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# Empowering Gen Z Learning: Wordwall-Based Educational Game Development in Differentiated Instruction for Elementary Students

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**Abstract.** This study aims to develop wordwall-based educational game media for the sixth-grade elementary students in learning the human skeletal system. In addition, this study is intended to explore students' perspectives of the use of such developed media. This research development research design employed the Four-D model to guide the development process and a single case study design to explore the students' perspectives and learning experiences on the use of developed media. The sixth-grade students of public primary school in Jakarta, Indonesia participated in the study. Data were garnered through observation, questionnaires, pretest and post-test, and interviews. The first finding reported the effectiveness of developed media from significant pretest-post-test improvements, with a mean final score of 79.6, surpassing the minimum competency standard, which is 73. The second finding indicated that the wordwall educational game media can accommodate students' auditory, kinesthetic and visual learning styles. In addition, the interviews revealed that the use of wordwall platform is aligned with students' interest, readiness to learn and learning profile as the principles of differentiated instruction. The study concludes that innovative learning media, such as wordwall-based educational games, makes learning interactive and enjoyable as well as facilitates differentiated instruction.

**Keywords:** Differentiated Instruction; Digital Game-Based Learning; Elementary Education; Learning Styles; Wordwall Platform

## 1. Introduction

The advancement of digital technology in schools has enhanced its use in learning, teaching methods, and classroom interactions. This directly influences how teaching is conducted, the pedagogical approaches applied, and the dynamics of interaction between students and teachers. The skills of critical thinking, collaboration, creativity, and problem solving (UNESCO, 2015) and high order competencies including the acquisition and application of knowledge, skills, attitudes, and values (OECD, 2019) are the successful keys in the 21st century to excel and create a better future for students. In the words of Redecker (2017), learning environments can include digital technologies to enable students to acquire these skills and competencies. The potential of digital technology to deliver differentiated instruction (DI) has been confirmed by numerous studies both nationally and internationally (Baron et al., 2019). Research findings indicate that many students find the use of digital technology enjoyable and motivating, which tends to have a positive impact on the overall learning environment (Johler & Krumsvik, 2022). Additionally, studies reveal that teachers who support learning through the use of digital technology optimize the application of diverse teaching strategies to facilitate learning and encourage students' exploration of knowledge (Harper, 2018). Thus, the push toward digital games to offer very interactive learning environments for players, either in single player or multiplayer games, has been fueled by developments in technology and the comparatively low cost of devices (Slimani et al., 2018). As a pedagogical tool that can offer a motivating and active learning environment for students, digital game-based learning has drawn great attention in educational and research circles (Udeozor et al., 2023). In addition, increasing proof of the capacity of games to improve cognitive, affective and psychomotor skills has led to widespread use in several academic fields (Connolly et al., 2012), especially in primary education context.

### 1.1. Problem Statement

To ensure that students receive instruction that meets their needs, teachers should ideally differentiate their lessons rather than employ a one-size-fits-all approach (George, 2005) However, implementing DI is regarded as a crucial but difficult teaching skill that many teachers lack proficiency in and feel unprepared for (W. Van de Grift et al., 2011; van Geel et al., 2019). Research in several countries have found the problems of employing DI in the classroom. German teachers reported both positive effects and increased stress linked to DI (Pozas et al., 2023). In Ethiopia, many primary school teachers had limited exposure to DI, resulting in low understanding and unfamiliarity with its key strategies (Melesse, 2016). In Australia, teachers reported challenges in implementing DI due to limited resources, student behaviour issues, and lack of planning time. School leaders also noted time constraints and reluctance among experienced teachers, while teacher education programs lacked clarity on DI as a universal teaching approach (Gibbs, 2023). In Indonesia, DI, which has become a central component of the Merdeka Curriculum under the *Merdeka Belajar* initiative, also encounters some problems. For instance, its implementation remains inconsistent and below expected benchmarks (Suprayogi et al., 2017). Teachers also experienced difficulties articulating the creative aspect of autonomy in DI classrooms (Hidayat et al., 2024). Putra (2023) found misconception regrading DI implementation including teacher-student relations, teacher-learning design, and teacher-learning goals. Lack of learning resources, students' lack of readiness for learning, teacher shortages, and poor infrastructure are all factors that hinder the implementation of DI (Ristiyati et al., 2023). Effective DI implementation was found to be hampered by issues like limited parental support, inconsistent student responsiveness, and time constraints for lesson preparation (Tundreng et al., 2025). In addition, digital technology has become widely used in all fields, including education sector. Therefore, in order to meet the diversity needs and abilities of the students, it would be desirable to create an innovative and appropriate learning strategy by integrating digital technology into media games in learning process.

DI in schools is implemented by modifying teaching strategies using technology familiar to students. Teachers play a key role by designing effective strategies to address cognitive differences among learners. In the views of Deunk et al. (2015), the quality of a school is largely determined by how teachers handle these differences and tailor instruction to individual needs, requiring advanced professional skills. Success in DI involves not only grouping students by ability but also adapting teaching to meet the needs of diverse ability groups. Roy et al. (2013) describe DI as an approach that varies and adjusts teaching to align with students' abilities through systematic academic progress monitoring and data-driven decision-making. Furthermore, in the words of Parsons et al. (2018), adapting DI is regarded "a corner stone of effective teaching" (p. 206) and "considered as the gold standard that teachers should strive for" (p. 206). The quantitative findings demonstrated a significant positive impact of educational game development on students' attitudes and academic performance. Additionally, qualitative data supported these results, with students expressing enjoyment during game implementation and reporting improved comprehension of the subject matter (Korkmaz et al., 2023). Nevertheless, when teachers do not use teaching techniques that fit students' learning styles, students often find it difficult to grasp and lose attention during class (Morgan, 2014). Teachers must therefore fit these variations in learning styles by using suitable or more appropriate media meant to improve the standard of education. Moreover, especially in the present age of technology developments and revolutions, teacher creativity is absolutely essential for enabling learning and knowledge transfer to students (Fatimah et al., 2024; Narmaditya et al., 2018). Therefore, it is crucial for teachers to be imaginative and original in order to create digital media to fit students' learning preferences and traits. As emphasized, teachers play a central role in designing and managing the types of learning experiences that determine whether creativity will be nurtured or suppressed in the classroom (Beghetto, 2021).

### 1.2. Related Research

The wordwall educational game serve as an effective tool when contextualized and integrated with supplementary information and activities before and after sessions, as well as through differentiated teaching approaches (Scurati et al., 2023). Game-based learning has

emerged as an innovative teaching technique that can boost student motivation, emotional engagement, and enjoyment (Hartt et al., 2020). Furthermore, previous study showed the Maze Chase Wordwall-based worksheet enhanced student motivation, engagement, and understanding by providing a dynamic, technology-integrated learning experience in natural and social sciences (Luthfitrania et al., 2025). Other research found that the developed Android media, which contains visual and audio elements enhances students' better understanding of the material and learning outcome (Purwanto et al., 2024).

Prior numerous studies have demonstrated that digital games can increase student engagement and even test scores, but the majority of them only look at the obvious results and ignore the more complex teaching techniques that underlie their effectiveness. Few studies, for instance, have examined the thoughtful use of wordwall and other tools to support DI, a teaching strategy that seeks to accommodate each student's particular learning requirements. Although DI is well known in the field of education, its practical application is challenging. However, the majority of wordwall research treats it as a general engagement tool without demonstrating how it can assist teachers in customising instruction according to the readiness, interests, and learning profile of their students as the principles of DI. Furthermore, very few studies take into account how digital resources like wordwall truly align with the learning styles of generation Z students.

