Use of gamification and game-based learning in educating Generation Alpha: A systematic literature review

Article *in* Educational Technology & Society · April 2024

DOI: 10.30191/ETS.202404_27(2).RP03

CITATIONS
2

READS
3,000

2 authors:

Pumudu A. Fernando
Informatics Institute of Technology
24 PUBLICATIONS **153** CITATIONS

SEE PROFILE

Salinda Premadasa
Sabaragamuwa University of Sri Lanka
26 PUBLICATIONS **81** CITATIONS

SEE PROFILE

Fernando, P. A., & Premadasa, H. K. S. (2024). Use of gamification and game-based learning in educating Generation Alpha: A systematic literature review. *Educational Technology & Society*, *27*(2), 114-132. https://doi.org/10.30191/ETS.202404_27(2).RP03

Use of gamification and game-based learning in educating Generation Alpha: A systematic literature review

Pumudu A. Fernando[1] and H. K. Salinda Premadasa[2*]

[1]Department of Computing, Informatics Institute of Technology, Sri Lanka // [2]Centre for Computer Studies, Sabaragamuwa University, Sri Lanka // pumudu.research@gmail.com // salinda@ccs.sab.ac.lk

[*]Corresponding author

(Submitted December 13, 2022; Revised June 11, 2023; Accepted June 16, 2023)

ABSTRACT: Children born after 2010 are labelled as members of Generation Alpha, who currently pursue their primary education. Gamification and game-based learning methodologies have gained popularity in the global education sector in the recent past. The goal of this study is to investigate the present state of adopting gamification and game-based learning for primary education student cohorts, with the aid of recent peer-reviewed research publications. By employing a systematic mapping design, reviewed paper results are categorized and further evaluated in relation to the attributes such as type of gamification, game mechanics and elements used, evaluation context, type of experimental outcome, gamified academic subject area, and type of application. With the aid of review results, this study proposes a mapping of gamification learning mechanics, suited to address Generation Alpha traits. It also recommends future research directions, which include investigating the realistic learning preferences of Generation Alpha, the need for designing novel educational game elements and adaptive gamification learning strategies, and the importance of long-term studies with diverse learner samples. The findings of this study will support prospective stakeholders, such as researchers, educators, parents, and educational policymakers, to utilize gamification approaches effectively in educating Generation Alpha.

Keywords: Gamification, Game-based learning, Adaptive learning, Generation Alpha, Primary education

1. Introduction

Generation Alpha is the latest generation of digital natives (Prensky, 2001). Kids belonging to this generation spend a considerable amount of time with games and technical devices. Hence, technology and game-based pedagogical approaches significantly impact the primary education process compared to traditional teaching methods (Fokides, 2018). Since Alphas' first generation was born after 2010, these kids are presently pursuing their primary education (including preschool and kindergarten) (Culala, 2016).

Due to the evolution of the global educational system and the skills of new generations, the teaching-learning process has undergone substantial changes. Hence conventional teaching methods are no longer suitable for Generation Alpha students (Chowanda et al., 2020). Therefore, a shift in learning engagement is expected in educating Generation Alpha, with schools switching from structural and auditory learning to engaging, visual, multimodal, and hands-on methods (McCrindle & Fell, 2020). Educational games are popular learning platforms in this digital age (Callaghan & Reich, 2020). Gamification and educational games support the development of students' motivational, cognitive, social, and emotional outlooks (Saxena & Mishra, 2021). Thus, it will be essential to determine whether prevailing gamification techniques can meet the specific learning requirements of Generation Alpha.

This study aims to perform a systematic literature review on educational gamification and game-based learning (GBL) applications in primary education, emphasizing Generation Alpha's characteristics. Although several recent literature reviews were conducted with regard to gamification and education (Dichev & Dicheva, 2017; Dos Santos et al., 2020; Hallifax et al., 2019; Saxena & Mishra, 2021; Swacha, 2021), none of these studies are explicitly focused on the influence of gamification on Generation Alpha or primary education sector.

Section Two of the paper introduces Generation Alpha and its unique attributes, followed by types of gamification techniques and their importance to education. Section Three elaborates on the systematic literature review process, accompanied by paper selection criteria. Section Four discusses the evaluation results of selected studies. Limitations of present studies and the future research requirements for this research domain are discussed in the final section.

2. Background

2.1. Education and Generation Alpha

Children who were born after the year 2010 belong to Generation Alpha. This generation is predicted to be the largest, most globally connected, and most influential generation with good technology awareness (McCrindle & Wolfinger, 2014).

App-based play, increased screen time, shorter attention spans, and high digital literacy are general characteristics of Generation Alpha (McCrindle & Fell, 2020). They could learn touchscreen and effortlessly navigate through numerous apps on smartphones by the age of two. They spend about 7-8 hours daily using mobile devices to explore the internet, use social media, and play games (Jha, 2020). Compared to Generation Z, Generation Alpha is found to exhibit behaviors like being more curious, free from any rules, more ill-tempered, more mobile, and self-centered (Apaydin & Kaya, 2020).

Gen Alpha students' learning styles will be heavily connected with technology. New approaches to teaching, such as experiential learning, will play a key role in their educational process due to the different cultural and academic expectations of Gen Alpha (Ziatdinov & Cilliers, 2021). Active engagement and hands-on experience will become core aspects of Alpha generation learning, rather than passive techniques such as memorizing textbooks or listening to teachers (Romero Jr, 2017). Hence, the development of new learning systems in physical and virtual aspects is required to cater to the learning needs of Gen Alpha (Kaplan-Berkley, 2021).

When learning environments integrate digital devices, such as computers or tablets, young children's learning has become collaborative and influential, and their social skills are developed naturally (Kaplan-Berkley, 2021). Digital playing techniques extend the space for collective activities with children's imaginative play, media characters, and experiences (Kaplan-Berkley, 2021). Children of the Alpha generation have improved hand-eye coordination and visual capabilities due to spending more time playing digital games (Turk, 2017).

The recent COVID-19 pandemic led to a growth in the global distance learning process. Both students and parents used mobile devices like smartphones, tablets, and computers to access school materials (Ziatdinov & Cilliers, 2021). Hence the use of digital devices, distance learning techniques, and collaborative learning environments has become more widespread in global education systems in recent years.

2.2. Gamification and game-based learning

Gamification is defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011, p. 10), which was initially attributed by Nick Pelling in 2003 (Werbach & Hunter, 2012). This concept is also interpreted as "using game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems" (Kapp et al., 2014, p. 54). While components of games such as points, badges, and challenges are employed in gamification, the goal is not to build a game. The idea is to incorporate game features to motivate learners to engage with the content and advance toward a goal (Kapp et al., 2014). Gamification has also been proposed as a new educational theory due to its widespread usage in education (Lavoué et al., 2019). Gamification-based learning domain is further elaborated under two categories, "structural gamification, and content gamification" (Kapp et al., 2014, p. 55).

Structural Gamification describes the application of game elements into a learning environment without altering the original learning materials (Kapp et al., 2014). Game elements such as points, levels, badges, leaderboards, and reward systems are used in structural gamification contexts to keep learners interested and progressing through the content.

Content gamification is the "application of game elements, game mechanics, and game thinking to alter content to make it more game-like" (Kapp et al., 2014, p. 55). This type involves game elements such as story, challenge, curiosity, mystery, and characters to engage the learner, which will partially restructure the initial learning materials to be compatible with the gamified learning environment.

In game-based learning (GBL), the course content is mapped into a game, to provide a virtual environment of learning, improved self-learning, continuous interaction and feedback which can increase the interest and motivation in learning (Ucus, 2015). GBL is an educational strategy that blends game activities with stated learning outcomes and improves teaching, learning, assessment, and evaluation with computer games.

Educational games can be categorized into different genres, including puzzle, strategy, adventure, role-playing, and casual games (Chen et al., 2020a). Type of game can determine the specific learning experiences and outcomes and can be tailored to meet the learning objectives and goals of the educational program.

Though game-based learning and gamification are usually considered as distinct entities, comparing the definitions of content gamification and game-based learning, it is evident that both aspects share similar features. Hence the lines separating content gamification and game-based learning have become blurred. A comparative analysis has been conducted between content gamification, structural gamification, and game-based learning to distinguish the characteristics of these approaches. The analysis focused on the design goals, game elements, content modifications, primary focus, and sample applications of each approach to provide a better understanding of their differences. Comparison results are presented in Table 1.

