GAMIFICATION AS A MEDIATOR OF TEACHER-RELATED FACTORS AND TEACHING EFFECTIVENESS IN SCIENCE PRIMARY EDUCATION

PINGALAN A/L GEJANDRAN

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ABSTRACT

This study aimed to develop a model explaining the mediating role of gamification in teaching effectiveness within the primary science education context. Data were collected from 686 primary school teachers in Perak using validated questionnaires on Technological Pedagogical Content Knowledge (TPACK), Teacher Behaviour, Teacher Self-Efficacy, Psychological Characteristics, Gamification, and Teaching Effectiveness. Measurement model analysis confirmed satisfactory reliability and validity (CR = 0.892–0.991; AVE = 0.623–0.868). Partial Least Squares Structural Equation Modeling (PLS-SEM) was conducted using SmartPLS 4.The results showed that Teacher Behaviour ($\beta = 0.063$, $p < 0.001$), Self-Efficacy ($\beta = 0.159$, $p = 0.001$), Psychological Characteristics ($\beta = 0.149$, $p = 0.001$), and Gamification ($\beta = 0.143$, $p = 0.004$) significantly influenced Teaching Effectiveness, while TPACK was not significant ($\beta = 0.063$, $p = 0.135$). Mediation analysis revealed that Gamification significantly mediated the effects of TPACK ($\beta = 0.048$, $p = 0.008$), Teacher Behaviour ($\beta = 0.024$, $p = 0.008$), and Self-Efficacy ($\beta = 0.038$, $p = 0.010$) on Teaching Effectiveness, but not Psychological Characteristics ($\beta = 0.005$, $p = 0.497$). The model explained 38% of the variance in Gamification ($R^2 = 0.380$) and 25% in Teaching Effectiveness ($R^2 = 0.257$), reflecting predictive power in the context of primary science education. In conclusion, this study highlights the importance of gamification and TPACK in enhancing science teaching effectiveness. The findings provide implications for improving teachers' professional competence, classroom engagement, and student learning. Further longitudinal research is recommended to examine the long-term effects of gamification.

GAMIFIKASI SEBAGAI PEMBOLEH UBAH MEDIATOR ANTARA FAKTOR GURU DAN KEBERKESANAN PENGAJARAN DALAM PENDIDIKAN SAINS RENDAH

ABSTRAK

Kajian ini bertujuan membangunkan model yang menjelaskan peranan mediasi gamifikasi terhadap keberkesanan pengajaran Sains sekolah rendah. Hubungan antara Pengetahuan Kandungan Pedagogi Teknologi (TPACK), tingkah laku guru, efikasi kendiri dan ciri psikologi dengan keberkesanan pengajaran melalui gamifikasi sebagai pemboleh ubah mediator telah dikaji.Menggunakan pendekatan kuantitatif berfalsafah positivisme, data primer diperoleh melalui soal selidik melibatkan 686 orang guru sekolah rendah di Perak. Soal selidik yang digunakan meliputi TPACK, Tingkah Laku Guru, Efikasi Kendiri, Ciri Psikologi, Gamifikasi dan Keberkesanan Pengajaran. Analisis model pengukuran mengesahkan kebolehpercayaan dan kesahan yang memuaskan (CR = 0.892–0.991; AVE = 0.623–0.868). Partial Least Squares Structural Equation Modeling (PLS-SEM) dijalankan menggunakan SmartPLS 4.Dapatan menunjukkan bahawa Tingkah Laku Guru ($\beta = 0.063$, $p < 0.001$), Efikasi Kendiri ($\beta = 0.159$, $p = 0.001$), Ciri Psikologi ($\beta = 0.149$, $p = 0.001$) dan Gamifikasi ($\beta = 0.143$, $p = 0.004$) mempunyai hubungan langsung yang signifikan dengan Keberkesanan Pengajaran, manakala TPACK tidak signifikan ($\beta = 0.063$, $p = 0.135$). Analisis mediasi mendapati Gamifikasi berperanan sebagai mediator signifikan bagi hubungan TPACK ($\beta = 0.048$, $p = 0.008$), Tingkah Laku Guru ($\beta = 0.024$, $p = 0.008$) dan Efikasi Kendiri ($\beta = 0.038$, $p = 0.010$) dengan Keberkesanan Pengajaran, tetapi tidak signifikan bagi Ciri Psikologi ($\beta = 0.005$, $p = 0.497$). Model ini menerangkan 38% varians Gamifikasi ($R^2 = 0.380$) dan 25% varians Keberkesanan Pengajaran ($R^2 = 0.257$), sekali gus mencerminkan kuasa ramalan dalam konteks pendidikan Sains sekolah rendah. Kesimpulannya, kajian ini menegaskan kepentingan gamifikasi dan TPACK dalam meningkatkan keberkesanan pengajaran Sains. Implikasi kajian memberi manfaat kepada guru dalam meningkatkan kompetensi professional serta penglibatan murid. Kajian lanjutan dicadangkan bagi menilai kesan jangka panjang gamifikasi terhadap keberkesanan pengajaran dan pencapaian murid.