Under this context, this current study addresses several gaps in current educational research and practice. Although differentiation is acknowledged as a good teaching tool, especially for generation Z students in elementary education, the use of digital technologies like wordwall into DI remains underexplored. Many current studies ignore customizing teaching strategies to the particular traits of generation Z, including their desire for interactivity, gamification, and technology-driven settings. Furthermore, despite the fact that game-based learning is widely recognized as an effective means of raising motivation and engagement, little research has been done on how to contextualize it within particular curricula, like Indonesia's Merdeka Curriculum. Additionally, despite wordwall's adaptability, its capacity to promote learners' learning styles, students' profile, learning readiness, and learning interest through DI has not been thoroughly investigated. This study offers several novel contributions to address these gaps. It pioneers the integration of wordwall-based educational game with DI strategies tailored to the Merdeka Curriculum, emphasizing flexible and competency-based education. The study is uniquely designed to meet the needs of generation Z learners, leveraging their digital-native tendencies with interactive, visually appealing, and gamified learning experiences.

### 1.3. Research Objectives

This present study aims to develop educational game media to implement DI using wordwall to enhance learning motivation and accommodate the learning styles of generation Z in an elementary school level. In addition, this study attempts to explore students' perspectives on the use of Wordwall media platform in terms of their learning readiness, learning interest and profile as the principles of DI. Thus, the instruments used to address the research objective (RO) are as follows:

a. RO1: to develop wordwall-based educational game media, the instrument is 4D developmental model and expert validation checklist. The Instrument validation aspects for content expert include content quality and learning objective, and learning process. Instrument validation for media expert include visual communication design and programming. While aspect of students' trial includes content, quality and learning quality.
b. RO2: to explore students' perspectives and experiences regarding the media based on DI principles, the instrument is semi-structure interview guideline. Sample questions such as 1) readiness to learn: did the wordwall media game help you understand the topic more easily?; 2) learning interest: what part of the game did you enjoy the most?; 3) learning profile: did you prefer learning with sounds, pictures or movement?.

This study has theoretical, practical and empirical contributions. Theoretically, this study contributes significantly to the theoretical development of DI by extending Tomlinson's framework into the realm of digital game-based learning. While DI has conventionally focused on modifying content, process, and product based on students' readiness, interests, and learning profiles, this study integrates these principles with wordwall learning platforms to explore how DI can be operationalized in technology-rich environments. From a practical perspective, this study provides elementary school educators with an adaptable instructional model that integrates wordwall game media with DI strategies. This innovation addresses the challenge of catering to students' varied learning styles and readiness levels in real classroom settings. For empirical contribution, this study provides empirical evidence on the effectiveness of integrating wordwall within the framework of DI at the elementary school level. Through direct classroom implementation and student feedback, the study captures authentic learner responses concerning readiness, interest, and learning profiles, which are often underrepresented in existing DI research. Moreover, by documenting students' perspectives on engagement and learning preferences, the study contributes rich qualitative and quantitative data that inform future innovations in both instructional design and educational technology integration.

## 2. Theoretical Framework

This study is grounded in two key theoretical perspectives: DI and DGBL. These frameworks are interrelated and jointly support the design of learning experiences that are engaging, flexible, and responsive to student diversity, core aims that align with the values of Indonesia's Merdeka Curriculum.

### 2.1. Differentiated Instruction (DI)

By addressing important facets of instruction, teachers' inventiveness in creating successful teaching strategies is essential to improving the learning process. One such strategy is DI as pedagogical philosophy and approach, which gains recognition and transform classroom practice benchmarks (Suprayogi et al., 2017). Bosker (2005) defines DI as the adjustment of various educational components, such as student grouping, learning objectives, teaching time, and instructional strategies in order to accommodate student differences. Performance levels, preparedness, IQ, motivation, and personality are a few examples of these differences. Building on this, Tomlinson (2001) and Tomlinson et al (2003) provided a widely recognized definition of DI that highlights how instructional content (what is taught), process (how students learn), and product (how students demonstrate their learning) are modified based on students' learning profiles, interests, and readiness. Similarly, Tomlinson and Imbeue (2010) noted that "the core of classroom differentiation practices involves modifying four curriculum-related elements: content, process, product, and impact based on three categories of student needs and variances: readiness, interest, and learning profile." This is because DI entails teachers adjusting their instruction to address student differences (Ruys et al., 2013). A range of instructional activities and didactical techniques, including tiered assignments and homogeneous or heterogeneous subgroups based on learners' performance or interests, can be used by teachers to implement DI (Coubergs et al., 2017; Hachfeld & Lazarides, 2021; Maulana et al., 2020). Tiered assignments, for example, could be design-based, based on qualitative and/or quantitative variations of materials (e.g., give high achievers extra assignments), and tasks based on resources, process, product, complexity outcome, and/or challenge level (Pozas & Schneider, 2019). Additional DI practices include the use of tutoring systems, staggered nonverbal material learning aids like checklists, and forms of open education like station-based work, interest-based centres, project-based learning, or portfolios (Tomlinson, 2014, 2017).

This concept aligns with the Merdeka Curriculum implemented in Indonesia, which emphasizes flexible and competency-based learning, a core principle of DI. DI is considered a complex teaching skill, requiring teachers to employ varied approaches to address diverse student needs in heterogeneous classrooms (Deunk et al., 2015; W. J. C. M. Van de Grift et al., 2011). Tomlinson (2017) describes DI as a proactive, student-centered approach that provides multiple pathways for acquiring content, processing ideas, and developing products. Rather

than individualizing instruction for every student, DI creates multiple options for learning activities within a blended classroom environment, offering both challenges and support to students with varying levels of readiness, interests, and learning profiles (Tomlinson, 2014, 2017). The rationale behind DI lies in its ability to address the inherent diversity in classrooms. Flexible teaching approaches are essential for ensuring that all students, regardless of their differences, can access meaningful and challenging learning opportunities profiles (Tomlinson, 2014). However, implementing DI presents challenges, particularly in aligning instruction with students' abilities. Insufficient preparation by teachers and students often hinders the effective adoption of differentiated strategies (Ruys et al., 2013). Despite these challenges, differentiated teaching is critical for fostering inclusive classrooms. DI enables students to engage in meaningful and innovative learning experiences while integrating valuable cultural heritage (norms) into lessons. It allows children from diverse backgrounds to maximize their potential, supporting their academic and personal growth (Tomlinson, 2001).

DI is a teaching strategy that customizes techniques, resources, and evaluations to fit the various needs, interests, and learning profiles of students in a classroom. Based on educational theories including Vygotsky's Zone of Proximal Development (ZPD) and Gardner's Multiple Intelligences, DI stresses customizing teaching to the developmental phases and strengths of every student (Tomlinson, 2014). Vygotsky's ZPD emphasizes the distance between what students can accomplish alone and with direction, so framing DI as a tool to offer suitable scaffolding for learning. Likewise, Gardner's theory emphasizes the importance of acknowledging personal intelligences so that teachers may create activities suited to different learning styles (Aliyeva, 2021). Based on students' readiness, interests, and learning profiles, DI entails adjusting four essential components: the learning environment, process, product, and content (Tomlinson, 2014). For example, process modifications enable a variety of instructional strategies catered to individual learning styles, while content can be modified to match the complexity of topics with students' readiness levels. A supportive learning environment guarantees engagement and success, while product differentiation gives students options for how they show their understanding (Aliyeva, 2021).