Table 1. Comparison of gamification types and GBL

Criteria	Structural gamification	Content gamification	Game-based learning
Design goal	Application of game design elements without altering the original content at all (Garone & Nesteriuk, 2019).	Integration of game context and activities into original learning content without full game design (Garone & Nesteriuk, 2019).	Convert learning materials to a complete game design with defined learning outcomes (El Mawas et al., 2019).
Main elements	Points, Levels, Badges, Leaderboards, Rewards	Storylines, Challenges, Mystery, Curiosity, Avatars	Storylines, Levels, Challenges, Avatars
Content change	Content does not change to become game-like (Kapp et al., 2014).	Game elements make the content more game-like but no content transformation into a complete game (Kapp et al., 2014).	Learning content is mapped into the game activities to provide a virtual environment of learning (Ucus, 2015).
Primary focus	Motivate learners to move through original content or curriculum (Kapp et al., 2014).	Motivate learners through engaging content or teaching learners new content (Kapp et al., 2014).	Teach a learner psychomotor skills and teach/test learners' knowledge of facts and terms (Kapp et al., 2014).
Sample usage	Award points for finishing tasks of a curriculum such as watching videos or finishing assignments (Kapp et al., 2014).	Add story elements to a compliance course or start a course with a challenge instead of a list of objectives (Kapp et al., 2014).	Design adventure-based game activities to teach certain cases of the Maths curriculum (Chowanda et al., 2020).

2.3. Adaptation in learning and gamification

Adaptive learning or personalized learning is the presentation and distribution of knowledge based on each individual's learning needs and preferences. As a result, each student receives learning tasks depending on their present knowledge and future learning expectations (Rozi et al., 2019).

"One size fits for all" approach is inappropriate for the modern teaching-learning process since it will disregard individual students' learning preferences (Lavoué et al., 2019). Their learning expectations and emotional responses to game mechanics may be different. Learner profiles, student personalities, and knowledge expertise are a few parameters that can be tailored to maximize the learner's effectiveness. Educational motives of the said parameters are further classified under static and dynamic adaptation (Hallifax et al., 2019). Adaptive gaming techniques are proven to work better in some contexts compared to non-adaptive methods since these techniques constantly assess children's performance and adapt the difficulty of the learning tasks according to the level of the student (Vanbecelaere et al., 2020).

3. Literature review process

The systematic literature review was carried out in accordance with the principles outlined in (Torres-Carrion et al., 2018). The initial process follows three main stages, planning, conducting, and reporting results. Formulating research questions, identifying research work that needs to be reviewed, formulating inclusion and exclusion

criteria, and analyzing the literature to find answers to the research questions, are the key steps associated with the review process.

3.1. Research questions

The aim of this study is to evaluate the context of gamification and game-based learning approaches applied to primary school teaching in educating Generation Alpha. Initial aim is decomposed into research questions below.

RQ1: What types of gamification and game-based learning are applied in primary education?
RQ2: What types of outcomes are provided based on the nature of the experiment?
RQ3: What are the types of gamification elements or game mechanics applied?
RQ4: What subject areas in the primary education field are mostly gamified?
RQ5: What types of applications are designed to inspect gamification learning techniques?
RQ6: How gamification and GBL techniques can be mapped with Generation Alpha traits?

3.2. Review scope and paper filtration

Four major scientific databases were used to explore the literature: IEEE Xplore, ScienceDirect, Springer, and Scopus. "Generation Alpha," "gam*" (gamification/ gamify), along with "'learning" and "education," are used as the primary keywords for the initial search. However, a sufficient number of studies related to the literature on gamified/game-based learning could not be found that explicitly target the education of "Generation Alpha." Hence authors expanded the search scope to include studies conducted on gamified learning and GBL during the 2017-2021 period that targeted primary or kindergarten school students below the age of 11. The rationale behind this assumption was that the oldest member of Generation Alpha would be 11 years by 2021; hence all members of Generation Alpha should pursue primary or kindergarten education stage during the consideration period. The paper selection process was carried out until 2022 January 15th. To broaden the scope and identify additional studies for review, a refined search was conducted using keywords: (("Gamif*" OR "Game") AND ("primary" OR "kindergarten") AND ("learning" OR "education")). In addition to empirical research, studies conducted on primary school teachers or research proposals focused on primary school gamified learning were also selected for review. Gamification-based education research, which targeted other educational levels except for primary education, was not selected for this study. Table 2 lists the inclusion criteria applied in the literature selection.

Table 2. Inclusion criteria

Criteria	Inclusion Considerations
Publication Type	Peer-reviewed Journal or Conference papers
Publication year	2017- 2021
Area of Study	Gamification or Game-based learning
Level of Education	Primary or kindergarten Education
Target Audience	Primary or kindergarten school students /teachers or Alpha generation kids
Type of Research	Empirical study, proposal, or literature review

A total of 34 papers were chosen that met the inclusion criteria. Table 3 depicts the breakdown of paper selection according to the scientific database.

Table 3. Filtration results by scientific database

Database	Count
ScienceDirect	9
Scopus	11
IEEE	07
Springer	07
Total	34

3.3. Data extraction and classification framework

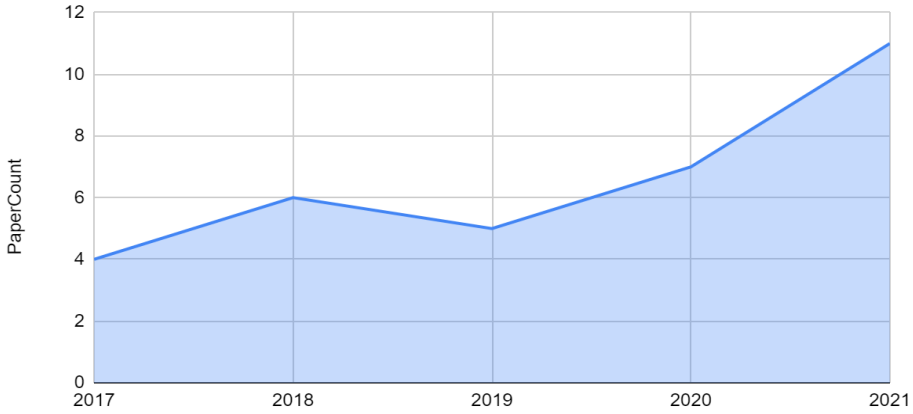
This study explores gamification implementation in educating Generation Alpha utilizing the classification framework presented in Table 4. The findings aim to address the research questions stated in Section 3.1.

Table 4. Data extraction and classification framework

Dimension	Nature of analysis
Type of gamification	Studies are classified into two main categories: gamification and GBL. Each of these categories is further divided into adaptive and non-adaptive subcategories. Studies categorized under gamification, are subdivided into content and structural gamification.
Experimental environment	Experimental environments discussed in the studies are analyzed in terms of factors such as sample size (participants count), duration, evaluation methodology used to measure the impact of the research, and the outcomes of the study.
Outcome	The reported outcomes of applying gamification in the studies are analyzed in terms of the learning process and learner behavior.
Game elements and mechanics	Types of game elements and mechanics adapted in the experimental environment are analyzed under adaptive and nonadaptive nature.
Subject area	Types of primary education subjects experimented under the Gamification applications.
Gamified applications	The nature of the application designed to test gamification is analyzed based on its type such as web, mobile, desktop or non-computing application.
Generation Alpha traits	An attempt will be made to build a mapping between Gen Alpha traits and game elements based on the findings from early dimensions and Gen. Alpha behaviors.

As per Figure 1, the number of publications shows a gradual rise from 2017 to 2021 except for a slight reduction in 2019.

Figure 1. Distribution by year of publication



4. Analysis and discussion

4.1. Type of gamification and experimental design

Table 5 depicts the studies classified based on the type of gamification, Category (Cat), Sample size, Experiment duration, Evaluation method (EM: Qn–Quantitative, Ql-Qualitative, Mx-Mixed), Overall outcome (OC: P-Positive, M-Mixed, N- Not Evaluated) and Outcome factors (positive factors: "+" symbol, negative or neutral factors: "-" symbol). The studies fallen under the category of Gamification, have been further classified as Content (Co) and Structural (St), which is listed in column 2 of Table 5.

As per Table 5, it is evident that 73% of the selected studies are based on non-adaptive (Gamification and GBL) methodologies. One reason for this would be that most studies utilized non-adaptive gamification as a supportive tool to increase learner motivation and interest within the traditional classroom environment. The use of adaptive gamification to accommodate different student learning preferences was not very prevalent. Adaptive gamification largely depends on the learner's non-cognitive factors, such as learning behavior, learning style, and mindset. Measuring such factors in young children is a complex and challenging task (Vanbecelaere et al., 2020), which could have resulted in less research on adaptive approaches.