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LIST OF ABBREVIATIONS

CFA	Confirmatory Factor Analysis
DLP	Dual-Language programme
EFA	Exploratory Factor Analysis
EER	Educational Effectiveness Research
ICT	Information and Communication Technology
ISTE	International Society for Technology in Education
MCO	Movement Control Order
MDA	Mechanics-Dynamics-Aesthetics
MOE	Ministry of Education
OECD	Organization for Economic Co-operation and Development
TIMSS	Trends in International Mathematics and Science Study
PdPc	Pembelajaran dan Pemudahcaraan
PISA	Programme for International Student Assessment
PLS	Partial Least Squares
PPSMI	Pembelajaran Sains dan Matematik dalam Bahasa Inggeris
SKPMG2	Standard Kualiti Pendidikan Malaysia Gelombang 2
SEM	Structural Equation Modeling
SPSS	Statistical Package for Social Sciences
STEM	Science Technology Engineering and Mathematics
TER	Teacher Effectiveness Research
TPACK	Technological Pedagogical Content Knowledge

APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides an overview of the proposed study background and problem statement, which facilitates the research process. Furthermore, the research objectives, questions, and hypotheses are presented in the chapter together with theoretical and conceptual frameworks and the operational definitions of relevant terms and concepts for a sound understanding of the study context. The chapter also highlights the study's significance and limitations before drawing a conclusion.

1.2 Background of the Study

Science instruction in Malaysian schools began with the integrated science curriculum, which was introduced in primary and secondary schools in the late 1980s to address stakeholder (teachers, parents, experts) calls on addressing student needs. This initiative has undergone various amendments over the years in terms of developing new objectives, content, teaching styles, instructional materials for science education, and a philosophical shift from teacher to student-centric classrooms with underlying complexities. Unprecedented economic growth and advancements in globalisation in the 1990s characterised the need to equip students with digital skills for the 21st century. For example, smart schools were introduced to propagate self-paced, self-accessed, and self-directed learning. Empirical works highlighted most teachers' challenges in handling multimedia and their emphasis on completing the syllabus, which led to a predominantly examination-centred learning environment (Seman et al., 2017; Mahmud et al., 2018).

A change in the language policy is another drastic measure impacting the teaching of science in Malaysia. The 'Pembelajaran Sains dan Matematik dalam Bahasa Inggeris' or PPSMI policy implemented in 2002 rendered English the medium of instruction for Science and Mathematics at both primary and secondary levels. It was deemed crucial to prepare students for careers in science and technology by using English: the language of international, science and technology. Regardless, this incorporation was hampered by various issues, such as teachers' low English proficiency and insufficient instructional materials. This policy was terminated in 2012 and substituted with the Dual-Language Programme (DLP), which provides flexibility

in choosing an instructional medium for science. With regards to DLP, Suliman et al. (2018) underscored the significance of teaching methods rather than instruction mediums in catalysing student achievement in Science and Mathematics.

The Ministry of Education (MOE) implemented the Malaysian Education Blueprint in 2013 to address on-going issues on science instruction in schools and compete with the global STEM movement. This blueprint proposed using a more active approach and with higher-order thinking skills through problem- and project-based learning and formative assessments (Annamalai, 2021). A more innovative approach to the gamification of science instruction in primary schools is necessary following concerted governmental efforts to develop STEM as an integrated academic discipline and consider the issues underpinning science education.

Science is a crucial subject given its relevance to daily life and developing problem-solving and critical-thinking skills. Thus, it is deemed vital to facilitate students' scientific inquiries with strong scientific grounding from the primary level. Studies on integrating gamification with multiple educational levels and subjects became prominent in the early 2010s within the education sector (Swacha, 2021). Gamification constitutes two components: structural and content. Structural gamification denotes the application of game design elements through instructional content without changes, while content gamification implies the application of elements, mechanics, and game-thinking to gamify the material (Kapp, 2013). For example, structural gamification could utilise points to complete assignments, while content gamification could initiate a lesson with a quiz.

Gamified learning improves students' motivation to interact and learn, the willingness to perform challenging tasks, and goal attainment and provides a better opportunity for critical reflection (Garone & Nesteriuk, 2019). Manzano-León et al.'s (2021) analysis of gamification in education stated that a balance in design regarding the various gamification elements (mechanics, dynamics, and aesthetics) increases student engagement and motivation. In this vein, context is a key factor in designing gamified learning to achieve the right balance in design and stimulate students' motivation following their educational levels.

In the past decade, gamification has emerged as a prominent topic among education researchers, capturing attention for its potential to revolutionize learning environments (Baah et al., 2023; Martin et al., 2020). This innovative approach integrates game-based mechanics, aesthetics, and game thinking into educational contexts, aiming to create more engaging and motivating experiences for students. As a pedagogical strategy, gamification has been hailed for its capacity to transform traditional learning paradigms by tapping into students' inherent attraction to game-like elements and competitive dynamics (Swacha, 2021). According to Manzano-León et al. (2021), a balance between different gamification elements is crucial for enhancing student engagement. This approach is also considered to be effective within the context of "Science, Technology, Engineering and Mathematics" (STEM) education, leading to the cognitive development of the students (Triantafyllou et al., 2024). Therefore, in the modern world of technology, teachers also need to focus on implementing innovative digital technology to increase student engagement.

