Adaptive Game-Based Learning (AGBL) Model: Enhancing Motivation and Engagement through a Financial Literacy Game Prototype

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***Abstract*—This study addresses the need for innovative educational methods, focusing on Adaptive Game-Based Learning (AGBL) to support financial literacy in developing countries, such as Indonesia's secondary schools. As Game-Based Learning (GBL) gains recognition for fostering interactive participation and enhancing motivation, this research develops and tests a tailored financial literacy game prototype for diverse student backgrounds. The AGBL model extends the Dynamical Model for Gamification of Learning (DMGL) by incorporating adaptive game mechanics and the Attention, Relevance, Confidence, Satisfaction (ARCS) motivational framework (Attention, Relevance, Confidence, Satisfaction), thus addressing the DMGL's lack of measurable learning outcomes. Using the Delphi method, expert insights were collected to determine design criteria and evaluation metrics, facilitating consensus on effective GBL elements. The game prototype was tested with 63 students, examining motivation, engagement, and learning outcomes. Findings reveal that adaptive educational games can significantly increase motivation, deepen learning, and improve long-term retention of financial literacy concepts. This study highlights the importance of personalized, adaptable educational tools, showing how these can be applied across different educational themes, especially in diverse and developing education systems like Indonesia's, to boost student engagement and educational outcomes.**

***Keywords*—adaptive game-based learning, financial literacy, high school students, motivation, engagement**

I. Introduction

Over the past decade, financial education has emerged as an essential competency for younger generations [1], particularly in societies that increasingly emphasize individual responsibility and independence. This is especially relevant for young people navigating a complex financial landscape, where a solid understanding of financial literacy—encompassing key concepts and risks—enhances their decision-making abilities [2, 3]. The urgency of preparing young adults to face these dynamic challenges is particularly pronounced in Indonesia. According to the Organisation for Economic Co-operation and Development (OECD)'s 2019 survey, the financial literacy levels of Indonesian high school students were significantly below the average of other member countries, underscoring a critical gap in their preparedness. Financial literacy, however, plays a pivotal role in social and economic development, equipping individuals with the ability to make informed financial decisions that improve their quality of life [1, 2, 4]. The World Economic Forum emphasizes the importance of six essential literacies, including financial literacy, as a foundation for fostering responsible behavior [5]. Similarly, the Asia-Pacific Economic Cooperation (APEC) Guidebook on Financial and Economic Literacy advocates for the integration of financial education into school curricula to develop responsible adults capable of effectively managing their financial lives [6].

In response, the Indonesian Financial Services Authority (OJK) has developed the Indonesian Financial Literacy Strategy [7], which focuses on national education campaigns, infrastructure development, and financial product innovation [8]. This initiative involves collaboration with the ministry of education, culture, research, and technology, the ministry of religious affairs, and the banking sector to integrate financial literacy into the education system, spanning early childhood to university levels [9]. Notable efforts, such as the 2021 Invest Incubation event organized by the Directorate General of Debt Management, illustrate innovative approaches to financial education through the use of books, games, and audiovisual tools [9]. This paradigm shift has spurred various pedagogical innovations within the education sector, leveraging diverse methods to ensure the sustainable delivery of financial literacy content [4, 10, 11].

Among these innovations, Game-Based Learning (GBL) has emerged as an effective method for fostering interactive participation and enhancing student enthusiasm. Research by Aburahma and Mohamed [12] demonstrates that educational games simplify complex concepts through real-life simulations. Additional studies further validate the efficacy of this approach when compared to conventional, passive learning methods [13]. This aligns with Indonesia's Kurikulum Merdeka (Ministerial Regulation No. 12/2024), which advocates for innovative teaching methods designed to enhance cognitive and socio-emotional skills [14]. Furthermore, GBL supports Edgar Dale's Cone of experience theory, which emphasizes deeper understanding and retention through active engagement [13]. Consistently, studies comparing educational games to traditional lecture-based methods have shown that students engaged in games achieve a more profound understanding and retention

of material, along with increased motivation and enjoyment in learning theoretical content [15, 16].

Although previous research has demonstrated the effectiveness of GBL [17, 18], its implementation in developing countries such as Indonesia faces significant challenges due to diverse student demographics, including socioeconomic factors and geographic disparities [19, 20]. For example, generic financial literacy games often fail to reflect students' social realities, resulting in reduced engagement and learning success [20]. Additionally, prior studies have shown that students' financial literacy is influenced by various factors, including family background, socioeconomic status, and time preferences [17, 21, 22]. It is crucial to align educational content with students' daily lives and experiences to ensure material is comprehensible and leads to effective learning outcomes [23, 24]. As Platz and Jüttler [22] point out, failing to consider students' social backgrounds can result in misconceptions about financial concepts—a concern echoed by Aprea and Ifenthaler [17].

To address these challenges, game designers have incorporated the Mechanics, Dynamics, Aesthetics (MDA) framework, developed by Hunicke *et al*. [25], into educational game design. However, as this framework was originally designed for non-educational digital games, its applicability in the education sector is limited. To enhance its relevance, adaptations such as Winn's [26] DPE (Design, Play, Experience) and Walk *et al*.'s [27] DDE (Design, Dynamics, Experience) frameworks have been introduced, better addressing the needs of educational game design. Additionally, Keller's [28] ARCS (Attention, Relevance, Confidence, Satisfaction) model, which emphasizes motivational design, has been integrated with the MDA framework. This integration led to the development of the Dynamical Model for Gamification Learning (DMGL), which combines game design elements with motivational theory [29]. However, the DMGL framework does not sufficiently account for players' specific backgrounds—a critical factor when designing educational games to address the financial literacy needs of Indonesian students. This limitation has been noted by Kim and Lee [30], the creators of DMGL, and further emphasized by Martinez *et al*. [31], who observed that DMGL is not well-suited for evaluating serious games.