Table 5 represents the studies, categorized as structural or content gamification based on the factors outlined in Table 1. Structural gamification applications were characterized by the use of gamified quizzes to assess student work (Alshammari, 2020; Anunpattana et al., 2021; Yabut et al., 2019) as well as the provision of rewards such as level increments, points, and badges upon the completion of class lessons and activities (Chen et al., 2020b; Cunha et al., 2018). It is important to note that the original learning materials, such as textbook lessons or class

activities, remained unchanged during this process. Most structural gamification applications reported improvements in student motivation and engagement in learning, as key positive outcomes. However, a study (Alshammari, 2020) has reported no improvements in student attention and confidence despite implementing structural techniques.

Table 5. Classification of studies by gamification type, experiment nature and outcomes

Type	Cat	Study	Size	Duration	EM	OC	Outcome Factors
Adaptive gamification	Co	Hubalovsky et al., 2019	30	not specified	Qn		+engage, attendance, effectiveness
	Co	Su, 2017	48	16 weeks	Mx	P	+performance
	St	Anunpattana et al., 2021	120	not specified	Mx		+engagement, motivation, interaction
	Co	Jagušt et al., 2018	54	05 months	Mx	M	+perform, collaborate, -high stress
	Co	Cerrato et al., 2018	100	not specified	-	N	student evaluation
	Co	Fadhil & Villafiorita, 2017	44	not specified	-		not completed
Non-adaptive gamification	Co	Udjaja et al., 2018	100	not specified	Ql		+interaction, performance
	St	Cunha et al., 2018	191	01 year	Ql		+skills, motivation, engagement
	Co	Sipone et al., 2019	75	03 months	Ql		+knowledge
	St	Yabut et al., 2019	25	03 days	Ql	P	+knowledge, performance
	Co	Folgieri et al., 2019	-	not specified	Qn		+attention, focus, self-learning, adopt
	St	Chen et al., 2020b	86	11 weeks	Qn		+creativity, peer interaction
	Co	Zhao et al., 2021	130	03 weeks	Mx		+participation, performance,
	Co	Ruiz-Bañuls et al., 2021	183	02 months	Mx		+motivation, performance, teamwork
	Co	Jagust et al., 2017	59	30m/session	Qn		+interest, -demotivation (leaderboard)
	Co	Hu & Shang, 2018	-	32vid mins	Mx	M	+motivation, -more play than learn
	St	Alshammari, 2020	58	09 weeks	Mx		+motivate, -attention, confidence
Adaptive game-based learning	GBL	Hooshyar et al., 2018	102	not specified	Qn	P	+performance
		Vidergor, 2021	528	not specified	Qn		+motivation, collaborate, socialization
		Vanbecelaere et al., 2020	191	05 weeks	Qn	M	+knowledge, -no motivation change
Non-adaptive game-based learning	GBL	Costa et al., 2018	17	not specified	Ql		+knowledge, interest
		El Mawas et al., 2019	53	20mins/game	Qn		+knowledge, enjoyment, experience
		Chen et al., 2020a	129	not specified	Qn		+knowledge, learning interest
		Chowanda et al., 2020	60	not specified	Qn	P	+performance, knowledge, engage
		Quintas et al., 2020	417	01 month	Qn		+motivation, performance
		Demirkiran & Tansu, 2021	63	~01 week	Mx		+knowledge, self-efficacy, attitude
		Wang & Zheng, 2021	93	01 hour	Qn		+perform, self-efficacy, assess content
		Kamarulzaman et al., 2021	4	not specified	Ql		+knowledge, interest, motivation
		Jiang & Hu, 2021	-	not specified	Ql		+knowledge, teamwork, participation
		Menendez-Ferreira et al., 2022	-	not specified	Mx		+social, emotional skills, motivation

	Huynh et al., 2021	33	01 hour	Ql	M	+engage, enjoy, -less perform (male)
Proposals and surveys	Callaghan & Reich, 2020	N/A	N/A	-		proposal
	López et al., 2021	56	not specified	Ql	N	survey
	Giannakoulas et al., 2021	N/A	N/A	-		proposal

Content gamification is the most employed technique in gamification studies, accounting for 70% of its applications. One of the prominent features of content gamification is the mapping of traditional learning activities into interactive digital lessons. These digital lessons incorporate various elements such as mobile-based activities, interactive e-books, and mini-games such as board and runner games (Hu & Shang, 2018). Moreover, engaging storylines and characters (Sipone et al., 2019) were used to enhance learning, creating a more game-like experience. However, the learning process has not been fully transformed into a complete game-based approach. As depicted in Table 5, key positive outcomes reported in content-gamified applications include increased knowledge acquisition and improved performance. Nevertheless, one study (Hu & Shang, 2018) has reported that some students may focus more on playing rather than actively engaging with the learning content. The positive impact of content gamification on enhancing students' knowledge and performance indicates that Gen. Alpha students are more responsive to learning when educational materials adopt game-like elements. This underscores the clear necessity of restructuring primary education curricula to effectively incorporate content gamification and meet the learning preferences of Generation Alpha.

Both qualitative and quantitative methodologies are equally used in analyzing studies, and most studies have found that gamification has a favorable influence on primary school education. However, the duration of the experiments was not provided in some studies, and a few of them utilized relatively small sample sizes for their evaluation, which raises concerns about the reliability of the reported outcomes. A significant number of studies have evaluated the outcome based on qualitative techniques such as questionnaires and learner's feedback, which may be biased toward individual's perceptions; hence it may show many conflicting opinions on final observations (Huynh et al., 2021).

4.2. Outcomes

Table 6 outlines a comprehensive overview of the specific game elements and mechanics employed in each study, reported outcomes, the factors used to measure those outcomes and produced gamified application type. In cases where adaptive gamification aids were used in the studies, they are marked with an asterisk (*****). The "Outcome Factors (OC)" column lists the positive factors with a "+" symbol, while the negative or neutral factors are indicated with a "-" symbol.

Table 6. Selected studies by game elements, application type, subjects, and outcome

Study	Game / *Adaptive Elements	Subject	App Type	OC	Outcome Factors
Hubalovsky et al., 2019	levels, *analytics, *learner models, *difficulty	Mathematics	Web & Mobile App	Positive	+engagement, attendance +learning effectiveness
Su, 2017	feedback, challenges, storyline *learning path, *learning style	Geometry	Mobile App	Positive	+performance
Anunpattana et al., 2021	points, goals, puzzle quiz, Kahoot, *difficulty	Assessment Preparation	Web App	Positive	+engagement, motivation, interaction
Jagušt et al., 2018	storyline, narratives, points leaderboard, feedback, *Time	Mathematics	Mobile App	Mixed	+performance, collaboration - increased stress
Cerrato et al., 2018	storyline, characters, levels, rewards, *analytics, *activities, *learner profiles	Assessment Planning	Desktop Software	No Eval	Evaluation not completed with the students.
Fadhil & Villafiorita, 2017	leaderboard, points, storyboard, *behavior patterns, *chatbot	Food Waste Mgmt.	Mobile gamified App	No Eval	

Udjaja et al., 2018	levels, feedback, multimedia elements	Mathematics	Web-based Game	Positive	+interaction, performance
Cunha et al., 2018	dynamics, rules, levels, awards, points (toy money)	Mathematics	Manual method	Positive	+skills, motivation, +engagement
Sipone et al., 2019	avatars, points, stories, badges,	Sustainable Mobility	Web app	Positive	+knowledge
Yabut et al., 2019	points, levels	Mathematics	Mobile /web App	Positive	+knowledge, performance
Folgieri et al., 2019	feedback, levels, avatars /characters, repetition	Mathematics	Desktop app	Positive	+attention, focus, self-learning +self{awareness, adaptation}
Chen et al., 2020b	storyline, challenges, avatar, rewards, content unlocking, levels, achievements	Mathematics English, Mandarin	Manual method in classroom	Positive	+creativity, peer interaction +verbal participation - graphic thinking not changed
Zhao et al., 2021	points badges, storyline, feedback, avatar	Mathematics	Mobile e-book app	Positive	+participation, performance, +motivation, metacognition
Ruiz-Bañuls et al., 2021	narratives, stories, collectable cards, experience bars, rewards, missions, badges	Spanish, Mathematics Science	Web app	Positive	+motivation, performance, +teamwork, interdisciplinary learning
Jagust et al., 2017	leaderboards, storyline	Mathematics	Mobile app	Mixed	+motivation, interest - demotivation (leaderboards)
Hu & Shang, 2018	feedback, levels	Mathematics	Desktop game	Mixed	+motivation, participation - focus on play than learn
Alshammari, 2020	points, badges, leaderboards, rewards, feedback	Arabic Language	Web app	Mixed	+motivation, knowledge, +learning effectiveness - attention/confidence neutral
Hooshyar et al., 2018	educational game, points, *content generation	English Reading	Web app	Positive	+performance
Vidergor, 2021	memory game, jigsaw puzzle, storyline	Mathematics	Web app	Positive	+motivation, collaboration, +social experience
Vanbecelaere et al., 2020	narratives, levels, stars *content, *difficulty	Reading Skills	Mobile app	Mixed	+knowledge, performance - no change in motivation
Costa et al., 2018	points, goals, challenges, augmented reality game	Astronomy	Mobile AR app	Positive	+knowledge, interest
El Mawas et al., 2019	levels, Goals, Story, adventure game, avatar	Science	Desktop app	Positive	+knowledge, enjoyment, +learning experience
Chen et al., 2020a	points, goals, challenges, AR game	Plant studies	Mobile AR app	Positive	+knowledge, learning interest
Chowanda et al., 2020	levels, avatar, points, storyline	Mathematics	Mobile app	Positive	+performance, knowledge +engagement,