In today's diverse classrooms, where inclusivity and individualized instruction are crucial, these modifications are especially pertinent. There is evidence to support DI's efficacy in raising student achievement. For instance, in the words of Magableh and Abdullah (2021), in mixed-ability classrooms, tenth-grade students' reading comprehension was considerably improved by DI strategies. Based on the report of Wong et al. (2023), tailoring instruction to students' readiness levels and interests improve intrinsic motivation and perceived competence in primary school students. Furthermore, the study demonstrated the positive impact of technology integration in DI, which underscores its ability to engage students and increase academic achievement. Despite these benefits, implementing DI presents challenges, including teacher preparedness, resource constraints, and classroom management issues (Harper & Milman, 2016). Effective DI requires teachers to possess a deep understanding of instructional strategies, accurate assessment skills, and sufficient resources to design and implement differentiated activities (Tomlinson, 2014). In a recent study, Van Geel et al. (2019) conducted a cognitive task analysis to explore the knowledge and skills teachers require to perform DI. Through their analyses, the authors identified several factors that contribute to the complexity of executing DI, including the lesson's content, the composition of the group (i.e., student diversity), school support services like collaboration and materials, and the accessibility and availability of student achievement data. In conclusion, DI offers a framework to address the diverse learning needs of students, supported by theoretical foundations and empirical evidence.

### 2.2. Digital Game-Based Learning (DGBL)

Current teaching approaches increasingly prioritize the use of technology to motivate students in their learning journey. Conventional media are often perceived as monotonous compared to technology-based learning tools. Research synthesis highlights the positive impact of technology on students' academic achievement (Harper & Milman, 2016). Teachers' creativity in determining engaging teaching strategies enhances the learning process by considering

essential aspects of instruction. Conventional media are perceived as monotonous compared to technology-based learning media.

Educational games have emerged as significant tools in modern pedagogy, offering interactive environments that enhance learning by engaging students in meaningful activities. These games facilitate the acquisition of knowledge and skills, reduce cognitive load, and boost learner initiative (Wang & Zou, 2025). The study provides evidence from child development research findings that games should: (1) be developmentally appropriate content; (2) integrate the theoretical frameworks from the learning science field; (3) embed learning in socially rich contexts; (4) develop diverse content; and (5) create a balance between play and real-world learning opportunities. The study builds the principles around a hypothetical educational game designed to facilitate language development (Miller & Kocurek, 2017). Plass, Homer, and Kinzer (2015) emphasize that an effective approach to game design and research requires integrating cognitive, motivational, affective, and sociocultural perspectives to fully understand the educational potential of games.

DGBL is an instructional strategy that incorporates educational content into digital games to support student learning through interactive and engaging experiences (Bahadoorsingh et al., 2016; Van Eck, 2015) . It is widely applied across various subjects and is recognized for fostering 21st-century skills such as problem-solving, collaboration, and critical thinking (Boyle et al., 2016; Connolly et al., 2012; Qian & Clark, 2016). There are two types of digital learning games: serious or educational games and entertainment games. Digital entertainment games (DEG) are video games created especially for enjoyment, leisure, or amusement. On the other hand, serious and educational games are ones that are primarily made with learning objectives other than enjoyment in mind. The purpose of these games is to encourage learning and behavioural changes (Connolly et al., 2012). Digital educational games, a subset of educational games, leverage technology to create immersive learning experiences. In mathematics education, for instance, DGBL has been recognized for increasing student interest and motivation, thereby improving learning outcomes (Hussein et al., 2022). Furthermore, educational games have been instrumental in developing computational thinking skills among primary school students. Studies indicate that such games effectively introduce programming concepts, fostering problem-solving abilities and critical thinking (Giannakoulas & Xinogalos, 2024). The study of Chen, Husnaini and Chen (2020) found that cooperative games significantly improved students' positive emotions and engagement while learning chemistry, particularly benefiting low and middle achievers, compared to traditional exercises. While traditional methods improved conceptual understanding, they negatively impacted the emotional engagement of middle and high achievers, highlighting the potential of innovative, game-based activities in science education. This finding also suggests that teachers are encouraged to incorporate collaborative games to sustain positive emotions and support conceptual learning, especially for low achievers. The systematic review of experimental studies in primary education reveal that most studies emphasized technology-assisted learning for higher-grade students in natural sciences, with gamification and intellectual problem-solving as prevalent elements. While game-based learning showed predominantly positive cognitive outcomes, theoretical foundations were often absent, and self-designed technologies were primarily used for formal learning (Guan et al., 2024).

The integration of video games as educational tools has also been explored, with research suggesting that they can enhance creativity and skill development in children and young people. However, challenges remain, including potential distractions and the need for careful design to balance educational value with gameplay (Saca-Hueledel et al., 2024). Despite these challenges, the potential of digital games as innovative pedagogical tools is substantial. Their ability to provide authentic and meaningful learning environments makes them valuable assets in education, particularly when designed to align with specific learning objectives (Dubey & Sinha, 2023). In conclusion, educational and digital educational games represent a promising frontier in educational technology. Ongoing research and development are essential to fully harness their potential and address existing challenges, ensuring they effectively contribute to educational outcomes.

A synergistic approach is provided by the combination of DI and DGBL. DGBL offers the resources and media to present that differentiation in an interesting and interactive way, while DI offers the instructional flexibility required to satisfy a range of student needs. For example, teachers can design adaptable learning games that target particular learning outcomes and can be tailored to fit various student readiness levels and learning preferences using digital platforms such as Wordwall. This integration is especially pertinent to the Merdeka Curriculum framework. Flexible learning pathways, project-based learning, and a focus on comprehensive, student-centered education are all recommended by the curriculum. Teachers can respond to the practical realities of student diversity and technological advancement while also aligning with the curriculum by implementing a Wordwall-based game into a differentiated instruction model.

## 3. Methods

### 3.1. Research Design

This study adopted a developmental research design based on the Four D model (Thiagarajan et al., 1974), which consists of four main phases: Define, Design, Develop, and Disseminate. The objective of this study in the field of education is to create and validate educational products. This process involves a series of stages including the research finding analysis related to the developed product, product development, product implementation in a trial setting, and product revisions to address issues identified during the trial. This ensures that the product aligns with the predetermined learning objectives (Gall et al., 2007). This development research aims to produce wordwall-based educational game media for DI within the Merdeka Curriculum in elementary schools. DI becomes more manageable when instructional media are tailored to students' learning styles, which is aligned with one of the primary objectives of the Merdeka Curriculum. During the development stages, the model used for this product offers a significant advantage: expert validation and evaluations (improvements) were conducted at each stage, ensuring the resulting product's validity and reliability. This study also integrated a qualitative single case study design (Yin, 2018) to explore students' perspectives on the use of the developed media in a classroom setting. Thus, the study adopted a mixed method approach, where quantitative aspects were involved in product validation such as expert judgement and tryouts, and qualitative data were garnered through students' interviews to gain in-depth understanding of their experiences, learning readiness, interest, and profiles as aligned with the principles of DI.