To address these gaps, this study introduces the Adaptive Game-Based Learning (AGBL) framework as a significant advancement in educational game design, specifically within the context of financial literacy education. The AGBL framework uniquely adapts game design to accommodate a range of player profiles, thereby overcoming the limitations of previous one-size-fits-all models. By incorporating diverse player characteristics, this framework enhances student engagement, motivation, and learning outcomes, addressing critical gaps in existing GBL models. A prototype developed using this framework was tested on 63 Indonesian high school students, providing empirical insights into its effectiveness in fostering greater engagement in financial literacy education. This study contributes not only to the evolution of educational game design but also offers a tangible example of how adaptive game-based tools can be effectively implemented to improve motivation and participation, particularly in developing countries such as Indonesia. Building on these insights, this study seeks to answer the following research questions: (1) How can game design frameworks be adapted to account for the diverse socio-economic and geographic backgrounds of Indonesian students in financial literacy education? and (2) What is the impact of using an AGBL framework on student engagement, motivation, and financial literacy outcomes?

II. Literature Review

A. Game-Based Learning and Financial Education

Technological advancements have propelled the education sector to adopt innovative methods, including GBL through computer games, which integrate educational elements [11, 31, 32]. Recognized as an effective pedagogical tool, GBL supports student learning, skill acquisition, and training while fostering positive learning behaviors and moods [4, 11, 33–35]. By offering a risk-free platform, GBL allows students to practice skills and explore concepts, serving as an alternative to traditional face-to-face education and promoting active engagement, motivation, and improved learning outcomes [36, 37]. In financial literacy education, GBL emerges as a promising approach, particularly given the mixed results of traditional methods. Studies such as those by Eyupoglu and Nietfeld [18] emphasize the need for more consistent operational constructs and better measurement practices. However, current research in this area often overlooks critical factors like students' socio-economic backgrounds, as highlighted by Aprea and Ifenthaler [17]. This gap underscores the importance of designing GBL frameworks that are inclusive and context-sensitive.

Despite its potential, challenges remain, as Platz and Jüttler [22] noted that high school students using GBL for financial literacy faced difficulties in achieving a comprehensive understanding. This aligns with Carless and Winstone's [38] assertion that effective feedback is crucial for improving learning outcomes. Maintaining motivation in GBL contexts is challenging, as Hwang *et al*. [37] emphasize the critical role of student engagement in ensuring success. In addition, Papadakis [39] offers insights into the importance of ensuring the accuracy and relevance of instruments used in designing GBL to achieve effective learning outcomes. Vergara *et al*. [40] further highlight the necessity of analyzing the profiles of potential game users to optimize GBL design for achieving specific learning objectives. The integration of findings from prior studies [22, 37–40] suggests that it is not only essential to develop an inclusive and context-sensitive GBL framework, but also to account for technical and psychological aspects that influence student engagement and motivation.

In designing GBL, prioritizing meaningful learning experiences and student engagement over mere gameplay is crucial [17], especially in fostering students' ability to synthesize and express information [22, 39]. Despite the advancements in game technology that now enable integration with Artificial Intelligence (AI) [23, 40], there remains a significant gap in research specifically addressing the application of AI in educational games for financial literacy. Huang *et al*. [41] successfully integrated Gamified Project-Based Learning (GPBL) and Artificial

Intelligence-Generated Content (AIGC) to enhance information literacy education in China, but their findings showed no significant differences in student engagement and motivation compared to conventional GBL designs. However, Huang *et al*. [41] highlighted the potential of linguistic creativity, which could have implications for deeper exploration of student experiences and the contextual factors influencing the outcomes of educational games. Therefore, a well-designed GBL framework should carefully balance interactive elements, educational aspects, and content relevance to ensure optimal learning outcomes. Thus, this study aims to address these gaps by developing a GBL framework that enhances financial literacy while also accounting for the socio-economic diversity of students. By addressing these gaps, this study enhances understanding of GBL's role in financial education and offers insights to improve its design and implementation.

B. Challenges in the Design of the Dynamical Model for Gamification of Learning (DMGL)

Despite the current landscape of GBL having evolved to align with the needs and characteristics of the educational sector while addressing problematic elements in game systems highlighted in various literature, challenges persist. For instance, Kim and Lee [30] developed a dynamic educational effectiveness model for gamified learning, known as the DMGL. This framework integrates the strengths of the MDA, Game Design Factors (GDF), ARCS, and Key Characteristics of a Learning Game (KCLG) models to create a more comprehensive approach to educational game design [30, 31]. By aligning the motivational focus of the ARCS model with the structural elements of MDA, Kim and Lee [30] addressed previous limitations in GBL. Additionally, Kim and Lee [30] involved 600 participants and assessed the impact of DMGL by analyzing players' responses across four factors: curiosity, challenge, fantasy, and control. However, their findings indicated significant differences in how age and gender influenced responses to game elements, with men and women reacting differently to aspects of fantasy and challenge, and older women showing heightened sensitivity to challenges. Meanwhile, Martinez *et al*. [31] identified a limitation in GMBL, noting that it is not specifically dedicated to evaluating serious games.

Furthermore, Martinez *et al*. [31], in addressing the issues within DMGL, designed the Gaming Educational Balanced Model (GEB), a measurement metric aimed at evaluating serious games. However, it is not suitable for application in financial education games aimed at students, necessitating adjustments to accommodate players with diverse backgrounds, as highlighted by Aprea and Ifenthaler [17]. Moreover, measurement practices in GBL design have become a crucial focus in this study, a concern also recognized by Kim and Lee [30]. Specifically, the target players' context must be carefully studied to ensure GBL's successful implementation and adoption within the educational sector [17, 18, 22]. Since players utilizing GBL come from varied backgrounds, establishing measurable assessments becomes essential as a reference for educators in guiding students. In this vein, this research has examined the necessity of considering demographic and geographic factors when designing educational games to optimize engagement and learning outcomes.

C. Adaptive Game-Based Learning (AGBL)

The design construct of GBL as a platform supporting student learning must consider optimization within a gamified environment. Prior studies have acknowledged this by striving to create serious gamified learning environments, such as measurement models [31], immersive gamification virtual labs [11, 42], system and design development [43–45], and achieving effective learning motivation [46–48]. Games in education provide opportunities for problem-solving, collaboration, and decision-making in a low-risk setting, fostering deeper understanding and practical application of content. However, while DMGL integrates game mechanics and motivational theory, it falls short in addressing player-specific backgrounds and contexts, particularly in diverse educational settings like financial literacy for Indonesia's student population [20].