According to Dustman et al. (2021), gamification refers to the practice of applying game mechanics to non-game contexts, such as educational settings. Indirectly, games tend to be popular among students since they are well-liked and entertaining, according to previous research. Krause et al. (2015) found that students' information retention improved by 25% with gamification and by 50% with gaming components. According to Marín-Díaz et al. (2020), gamification can alleviate students' anxiety related to subjects in the classroom. Using game components to create a more calm and fun learning environment can help decrease students' anxiety, according to Caglar and Senol, H. (2021). Anxiety can impede students' learning and performance in education.

Accordingly, research into the organised growth of kids and teens in Physical Education (PE) settings is a relatively new and important area of study in modern culture (Branquinho, Santos, & Noronha, 2022). Specifically, with the convergence of state-of-the-art mobile technology, Virtual Reality (VR), and social networks, gamification tactics have been rising to the forefront in many educational settings (Jayanthi & Rajalakshmi, 2022). According to Arufe-Giráldez, Sanmiguel-Rodríguez, Ramos Álvarez and Navarro-Patón (2022), gamification is the process of adding game mechanics and components to physical education classes in order to make them more engaging and participatory. According to Santos, Oliveira, and Hamari (2021), gamification techniques can be effectively integrated with current teaching paradigms and used in several areas of children and adolescent education.

The regular engagement in physical activity and motor development can be predicted by these domains, which are essential for children's healthy development

(Batista et al., 2019). So, it's crucial that educators and researchers come up with creative and entertaining ways to inspire kids to exercise, build their motor skills, and engage in psychosocial activities (Dichev, Dicheva & Irwin, 2020). Area-Moreira et al. (2016) and Harvey et al. (2020) both found that traditional teaching models are still widely used in classrooms. So, gamification approaches appear to develop in response to distinct variables like gender, age, and application context. According to Metzler (2017) and Pozo et al. (2018), teaching models are comprehensive plans that try to convey a core teaching principle through a standardised theoretical framework that facilitates the teacher's decision-making process. Gamification is a strong and interesting method of enhancing the learning process when added to current models of instruction (Arufe-Giráldez et al., 2022). Cognitive abilities relevant to athletic activity, such as problem-solving, decision-making, and strategic thinking, can be effectively taught in physical education classes through the use of gamification tactics that enable students to set precise goals and follow a defined path to success (Dichev et al., 2020).

Through the incorporation of game mechanics into educational activities According to Jung et al. (2021), gamification has the potential to inspire pupils, calm their nerves, and strengthen their routines. Motivating pupils to seek out new information is the primary benefit of using gamification in mathematics classes. As a result, kids become more engaged in their learning and develop a stronger passion for mathematics. Gamification also encourages social development, which is a great plus. (Dash et al., 2022) when playing activities that include cooperation and competition. By presenting mathematical topics in an interactive and entertaining way, gamification also offers a means to accomplish educational goals. Students might be

motivated to improve their math skills by incorporating game aspects into mathematics education, such as challenges, levels, and rewards. Students' ability to solve problems may be improved with the use of gamification in mathematics classes (Abu-Hammad & Hamtini, 2023).

Furthermore, research has shown that gamification tactics can have both short-term and long-term positive effects on children and youth by increasing their motivation (Kulkarni et al., 2022). It should be emphasised that gamification tactics should be carefully planned so that they complement the educational setting's aims and purposes for learning (Fulton, 2019; Kulkarni et al., 2022). According to Baah, Govender and Rontala Subramaniam (2023), gamification has the potential to make learning more engaging, fun, and motivating for students. There is an immediate need for pedagogical innovation and formative change in physical education classrooms as student enthusiasm to engage in the subject continues to decline. According to Quintas et al. (2020), one creative and effective way to achieve this goal is by gamifying the instructional process.

The development of gamification in science education parallels the teacher digital competence frameworks, where modern-day teachers should demonstrate relevant skills to guide their students towards a technology-driven learning process (Garzon Artacho et al., 2020). Multiple institutions have designed frameworks, such as the European Framework of Digital Competence for Teachers, Framework of the “International Society for Technology in Education” for teachers, the UNESCO ICT Competence Framework for Teachers, and the British Framework of Digital Teaching with distinctive indicators and standards. Although most of the frameworks emphasise

technicalities, the focus has shifted to higher-order thinking skills, which is a prerequisite to modern-day teaching (Janssen et al., 2013).

Teaching effectiveness is a measure of job performance in the teaching profession that does not possess a consensual definition but can be measured through students, teachers or a combination of both (Kim et al., 2019). Competence in education refers to the basic rules that a teacher must follow and understand in order to meet the aspirations of students and the education system as a whole. are the primary implementers of all educational policies and curriculum objectives (Zaaim et al., 2019). Teachers are responsible for setting up environments and opportunities for deep learning experiences that can uncover and boost pupils' capacities. Teachers are called on to be activators of meaningful learning, not just facilitators, and being creative in choosing from a wide palette of strategies to be mixed and adjusted to context and learner (Caena, 2017). Based on Sánchez-Cabrero et al. (2021), educators' teaching effectiveness significantly influences students' educational process. It is deemed challenging for students to attain notable learning progress without effective teacher facilitation.