					curiosity
Quintas et al., 2020	badges, points, avatars, exergame	Physical Education	Mobile app	Positive	+motivation, performance
Demirkiran & Tansu, 2021	challenges, Minecraft hour of code game,	Coding	Desktop app	Positive	+knowledge, self-efficacy, +attitude, engagement
Wang & Zheng, 2021	puzzle game, levels, challenges, goals, feedback	Science	Mobile app	Positive	+performance, self-efficacy +content assessment
Kamarulzaman et al., 2021	storyboard, feedback, points	Assessment Planning	Desktop 2d game	Positive	+knowledge, interest, understanding, motivation
Jiang & Hu, 2021	avatars, storyline, role-playing 2D Game	Fire Safety	Desktop 3d game	Positive	+knowledge, teamwork, +participation, interest
Menendez-Ferreira et al., 2022	avatar, storyline, narratives	Resilience skills	Desktop video game	Positive	+social, moral, emotional skills, motivation
Huynh et al., 2021	storyline, avatar. role-playing game, narratives	Visual Literacy	Mobile game	Mixed	+engagement and enjoyment - performance (male learners)
Callaghan & Reich, 2020	review on educational game design	-	-	No eval	N/A
López et al., 2021	teachers' perspective on primary school gamification	-	-	No eval	N/A
Giannakoulas et al., 2021	avatar, levels, maze-puzzle game, *content generation	-	Web/ mobile app	No eval	N/A

As evident in Table 6, among the studies that assessed outcomes, 82% reported positive results in implementing gamification and GBL in the learning process. Authors have employed Four-Dimensional Education (4DE) Framework (Fadel & Groff, 2019) to classify the positive outcome factors reported in Table 6. This framework emphasizes the expectations of 21st-century learners and identifies four dimensions of learning outcomes that are necessary for success in the modern world. 4DE dimensions are listed below.

- Knowledge: focuses on the acquisition of subject-specific knowledge and content.
- Skills: focuses on the development of key skills required for learning.
- Character: emphasizes the importance of cultivating positive character traits in learning.
- Meta-Learning: focuses on developing meta-cognitive skills.

Table 7. Mapping outcome factors into 4DE framework

4DE framework dimension	Positive Outcome factors
Knowledge	• Improved knowledge of the subject matter • Awareness of subject content. • Better content knowledge assessment • Improved interdisciplinary learning
Skills	• Peer interaction • Creativity and imagination • Higher self-efficacy • Increased collaboration in learning • Performance, Engagement • Increased attention • Self-adaptation and self-learning
Character	• Motivation • Enjoyment and interest towards learning • Curiosity
Meta-Learning	• Learning effectiveness • Learning experience

Table 7 presents a mapping between reported positive outcomes and dimensions of the 4DE Framework. The data presented in the table indicate that positive outcomes have been observed across all four dimensions of the framework. This suggests that gamification has effectively addressed the diverse needs and expectations of learners in contemporary educational contexts.

Some studies did report negative or neutral effects of gamified learning, combined with positive factors indicated in Table 7. Game elements, such as leaderboards, have demotivated the students (Jagust et al., 2017); students' attention level or confidence has not been increased due to gamification techniques (Alshammari, 2020); the usage of narrative elements had a negative impact on the performance of male learners, (Huynh et al., 2021); some gamification conditions produced a number of non-achievers due to increased levels of stress (Jagušt et al., 2018); Students focus on gameplay than learning (Hu & Shang, 2018) are such findings on the adverse outcomes on gamification.

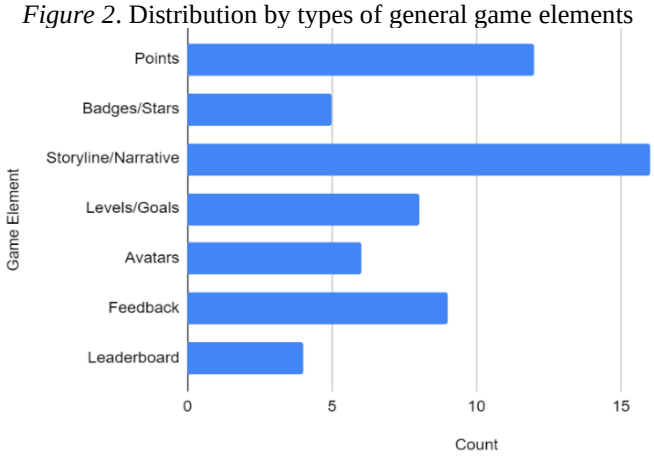
4.3. Gamification elements and mechanics

The application of game elements directly impacts learners' engagement, motivation, performance participation, and enjoyment of learning (Nah et al., 2014; Sanmugam et al., 2015). It is important to integrate and properly blend multiple game elements, which can significantly improve student performance (Jagušt et al., 2018). As shown in Table 6, all the studies have utilized combinations of game elements in experiments. The combination of storylines, narratives, and avatars appears to be a popular choice among these studies, while the traditional triad of game elements - points, badges, and leaderboards (PBL) - are used less frequently and in fewer combinations. Increased use of feedback game element confirms that continuous visual feedback within learning games supports in improving learners' working memory skills (Callaghan & Reich, 2020) and makes it easier for them to overcome the difficulty in accomplishing tasks and fulfilling learning objectives (Wang & Zheng, 2021).

To examine the individual impact of game elements on gamification, the authors have grouped main game elements into two categories based on their usage in the selected studies.

- General game elements: Points, Badges, Storyline, Levels, Avatars, Feedback, and Leaderboards. (Figure 2)
- Adaptive gamification aids: Parameters used to personalize student experience in adaptive studies. (Table 8)

Figure 2. Distribution by types of general game elements



As per Figure 2, storylines and narratives have become the most widely applied game element. The probable reason for this would be that visual literacy is considered as one of the crucial aspects of Generation Alpha because the daily life of the child is closer to visuals, such as games and television (Ramadlani & Wibisono, 2017). Hence storylines and narratives could relate to their daily life experiences. Leaderboards are being used less frequently in selected research work.

Table 8 provides an overview of the major adaptive parameters that were reported in selected studies.

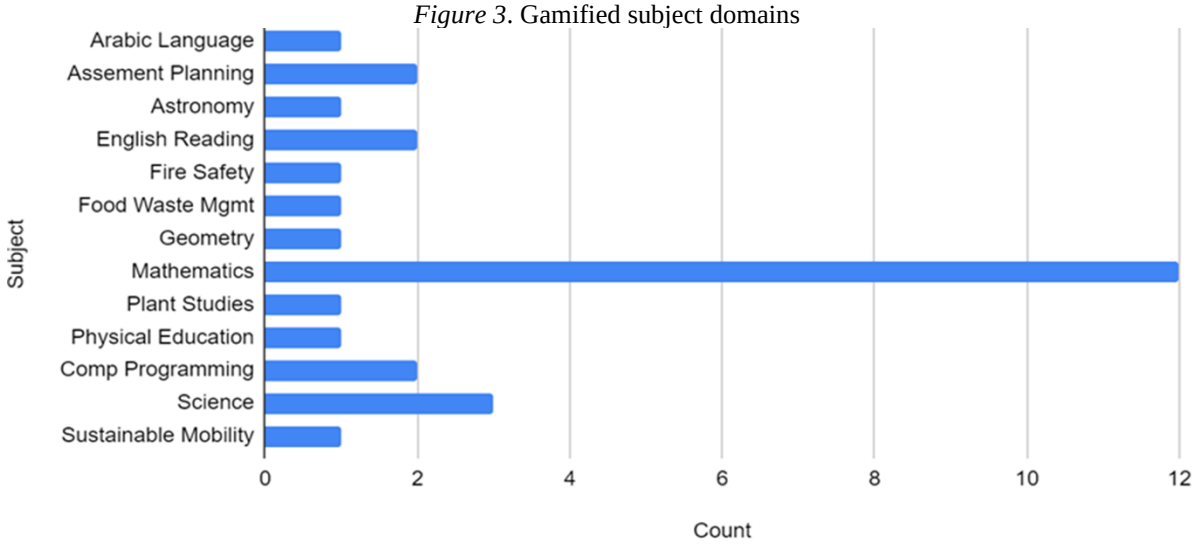
Table 8. Summary of adaptive parameters employed in studies