Meanwhile, DMGL primarily emphasizes game mechanics and motivational triggers [30] but lacks evaluation metrics [31], particularly the adaptability required to cater to varying socio-economic and cultural backgrounds critical for personalized learning [17, 24]. Relying solely on the fun element in DGBL design can result in overly complex games that fail to positively impact learning [49, 50]. Studies by Martinez *et al*. [31] and Platz and Jüttler [22] highlight the need for models sensitive to players' environments and backgrounds, especially in diverse educational systems. Addressing these gaps, AGBL improves the DMGL framework by integrating elements from the MDA framework and the ARCS (Attention, Relevance, Confidence, Satisfaction) model, providing a holistic and adaptive foundation for GBL [25, 48, 51, 52].

In addition, the MDA framework, developed by Hunicke *et al*. [25], structures game design by balancing mechanics (rules and structure), dynamics (player interactions), and aesthetics (emotional response) [31, 53]. However, it has been critiqued for prioritizing the designer's perspective over the player's, particularly in content-rich educational games [27, 54]. To address this, Duarte and Uhlmann [55] proposed modifications to better align designers' and players' experiences. Complementing the MDA framework, the ARCS model focuses on maintaining attention, ensuring relevance, building confidence, and promoting satisfaction, effectively tailoring motivational strategies to diverse learner profiles [28, 31, 56, 57]. By combining the adaptability of the MDA framework with the motivational aspects of the ARCS model, AGBL offers a dynamic and personalized learning experience. This integration allows real-time adjustments based on the player's progress and background, ensuring the educational content remains relevant and engaging [30, 31]. This personalized adaptation is especially critical for financial literacy education, where socio-economic backgrounds, access to financial services, and prior knowledge vary widely. Consequently, AGBL provides a more effective and inclusive framework for GBL in diverse educational environments.

III. Materials and Methods

A. Research Design

In this study, the Delphi method is used to gather expert opinions on the design criteria and measurement of

educational games that can stimulate motivation and student engagement with a focus on financial literacy in Indonesia. The Delphi method operates through four main features: anonymity, iteration, controlled feedback, and statistical summary [58, 59]. Furthermore, the Delphi method is used for an interactive iterative process to seek expert consensus, make decisions or evaluations, or conduct predictive research [58, 59]. In designing GBL that is expected to address identified issues and gaps [59], the Delphi method serves as a suitable framework for this study. In this research, the Delphi process is carried out over several repeated rounds to achieve consensus among a diverse panel of experts [59], specifically in game design and financial education. Thus, this approach aligns with the research objective of addressing identified gaps in GBL frameworks by developing the AGBL model tailored to Indonesia's unique socio-economic and educational context.

The experts were selected based on their professional backgrounds in educational game design and financial literacy, ensuring that a variety of perspectives were included. This follows Okoli and Pawlowski [59], who emphasize that expert selection is crucial in the Delphi method, requiring knowledge and experience, willingness and availability to participate, and communication skills. Therefore, experts were purposefully chosen using recommendations or snowball sampling [59]. Thus, a panel of nine experts in game design and finance, as shown in Table 1, contributed to the consensus on the AGBL model. These experts, whose board game experience ranged from 5 to over 20 titles and professional experience from under 5 to over 20 years, provided insights through six targeted questions to identify sub-variables for enhancing financial literacy education.

Table 1. Professional qualifications of surveyed experts

Profession	Number of board games played	Length of Professional Experience
Visual Communication Design Lecturer	5 to 10 titles	More than 20 years
Director of Company A	More than 20 titles	5 to 10 years
Game Designer	More than 20 titles	15 to 20 years
Director of Company B	15 to 20 titles	15 to 20 years
Director of Company C	More than 20 titles	5 to 10 years
Game Master	More than 20 titles	Less than 5 years
Consultant	More than 20 titles	15 to 20 years
Financial Educator	5 to 10 titles	15 to 20 years
Lecturer in Financial Accounting	5 to 10 titles	5 to 10 years

B. Pre-Round of Delphi Method

In the initial stage of this study, a Focus Group Discussion (FGD) with experts was conducted to explore their practical experiences in designing GBL, with three key questions posed. The first question focused on determining the design criteria for financial literacy educational games, with expert engagement essential for investigating the defining criteria of educational game design focused on financial literacy in Indonesia. Two simulation rounds were carried out to identify early challenges in expert engagement and response collection. This ensured that the research protocols, including language use and coordination via messaging and meeting apps, were optimized for efficiency. The second question centered on designing an adaptive prototype for a financial literacy game aimed at enhancing motivation and engagement among high school students.

The design of the financial literacy game prototype was guided by the AGBL model, which integrates key components from the MDA and ARCS frameworks, ensuring that the game was both educational and engaging for high school students. The game mechanics, inspired by the local financial literacy game Financial Planner 101, focused on financial simulations and decision-making scenarios [25, 28]. The game's complexity was adaptive, allowing students to engage with the content at their own pace, with game sessions designed to last between 30 and 60 min. The game supported both individual and group play, encouraging collaboration as well as independent learning. The game's narrative and visual design were closely aligned with the financial realities faced by Indonesian students, helping them to relate more deeply to the educational content [52].

Table 2. Validity and reliability test

Construct	Item	Corrected Item-Total Correlation (CITC)	Cronbach's α
Attension	Attension1	0.396	0.881
	Attension2	0.301	
	Attension3	0.354	
	Attension4	0.555	
	Attension5	0.650	
	Attension6	0.322	
	Attension7	0.456	
	Attension8	0.559	
Relevance	Relevance1	0.682	0.881
	Relevance2	0.406	
	Relevance3	0.319	
	Relevance4	0.559	
	Relevance5	0.470	
	Relevance6	0.511	
	Relevance7	0.444	
	Relevance8	0.555	
	Relevance9	0.678	
Confidence	Confidence1	0.552	0.876
	Confidence2	0.328	
	Confidence3	0.410	
	Confidence4	0.545	
	Confidence5	0.325	
	Confidence6	0.697	
	Confidence7	0.604	
	Confidence8	0.535	
Satisfaction	Satisfaction1	0.363	0.878
	Satisfaction2	0.589	
	Satisfaction3	0.516	
	Satisfaction4	0.633	
	Satisfaction5	0.724	
	Satisfaction6	0.639	
	Satisfaction7	0.477	
	Satisfaction8	0.667	
	Satisfaction9	0.425	

The final question focused on testing the outcomes of the newly designed financial literacy game using an experimental method. The prototype was tested with 63 twelfth-grade students from vocational high school in Surabaya and Mojokerto, and their motivation and engagement were assessed using the ARCS model. Observational data was collected during gameplay to measure attention, while post-game questionnaires were administered to evaluate relevance, confidence, and satisfaction [52]. The questionnaire asked students to reflect on the engagement of the financial scenarios, how well the game helped them understand financial decision-making, and

how confident they felt in managing their finances after playing. The ARCS framework guided the analysis of student motivation, ensuring the game captured their attention, demonstrated relevance to their personal financial experiences, and boosted their confidence in financial management, ultimately providing a satisfying learning experience.