Digital competence proves necessary to navigate dynamic teaching and learning environments and complements educators' teaching effectiveness in the 21st century through professional development. Teachers' development of TPACK, which explains teachers' extensive knowledge and skills to successfully utilise technology in curriculum design and organisation, is essential to achieve digital competence for more effective classroom teaching (Dong et al., 2020). Educators would struggle to incorporate advanced technology into their lessons without an updated TPACK,

which could adversely affect their lesson outcomes. Teacher behaviour is another key determinant of teaching effectiveness. Reportedly, teachers with effective teaching behaviours (efficient classroom management, clear instruction, and flexible teaching strategies) positively impacted students' academic achievement (Maulana et al., 2017).

Teachers' self-efficacy or belief in their abilities to perform certain tasks could also influence teaching effectiveness and the use of technology in lessons (Dong et al., 2020). Higher self-efficacy with technology-driven integrations implies higher and updated TPACK. Educators' psychological attributes in terms of personality, attitude, experience, and aptitude also influence teaching effectiveness. Following Göncz (2017), students perceive efficient teachers as emotionally stable and conscientious individuals. Teachers' attitude towards technology also impacts their tendency to use technological innovations in lesson plans (Islahi, 2019).

The method teachers use in classes has a major bearing on how their students react in class. In order to encourage active learning, STEM instructors should try new things and break away from the traditional ways of teaching the subject (Nguyen et al., 2021). The claim that creative methods of instruction can boost students' interest and performance in the classroom is backed up by research (Hussein, A., 2024). Teachers may now be more creative than ever before in creating interesting and interactive lesson plans that really grab students' attention, all thanks to the advancements in technology. One way to make maths classes more interesting and get students involved is to employ gamification of learning. The use of gamification in the classroom has several benefits, including raising students' interest, motivation, and focus (Rahmani et al. 2020).

There has been a decline in student motivation to study due to the prevalence of traditional one-way teaching approaches in the field of education (Noreen & Rana, 2019; Putz et al., 2020). Research has shown that pupils aren't motivated to study when the emphasis is only on the instructor or the material being taught in one-way classrooms. Students' academic performance is negatively impacted by boredom, which in turn raises their unhappiness with the training program, teacher, and learning topic (Noreen & Rana, 2019; Putz et al., 2020). Consequently, innovative pedagogical approaches are required to boost student achievement while simultaneously satisfying educators. According to recent research (Wang et al., 2020; Zainuddin et al., 2020), gamification of learning is a new approach that can assist in attaining the intended learning results. One of the most prominent developments in software nowadays is gamification. In our everyday lives, gamification is present, even though it isn't often seen (Baptista & Oliveira, 2018). The process of gamification entails enhancing user experience and engagement through the incorporation of game elements into non-game environments (Aparicio et al., 2021).

1.3 Problem Statement

Students must demonstrate sufficient science-oriented knowledge and skills to discuss pertinent issues and be conscientious consumers of scientific and technological information that is connected to daily life. In this vein, science is an important subject that hones specific skills in scientific inquiries, such as critical reasoning and analysis of evidence (Sonia, 2017). The learning of science should begin at the primary level of schooling to prepare students for a life where science and its technological applications play pivotal roles. This early introduction enables young children to understand simple notions of science before presenting them with complex ideas in secondary school (Harlen & Qualter, 2018).

Nevertheless, the apparent lag in professional development at work may expose students to a low or mediocre quality of education as teachers are yet to optimise their skills (Sánchez-Cabrero et al., 2021). Educators could rapidly enhance their capability by gauging and internalising the factors that improve or hinder teaching effectiveness. Safapour et al.'s (2019) study on non-traditional teaching methods highlighted the positive impact of gamification on students' learning compared to flipped classrooms, self-learning, and social media. Nevertheless, the focus of most studies involving the gamification effects on adult or higher-education students' learning of science renders it challenging to generalise the study findings to other levels of learning, such as primary education.

The new generation of students who live in this digital era are already equipped with the skills necessary for modern-day learning (Abdullah & Hendon, 2022). As such, they expect interactive and engaging technology-oriented lessons. Otherwise, incongruencies between students' lifestyle and their learning experiences could instigate demotivation and boredom in class. Suliman et al.'s (2018) study on students' level of confidence and enthusiasm in DLP revealed the substantial impact of teaching methods on students' confidence. Science teachers must upgrade their teaching techniques as part of their professional development or risk reflecting poor skills in integrating technology with their teaching (Mahmud et al., 2018). Despite the strong consensus on teachers' role and teaching methods, studies on the factors influencing teachers' teaching effectiveness in primary science education through gamification (as a mediator) for improved student engagement and learning remain scarce. A literature gap on gamification as a mediator in teaching effectiveness was also identified as most of the studies emphasised its effects on students' learning effectiveness and motivation.