Adaptive game aids	Overview
Adaptive difficulty	Applied by determination of the optimal path for passing through learning exercises based on Bloom's Taxonomy and learner profiles (Hubalovsky et al., 2019) and by changing the number of activities children are presented with, according to their performance during playing (Vanbecelaere et al., 2020).
Adaptive content generation	Content created by the instructor, such as material and game-level activities, can be adapted to the student's progress as they play the game (Giannakoulas et al., 2021). Personalizing the understandability of content based on student's skill levels is proposed by Hooshyar et al. (2018) which employs a genetic algorithm to produce educational activities from knowledge of given content.
Creation of learner models and profiles	Unique student profile creation based on behavioral data and learning analytics is suggested by Cerrato et al. (2018) to allow children to explore different activities and create a unique profile for each child depending on learners' choices.
Adaptive time changes	Used to update the amount of time provided to each student for every problem to be solved by analyzing the speed of working on learning activities (Jagušt et al., 2018).
Adaptive conversational user interfaces	Proposed by Fadhil and Villafiorita (2017) regarding the development of a chatbot that automatically identifies learners' emotions and behavioral patterns to provide personalized suggestions.
Adaptive learning path recommendation	Proposed by Su (2017) to find the most suitable learning path for satisfying students' learning needs according to learners' learning styles.

4.4. Subject areas

Figure 3 represents the study distribution according to the gamified subject domain in primary education. Mathematics stands out as the most widely gamified subject. Studies have highlighted the impact of the Mathematics module in shaping primary school students' skills (Kamarulzaman et al., 2021; Yabut et al., 2019). Mathematics was considered the most complicated subject for selected cohorts of primary school students in certain studies (Chowanda et al., 2020; Udjaja et al., 2018).

Figure 3. Gamified subject domains



Furthermore, gamification techniques have reported positive effects on language learning (Arabic) and reading (Hooshyar et al., 2018; Vanbecelaere et al., 2020), improving behavioral habits and skills such as food waste management (Fadhil & Villafiorita, 2017), fire safety (Jiang & Hu, 2021) and physical education (Quintas et al., 2020). Nevertheless, neutral effects on attention and motivation have been reported when gamification was applied to Reading skills and language learning (Table 6).

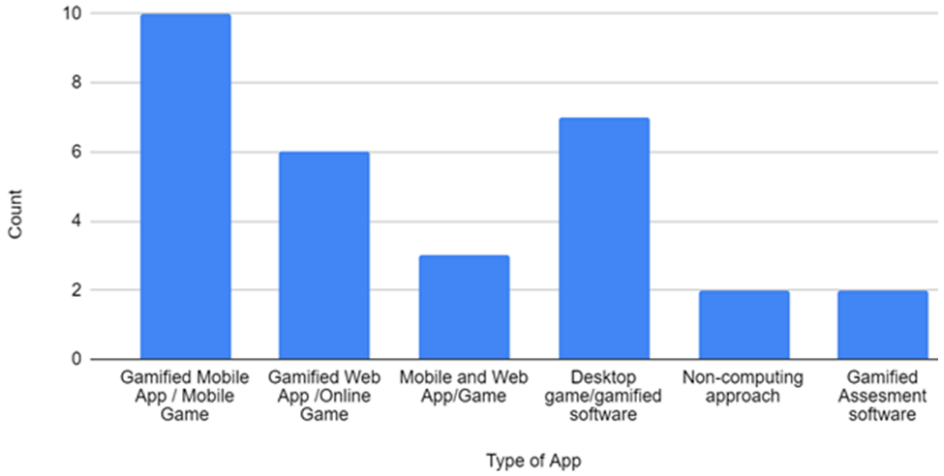
4.5. Gamified applications

As evident in Figure 4, the development of gamified mobile applications and mobile educational games is the most prevalent application type, resulting in selected studies. Children under the age of 12 spend most of their

time playing games on their mobile phones (Yabut et al., 2019), and almost 97% of children have used mobile devices before they are one year old. (Kabali et al., 2015). Hence using gamified mobile learning applications may have benefited young learners. Further implementations of mobile applications include gamified eBooks (Zhao et al., 2021), adaptive chatbots (Fadhil & Villafiorita, 2017), and augmented reality (AR) based mobile applications (Chen et al., 2020a; Costa et al., 2018).

Some studies have proposed implementing hybrid applications, which include both web and mobile interfaces (Giannakoulas et al., 2021; Hubalovsky et al., 2019; Yabut et al., 2019). The mobile application was used as a gamified learning tool, while the web interface provided a dashboard for teachers to monitor student performance (Yabut et al., 2019). Implementing gamified web-based applications includes integration of LMS Moodle E-learning (Hubalovsky et al., 2019) and online gamified tools such as Kahoot (Anunpattana et al., 2021). Other successful applications of gamification comprise of gamified quiz platforms using challenged-based gamification (Anunpattana et al., 2021), an assessment tool to examine the attitudes of kindergarten pupils (Cerrato et al., 2018), and digital escape rooms (Vidergor, 2021).

Figure 4. Gamified application types



4.6. Multi-factor analysis on experimental outcomes

Sections 4.1 to 4.5 of this study have primarily examined the individual influence of factors such as type of gamification, experimental environment, outcome, game elements and mechanics, subject area, and gamified application types, to evaluate the role of gamification in educating Generation Alpha. The aim of this section is to perform a cross-analysis of the above-mentioned factors to ascertain the relationships between them and the reported outcomes. This analysis will be based on the information provided in Tables 5 and 6, allowing for a comprehensive understanding of the interplay between the aforementioned factors and their impact on the observed outcomes.

Among the studies that assessed outcomes, 82% reported positive results in implementing gamification and GBL in the learning process. While none of the studies produced entirely negative results, some did report mixed outcome factors. Out of the general game elements, the use of leaderboards has caused a negative impact on student's motivation mainly those who are underachievers (Jagust et al., 2017). In addition, the use of narratives element had caused a reduction in performance in Male learners (Huynh et al., 2021). Out of the Adaptive Game elements, adaptive time difficulty has caused an adverse impact on performance as it has increased student's stress levels during learning activities.

The most frequently reported positive outcomes in non-adaptive studies include improvements in student motivation, engagement, and performance. Factors such as storylines, narratives, avatars, and rewards played a significant role in enhancing student engagement, motivation, and enjoyment of the learning process. Additionally, the incorporation of the feedback component was associated with a positive impact on student performance and knowledge acquisition. The utilization of goals, challenges, and missions also yielded positive outcomes in terms of teamwork, learning experience, and interest. Game Challenges were reported as the common game element that positively influenced students' self-efficacy. Adaptive studies, although limited in number, reported increased performance, collaborative learning, and interaction as key positive outcomes.

Adaptive difficulty, learner models, and learning styles were identified as crucial factors contributing to these positive outcomes in adaptive studies.

Levels, points, and feedback game elements are frequently utilized in the gamifying Mathematics subject through mobile applications. This gamification approach has resulted in positive outcomes in terms of performance, knowledge acquisition, and engagement. Adaptive parameters, including adaptive difficulty and learner profiles, were predominantly employed to gamify assessments, while adaptive content generation was commonly used to enhance reading skills through web and desktop applications. Additionally, two studies reported the use of AR mobile applications to gamify science-related content, specifically in the fields of astronomy and plant studies.

4.7. Connecting Generation Alpha traits with gamification aids

While studies have reported that Generation Alphas spend considerable time with games and technical devices (Taylor & Hattingh, 2019), gamification is identified as a formidable tool for teachers at all levels of the educational system (López et al., 2021). Hence the authors have attempted to establish a connection between the characteristics of Generation Alpha and gamification learning methods. Table 9 represents the proposed mapping of how Generation Alpha traits could be addressed using gamified learning components. Reported characteristics of Gen. Alpha and evaluation results of the first five research questions were considered in designing the mapping.