This study also examined the reliability and validity of the instrument using a five-point Likert scale. As part of the process to evaluate the design of the AGBL game, a questionnaire was distributed to 63 twelfth-grade students from a vocational high school who served as the study's target participants to ensure accuracy and reliability. The validity and reliability tests were conducted using SPSS statistical tools. For validity, the study employed the Corrected Item-Total Correlation (CITC) with a minimum threshold of 0.15, as suggested by Bujang *et al*. [59]. Reliability, on the other hand, was assessed using Cronbach's α, with a minimum threshold of 0.5 [60]. As shown in Table 2 below, the results indicate that the validity and reliability values exceeded the recommended minimum thresholds, confirming the robustness of the instrument used in the study.

C. Data Collection

In this study, data collection is divided into quantitative and qualitative types, with several variables being collected beyond player profiles, namely engagement and motivation. Player engagement variables are collected through observations of emotions and actions during gameplay and processed using observation notes and interviews. Motivation variables are collected using an ARCS-based Likert scale questionnaire consisting of 34 questions, employing the Course Interest Survey (CIS) type due to its suitability for both offline and online implementation. Player profiling is conducted using open-ended questionnaires to gather personal data and classify respondents according to the research needs.

Qualitative data is collected during gameplay experiments, where researchers observe player behavior and emotional responses based on actions taken during the game. These observations are documented as game history and recording analysis. Post-game interviews are conducted as a means of triangulation to discuss player satisfaction and motivation, with questions focused on personal experiences and the impact of the gaming experience. Furthermore, Richardson [61] measured the interaction variable by mapping the customer journey and its impact on their engagement with a product or service, with engagement levels represented by emoji symbols that convey emotions at various touchpoints. This approach helps identify critical interaction moments or "moments of truth," enhancing the customer experience by guiding designers on necessary improvements.

Therefore, this study uses observational variables to establish emotional criteria, categorizing player emotions during game interactions into levels of enthusiasm, focus, and enjoyment. Observations of player interactions with game elements are carefully recorded during each phase of gameplay. Observations of player interactions with game elements are meticulously noted during each phase of gameplay. These observations serve as references for subsequent interviews to delve deeper into the reasons behind players' actions. Motivation measurements employ the ARCS model, with a 34-question questionnaire distributed to participants. The responses are analyzed to derive average scores for the ARCS components according to Keller and Keller [62]. These average scores are then used to draw conclusions about the players' motivation.

D. Ethical Approval

This study received ethical approval from the Directorate of Research and Community Service (DRPM) of Institut Teknologi Sepuluh Nopember, with approval number 1516/PKS/ITS/2023. The research adhered strictly to the principles outlined in the Declaration of Helsinki, ensuring the highest ethical standards in research involving human participants. All participants were informed about the purpose, procedures, and potential risks of the study. Written informed consent was obtained from all participants prior to their involvement, ensuring their voluntary participation. Participants were assured of confidentiality and anonymity, and they retained the right to withdraw from the study at any time without any repercussions. The collected data were securely stored and used solely for the purposes of this research.

E. Measurement

The educational content for financial literacy is derived from various frameworks established by organizations and previous research. For instance, the OECD categorizes financial literacy into four main frameworks: (1) money and transactions, (2) planning and managing finances, (3) risk and reward, and (4) the financial landscape, specifically targeting high school students. Similarly, Indonesia's Financial Services Authority (OJK) employs these frameworks, focusing on adults and retirees. Indonesia's Ministry of Education and Culture adapts these frameworks to emphasize fundamental financial behaviors: (1) saving, (2) spending, (3) sharing, and (4) investing. Nadolny *et al*. [52] have also developed a curriculum based on OECD/PISA principles but with a more practical application. Based on these references, this study will primarily utilize the OECD/PISA framework along with additional financial literacy components from the Ministry of Education and Culture, focusing on principles such as simple living and charity in the educational material.

Regarding the measurement of engagement and motivation, various studies provide insights into how these can be effectively assessed in GBL environments. Previous research has identified several variables of engagement in GBL, including involvement, motivation, and interaction, as noted by Pesare *et al*. [63], and emotional, cognitive, and behavioral factors highlighted by Schindler *et al*. [64]. Bangalee *et al*. [65] emphasize the cognitive, emotional, and social aspects, while Wang and Liu [66] focus on classroom interaction, learning satisfaction, and game acceptance. This study will adopt the modeling from Pesare's research as the primary reference, which clearly distinguishes between motivation and engagement both theoretically and in measurement, concentrating on satisfaction, motivation, and knowledge as key metrics. This approach aligns with the ARCS model by Keller [28] for measuring student motivation, utilizing tailored questionnaires to collect data.

The study will employ the DMGL framework proposed by Kim and Lee [30] for designing adaptive games, as it integrates elements from all frameworks and incorporates the ARCS model, making it the most comprehensive and suitable for this research.

IV. Result

A. Determination of GBL Design Criteria for Financial Literacy in Indonesia

The financial literacy framework model was developed using the Delphi method, gathering expert opinions to identify variables for designing an educational game. Prior to consulting the experts, two simulation processes were conducted to test the survey instruments and research protocols. In the pre-round of the Delphi method, during the first stage, experts were asked to evaluate the key elements of GBL, with the order of questions in each expert questionnaire randomized to avoid bias [59]. In the second stage, the participating experts were asked to re-evaluate the key elements of GBL using the same mechanism. This process aimed to emphasize consistency in the experts' responses. Descriptive statistical analysis of the results from the first and second stages, including the mean and standard deviation, revealed no significant differences in the rankings (see Table S1). This consistency in expert responses demonstrates the reliability of the evaluation process, ensuring the robustness of the methodology. Furthermore, the lack of significant differences across stages highlights a shared consensus among the experts, reinforcing the validity of the identified key elements.