### 3.2. Participant

A teaching practitioner, an elementary school classroom teacher, provided practical insights into the application of the media in a real classroom setting and offered feedback on its alignment with instructional strategies and the Merdeka Curriculum. The study also involved six Grade VI students for a limited trial, chosen based on diverse learning styles: visual, auditory, and kinesthetics to evaluate how well the media accommodated different preferences and abilities. Finally, a broader field trial included 30 Grade VI students to test the media on a larger scale, providing extensive data on usability, effectiveness, and student engagement. This diverse group of participants ensured that the educational media was thoroughly evaluated for its content accuracy, design quality, practical usability, and effectiveness in addressing the varied learning needs of students. The recruitment of other participants includes six students who represented three different learning styles to be interviewed about their points of view and experiences on the use of wordwall learning media in their learning process. We used their initials to protect their privacy. Table 1 shows the data demography of six students who were interviewed.

**Table 1.** Data Demography of Six Student Participants

| Students | Gender | Age | Learning style | The results of learning style grouping questionnaire based on non-cognitive test | | |
|---|---|---|---|---|---|---|
| | | | | Kinesthetic | Visual | Auditory |
| S1 | Male | 12 years | Kinesthetic | 3 | 1 | 1 |
| S2 | Female | 12 years | Kinesthetic | 3 | 2 | 1 |
| S3 | Male | 12 years | Visual | 0 | 3 | 2 |
| S4 | Female | 12 years | Visual | 1 | 3 | 2 |
| S5 | Female | 12 years | Auditory | 1 | 0 | 3 |
| S6 | Male | 12 years | Auditory | 1 | 0 | 3 |

### 3.3. Data Collection

The data collection techniques used in this research and development of wordwall-based educational game media included observation, interviews, tests consisting of pre-tests and post-tests, questionnaires. Observations were conducted by the researcher to understand and interpret observed behaviours. Aspects considered during observation included the use of media and teaching methods, students' attitudes during the learning process, and supporting learning facilities. The observation results were documented in observation sheets, providing valuable input for media development. Questionnaires were used at multiple stages of the research. Initially, they were employed to assess students' learning needs during the early analysis phase. Additionally, questionnaires were directly distributed to students to gather their responses to the developed application. These responses included criteria such as the content taught, learning activities, media appearance, and the usability of the learning media. Interviews were conducted during the initial analysis phase to gather data for media development and to identify potential issues. Teachers teaching Grade VI were interviewed to obtain input for the preparation of teaching modules. Product evaluation was carried out to assess the developed product based on predetermined aspects. Experts provided results in the form of percentage scores indicating the alignment of the content, while student responses were summarized as average scores classified into feasibility levels. Furthermore, six students with different learning styles were interviewed to explore their views and experiences with the use of wordwall-based media in learning.

### 3.4. Data Analysis

#### *3.4.1. Quantitative Analysis: Analysis of the Test Results for the Effectiveness of Wordwall-Based Educational Game Media*

The test conducted in this study used the one-group pre-test and post-test design method. One-group pre-test and post-test design were conducted on one group without a control group. This study was adjusted to the objectives to be achieved, namely to determine the effectiveness of the use of wordwall-based educational game media in the science subject of grade VI students. The pre-test was used to determine the initial knowledge of students before being given the learning media treatment. The post-test was used to determine the learning outcomes and knowledge of students after being given the learning media treatment. The results of the pre-test and post-test of students in order to measure the average accuracy, the N-Gain method was used to calculate it. The results of the pre-test were conducted on 30 students with a total of 15 questions consisting of 5 multiple choice questions, 5 short answer questions and 5 essay questions. The questions have a maximum value weight of 25 points.

#### *3.4.2. Qualitative Analysis*

The qualitative analysis in this study employs thematic content analysis of interview data with students to explore their perceptions and experiences with the use of wordwall learning media. Thematic analysis is a technique for examining data collected by researchers in order to find

patterns or reveal themes (Braun & Clarke, 2022). Through several stages including a) familiarizing with the data, b) generating codes, and c) identifying themes, this method helps researchers to find important themes arising from participants' interview responses. This approach lets the researchs offer more in-depth analysis of how people view and interact with the use of the learning media inside the learning environment.

### 3.5. Validity and Reliability

The validity of the media assessment instrument was tested using Aiken's V formula, which calculates the content validity coefficient based on the evaluation results of *n* experts regarding how well an item represents the construct being measured. Aiken proposed the following formula:

$V = \sum s / [n(c-1)]$

where:

$s = r - lo$

lo = the lowest possible validity rating (e.g., 1)
c = the highest possible validity rating (e.g., 4)
r = the rating given by each evaluator.

The Aiken's V index ranges from 0 to 1. An item is considered valid if it has a minimum Aiken's V index categorized as fairly high, with a value of at least 0.4. Based on this criterion, all items in the instrument were declared valid.

The reliability of the instrument was obtained through analysis using SPSS 22.0 to calculate the Cronbach's Alpha value. The reliability analysis conducted with SPSS showed that the instrument had a Cronbach's Alpha of 0.729, which exceeds the minimum standard value (>0.7). Therefore, it can be concluded that the media assessment instrument is reliable.

### 3.6. Research Context

The "Merdeka" Curriculum, which was introduced in Indonesia in 2022, initiates innovative changes, one of them is the integration of Natural Sciences (IPA) and Social Sciences (IPS) into a unified subject, called "IPAS" at the elementary level. Such integration addresses the needs for a holistic approach to understanding universal challenges by fostering critical thinking, curiosity, and problem-solving skills. Designed for the concrete thinking stage of elementary students, IPAS encourages exploration of natural phenomena, human interactions, and environmental relationships. Through critical thinking, cultural appreciation, and community engagement, IPAS supports the Pancasila Student Profile (Indonesian project-based learning) and stresses the application of knowledge to solve real-world problems in line with sustainable development goals. The integration also reflects the dynamic nature of science, where knowledge changes over time and interdisciplinary approaches are necessary to address complex issues like population growth and resource depletion (Sammel, 2014; Yanitsky, 2017). By combining scientific and social perspectives, IPAS equips students with the process skills and comprehensive understanding, which enable them to give meaningful contribution to their communities and adapt to the needs of social change. This supports the Merdeka curriculum's goals of fostering critical thinking, adaptability, and the real-world application of knowledge.

Technology plays an imperative role in facilitating learning processes and adapting to diverse student learning styles in the framework of DI of the Merdeka Curriculum. In elementary school level, students took diagnostic tests to identify their learning interests, styles, and cognitive abilities. Teachers then tailor learning experiences according to their students' interests and aptitudes. Based on our preliminary research in a Grade VI class during the 2024/2025 academic year, diagnostic test results revealed that 40% of students have a visual learning style with an interest in IPAS, 25% have an auditory learning style, and 35% prefer a kinesthetic learning style. These results underline the diversity of students' learning styles, with a predominant preference for visual learning. On the other hand, teachers face challenges in implementing differentiated instruction, especially in selecting more appropriate teaching methods and instructional media, which affects student motivation. This situation has

motivated teachers to embrace creativity and innovation, especially through the development of digital learning media, which is essential for accommodating the characteristics of generation Z, which grown up with access to the internet and portable digital technology from a young age (Turner, 2015). Based on the preliminary research, we developed media tailored to accommodate these varied learning styles and abilities. The media is tailored to capture students' attention through interactive features, engaging visuals, and gamification elements. The wordwall-based educational game is developed in alignment with the principles of the Merdeka Curriculum, which emphasizes flexible learning and competency-based development. The target audience for this research is elementary school students as the primary users of the educational game media. The development of wordwall-based educational games focuses on the human skeletal system (Bones), providing an engaging, context-based approach to learning that aligns with generation Z's digital-centric characteristics.