Table 9. Mapping of Generation Alpha traits and gamification aids

Generation Alpha traits	Gamification aids
Making their own choices is essential. They expect teachers to consider their individual needs (Yurtseven, 2020, p. 16).	Use of tailored gamification and GBL to support individual learning preferences and recommend personalized adaptive learning paths (Su, 2017).
They use the power of logical reasoning in the learning process. They go beyond the information given to them, and they clarify problems in their minds (Yurtseven, 2020, p. 16).	Varied difficulty levels with challenging goals mapped into learning outcomes. Adoption of visual clues and instructional design strategies (Hu & Shang, 2018) to encourage self-learning.
They operate their metacognition, which helps them plan themselves before taking action and monitor their learning process (Yurtseven, 2020, p. 16).	Use of game elements such as badges, customized leaderboards, and progress bars to self-monitor the learning process.
Stories and characters portrayed in the movies they viewed formed the common communication thread & basis for social interactions (Kaplan-Berkley, 2021).	Use of personalized avatars/role-playing games with interactive storylines or narratives designed in line with the learning objectives (Huynh et al., 2021).
Shorter attention spans (McCrindle & Fell, 2020). Thought patterns are constantly shifting, making them exceedingly challenging to predict (Ramadlani & Wibisono, 2017).	Concise level-based, adaptive learning exercises to select according to student preference. Challenge and activity-based problem-solving strategies.
"Connection" is a central characteristic of the alpha generation ((Apaydin & Kaya, 2020) who utilizes digital environments for social interactions. They engage individually in online social environments (Kaplan-Berkley, 2021).	Integration of social communication features such as chatbots with existing gamification learning (Fadhil & Villafiorita, 2017). Integration of collaborative gamified learning techniques into social media platforms.
App-based play and increased screen time (McCrindle & Fell, 2020). Heavily dependent on smartphone features (Ramadlani & Wibisono, 2017).	Integrate mobile learning with mobile gamification and game-based learning strategies.
More than enjoying outdoor activities or real-life play, they hop upon mobile games like PUBG, Xbox, and Pokemon, within their comfort zone (Jha, 2020).	Interactive game-based learning applications powered by techniques such as augmented reality (Costa et al., 2018) integrated into interactive characters/storylines.

5. Future research requirements

5.1. Observation of realistic behavioral attributes of Generation Alpha

Literature evidence presented in section 2.1 and Table 9 regarding the behavioral qualities of Generation Alpha primarily reflects the assumptions made by researchers attributed to the data available from preceding generations (i.e., generation Z). The body of research on this generation is limited since the Alpha generation is still evolving (Ziatdinov & Cilliers, 2021). Therefore, further empirical, and qualitative research is required to verify the realistic learning preferences and behavioral patterns of Generation Alpha, which will aid future researchers in developing more effective Gamification and GBL learning techniques.

5.2. Need for novel gamification mechanics

As shown in Table 6, PBL (Points, Badges, Leaderboards) is the basis of several studies in gamification element design. Nevertheless, the efficacy of commonly used game mechanisms (e.g., leaderboards, points) should not be assumed (Jagušt et al., 2018). To design games, providers can consider other gamification elements beyond the PBL architecture (Quintas et al., 2020). Since Gen. Alpha students instantly get bored due to their constantly changing behavior (Apaydin & Kaya, 2020), more interactive and innovative game mechanics must be designed to maintain engagement and attention toward gamified lessons. Not only gamification elements but the overall instructional design (Hu & Shang, 2018) and user interface design spectrum (Callaghan & Reich, 2020) also has a crucial role in gamified learning systems' success. Augmented Reality tools (El Mawas et al., 2019), gamified e-books (Zhao et al., 2021), interactive avatars, and narrative-focused role-playing games (Huynh et al., 2021) are a few areas that require further research. The popularity of mobile-based gamified learning systems, and Generation Alpha's tendency to spend their time on mobile devices, make it crucial to incorporate mobile-friendly novel gamification components. Furthermore, online social communication features such as chatbots (Fadhil & Villafiorita, 2017), video conferencing and video-based self-learning, and emoji-based instant feedback techniques can be adapted with existing gamified learning techniques to provide a more cooperative online learning atmosphere for Gen Alpha students, as they prefer spending more time in online social environments (Kaplan-Berkley, 2021).

5.3. Need for further adaptive gamification-based learning strategies

The mapping in Table 9 indicates that Generation Alpha's core behavioral traits are best served by adaptive gamification strategies. However, as evident in Table 5, the number of present studies conducted on adaptive gamification in primary education is comparatively low. Further research is required on the application of parameters such as learning style (Su, 2017), student preferences and skill levels (Jagušt et al., 2018), the present level of knowledge (Hooshyar et al., 2018), cognitive abilities, and learners' emotions (Plass et al., 2015) which leads to generating a better learner profile for adaptation. Further research on machine learning and deep learning techniques is required in forecasting student performance and customizing the in-game learning experience for primary education. Empirical evidence on the effectiveness of adaptive games, compared to non-adaptive games, is limited. More fine-grained adaptivity algorithms are required to enhance the effectiveness of adaptive games compared to traditional teaching methods (Vanbecelaere et al., 2020).

5.4. Need for long-term studies with diverse learner samples

As evident in Table 5, the experimental duration of most selected studies was below one year, which in some cases may not be sufficient to evaluate the definite impact of gamified learning. Studies have reported that the biggest challenge in implementing gamified educational activities for the primary school student cohort is sustaining gameplay engagement and student performance throughout lessons for a more extended period (Jagušt et al., 2018). However, long-term and large-scale experiments are essential for better observation of students' behavioral characteristics in a gamified learning environment (Zhao et al., 2021) and to explore long-term psychological effects on the learner based on the gamified learning process (Quintas et al., 2020). Furthermore, adaptive gamification strategies require more time to closely analyze the adaptation patterns of the learner (Hallifax et al., 2019).

Existing studies have also reported that the impact of gamification on leaner may vary depending on factors such as gender (Demirkiran & Tansu, 2021), skill level (Hooshyar et al., 2018), socio-cultural and economic reasons

of the student (Halloluwa et al., 2018) and previous knowledge of the subject domain (Sipone et al., 2019). Thus, researchers should consider the aforementioned characteristics when choosing appropriate learner samples to evaluate gamification's influence on learning.

6. Conclusion

The aim of this study was to investigate the application of gamification and game-based learning in the context of primary education, emphasizing the behavioral attributes of Generation Alpha. Despite the scarcity of research work, 34 primary education-based gamified learning studies are selected for the review published between 2017 and 2021.

It was observed that the adaptive gamification strategies best suit the behavioral characteristics of Gen Alpha students. However, compared to non-adaptive techniques, fewer studies are conducted on the adaptive gamification domain. The use of the leader board game element was relatively sparse, while the use of narrative and storylines was prevalent. Studies have also emphasized the importance of integrating several game elements to maximize the positive outcome. Dynamic difficulty, time, learning style adaptation, and dynamic content generation were some attributes evaluated in adaptive gamification-based studies.

Most studies have found that gamified learning positively impacts learners' motivation, attention, performance, and engagement, while few studies have reported mixed results. However, the results of several findings mainly relied on qualitative comments and surveys rather than an accurate assessment of the empirical data. Furthermore, some studies have presented insufficient data regarding the experiment context, duration, and sample selection. Hence, it is challenging to perform a meta-analysis of the findings from certain studies.

Most studies have chosen Mathematics as the subject to assess the influence of gamification on primary school children. The majority of research proposed mobile educational games or gamified mobile apps as best fits for primary school learning. This complements the characteristics of Generation Alpha, which reported spending more time with digital screens and mobile devices.

This study emphasizes the crucial role of educational technology in enhancing pedagogical, technical, and human resources to meet the unique educational needs of Generation Alpha, who have grown up in a digital age. Given that the majority of teaching approaches used in primary education, particularly in developing nations, may not facilitate the integration of technology-enhanced learning (Halloluwa et al., 2018), it is crucial to reassess and modify the educational content and curriculum. This will involve incorporating innovative gamification techniques, as outlined in Section 5.2. Furthermore, as emphasized in this study, Generation Alpha is heavily reliant on mobile devices and gaming, hence mobile and gamified learning will become an integral part of their educational cycle. Consequently, classrooms must be updated with appropriate hardware and software resources capable of facilitating technology-enhanced learning curriculums. Finally, the role of the teacher is vital in primary education. However, it is reported that some teachers and educators lack technology literacy (Apaydin & Kaya, 2020), and resources in planning gamified activities (López et al., 2021), which may substantially impact the quality of education delivered to Gen. Alpha. Hence, primary school teachers and educators must be equipped with state-of-the-art technical and pedagogical skills to implement digitally gamified learning environments.