To further strengthen these findings, quartile analysis was also conducted, which revealed minimal variation in the rankings of the key elements between stages. In Stage 1, the Interquartile Range (IQR) was 0.89, and in Stage 2, the IQR decreased slightly to 0.53. These results demonstrate a strong consensus among the experts, further supporting the consistency and reliability of the evaluation process. The responses were analyzed during a FGD, where similar sub-variables were merged. Additional variables from Kim and Lee's [30] DMGL framework were incorporated where necessary, as indicated by an asterisk in Table S1.

Although Skulmoski *et al.* [67] suggest that the Delphi method typically involves 4 to 170 experts, the specific number of experts for this project was not predetermined. Sub-variables specific to video games were excluded to focus on offline and physical media. The Delphi method was employed to compile and rank numerous sub-variable elements within the MDA framework. Responses from the nine experts were consolidated, and sub-variables scoring below the group average were eliminated. The panel reviewed and approved the remaining sub-variables, with no group showing a disagreement rate exceeding 60%, as detailed in Table S2, thereby validating the results. These sub-variables were subsequently organized into the MDA framework and aligned with the ARCS components from Kim and Lee's [30] DMGL. This integration resulted in the development of the AGBL model framework (Fig. 1), designed to enhance financial literacy education.

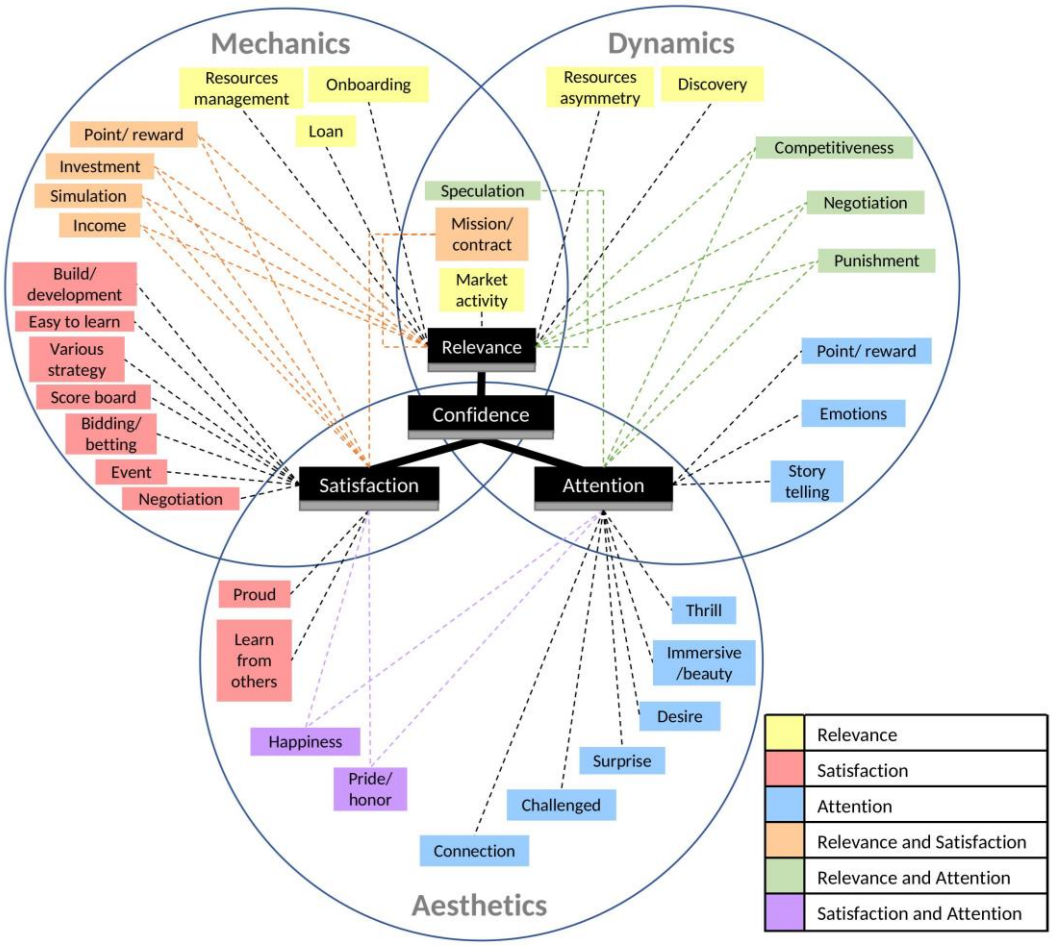

Fig. 1. AGBL model for the financial literacy education game.

Mechanics sub-variables that ranked highest for relevance include simulation and resource management (rank 1), investment (rank 2), and mission/contract (rank 3). Simulation emphasized using real-world analogies, financial terms, and practical case examples. At the same time, resource management taught students to handle money for asset growth and liability payments, which tied into investment sub-variables involving profit/loss outcomes. For satisfaction, the top mechanics were simulation, ease of learning, and building/development, where the experts believed that allowing players to experiment without real financial risk was critical. In the dynamic category, mission/contract, competitiveness, and negotiation ranked highest for relevance and attention, as competition and interaction mirrored real-life financial decisions. Aesthetics sub-variables like pride/honor, challenge, and surprise were vital in maintaining attention and fostering long-lasting satisfaction, with immersive elements such as visuals, clarity, and narrative design also playing an essential role in enhancing engagement, as aligned with Duarte and Battaiola's [54] findings. The AGBL model also incorporated practical elements, making it accessible without advanced technology or the internet, a notable difference from the DMGL. model, which is more suited for digital environments (Table S3). Despite this, both models share familiar mechanics (onboarding, leaderboard, goals) and aesthetics (pride, thrill, surprise) that motivate players to apply real-life financial literacy skills.