The Collaborative Reading Annotation System was employed in studies involving researcher-created gamified content, as demonstrated by the work of Chen et al. (2023). There was a considerable increase in annotations and engagement levels among students in the experimental group. On the other hand, the reading abilities of the control and experimental groups were not different, according to Chen et al. (2023). Students built and ran a virtual business in a role-playing game developed by Hernández-Prados et al. (2021) as part of an action research technique. Motive and second language acquisition were both affected by the application of gamification in the learning process, according to the researchers. Fewer studies have looked at the

components of gamification as a mediator, as opposed to the many that have examined them individually. This study aimed to fill a gap in the literature by collecting and analysing teacher effectiveness using gamification as the mediator in primary classrooms. This research looks at the ways in which primary educators are using gamification and how they feel it has affected student achievement. Parallel to Iberahim and Md. Noor (2020), teachers primarily struggle with inadequate knowledge of technology skills, which subsequently impacts their use of technology for student-centric learning. Teachers need to gauge and internalise the mediating effect of gamification, which proves beneficial at multiple learning levels and enhances their teaching effectiveness through optimal professional development.

Moreover, the instruction of primary science in Malaysia has been significantly shaped by alterations in curriculum, modifications in legislation, and teacher-centric pedagogical approaches. International evaluations, like PISA (2018) and TIMSS, repeatedly indicate that Malaysian pupils underperform relative to OECD averages, with approximately 50% of 15-year-olds failing to achieve basic competency standards in science. UPSR findings at the elementary level have exhibited a deteriorating tendency, prompting worries over the foundations of scientific literacy. These deficiencies are frequently ascribed to examination-centric methodologies, restricted digital proficiency among educators, and inadequate pedagogical efficacy in fostering engagement and advanced cognitive processes.

Current research on gamification in Malaysia predominantly emphasizes higher education or adult learners, with scant concentration on basic education. Moreover, most studies highlight the impact of gamification on student motivation,

satisfaction, or learning results, neglecting its function as a mediator in instructional efficacy. Several studies have examined the relationship between student satisfaction and learning effectiveness, sometimes known as academic performance (Hazzam & Wilkins, 2023; Soesmanto et al., 2023; Wu et al., 2022). Nevertheless, there is a lack of knowledge regarding how gamification affects the relationship between learning effectiveness and student learning satisfaction. We need to know if the higher learning effectiveness is what's making students happy or if it's just the game itself. According to El-Sayad et al. (2021), students report higher levels of satisfaction and favourable evaluations of their learning when they think that it is successful.

To fully realise gamification's promise in the classroom, future studies should investigate the relationship between game mechanics and the efficacy of learning. In the end, this will help teachers and students alike by revealing fresh approaches to gamification in the classroom. (Pérez-Pérez et al., 2020; Wirani et al., 2022). Several research have investigated how technology affects students' satisfaction within the setting of technology-based education. According to the research conducted by Hanus and Fox (2015), and Van Roy and Zaman (2018), the majority of gamification studies in the classroom have concentrated on how the technology influences student motivation.

The employment of digital tools during the COVID-19 pandemic was also discovered by Ignacio Pichardo et al. (2021). These tools included programs like Izzi Kivizzi, Microsoft Forms, and Mentimeter, which were utilised to generate interactive quizzes with and without leaderboards. The significance of instructors' roles in gamification has not been well studied, according to Saggah et al. (2020), even though

there is literature on the topic. Furthermore, research on student expectations, instructor satisfaction, and the gamified model's acceptability as a curriculum is necessary (Chung et al., 2019). Sánchez-Mena and Martí-Parreño (2017) suggested studying how teachers see students' disinterest in gamified activities and whether it's because students see them as just a game and not a way to learn. One area that needs further investigation is how to incorporate student feedback into the goal-setting process (Beemer et al., 2019). Incorporating game mechanics into the classroom was seen by teachers as a way to get pupils more invested in the material, more cautious, less careless, and more eager to experiment with new ideas (Alabbasi, 2018).

Adopting effective gamification methods is hindered by a lack of comprehensive understanding of the impacts of gamification in different learning situations (Chen et al., 2022). The factors suggested by Hamari et al. (2021) are most crucial to improving students' educational experiences. Additionally, studies should be conducted to determine how much comprehensive and detailed information students require regarding the game aspect of payment before beginning a gamified experience (Smiderle et al., 2020). In addition, Fadhli et al. (2020) recommended looking into whether or not the gamification was the cause of the elementary students' improved skills. According to Landers et al. (2018), researchers studying gamification should look at how goals are defined in gamified therapies and how effective they are.

Consequently, gamification can make learning more engaging and immersive and aims to improve the learning process overall (Abhishek Behl et al., 2022). However, there is a lack of studies on how to incorporate gamification in primary school

students (Oyedotun, 2020). Researchers are starting to grasp gamification's function in the classroom, but more research is required to identify which gamification components work best in various settings (Aldemir et al., 2018; Schöbel et al., 2020). There is limited understanding of Malaysian primary science Malaysian teachers' perceptions and implementations of gamification, as well as its interaction with teacher competency (TPACK), pedagogical behaviors, psychological traits, and self-efficacy. Although studies on gamification components have been conducted on older student populations (Özdener, 2017; Özer et al., 2018; Ryan et al., 2017) and adult populations (Ukala & Agabi, 2017), the number of studies concentrating on K-8 populations is very limmited (Kuo & Chuang, 2021).