The study concludes by providing compelling evidence that game-based learning and gamification will play a significant role in the Generation Alpha cohort's future teaching and learning process. Upcoming research should concentrate on designing adaptive learning systems with unique gamification components tailored to Generation Alpha's natural cognitive and behavioral characteristics.

References

Alshammari, M. T. (2020). Evaluation of gamification in e-learning systems for elementary school students. *TEM Journal, 9*(2), 806–813. https://doi.org/10.18421/TEM92-51

Anunpattana, P., Khalid, M. N. A., Iida, H., & Inchamnan, W. (2021). Capturing potential impact of challenge-based gamification on gamified quizzing in the classroom. *Heliyon, 7*(12), e08637. https://doi.org/10.1016/j.heliyon.2021.e08637

Apaydin, Ç., & Kaya, F. (2020). An analysis of the preschool teachers' views on Alpha generation. *European Journal of Education Studies, 6(*11), 254–272. https://doi.org/10.5281/zenodo.3627158

Callaghan, M. N., & Reich, S. M. (2020). applying a developmental lens to educational game designs for preschoolers. *International Journal of Mobile and Blended Learning, 12*(2), 1–15. https://doi.org/10.4018/IJMBL.2020040101

Cerrato, A., Ferrara, F., Ponticorvo, M., Sica, L. S., Ferdinando, A. Di, & Miglino, O. (2018). DILIGO assessment tool: A smart and gamified approach for preschool children Assessment. In V. L. Uskov, R. J. Howlett, & L. C. Jain (Eds.), *Smart Education and e-Learning* (Vol. 75, pp. 235–244). Springer International Publishing. https://doi.org/10.1007/978-3-319-59451-4

Chen, M.-B., Wang, S.-G., Chen, Y.-N., Chen, X.-F., & Lin, Y.-Z. (2020a). A preliminary study of the influence of game types on the learning interests of primary school students in digital games. *Education Sciences, 10*(4), 96. https://doi.org/10.3390/educsci10040096

Chen, P. Z., Chang, T. C., & Wu, C. L. (2020b). Effects of gamified classroom management on the divergent thinking and creative tendency of elementary students. *Thinking Skills and Creativity, 36*, 1–9. https://doi.org/10.1016/j.tsc.2020.100664

Chowanda, A., Prasetio, Y. L., Nicodemus, & Fadhlurrahman, N. R. (2020). Designing digital games as learning tools for mathematics. *ICIC Express Letters, 14*(9), 927–934. https://doi.org/10.24507/icicel.14.09.927

Costa, M. C., Patricio, J. M., Carranca, J. A., & Farropo, B. (2018). Augmented reality technologies to promote STEM learning. In *Iberian Conference on Information Systems and Technologies, CISTI* (pp. 1–4). https://doi.org/10.23919/CISTI.2018.8399267

Culala, H. J. D. (2016, April 18). *Educating Generation Alpha: What are the demands of the 21st century workforce?* [Paper presentation]. Digital Education Show Asia, Kuala Lumpur Convention Centre (KLCC) Kuala Lumpur, Malaysia.

Cunha, G. C. A., Barraqui, L. P., & de Freitas, S. A. A. (2018). Evaluating the use of gamification in mathematics learning in primary school children. In *2018 IEEE Frontiers in Education Conference (FIE)* (pp. 1–4). https://doi.org/10.1109/FIE.2018.8658950

Demirkiran, M. C., & Tansu, H. F. (2021). An investigation on primary school students' dispositions towards programming with game-based learning. *Education and Information Technologies, 26*(4), 3871–3892. https://doi.org/10.1007/s10639-021-10430-5

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011* (pp. 9–15). https://doi.org/10.1145/2181037.2181040

Dichev, C., & Dicheva, D. (2017). Gamifying education: What is known, what is believed and what remains uncertain: A critical review. *International Journal of Educational Technology in Higher Education, 14*(1), 9. https://doi.org/10.1186/s41239-017-0042-5

Dos Santos, L. S., De Lima Sobreira, P., Santiago, L. M. S., Abijaude, J. W., El Guemhioui, K., & Wahab, O. A. (2020). Gamification-supported collaborative learning: A systematic literature review. In *Proceedings of EDUNINE 2020 - 4th IEEE World Engineering Education Conference: The Challenges of Education in Engineering, Computing and Technology without Exclusions: Innovation in the Era of the Industrial Revolution 4.0* (pp. 2–6). https://doi.org/10.1109/EDUNINE48860.2020.9149543

El Mawas, N., Tal, I., Moldovan, A. N., Bogusevschi, D., Andrews, J., Muntean, G.-M., & Muntean, C. H. (2019). Improving STEM learning experience in primary school by using NEWTON Project innovative technologies. In *Communications in Computer and Information Science* (Vol. 1022, pp. 214–230). Springer International Publishing. https://doi.org/10.1007/978-3-030-21151-6_11

Fadel, C., & Groff, J. S. (2019). Four-Dimensional Education for Sustainable Societies. In J. W. Cook (Ed.), *Sustainability, Human Well-Being, and the Future of Education* (pp. 269–281). Springer International Publishing. https://doi.org/10.1007/978-3-319-78580-6_8

Fadhil, A., & Villafiorita, A. (2017). An adaptive learning with gamification & conversational UIs: The rise of CiboPoliBot. In *UMAP 2017 - Adjunct Publication of the 25th Conference on User Modeling, Adaptation and Personalization* (pp. 408–412). https://doi.org/10.1145/3099023.3099112

Fokides, E. (2018). Digital educational games and mathematics. Results of a case study in primary school settings. *Education and Information Technologies, 23*(2), 851–867. https://doi.org/10.1007/s10639-017-9639-5

Folgieri, R., Vanutelli, M., Galbiati, P., & Lucchiari, C. (2019). Gamification and coding to engage primary school students in learning mathematics: A case study. *Proceedings of the 11th International Conference on Computer Supported Education* (pp. 506–513). https://doi.org/10.5220/0007800105060513

Garone, P., & Nesteriuk, S. (2019). Gamification and learning: A comparative study of design frameworks. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 11582 LNCS* (pp. 473–487). https://doi.org/10.1007/978-3-030-22219-2_35

Giannakoulas, A., Terzopoulos, G., Xinogalos, S., & Satratzemi, M. (2021). A proposal for an educational game platform for teaching programming to primary school students. In *Communications in Computer and Information Science: Vol. 1384 CCIS* (pp. 463–475). Springer International Publishing. https://doi.org/10.1007/978-3-030-73988-1_38

Hallifax, S., Serna, A., Marty, J. C., & Lavoué, É. (2019). Adaptive gamification in education: A literature review of current trends and developments. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 11722 LNCS* (pp. 294–307). https://doi.org/10.1007/978-3-030-29736-7_22

Halloluwa, T., Vyas, D., Usoof, H., & Hewagamage, K. P. (2018). Gamification for development: A case of collaborative learning in Sri Lankan primary schools. *Personal and Ubiquitous Computing*, *22*(2), 391–407. https://doi.org/10.1007/s00779-017-1073-6

Hooshyar, D., Yousefi, M., & Lim, H. (2018). A procedural content generation-based framework for educational games: Toward a tailored data-driven game for developing early English reading skills. *Journal of Educational Computing Research*, *56*(2), 293–310. https://doi.org/10.1177/0735633117706909

Hu, R., & Shang, J. (2018). Application of gamification to blended learning in elementary math instructional design. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (pp. 93–104). https://doi.org/10.1007/978-3-319-94505-7_7

Hubalovsky, S., Hubalovska, M., & Musilek, M. (2019). Assessment of the influence of adaptive e-learning on learning effectiveness of primary school pupils. *Computers in Human Behavior*, *92*, 691–705. https://doi.org/10.1016/j.chb.2018.05.033

Huynh, E., Nyhout, A., Ganea, P., & Chevalier, F. (2021). Designing narrative-focused role-playing games for visualization literacy in young children. *IEEE Transactions on Visualization and Computer Graphics*, *27*(2), 924–934. https://doi.org/10.1109/TVCG.2020.3030464

Jagust, T., Boticki, I., Mornar, V., & So, H.-J. (2017). Gamified digital math lessons for lower primary school students. In *2017 6th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)* (pp. 691–694). https://doi.org/10.1109/IIAI-AAI.2017.17

Jagušt, T., Botički, I., & So, H. J. (2018). Examining competitive, collaborative and adaptive gamification in young learners' math learning. *Computers and Education*, *125*, 444–457. https://doi.org/10.1016/j.compedu.2018.06.022

Jha, A. K. (2020). *Understanding Generation Alpha*. https://doi.org/10.31219/osf.io/d2e8g