B. Development of the Adaptive Financial Literacy Game-Based Learning Prototype

The design criteria for financial literacy GBL are based on the Conceptual Framework developed in the previous stage. Each criterion is then implemented into the game prototype. This phase involves mapping the criteria according to game aspects (i.e. MDA) and motivation aspects (i.e. ARCS), which are then translated into technical responses to be incorporated into the prototype. The criteria mapping for the AGBL model, as shown in Table 3, details how different game aspects correspond to the motivational aspects from the ARCS model. This structured mapping ensures that each game element is purposefully designed to enhance specific motivational outcomes.

Table 3. Mapping the design criteria of educational financial literacy games

Aspects	Mechanics	Dynamics	Aesthetics
Relevance	Simulation, Resource management, Investment, Mission/contract, Market activity, Loan, Income, Onboarding, Point/reward, Speculation	Mission/contract, Competitiveness, Negotiation, Resource asymmetry, Speculation, Market activity, Discovery, Punishment	
Satisfaction	Simulation, Easy to learn, Build/development, Point/reward, Mission/contract, Negotiation, Bidding/betting, Various strategy, Events, Investment, Scoreboard, Income		Pride/honor, Proud, Happiness, Learn from others
Attention		Competitiveness, Negotiation, Speculation, Point/reward, Emotions, Punishment, Storytelling	Challenged, Pride/honor, Surprise, Happiness, Immersive/beauty, Thrill, Connection, Desire

Building on this foundation, the implementation of the design criteria is demonstrated by creating a prototype of a financial literacy game. This prototype is based on adapting and redesigning a board game, Financial Planner 101, to meet the research requirements. The key elements in developing the prototype include the number of players, duration, gameplay, and complexity rating. The game can be played by 2 to 4 players, with the optimal number being four. This number is sufficient to facilitate interaction and maintain a competitive atmosphere. The maximum of 4 players also considers the downtime players experience while waiting for their turn and aligns with the average class size in schools, which typically ranges from 20 to 30 students. Each game session lasts between 30 and 45 min, which is ideal given the time constraints of high school students' schedules. This duration allows for gameplay, post-game evaluation, and additional instruction from teachers or mentors.

The game's flow is designed according to the criteria established in the previous section, incorporating elements such as simulation, resource management, investment, individual missions, market activities, debt, income, rule clarity, point systems, speculation, ease of rules, progress, negotiation, bidding, strategy variation, events, and point markers. The game rules are designed to be as simple as possible to ensure easy comprehension, and they can be explained within 10 to 15 min. According to the complexity rating scale on boardgamegeek.com, this game falls within a complexity rating of 2/5, indicating it is relatively easy to understand and play.

Table 4. Design phases of the game prototype

Phase	Description
Early Phase of Round	Consists of 3 stages:
	1. Income: 6 coins to each player (expert mode: +1 for each bond card)
	2. Exchange deposit cards for 9 coins (if any)
	3. Return insurance cards (if any)
Playing Phase	Consists of 5 actions each player can perform:
	1. Buy Asset and Spending Cards
	2. Sell Assets
	3. Negotiate Spending Cards
	4. Buy insurance cards
	5. Give Donations
End Phase of Round	Consists of 2 stages:
	1. Give 1 event card randomly to each player
	2. Asset Fluctuations: Open fluctuation card and adjust asset prices

The game prototype is designed to be completed in 5 rounds, each with several phases. The beginning phase starts with each player receiving an income of 6 money, plus an additional one money for each bond card held in advanced mode. Deposit cards are exchanged for nine money, if any, and insurance cards are returned. During the gameplay phase, players have five possible actions: buying asset cards and

shopping cards, selling assets, negotiating shopping cards, buying insurance cards, and donating. The end phase involves each player receiving a random event card, and asset prices are adjusted by revealing fluctuation cards and subsequent price modifications. The details of each phase can be seen in Table 4.

The technical response criteria for AGBL are divided into mechanics, dynamics, and aesthetics, focusing on creating the expected motivational responses from players throughout the game. In mechanics, criteria such as simulation, resource management, investment, mission/contract, market activity, loan, income, onboarding, point/reward, and speculation are considered. For dynamics, criteria include mission/contract, competitiveness, negotiation, resources asymmetry, speculation, market activity, discovery, and punishment. Aesthetics criteria focus on eliciting emotional responses such as pride/honor, pride, happiness, learning from others, challenge, surprise, immersion, thrill, connection, and desire. The adaptive aspects of the game include modular elements that allow players to choose educational content and personalize their gameplay experience. These modules include a money generator, a spending module, and a private area module, each offering various options to suit the players' needs and preferences. The adaptive design ensures high levels of engagement and emotional connection by providing flexibility in avatars, goals, entertainment choices, currency, money generators, asset types, and more.

The money generator module features mechanics for generating wealth, with various action choices available to players to produce income within the game. This module includes options for investment and small businesses. The spending module involves mechanics to generate points or scores, offering diverse actions for players to spend their wealth in order to gain points. This module includes entertainment cards and insurance options. The private area module pertains to what each player owns in the game, including elements that support players' choices, such as wealth (money and assets), set collections, events experienced, and goals.

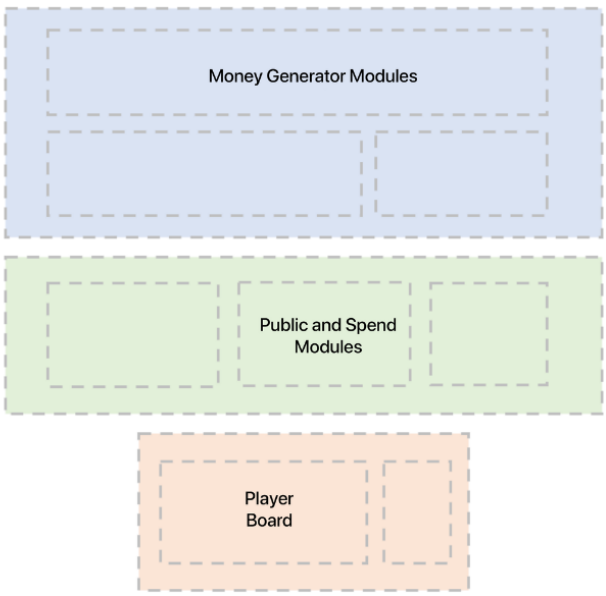

Fig. 2. Modular system in AGBL.