### 3.7. Ethical Consideration

Before conducting the study, we contacted the school principal about the research plan and obtained permission. We explained all the things regarding the research objectives, research methodology, and potential outcome of the study. Since one of us is the teacher where the study was conducted, she facilitated communication with the principal and she also implemented the use of wordwall media in the classroom. We used initial to protect the privacy of all voluntary participants and the school. This ensured confidentiality and compliance with ethical standards.

## 4. Findings

### 4.1. The Development of Wordwall Based Educational Game Media

#### *4.1.1. Define Stage*

At the define stage, the requirements or needs required in developing educational game media based on wordwall are determined. Data at this stage are obtained through observations of the implementation of learning in class VI by conducting non-cognitive diagnostic tests to group students based on their learning styles and interests, as well as interviews related to learning by class VI teachers which are then analysed descriptively based on relevant theoretical studies. The following is a table of observations of the implementation of learning and interview results:

**Table 2**. Observation of Learning Implementation

| Aspects observed | Description of observation results |
|---|---|
| Use of learning methods | Learning in the implementation of the independent curriculum has not yet implemented differentiated learning |
| Use of learning media | The use of learning media is still traditional and does not meet the needs of students. |
| Student attitudes in the learning process | • The interaction between teachers and students is still dominated by the teacher.<br>• Students take more notes while listening to the teacher's explanation.<br>• When the teacher asks questions, only a few students are active and answer or respond to the teacher.<br>• Students do not appear enthusiastic about learning |
| Learning support facilities | Each classroom is equipped with a whiteboard, LCD projector, laptop. There is also Wi-Fi in each classroom. |

Based on the interview with a grade VI teacher, it reveals that while the school is actively implementing the Merdeka Curriculum, teachers face difficulties in selecting effective media for DI, particularly in the IPAS subject. Traditional teaching methods still dominate, but the use of videos and PJBL is growing. Technological limitations (e.g., shared projectors) pose occasional barriers. The teacher expresses enthusiasm for using more engaging and customizable digital tools like wordwall-based educational games. These tools are seen as suitable for the digital-savvy generation Z students and could support DI by offering tailored content and interactive formats. The school environment is supportive of tech integration, with students allowed to use personal devices and parents backing such initiatives. Overall, there's optimism that educational games can boost student interest and make teaching more adaptive and inclusive.

The steps of define stage include:

1) Front-end analysis: The objective of media is to align learning with students' interests and talents, thereby enhancing the effectiveness and practicality of DI for generation Z. Current instructional methods are still conventional and teacher-centered, resulting in passive student engagement. The media is expected to provide interactive and varied learning experiences.
2) Student needs analysis: Grade VI students show limited activeness during lessons due to minimal opportunities for exploration. According to Piaget's cognitive development theory, they are in the concrete operational stage, able to think logically and understand multiple attributes simultaneously. Thus, media should foster curiosity and enable students to actively explore content, with the teacher acting as a facilitator.
3) Concept analysis: The educational game focuses on the IPAS subject, specifically the human musculoskeletal system. Concepts include identifying parts of the movement system, understanding their functions, describing how the body moves, the role of the nervous system, and maintaining health. These are aligned with the Merdeka Curriculum's learning outcomes.
4) Task analysis: Tasks within the media are designed to be engaging and interactive, helping students meet all learning indicators. Activities include simulations, identification, explanation, and reflection, encouraging independent and group learning.
5) Formulation of learning objectives: Based on the analyses, the students' learning objectives are to understand the human movement system in IPAS through interactive educational game media. The goal is to support concept mastery and differentiated learning tailored to each student's characteristics and needs.

### *4.1.2. Design Stage*

It focuses on preparing the initial design of the media to be developed. This stage consists of the following steps:

1) Constructing criterion-referenced tests (Assessment parameters): Non-test instruments are used in this study. The feasibility parameters for the media are determined through questionnaire results, which serve as non-test instruments.
2) Format selection: Five interactive application formats are developed to integrate the educational game media with student worksheets. The application utilizes Canva, where links are embedded to ensure seamless integration of learning achievements, objectives, and usage instructions for the media presented in the student worksheets format.
3) Media selection: The wordwall platform is chosen and developed as the primary game medium. It is customized to match students' interests and learning styles, based on the diagnostic analysis conducted earlier. Additionally, Canva is used for creating illustrations and instructional videos for the wordwall content during the media development process.
4) Initial design: It includes a) Content design: It is organized and structured using flowcharts and storyboards. Flowcharts depict the link flow between media pages, while storyboards outline the design of each page within the media. b) Development of wordwall-based educational game media: The media is developed according to the flowchart and content design through the following steps:

a) User interface design: Creating an easy-to-use and visually appealing layout for the game
b) Game content selection: Games are selected and tailored to fit different learning styles and materials.
c) Selection of learning materials: Focused on the *human musculoskeletal system*, using relevant visuals and audio.
d) Development of student worksheets: Differentiated based on students' learning styles.
e) Development results: the final product is titled "edugame wordwall differentiated", which the page includes: cover page; learning goals and objectives; learning material (via video); usage instructions; activity page ("*Ayo beraktivitas*"); differentiated student worksheet pages (visual, auditory, kinesthetic); creative tasks and presentations; quiz page (assessment through "Open the box" game).

### *4.1.3. Develop Stage*

In this phase, expert validation was conducted by content and media experts to ensure the quality of the developed educational game media. Content expert validation involves assessing the alignment of the content with the curriculum and its suitability for learning objectives. While media expert validation focuses on two aspects: 1) visual communication, which assesses the visual design and appeal of the educational game; 2) Programming, which evaluates the reliability and ease of use of the educational game as it is seen in the following table 3 and table 4.

**Table 3**. Instrument Validation Results by Content Expert

| Validator | Aspect | | Average |
|---|---|---|---|
| | Content quality and learning objective | Learning process | |
| Content Expert 1 | 3.83 | 3.56 | 3.69 |
| Content Expert 2 | 3.71 | 3.43 | 3.57 |
| Overall Average | 3.77 | 3.49 | 3.63 |
| Category | Very Feasible | Very Feasible | Very Feasible |

**Table 4**. Instrument Validation Results by Media Experts

| Validator | Aspect | | Average |
|---|---|---|---|
| | Visual communication design | Programming | |
| Media Expert 1 | 3.56 | 3.62 | 3.59 |
| Media Expert 2 | 3.43 | 3.87 | 3.65 |
| Overall Average | 3.495 | 3.475 | 3.62 |
| Category | Very Feasible | Very Feasible | Very Feasible |

In this phase, two trials were conducted to investigate students' responses as the following table 5:

a. Limited trial, which was conducted with sixth-grade elementary school students. Participants include six students: two with visual learning styles, two with kinesthetic learning styles, and two with auditory learning styles. The data from this trial are used to refine the application before proceeding to a broader trial.

b. Broader Trial. After revisions based on the limited trial, the educational game is tested with a larger group of 30 sixth-grade students at elementary school. Data from this phase are analyzed to gather student responses and evaluate the effectiveness of the educational game.