Jiang, J., & Hu, S. (2021). Application of gamification teaching in primary school fire safety course in smart learning environment. In *ICCSE 2021 - IEEE 16th International Conference on Computer Science and Education (ICCSE)* (pp. 72–75). https://doi.org/10.1109/ICCSE51940.2021.9569628

Kabali, H. K., Irigoyen, M. M., Nunez-Davis, R., Budacki, J. G., Mohanty, S. H., Leister, K. P., & Bonner, R. L. (2015). Exposure and use of mobile media devices by young children. *Pediatrics*, *136*(6), 1044–1050. https://doi.org/10.1542/peds.2015-2151

Kamarulzaman, N. S. B., Phon, D. N. E., & Baharuddin, M. S. (2021). A mathematical educational game application for primary school slow learner. *Proceedings - 2021 International Conference on Software Engineering and Computer Systems and 4th International Conference on Computational Science and Information Management, ICSECS-ICOCSIM 2021* (pp. 348–353). https://doi.org/10.1109/ICSECS52883.2021.00070

Kaplan-Berkley, S. (2021). Digital tools and streaming media converge to inspire social interactions of Generation Alpha. *International Journal of Early Childhood*, *54*, 185–201. https://doi.org/10.1007/s13158-021-00301-y

Kapp, K., Blair, L., & Mesch, R. (2014). *The Gamification of learning and instruction*. Fieldbook. John Wiley & Sons.

Lavoué, É., Monterrat, B., Desmarais, M., & George, S. (2019). Adaptive gamification for learning environments. *IEEE Transactions on Learning Technologies*, *12*(1), 16–28. https://doi.org/10.1109/TLT.2018.2823710

López, P., Rodrigues-Silva, J., & Alsina, Á. (2021). Brazilian and Spanish mathematics teachers' predispositions towards gamification in STEAM education. *Education Sciences*, *11*(10). https://doi.org/10.3390/educsci11100618

McCrindle, M., & Wolfinger, E. (2014). The ABC of XYZ: Understanding the global generations. UNSW Press Book.

McCrindle, M., & Fell, A. (2020). *Understanding Generation Alpha*. McCrindle Research Pty Ltd. https://generationalpha.com/wp-content/uploads/2020/02/Understanding-Generation-Alpha-McCrindle.pdf

Menendez-Ferreira, R., Torregrosa, J., López-Fernández, D., & Mayor, J. (2022). Design of a serious games to improve resilience skills in youngsters. *Entertainment Computing*, *40*, 100462. https://doi.org/10.1016/j.entcom.2021.100462

Nah, F. F.-H., Zeng, Q., Telaprolu, V. R., Ayyappa, A. P., & Eschenbrenner, B. (2014). Gamification of education: A review of literature. In *Lecture Notes in Computer Science* (Vol. 8527, pp. 401–409). Springer. https://doi.org/10.1007/978-3-319-07293-7_39

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist, 50*(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Prensky, M. (2001). Digital native, digital immigrant Part 1. *On the Horizon, 9*(5), 2–6.

Quintas, A., Bustamante, J. C., Pradas, F., & Castellar, C. (2020). Psychological effects of gamified didactics with exergames in Physical Education at primary schools: Results from a natural experiment. *Computers and Education, 152*, 103874. https://doi.org/10.1016/j.compedu.2020.103874

Ramadlani, A. K., & Wibisono, M. (2017). Visual literacy and character education for Alpha generation. In *International Seminar on Language, Education and Culture* (pp. 1–7).

Romero Jr, A. (2017). Colleges need to prepare for Generation Alpha. *The Edwardsville Intelligencer*, 3. https://academicworks.cuny.edu/cgi/viewcontent.cgi?article=1177&context=bb_pubs

Rozi, F., Rosmansyah, Y., & Dabarsyah, B. (2019). A systematic literature review on adaptive gamification: components, methods, and frameworks. *Proceedings of the International Conference on Electrical Engineering and Informatics* (pp. 187–190). https://doi.org/10.1109/ICEEI47359.2019.8988857

Ruiz-Bañuls, M., Gómez-Trigueros, I. M., Rovira-Collado, J., & Rico-Gómez, M. L. (2021). Gamification and transmedia in interdisciplinary contexts: A didactic intervention for the primary school classroom. *Heliyon, 7*(6), e07374. https://doi.org/10.1016/j.heliyon.2021.e07374

Sanmugam, M., Zaid, N. M., Mohamed, H., Abdullah, Z., Aris, B., & Suhadi, S. M. (2015). Gamification as an educational technology tool in engaging and motivating students; An analyses review. *Advanced Science Letters, 21*(10), 3337–3341. https://doi.org/10.1166/asl.2015.6489

Saxena, M., & Mishra, D. K. (2021). Gamification and gen Z in higher education: A systematic review of literature. *International Journal of Information and Communication Technology Education, 17*(4), 1–22. https://doi.org/10.4018/IJICTE.20211001.oa10

Sipone, S., Abella-García, V., Barreda, R., & Rojo, M. (2019). Learning about sustainable mobility in primary schools from a playful perspective: A focus group approach. *Sustainability, 11*(8), 2387. https://doi.org/10.3390/su11082387

Su, C. H. (2017). Designing and developing a novel hybrid adaptive learning path recommendation system (ALPRS) for gamification mathematics geometry course. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(6), 2275–2298. https://doi.org/10.12973/EURASIA.2017.01225A

Swacha, J. (2021). State of research on gamification in education: A bibliometric survey. *Education Sciences, 11*(2), 1–15. https://doi.org/10.3390/educsci11020069

Taylor, L., & Hattingh, S. (2019). Reading in Minecraft: A Generation Alpha case study. *TEACH Journal of Christian Education, 13*(1), 29-36. https://doi.org/10.55254/1835-1492.1388

Torres-Carrion, P. V., Gonzalez-Gonzalez, C. S., Aciar, S., & Rodriguez-Morales, G. (2018). Methodology for systematic literature review applied to engineering and education. In *2018 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1364–1373). https://doi.org/10.1109/EDUCON.2018.8363388

Turk, V. (2017). *Understanding generation Generation Alpha*. Wired Consulting. https://cnda.condenast.co.uk/wired/UnderstandingGenerationAlpha.pdf

Ucus, S. (2015). Elementary school teachers' views on game-based learning as a teaching method. *Procedia - Social and Behavioral Sciences, 186*, 401–409. https://doi.org/10.1016/j.sbspro.2015.04.216

Udjaja, Y., Guizot, V. S., & Chandra, N. (2018). Gamification for Elementary Mathematics Learning in Indonesia. *International Journal of Electrical and Computer Engineering (IJECE), 8*(5), 3860. https://doi.org/10.11591/ijece.v8i5.pp3860-3865

Vanbecelaere, S., Van den Berghe, K., Cornillie, F., Sasanguie, D., Reynvoet, B., & Depaepe, F. (2020). The effectiveness of adaptive versus non-adaptive learning with digital educational games. *Journal of Computer Assisted Learning, 36*(4), 502–513. https://doi.org/10.1111/jcal.12416

Vidergor, H. E. (2021). Effects of digital escape room on gameful experience, collaboration, and motivation of elementary school students. *Computers & Education, 166*, 104156. https://doi.org/10.1016/j.compedu.2021.104156

Wang, M., & Zheng, X. (2021). Using game-based learning to support learning science: A study with middle school students. *The Asia-Pacific Education Researcher, 30*(2), 167–176. https://doi.org/10.1007/s40299-020-00523-z

Werbach, K., & Hunter, D. (2012). *For the Win: how game thinking can revolutionize your business*. Wharton Digital Press. https://books.google.lk/books?id=aL2tzgEACAAJ

Yabut, E. R., Jamis, M. N., Manuel, R. E., & Fabito, B. S. (2019). Empowering Elementary Schools on Learning Math: A Development of Gamified Educational Mobile Application for Grade 3 Students. In *11th International Conference on*

Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM, (pp. 1–5). https://doi.org/10.1109/HNICEM48295.2019.9073428

Yurtseven, N. (2020). *The teacher of Generation Alpha*. Peter Lang D. https://doi.org/10.3726/b16823

Zhao, J., Hwang, G. J., Chang, S. C., Yang, Q. F., & Nokkaew, A. (2021). Effects of gamified interactive e-books on students' flipped learning performance, motivation, and meta-cognition tendency in a mathematics course. *Educational Technology Research and Development, 69*(6), 3255–3280. https://doi.org/10.1007/s11423-021-10053-0

Ziatdinov, R., & Cilliers, J. (2021). Generation Alpha: Understanding the next cohort of university students. *European Journal of Contemporary Education, 10*(3), 783–789. https://doi.org/10.13187/ejced.2021.3.783