Additional adaptive elements include avatar cards representing various archetypes and personalities, covering aspects such as gender, body shape, activity poses, and attributes. There are blank spaces for players to fill in their identity details (name, nickname, profession). Dream cards provide goal options divided into eight categories relevant to the target audience, with blank spaces for players to add details about their personal goals. Entertainment cards offer choices across four categories pertinent to the target audience, with blank spaces for additional player-selected details. The currency denominations allow gameplay with either small or large nominal values, accommodating both beginners and experienced players. The money generator module includes options for investment and small businesses, with players agreeing on which module to use before starting. The asset types are modular, with agreements on which modules to play, including options such as gold, stocks, deposits, mutual funds, cryptocurrencies, and bonds, each accompanied by ownership and fluctuation cards.

The detailed phases and adaptive elements are further elaborated in the appendices, providing comprehensive guidelines for implementing these design criteria into a cohesive game prototype. The game prototype aims to improve financial literacy among high school students in Indonesia by ensuring relevance, satisfaction, and attention through carefully designed game mechanics, dynamics, and aesthetics. This prototype offers a comprehensive educational experience tailored to the needs of its target audience, promoting high levels of engagement and emotional connection. The details of each phase can be seen in Table 4, and the specific elements involved in each adaptive aspect are further explained in Fig. 2.

The financial literacy game incorporates various components to enhance educational outcomes and player engagement, as shown in Table S4. These components include avatar cards, initial capital/resource cards, dream cards, entertainment cards, debt cards, currency, bank checks, various asset cards (such as deposits, gold, mutual funds, stocks, bonds, crypto, trading, content, and culinary business), fluctuation cards for different assets, insurance cards, event cards, donation envelopes, boards for different game modes (beginner, advanced, small business), Bank and Insurance Board, Entertainment Cards Board, Happiness Point Tokens, Player Aids, and a Rulebook. These elements are meticulously designed to map onto the game's mechanics, dynamics, and aesthetics, aligning with motivational aspects from the ARCS model. This structured approach ensures that each game component is purposefully integrated to create an immersive and educational experience for high school students, facilitating their understanding of financial literacy concepts through engaging gameplay. The game's detailed phases and adaptive elements are elaborated in Table S5. The visual components of the game are designed to implement the DMGL framework, encompassing various elements such as avatar cards, initial capital cards, dream cards, entertainment cards, debit cards, currency, bank checks, asset cards, asset fluctuation cards, insurance cards, event cards, donation envelopes, and various boards for different gameplay modes. Each component is tailored to reflect real-world financial scenarios and educational objectives, enhancing the game's realism and engagement.

(a)

(b)

Fig. 3. (a) Beginner mode investation; (b) Expert mode investation.

There are two investment mode options: Beginner Mode and Advanced Mode. The primary difference between these two modes lies in the Wealth Generation Module. Beginner Mode offers three asset choices: stocks, gold, and deposits, as shown in Fig. 3(a). In contrast, Advanced Mode includes three different asset choices: cryptocurrency, mutual funds, and bonds, as shown in Fig. 3(b). Other components within the shopping module and private area module are the same for both modes, with the exception that players can choose the nominal value of the transaction currency used, selecting either money for small to medium denominations or checks for medium to large denominations. In addition to these modes, there is a Small Business Mode in the Wealth Generation Module, which focuses on three types of businesses: culinary, content creation, and trading. In this mode, other components within the shopping module and private area module remain unchanged from the basic setup, except for the nominal value of money or checks. This mode follows the same principles as the other two modes, providing consistency in gameplay while allowing for a focus on entrepreneurial activities.

C. Motivation and Student Engagement in Financial Literacy Games

In October 2023 and September 2024, a trial of the TATA

HARTA financial literacy game prototype was conducted with 63 twelfth-grade students from State Vocational High Schools in Surabaya and Mojokerto. Surabaya represented respondents from a large city in East Java, while Mojokerto represented respondents from a rural area. Each session lasted 120 minutes, including an introductory financial literacy presentation, gameplay instructions, playing the game, group discussion, and a questionnaire. Students were divided into sixteen groups with 3–4 members each, playing the prototype under the supervision of a game master. The trial used the investment mode, focusing on assets such as gold, stocks, deposits, mutual funds, bonds, and cryptocurrencies.

Several logistical issues were noted, such as the need for thicker game board material and a more efficient setup process. The highest score achieved was 31 points, with the average group score ranging from 17 to 25 points, which falls into the fairly high category, indicating that the respondents could understand and play it well. After the gameplay, a 34-question Likert scale questionnaire based on the ARCS model was used to evaluate student engagement and educational impact, focusing on attention, relevance, confidence, and satisfaction, as outlined in Table S6. Data analysis revealed diverse responses across different income groups. Middle-income students showed the highest engagement, particularly in terms of gameplay attention, while lower-income students were most attracted to the game's visual and thematic elements. In terms of relevance, middle- and upper-income respondents found the game's content highly applicable to their financial learning needs. Confidence levels were strongest among middle-income participants, who felt well-equipped to navigate the game. Lower-income students expressed the highest satisfaction, enjoying the learning experience regardless of their game performance. Overall, the educational effectiveness of the game was evident across different socio-economic backgrounds, with each group responding uniquely to the game's motivational and educational components.

V. Discussion

In this study, the AGBL model is designed to expand the DMGL framework into an educational game model specifically tailored for financial literacy education. This model aims to address gaps related to evaluation measurement that are not accommodated in the DMGL, as also noted in previous research [31]. Several issues highlighted in this research are to be developed and their relevance to the education sector in Indonesia is emphasized. The Delphi method was used in this study, involving experts in designing AGBL, which includes determining design criteria, developing a prototype, and testing the results of the financial literacy game design focused on student motivation and engagement. Thus, the determining criteria for game aspects (i.e. MDA) and motivation aspects (i.e. ARCS) are integrated to create an AGBL learning experience that stimulates student motivation and engagement, potentially enhancing educational outcomes related to financial literacy. This aligns with the emphasis by Aprea and Ifenthaler [17] that measuring GBL is necessary to understand learning outcomes in financial literacy so that students can apply these skills in the real world. Therefore, this study contributes to addressing gaps in the development of the DMGL framework, even though Martinez *et al*. [31] have created GEB metrics for evaluating serious games. However, they still do not highlight the characteristics of students from diverse backgrounds, which is emphasized by Aprea and Ifenthaler [17].