**Table 5**. Recapitulation of Students' Responses

| Aspect | Limited trial (six students) Average score | Broader field trial (30 students) Average score | Category |
|---|---|---|---|
| Content | 3,75 | 3,53 | Very Feasible |
| Quality | 3,71 | 3,59 | Very Feasible |
| Learning Quality | 3,65 | 3,46 | Very Feasible |
| Average | 3,69 | 3,50 | Very Feasible |

### *4.1.4. Disseminate Stage*

The dissemination stage is the final phase of developing the wordwall-based educational game. At this stage, the media is shared on a limited scale, specifically within elementary school community. At this point, the product was tested on elementary school students. Following that, students were given a questionnaire about the educational game in order to gather their opinions and responses.

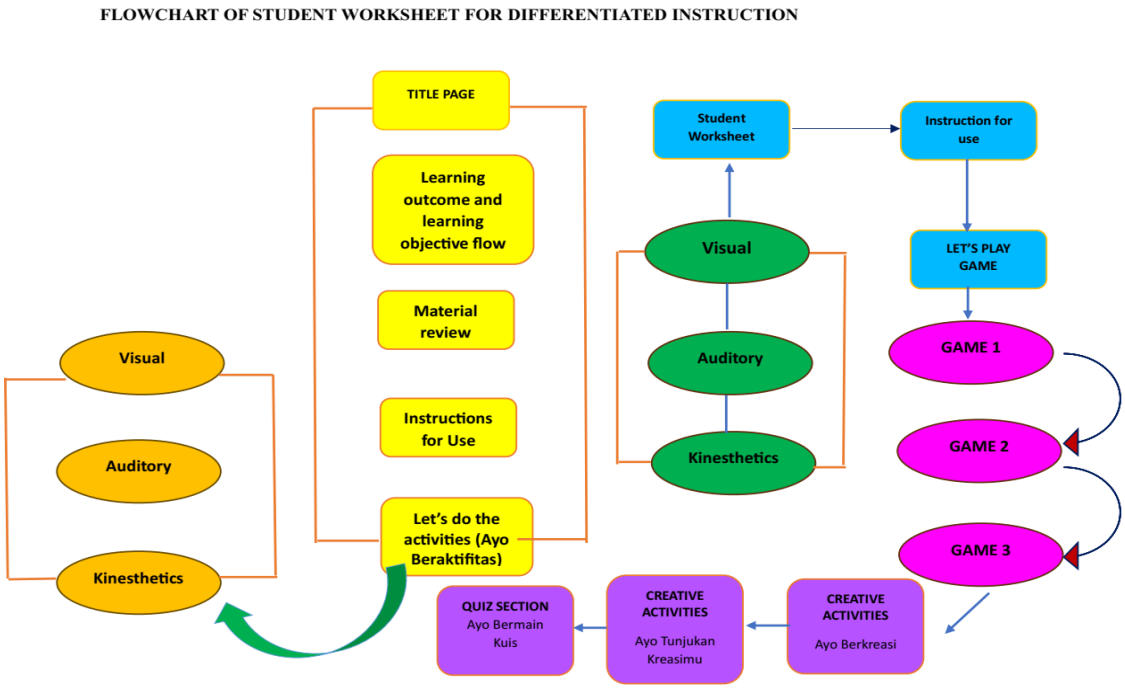


**Figure 1**. Student Worksheet


**Figure 2.** Cover Page (Human movement system)


**Figure 3.** Game Display "*Ayo Berkreasi*" (Let's create) for Visual Learners (The words listed on the box are paired with pictures)


**Figure 4.** Game Display "*Ayo Berkreasi*" (Let's create) For Kinesthetic Learners (matching tile with the picture about lower limb skeletal parts)


**Figure 5.** Game Display "*Ayo Berkreasi*" (Let's create) for Auditory Learners (Create songs from the names of skull bone)

### 4.2. The Effectiveness of The Wordwall Online Platform in Improving Learning Motivation

The pretest results showed that 30 students still got scores below the minimum completion criteria with a total score of 1593 with an average of 53.1 while the minimum completion criteria in class were 73. The post-test results showed that 27 students got scores above the minimum completion criteria and 3 students still experienced below the minimum completion criteria with a total score of 2388 with an average of 79.6. It can be concluded that there was an increase in the pre-test with a score of 53.1 and to the post-test with a score of 79.6 with an average interval value of 26.6. Based on these results, it can be concluded that there is a significant difference in the pre-test and post-test results which shows the effectiveness of developing wordwall-based educational game media for generation Z which can increase their learning motivation.

**Table 6**. The Result of Pre-Test and Post Test

| | Pre test | Post test | Interval |
|---|---|---|---|
| Average score | 53.1 | 79.6 | 26.6 |

### 4.3. Students' Perspectives on the Use of Wordwall Based Educational Game Media Based on the Principles of Differentiated Instruction

The following table 7 presents students' perspectives on the use of Wordwall-based educational game media, categorized by their learning styles and key principles of DI: learning readiness, interest, and learning profile. The data highlight how each student uniquely engaged with the media according to their individual learning needs.

**Table 7.** Students' Interviews Based on Principles of DI

| Students | Learning style | Readiness to Learn | Learning interest | Learning profile |
|---|---|---|---|---|
| S1 | Kinesthetic | I think I have understood much better after directly clicking and dragging and seeing the pictures in the game. | I like it directly when I can move while studying, so I don't get bored easily. I also like the part of matching the images. | Since I practice directly, I feel I understand the names of the bones better through game activities. |
| S2 | Kinesthetic | At first, I am confused, but after I start attempting to play the game, I have understood better and become more enthusiastic. | I feel so content that I can answer all the questions easily looking at the colourful picture, especially about identifying the words and the picture. | Well, I think I have better memory that I can memorize almost all the words of body organ. I study and play the game at the same. It is so fun. |
| S3 | Visual | When I see the colourful initial display of wordwall screen, I am immediately excited and interested. | I am keen on the pictures and animations, characters so I'm excited to learn. | Since the pictures are colourful, quite big, and clear, I can remember the position of the bones, the name of body organ. It's not easy to forget all the names. |
| S4 | Visual | Since my mother also teaches me the body organ names and the functions, I think I more prepared to study in the class, especially using digital media. | The pictures look cute and interesting. | I memorize the names of body organ faster because I can see the shape of the bones and match them with the names on the screen. |
| S5 | Auditory | As the teacher explains the lesson first, I am ready to learn before playing Wordwall. It also has a voice which gives explanation before the game starts. | I find the lesson easy as the media has music and clear instructions. | I remember the names of the human skeleton better because I hear the explanation while looking at the |

| | | | | |
|---|---|---|---|---|
| | | | | questions. It is so exciting to learn by using the application. |
| S6 | Auditory | I was only ready when the teacher explained it first. | The game becomes fun because there are sounds, it's not boring. | I understand the function of bones better because I heard the questions and read the answers out loud. |

Based on the analysis of students' responses, four key themes also emerged from the interviews: multisensory engagement, scaffolded readiness, reinforced retention, and joyful learning experience as in the following table 8.