This highlights a deficiency in comprehending how gamification might be systematically included into models of teaching success inside elementary science classrooms, where the initial foundations of scientific literacy are developed. Furthermore, while gamification has been demonstrated globally to improve engagement, problem-solving, and motivation (López & Tucker, 2018; Van Roy & Zaman, 2018; Wirani et al., 2022), Malaysian classrooms encounter contextual obstacles: teachers' unfamiliarity with gamification techniques, insufficient resources, and a disconnect between conventional assessments and interactive learning experiences. There is minimal evidence that gamification elements can have both direct and indirect effects on learning efficacy at the same time, according to research in gamified education. In addition, the role of learning effectiveness and engagement as mediators between gamification components and satisfaction has received minimal attention (López & Tucker, 2018; Van Roy & Zaman, 2018; Wirani et al., 2022).

1.4 Research Objectives

This study aims to develop a model that explains (i) the mediating role of gamification in teaching effectiveness within the primary science education context and (ii) facilitates science teachers' understanding of gamification effects for effective teaching, higher-order thinking skills, and improved student motivation to learn. The research objectives are proposed below:

OB1: To determine the relationships of TPACK, teacher behaviour, self-efficacy, and psychological characteristics with teaching effectiveness.

OB2: To determine the effect of gamification on teaching effectiveness.

OB3: To investigate the effects of TPACK, teacher behaviour, self-efficacy, and psychological characteristics on the implementation of gamification.

OB4: To identify the mediation effect of gamification in the relationships between TPACK, teacher behaviour, self-efficacy, and psychological characteristics with teaching effectiveness.

OB5: To develop a model of teaching effectiveness with the mediating role of gamification for primary science education.

1.5 Research Questions

The following research questions are proposed in line with the study objectives:

RQ1: What are the relationships of TPACK, teacher behaviour, self-efficacy, and psychological characteristics with teaching effectiveness?

RQ2: Does the implementation of gamification affect teaching effectiveness?

RQ3: What are the effects of TPACK, teacher behaviour, self-efficacy, and psychological characteristics with the implementation of gamification?

RQ4: How does the implementation of gamification as a mediator affect the relationships between TPACK, teacher behaviour, self-efficacy, and psychological characteristics with teaching effectiveness?

RQ5: What are the constructs of a model for teaching effectiveness with the mediating role of gamification for primary science education?

1.6 Research Hypotheses

The research hypotheses are presented below following the study objectives:

OB2: To determine the relationships of TPACK, teacher behaviour, self-efficacy, and psychological characteristics with teaching effectiveness.

Ha1: TPACK has a significant effect on teaching effectiveness.

Ha2: Teacher behaviour has a significant effect on teaching effectiveness.

Ha3: Self-efficacy has a significant effect on teaching effectiveness.

Ha4: Psychological characteristics have a significant effect on teaching effectiveness.

OB3: To determine the effect of gamification on teaching effectiveness.

Ha5: Gamification has a significant effect on teaching effectiveness.

OB4: To investigate the effects of TPACK, teacher behaviour, self-efficacy, and psychological characteristics with the implementation of gamification.

Ha6: TPACK has a significant effect on the implementation of gamification.

Ha7: Teacher behaviour has a significant effect on the implementation of gamification.

Ha8: Self-efficacy has a significant effect on the implementation of gamification.

Ha9: Psychological characteristics have a significant effect on the implementation of gamification.

OB5: To investigate the implementation of gamification as a mediator in the relationships between TPACK, teacher behaviour, self-efficacy, and psychological characteristics with teaching effectiveness.

Ha10: Gamification mediates the relationship between TPACK and teaching effectiveness.

Ha11: Gamification mediates the relationship between teacher behaviour and teaching effectiveness.

Ha12: Gamification mediates the relationship between self-efficacy and teaching effectiveness.

Ha13: Gamification mediates the relationship between psychological characteristics and teaching effectiveness.

1.7 Theoretical Framework

1.7.1 Technological Pedagogical Content Knowledge (TPACK)

Essentially, TPACK denotes a complex interaction of the three pillars of knowledge (technology, pedagogy, and content) to generate the knowledge required in integrating technology with teaching. Koehler et al. (2013) highlighted the reliance of teaching effectiveness on flexible access to abundant, organised, and integrated knowledge from various domains of pedagogy, content and technology. Based on the TPACK theory, the foundation of teaching effectiveness goes beyond knowledge of technology to include expert knowledge on integrating technology information with pedagogical and content knowledge (Saubern et al., 2020). As such, the TPACK implications on teaching effectiveness are the combination of expert knowledge and successful practice acquired through teachers' holistic professional development.

