compatibility across various LMS platforms, and keeping up with evolving SCORM standards [19]. Recent trends in SCORM standards emphasize flexibility and interoperability, enabling e-learning content to adapt to diverse digital learning environments. This development can influence the architecture of e-learning content in the future by encouraging developers to create more dynamic, modular, and easily customizable content for different platforms and learning needs. The creation of high-quality standards material is already a quite demanding goal. Additionally, trends include increased support for responsive and adaptive content and the integration of new technologies like augmented reality (AR) and virtual reality (VR) to enhance the overall learning experience [20]. In the other side, academic and research science gateways have yet to fully adopt the tools of AI [21]. Considering these trends, future e-learning content architecture development needs to address the demand for flexibility, responsiveness, and technological invention to achieve optimal learning experiences.

V. CONCLUSION

In developing e-learning content, this design employs a holistic and structured approach using the SCORM standard to facilitate seamless integration with various LMS. Leveraging advanced web technology and robust JavaScript libraries enables the creation of responsive, interactive content across diverse devices.The integration of SCORM allows e-learning content to seamlessly integrate with various LMS platforms, providing end-users flexibility in usage and content distribution. Meanwhile, web-based applications ensure easy and swift access without the need for additional installations, thereby extending the reach of the content.The interactive elements embedded within the JavaScript libraries offer engaging and compelling learning experiences for participants, enhancing engagement and retention of learning materials. Thus, this design combines the reliability of SCORM, the flexibility of web technology, and the interactivity of JavaScript high potentially to create a comprehensive and practical e-learning experience.

REFERENCES

[1] V. M. Bradley, “Learning Management System (LMS) Use with Online Instruction,” International Journal of Technology in Education, vol. 4, no. 1, p. 68, Dec. 2020, doi: 10.46328/ijte.36.

[2] D. Purbohadi, “Pengembangan E-Learning Interaktif Berbasis LMS dan SCORM,” vol. 7, no. 5, 2022.

[3] F. Yahiaoui et al., “The Impact of e-Learning Systems on Motivating Students and Enhancing Their Outcomes During COVID-19: A Mixed-Method Approach,” Front Psychol, vol. 13, Jul. 2022, doi: 10.3389/fpsyg.2022.874181.

[4] P. Veluvali and J. Surisetti, “Learning Management System for Greater Learner Engagement in Higher Education—A Review,” Higher Education for the Future, vol. 9, no. 1, pp. 107–121, Jan. 2022, doi: 10.1177/23476311211049855.

[5] L. Yordanova, N. Angelova, G. Kiryakova, A. Nadezhda, and G. Kiryakova, “Interactive Models of E-learning for Active Learning,” Journal of the Faculty of Technics and Technologies, vol. 3, no. 4, 2015, doi: 10.15547/artte.2015.04.008.

[6] P. Gil, F. A. Candelas, and C. A. Jara, “Computer networks E-learning based on interactive simulations and SCORM,” International Journal of Online Engineering, vol. 7, no. 2, pp. 15–23, 2011, doi: 10.3991/ijoe.v7i2.1638.

[7] S. Petrovica, A. Anohina-Naumeca, and A. Kikans, “Definition and Validation of the Subset of SCORM Requirements for the Enhanced Reusability of Learning Content in Learning Management Systems,” Applied Computer Systems, vol. 25, no. 2, pp. 134–144, Dec. 2020, doi: 10.2478/acss-2020-0015.

[8] S. Pradono, M. S. Astriani, and J. Moniaga, "A Method for Interactive Learning," CommIT (Communication and Information Technology) Journal, vol. 7, no. 2, p. 46, 2013, doi: 10.21512/commit.v7i2.583.

[9] A. Khamparia and B. Pandey, "Impact of interactive multimedia in E-learning technologies: Role of multimedia in E-learning," in Enhancing Academic Research With Knowledge Management Principles, IGI Global, 2017, pp. 199–227. doi: 10.4018/978-1-5225-2489-2.ch007.

[10] F. Kamran, A. Kanwal, A. Afzal, and S. Rafiq, "Impact of Interactive Teaching Methods on Students Learning Outcomes at University level," 2023. [Online]. Available: https://www.researchgate.net/publication/372289203

[11] S. Joseph, "The Impact of Computer-Based Learning on Student Engagement and Achievement," 2023. [Online]. Available: https://www.researchgate.net/publication/376754412

[12] S. Abbasi and G. Dastghaibyfard, "An Architecture for a SCORM-Conformant Content Delivery System in an E-learning Solution," in Innovations in E-learning, Instruction Technology, Assessment, and Engineering Education, 2007, pp. 347–350.

[13] R. Wu, R. Li, F. Yu, G. Yue, and C. Xu, "Research on advanced distributed learning by using SCORM," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), Springer Verlag, 2007, pp. 571–574. doi: 10.1007/978-3-540-72588-6_95.

[14] Emil Sandberg, "Creative Coding on the Web in p5.js," Blekinge Institute of Technology , Karlskrona Sweden, 2019.

[15] M. Basurah, W. Swastika, and O. H. Kelana, "Implementation of Face Recognition and Liveness Detection System Using TensorFlow.js," Jurnal Informatika Polinema, pp. 509–516, 2023.

[16] H. Effendi, Y. Hendriyani, and J. Diva Humaira, "The Future of E-Learning: Leveraging VR, AR, And AI for More Effective and Engaging Learning Experiences," 2023.

[17] P. Arapi, N. Moumoutzis, and S. Christodoulakis, "Supporting interoperability in an existing e-learning platform using SCORM," in Proceedings - 3rd IEEE International Conference on Advanced Learning Technologies, ICALT 2003, 2003, pp. 388–389. doi: 10.1109/ICALT.2003.1215137.

[18] S. C. Peres, T. Pham, and R. Phillips, "Validation of the system usability scale (sus): Sus in the wild," Proceedings of the Human Factors and Ergonomics Society, no. June, pp. 192–196, 2013, doi: 10.1177/1541931213571043.

[19] D. Purbohadi, T. W. Wijaya, and D. S. Aditya, "Developing Online Laboratory as an English Learning Media for Muhammadiyah Schools in Bantul Regency," Warta LPM, pp. 278–288, Jul. 2023, doi: 10.23917/warta.v26i3.1460.

[20] R. P. Anggara, P. Musa, S. Lestari, and S. Widodo, "Application of Electronic Learning by Utilizing Virtual Reality (VR) and Augmented Reality (AR) Methods in Natural Sciences Subjects (IPA) in Elementary School Students Grade 3," vol. 23, no. 1, pp. 58–69, 2021, doi: 10.21009/JTP2001.6.

[21] S. Gesing et al., "Science Gateways and AI/ML: How Can Gateway Concepts and Solutions Meet the Needs in Data Science?" [Online]. Available: www.intechopen.com