**Table 8.** The Identified Themes from Students' Interviews

| Theme | Excerpts | Description |
|---|---|---|
| Multisensory engagement | I like it directly when I can move while studying, so I don't get bored easily. (S1)<br>I am keen on the pictures and animations. (S3) | Wordwall media enhances engagement by aligning with kinesthetic, visual, and auditory learning styleS |
| Scaffolded readiness | At first, I am confused, but after I start attempting to play the game, I have understood better and become more enthusiastic. (S3)<br>As the teacher explains the lesson first, I am ready to learn before playing Wordwall. (S5) | Readiness is supported by clear instructions, visual scaffolds, and teacher guidance. |
| Reinforced retention | I memorize the names of body organ faster because I can see the shape of the bones and match them with the names on the screen. (S4)<br>I understand the function of bones better because I heard the questions and read the answers out loud. | Students retain content better through interactive and multimodal features such as image, sound, movement |
| Joyful learning environment | It is so fun. (S2)<br>It is so exciting to learn by using the application. (S5) | Game-based learning creates a fun, emotionally positive learning experience that motivates students |

## 5. Discussion

### 5.1. The Development of Wordwall Based Educational Game Media and Its Effectiveness in Improving Learning Motivation

The Four-D model's phases were followed in the development of wordwall-based educational game media intended to improve learning outcomes, and student motivation, and facilitate differentiated instruction. Pre-test and post-test results showed that the platform was effective because it significantly increased student motivation. This aligns with prior research, such as Luthfitrania, et al (2025), who reported that wordwall effectively increased student motivation

and improved comprehension of evaluation questions. As a form of DGBL, Wordwall has also been shown to boost emotional engagement, enjoyment, and overall motivation (Hartt et al., 2020). In addition, Wang and Zou (2025) highlighted its role in facilitating skill acquisition, reducing cognitive load, and encouraging learner initiative, while Hussein et al, (2022) confirmed that it increases student interest and motivation, ultimately leading to improved learning outcomes. Other studies which are related to the platform of DGBL also give impact to student's learning. For instance, the study reported that multisensory educational game contributes to students' learning performance, engagement and the quality of experience. In addition, multisensorial cues can improve memory and attention and increase the cognitive and sensory-motor performance (Covaci et al., 2018). Previous research revealed that Minecraft Education (ME) as a DGBL platform can be utilized in the classroom to support curriculum content while also assisting students in developing the skills and competencies they will need to succeed in the future (Slattery et al., 2023).

DGBL, which is designed with the aim to promote learning and behavioral changes (Connolly et al., 2012) has facilitated the principles of DI and accommodate student learning styles as the interviews with students revealed. The teacher's knowledge to understand student learning style plays an essential aspect to the success of students' learning. As it is supported by Bascopé, et al. (2019) that the significance of pedagogical approaches in education lies in enabling teachers to adapt their teaching methodologies to the needs and characteristics of their student group, which lead to their better comprehension and knowledge retention. DI, as supported by Tomlinson (2014), stresses tailoring content, process, and product based on learners' readiness, interests, and profiles. The educational game effectively operationalized this by providing visual, auditory, and kinesthetic options, demonstrating its alignment with evidence-based instructional design for inclusive education. The product also meets the digital expectations of Generation Z learners. For example, the use of colourful visuals and animation in the wordwall platform for visual learners attracts the students' attention, which aids the retention of information regarding the names of bones and their position (Covaci et al., 2018). A study by Pesare et al. (2016) demonstrated that integrating gamified elements into learning environments significantly boosts student motivation and engagement. The use of platforms like wordwall was highlighted as effective in promoting active learning behaviour and a promising solution to sustain student motivation and engagement.

As an active participant, students feel responsible for their own learning when using the wordwall platform. This is related to the concept of student agency which OECD (2019) defined as the 'capacity to set a goal, reflect and act responsibly to effect change' (p.16). as a crucial aspect of education in 21st century. In the perspective of Taub et al, (2020), providing students with a high degree of agency is a core DGBL design characteristic. At the core of student agency is students making decisions about what and how they will learn. Crucially, students want to learn with Minecraft (i.e. how). Moreover, the plat-form gives students the opportunity to direct the learning process (i.e. what) because of its freedom and choice. As Vaughn (2020) argues this autonomy promotes student agency as students can take charge of their own learning experience. Previous research has shown that student agency in DGBL can improve students' learning outcomes (Taub et al., 2020). Under these circumstances, the novelty of this study lies on the integration of wordwall-based educational games into the curriculum effectively, which addresses the diverse learning needs of students studying the human skeleton particularly. By aligning with the principles of DI and leveraging multisensory engagement, such tools can enhance understanding, retention, and overall student satisfaction.

### 5.2. Students' Perspectives on the Use of Wordwall Based Educational Game Media Based on DI Principles

The second objective of this study is to explore the students' perspectives on the developed wordwall media used by a teacher regarding the principles of DI, namely students' readiness to learn, interest, and learning profile. It was found that four themes were identified: multisensory engagement, scaffolded readiness, reinforced retention, and joyful learning

environment. Students consistently expressed that wordwall's integration of visual, auditory, and interactive elements helped maintain their focus and enjoyment. For example, S3 (visual learner) stated, "I'm keen on the pictures and animations, so I'm excited to learn," while S5 (auditory learner) noted, "The media has music and clear instructions." These responses reflect how matching content delivery with students' sensory preferences enhances engagement. In accordance with the results, the developed media greatly facilitated multisensory engagement, which enables students with a range of learning preferences (visual, auditory, and kinesthetic) to actively engage in the educational process. This strengthens Tomlinson's (2014) claim that taking learners' preferences and cognitive styles into account maximises the effectiveness of DI. In line with Fleming and Mills (1992) and Prensky (2010), who contend that multimodal engagement improves digital learning experiences, particularly for generation Z learners, students reported feeling more motivated when interacting with game features that matched their sensory modalities. Multisensory learning has been recognized as an effective approach for enhancing the learning process (Cincera et al., 2020). It involves instructional strategies that engage multiple sensory modalities, enabling students to interact with the content through various sensory channels (Cuturi et al., 2022). Research indicates that learners tend to retain multisensory experiences more effectively and with greater detail than information acquired through single-sensory methods (Ponticorvo et al., 2019).

In terms of the second theme, the media offered scaffolded readiness by combining interactive content, visual cues, and teacher explanations. Readiness to learn was often linked to initial support, either from the teacher or through the media's design. S2 shared, "At first, I was confused, but after I started playing the game, I understood better," indicating how digital games can scaffold understanding when well-integrated. S5 emphasized the importance of teacher explanation before gameplay: "As the teacher explains the lesson first, I am ready to learn before playing." This finding is in line with Vygotsky's sociocultural theory (Vygotsky, 1978), which highlights the necessity of scaffolding as an effective educational strategy. This finding is also supported by previous research, which revealed that when technology is used, scaffolding helps close the knowledge gap between students and what they need to learn (Kim & Hannafin, 2011). In addition, students benefit from scaffolding when they begin learning something new (Hoff-Jenssen, 2025; Taylor et al., 2024). Thus, by employing scaffolding, which teachers offer support structure, students become more engaged with the activities and have more confident. It indicates that the use of wordwall media can serve as a bridge to autonomous learning or self-directed learning. As defined by Wood et al (1976) that the process of scaffolding allows children to complete tasks that would be beyond their current comprehension level.

Reinforced retention was another important theme. Through visual, auditory, and kinesthetic channels, students were better able to retain and comprehend concepts like body organs and bone structure. Students demonstrated improved memory of content through multimodal reinforcement. S4 said, "I memorize the names faster because I can see the shape of the bones and match them," while S6 stated, "I understand the function of bones better because I heard the questions and read the answers out loud." These findings align with principles of DI that promote matching instructional approaches with students' learning profiles. According to Mayer's (2009) Multimedia Learning Theory, cognitive processing and long-term memory retention are improved when verbal and visual information are integrated. Given the importance of retention for long-term knowledge building retention, the use of interactive media, such as wordwall can impact students' retention as it is perceived by the research participants.