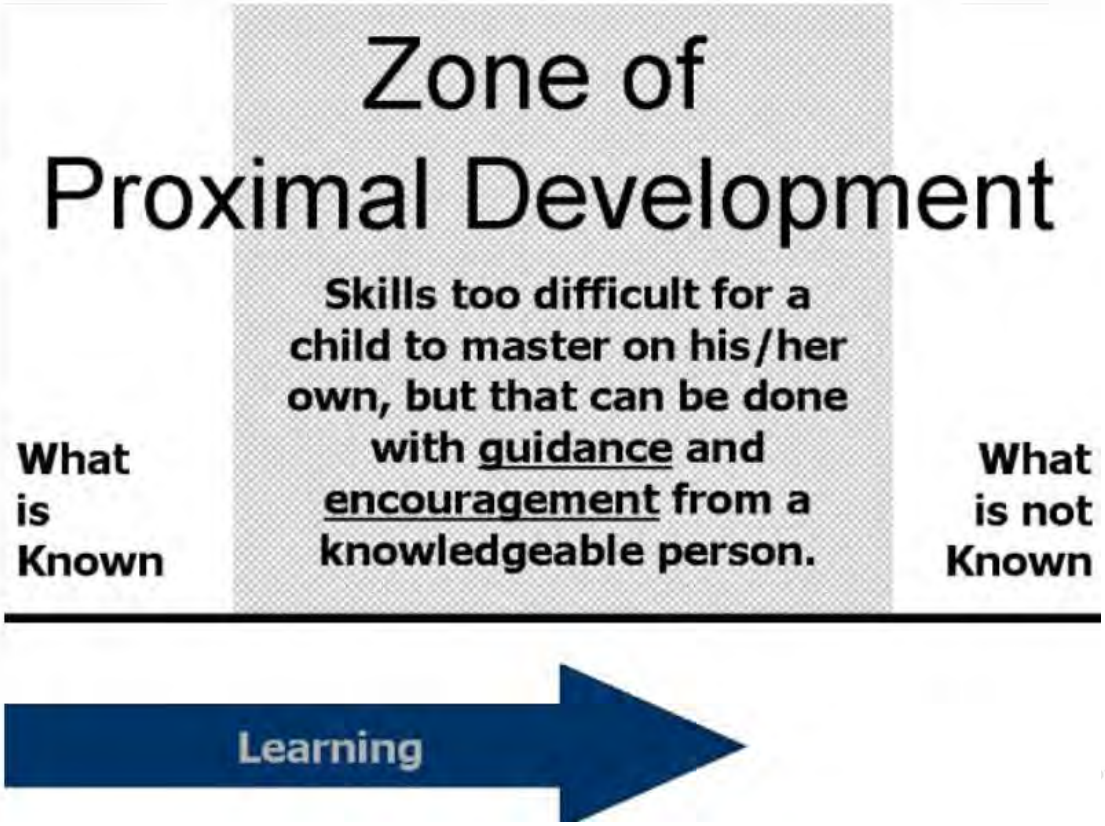
The use of gamification in lessons fulfils the TPACK concept that integrates knowledge with pedagogy, content, and technology (Prabawa, 2017). Teachers can flexibly choose relevant pedagogical approaches from various gamification types for the specific content area using technological gamification elements. Likewise, Mårell-Olsson (2021) proposed using gamification designs to hone students' modern-day skills despite planning and implementation-related intricacies. The challenge in achieving a pedagogical balance to implement gamification is hence associated with identifying a balance between the lesson content and knowing which pedagogical methods suitably complement the selected digital tools.

According to Zdravkova (2016), educational pedagogy needs to change so that students can engage in active learning, where they build their own knowledge, collaborate on projects, and make use of online resources like social media. According to Mattar (2018), we need to reframe Vygotsky's zone of proximal development (ZPD) as something that is controllable, internal, and individual in this technological age. This suggests that connectivism is the constructivist ideology that works best in this digital era. According to Kop and Hill (2008), the main idea behind connectivism is the growth of one's cognitive abilities, rather than how connections in a network are explained in relation to factors like exposure or maturation.

Vygotsky's Zone of Proximal Development (ZPD) is defined as the gap between the kinds of tasks that students can complete independently and those that require more guidance from an instructor. According to Vygotsky (1978), when children interact with adults in their surroundings and work together with their classmates, internal developmental processes take place. In order for a kid to develop autonomy and psychological functions that are organised according to their culture, Vygotsky (1978) claimed that these processes must be internalised. Kop and Hill (2008), argued that in order to scaffold learning effectively, educators need to have a grasp of ZPD. Figure 1.1 illustrates Vygotsky’s Zone of Proximal Development that from a constructivist stance, teachers must be sensitive to and knowledgeable about their students' genuine passions and areas of interest. They also need to make sure that the design process incorporates real learning activities. In constructivism, the method, rather than the result, is central (Mattar, 2018).

Figure 1.1

Vygotsky's Zone of Proximal Development



Adopted from Dastranj & Helali, 2016

According to Hamari et al. (2017), students will remain actively involved in their learning and progress towards goals if they can practise what they've learnt within their zone of proximal development (ZPD), which is illustrated in Figure 1.1. The goal of teaching in a constructivist classroom is not merely to impart information but rather to foster an environment where students and teachers work together to build upon prior knowledge and address individual interests, needs, and experiences (Marhan, 2016). According to Mattar (2018), connectivism is a new form of constructivism that is more applicable to the modern digital era. The main point was that, according to connectivism, ZPD is no longer just something that happens in

the brain of the individual learner; it is also an activity that takes place in groups or networks. In addition, Mattar (2018) stated that the ZPD in the digital era is adaptable because learning may now happen externally, be accessed selectively, and then be changed with fresh material to complete different activities. Training students in the domains of digital literacy (DLS), career and life skills (CLS), and critical thinking, problem solving, creativity, and innovation (LIS) was proposed by Kivunja (2014) as a paradigm shift from the traditional pedagogy of constructivism.