The findings of this study underscore the significant potential of the AGBL model in advancing financial literacy education, particularly in diverse and complex contexts such as Indonesia. By incorporating adaptive game design, the AGBL model effectively accommodates a wide range of player characteristics, including variations in socioeconomic status, cultural backgrounds, and learning preferences. This adaptability ensures that the educational experience is both inclusive and relevant, enabling students from different backgrounds to engage meaningfully with the content. The integration of the ARCS model further enhances the generalizability of the AGBL framework by addressing universal motivational needs—attention, relevance, confidence, and satisfaction—that transcend specific demographic or geographic boundaries. This alignment with motivational theory allows the model to foster engaging and supportive learning environments, promoting both enthusiasm and sustained participation among students. The inclusion of real-life financial scenarios adds another layer of relevance, ensuring that the learning process is applicable across diverse social contexts and increasing the likelihood of concept retention. This approach sets a precedent for future advancements in adaptive and inclusive GBL methodologies.

The findings of this study have several important managerial implications, particularly for educators, curriculum developers, and educational game designers. First, integrating adaptive elements into educational games, as demonstrated by the AGBL model, serves as a powerful tool to enhance student engagement, motivation, and learning retention. This suggests that educational institutions should consider adopting AGBL tools, especially in areas like financial literacy, where diverse student backgrounds and learning styles must be addressed. Furthermore, the use of motivational frameworks, such as the ARCS model, can significantly boost students' confidence and satisfaction, making learning more interactive and enjoyable. Educational policymakers and school administrators can leverage these insights to develop more tailored and engaging learning experiences that can be implemented across various subjects. For game designers, this research underscores the importance of incorporating real-life scenarios and adaptive mechanics to ensure that educational games remain relevant and effective for students from different socioeconomic backgrounds. By adopting these practices, educational systems can enhance their pedagogical approaches, leading to improved student outcomes and more dynamic learning environments.

Meanwhile, to address resource constraints in implementing games within the educational sector, AGBL is designed to produce adaptive educational games, allowing it to adjust to the needs of players—focusing specifically on financial literacy. Therefore, stakeholders should carefully determine the educational content required by students, such as whether to prioritize learning about investment, saving, or a general understanding of financial literacy. This targeted approach ensures that AGBL does not necessitate high costs

to produce a complex prototype encompassing all possible content; instead, it focuses solely on the essential material. Additional content can be incorporated into the board game incrementally as supplements or add-ons.

As this study remains in the development stage of the AGBL design, several potential limitations are evident. First, the effectiveness of the AGBL model may be influenced by the technological infrastructure available in educational settings. In areas with limited access to high-quality gaming platforms or reliable internet connectivity, the adaptability and overall effectiveness of the model could be compromised. Future research should examine how the AGBL model can be optimized for varying technological contexts to ensure accessibility for all students. Second, the study primarily focuses on Indonesian high school students. While this provides valuable insights into the local context, the findings may not be directly generalizable to other regions or educational settings. Future studies could involve a larger, more diverse sample, including students from different countries or educational systems, to assess the broader applicability of the AGBL model. Finally, the study evaluates the immediate post-game impact of educational games on financial literacy. However, the long-term effectiveness of GBL—particularly in retaining knowledge and fostering sustained financial behaviors—remains unexplored. Building on the work of Nadolny *et al*. [52], future research could explore whether initial improvements in engagement and motivation translate into lasting knowledge retention and practical application over time.

VI. Conclusion, Limitation, and Future Work

The primary objective of AGBL is to facilitate the development of educational games that are adaptable to diverse learner needs. This research demonstrates conclusively that financial literacy games incorporating adaptive elements, grounded in the ARCS model, can significantly enhance student engagement and learning outcomes. By integrating game mechanics such as simulation, resource management, and investment with educational objectives, these games make financial literacy concepts more accessible and engaging for high school students. The adaptability to different learning paces and preferences further underscores the effectiveness of these games across diverse demographic settings, highlighting the critical role of adaptability in educational tools. The findings provide practical insights for educators and game designers, serving as a valuable reference for the design of GBL systems, not only for financial literacy but also for other educational themes. This approach is applicable to both digital and physical games. For educational institutions, particularly those in regions with diverse student populations, such as Indonesia, incorporating adaptive learning tools can significantly enhance both educational outcomes and student engagement.

The AGBL approach presented in this study, while promising, has notable limitations. The primary constraint lies in its narrow demographic and geographic focus, as the study exclusively examines high school students from a specific region. This limited scope may not sufficiently capture the diversity of responses to GBL across broader populations. Future research should aim to include participants from varied age groups, educational levels, and geographic areas to enhance the generalizability of the findings. Additionally, potential biases in the sample—such as differences in socioeconomic, cultural, or educational backgrounds—should be acknowledged and mitigated in subsequent studies. Addressing these biases would provide a more nuanced understanding of how diverse groups interact with and benefit from GBL. To advance the field, future research could explore innovative methodologies for assessing the long-term impacts of AGBL, such as longitudinal studies or mixed-method approaches that combine quantitative evaluations with qualitative insights. Furthermore, incorporating diverse game designs tailored to various learning styles could offer valuable insights into how customization influences educational outcomes. Collectively, these efforts would provide a comprehensive roadmap for deepening our understanding of the role of GBL in education.

As education systems worldwide strive to adapt to the dynamic demands of the 21st century, integrating AGBL tools offers a unique opportunity to revolutionize teaching and learning practices. This study serves as a stepping stone toward reimagining how educational games can be designed, implemented, and evaluated. By continuously refining and expanding the AGBL framework, educators, researchers, and policymakers can work together to create more engaging, inclusive, and impactful learning experiences. These efforts are not only timely but also essential for preparing learners with the skills and knowledge needed to thrive in an increasingly complex world. The urgency to act is clear, as the rapid pace of technological and societal change demands innovative educational approaches that ensure no learner is left behind.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

In this study, each author contributed to the development of the research. Rabendra Yudistira Alamin conducted research involving data collection, the design of the game-based learning system, and writing of this article; Ellya Zulaikha. assisted in research focused on research methodology, game-based learning guidelines, and supervising the study; I Ketut Gunarta and Putri Dwitasari reviewed and refined the research; and Luqman Lee finalized the article draft. All authors had approved the final version.

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