Lastly, the research discovered that the utilisation of wordwall media produced a joyful learning atmosphere, which resulted in favourable emotional reactions and heightened intrinsic motivation. Across responses, students described the learning experience as fun and exciting, contributing to increased motivation. S2 remarked, "It is so fun," and S5 added, "It is so exciting to learn by using the application." This emotional response supports the use of gamified learning to foster student interest and engagement. It is because digital media introduces innovative opportunities for enhancing movement-based learning experiences

(Greve et al., 2022). This supports the ARCS model developed by Keller (2010) and the Self-Determination Theory developed by Deci and Ryan (2000), both of which emphasise the importance of enjoyment and satisfaction in maintaining learning engagement. Research from the interdisciplinary science of learning concluded that children learn best when actively participating in meaningful, socially interactive, iterative, and joyful learning (Nesbitt et al., 2023).

### 5.3. Challenges

Despite the promising results, introducing wordwall-based educational games as part of DI is not without its challenges. The prior findings indicate that external factors including language barriers, technophobia, parental influence, and students' low reading skills negatively impacted teachers' perceptions of the usefulness of DGBL. However, teachers' positive attitudes, shaped by favorable perceptions of DGBL, positively influenced their intention to use digital games, particularly for teaching mathematics (Saal et al., 2025). The results of five participants' semi-structured interviews revealed that the use of educational technology in mathematics instruction was influenced by both a sufficient technological infrastructure and skilled IT specialists (Saal et al., 2020). External technological barriers can also hinder the use of digital game in the classroom (Slattery et al., 2023). In the terms of teachers' sides, some problems can affect the teaching quality of using technology. For example, teachers' technophobia can significantly impede the uptake and efficient application of DGBL (Moodley et al., 2020). Digital games that use specialised grammar and vocabulary can limit their educational potential by making it difficult for teachers to incorporate them into their lessons (Shi, 2022). The recent study shows that teachers may be discouraged from making effective use of DGBL tools if the game design is not user-friendly (Saal et al., 2025). In terms of language barrier, Jantjies et al. (2016) emphasized that individuals who are not proficient in English may find it difficult to comprehend and interact with digital tools that are primarily available in English. According to Jääskä and Aaltonen (2022), games that are hard to use or take a long time to set up can cause frustration and make it less likely that they will be incorporated into regular teaching practices. Many still face limited access to devices, internet connectivity, or technical support, especially in schools with fewer resources (Gudmundsdottir & Hathaway, 2020). Under these circumstances, in order to make digital DI truly effective and accessible for all students, schools must support teachers with continuous training and provide the necessary infrastructure.

### 5.4. Implications

This study has empirical, practical and pedagogical implications. This study offers empirical contributions to both DI and educational media development research. By integrating qualitative data from student interviews within a developmental research framework, it provides rich, contextual insights into how gamified learning environments support readiness, interest, and individual learning profiles. Unlike traditional R &D studies that focus predominantly on product effectiveness, this study highlights student perspectives as a critical component in evaluating the pedagogical value of educational games. It also demonstrates how digital media can concretely operationalize theoretical constructs such as DI in authentic classroom settings.

For practical implication, this study offers practical insights for teachers, instructional designers, and school administrators. The wordwall-based educational game developed through this study can be directly adopted or adapted by teachers to differentiate content delivery in various subjects, particularly for elementary school students, who love using technology in learning process. For instructional designers, because of its affordability, web-based accessibility, and user-friendliness, they find it ideal for integrating into elementary school classrooms, particularly in settings with limited resources. Furthermore, students' positive emotional and cognitive reactions indicate that gamified tools like these can enhance formative assessment techniques, improve classroom dynamics, and decrease student disengagement. For school leaders and policymakers, the study demonstrates the magnitude

of supporting teacher training on digital media integration to effectively promote student motivation, engagement, and DI in daily practice.

For pedagogical implication, the findings reinforce the value of interactive, student-centered pedagogy through gamification. For educators, the use of wordwall-based media represents a practical tool for implementing DI without requiring high-level technical skills. Teachers can use wordwall's customisable and sensory-rich formats to manage student diversity, customise content, and improve classroom engagement. By enabling students to interact with content in ways that best fit their learning styles, the media promotes greater autonomy and inclusivity, which improves learning outcomes and participation. This backs up the Merdeka Curriculum's focus on joyful education, student agency, and active learning.

## 6. Conclusion

Positive outcomes have come from this work on the evolution of wordwall-based educational game media. A remarkable rise in students' performance, with post-test scores indicating a notable increase, shows the media's efficacy. The media has also shown inclusive by covering different student learning styles: auditory, kinesthetic, and visual, thereby enabling every student to interact with the content in a manner that best fits them. Interviews provided insights that helped to verify even more that the media helps varied instruction by matching students' personal interests, degrees of readiness, and learning preferences. Ultimately, the platform of created wordwall based educational game media is a useful tool for 21st-century classrooms since it improves academic performance and promotes interesting and individualized learning opportunities. The integration of wordwall-based educational games into the curriculum effectively addresses the diverse learning needs of students studying the human skeleton. By aligning with the principles of DI and leveraging multisensory engagement, such tools can enhance understanding, retention, and overall student satisfaction.

## Limitation

The developed educational game media product has certain limitations. Firstly, it requires an internet connection to function, making it unusable in offline settings. This limitation affects the scalability and inclusivity of such digital tools, as not all students and teachers may have equal access to the necessary infrastructure. It also means that the positive outcomes observed in this study may not be easily replicated in settings where internet access remains a barrier. Secondly, the wordwall platform used in the media has a limited usage period each month, which necessitates a subscription renewal to continue accessing its features regularly. This ongoing cost and usage restriction may hinder long-term or widespread use, particularly in schools with tight budgets or limited access to funding for digital tools. In addition, we just interviewed six participants to ask their perspectives and experiences, which it will result insufficient data or incomprehensive data. Students' perspectives were gathered immediately after they used the wordwall game media, which may have captured more of their initial excitement rather than deeper reflections on long-term learning. Given that young learners often respond enthusiastically to new experiences, it's possible that their positive feedback reflects their enjoyment in the moment rather than sustained academic impact. These limitations do not diminish the value of what was learned, but they do suggest that more research is needed, ideally across multiple schools, involving broader participant samples with a longer implementation period and a wider range of data to better understand how game-based media can be used effectively and sustainably in everyday classrooms to support DI. Thus, for future research, the researchers can develop such media, which can be used without any internet connection.

## Recommendation

Some recommendations can be added for the better development of the media. First of all, for the other researchers, the product development can be further enhanced by adding more

activity features, starting with expanding the material content to move towards an interactive e-module. For stakeholders, the needs to establish professional learning community (PLC) is a priority agenda that the teachers share best practice to improve digital and technology literacy as well as teacher professional development.

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## Conflict of Interest

No conflict of interest was declared by the authors.

## Declaration of Generative AI-assisted Technologies

This manuscript was prepared with the assistance of ChatGPT and QuillBot to assist in language refinement and content organization. All intellectual contributions, critical analysis and final revisions were conducted by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the content presented in this work.

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