The Zone of Proximal Development (ZPD) asserts that learners can attain elevated levels of comprehension when aided by more knowledgeable individuals, educators, or educational resources. In gamified scientific education, the implementation of challenges, feedback systems, and progressive difficulty levels aligns directly with scaffolding tactics inside the Zone of Proximal Development (ZPD). Gamification offers organized opportunities for learners to advance from tasks requiring assistance to those they can accomplish autonomously, so promoting cognitive growth. The motivating benefits of gamification correspond with Vygotsky's focus on social contact and mediated learning, as collaborative and competitive game components promote peer support, dialogue, and collective problem-solving.

Students can connect with others on a local, national, and even global scale using gamified learning features like leaderboards. The formation of new bodies of knowledge may be stimulated by these links. While gaming features like badges and experience points offer external motivation, they also have the potential to improve students' academic performance. Relationship building, active participation,

integration, collegiality, and cooperation are all necessary for successful learning in a connective learning setting (Kivunja, 2014; Marhan, 2016). Teachers establish rapport when they foster an atmosphere of trust and camaraderie with their students. Engaged pupils are ones that teachers are able to draw in and maintain their interest in the learning process. According to Kivunja (2014) and Marhan (2016), students demonstrate collegiality when they build relationships with one another and, in certain instances, work together with the teacher. How well students collaborate to achieve a shared objective in the classroom is known as cooperation (Kivunja, 2014; Marhan, 2016).

Cooperation was defined more broadly by Kivunja (2014) to incorporate Cooperative Learning Strategies abilities like adaptability and independence. To engage, encourage, solve issues, or increase learning, gamification uses gaming aspects (Kapp, 2012). While there is some evidence that gamification can be effective in some settings and subject areas, studies examining its application from educators' points of view are lacking. Studies on gamified material in social media apps like Snapchat have started to surface. Edmodo, Socrative, Class Dojo, Kahoot, ClassCraft, Duolingo, and Quizziz are just a few examples of these gamified content programs that have been the subject of research. Other examples include Edmodo, ClassCraft, Kahoot, and Edmodo for second language learners. According to Figueroa-Flores (2016), Edmodo is a educational social media site that lets users earn badges and complete quests. The site also has an interface where students may post and comment on assignments, monitor their progress, take part in polls, and create their own quizzes.

To increase students' interest, ClassCraft incorporates technology and creativity into preexisting systems of team points, houses, table awards, raffles, tickets, and incentive systems (Qi Zhang et al., 2021). According to Qi Zhang et al. (2021), one criticism levelled against ClassCraft was that it was too reliant on rewards to motivate specific actions. Educators can use the free virtual application Kahoot, which combines game-based pedagogy with internet-enabled devices, to make online surveys, quizzes, and conversations with points for right answers (Bicen & Kocakoyun, 2018).

Gamification uses elements of game mechanics to provide practical solutions by building interest (engagement) in certain groups (Vianna, 2018). Gamification not only uses game elements and game design techniques in non-game contexts (Werbach & Hunter, 2019) but also empowers and engages learners with the ability to use a motivational learning approach and maintain a relaxed atmosphere. A framework called Technological Pedagogical Content Knowledge (TPACK) should be referenced in understanding technology as an integral educational partner. The TPACK was first proposed by Koehler et al. (2013) to describe an integrated connection between content, pedagogical, and technological knowledge. The framework illustrates essential knowledge of how teachers could integrate technological tools into their teaching of specific content in their school practice (Kapp, 2012). Hence, teaching involves students getting active in the construction of knowledge. In this case, teaching demands that teachers not only master the knowledge of the subject matter and the ways to transform them into active students but also have teaching skills that help them to fulfil the demands of modern society and standards of quality education.

TPACK model provides a systematic framework for evaluating instructors' ability to effectively incorporate technology into subject-specific pedagogy. It emphasizes that effective teaching involves not only technology proficiency but also the harmonious integration of content knowledge, pedagogical knowledge, and technological expertise. In the realm of gamification, educators must possess both the technical proficiency to utilize digital technologies and the pedagogical acumen to create interesting, meaningful, and contextually relevant activities that correspond with scientific subject. In the absence of TPACK, gamification may devolve into a mere superficial application of points or badges, failing to authentically facilitate higher-order thinking, inquiry-based learning, and the enduring recall of scientific concepts. This theoretical synthesis is pertinent to Malaysian primary education, where teacher-centered methodologies prevail and children' science performance falls short of international standards.

The student's solitary demands may not be satisfied by a single technique of teaching since they have numerous queries in relation to teaching concepts, and their attention will be divergent (Ali & Anwar, 2021). According to Kalyani (2024), learning tasks that affect different kinds of knowledge production and student participation in the course curriculum would play a key role in obtaining learning results in a technologically oriented setting.

1.7.2 Teacher behaviour

Teacher behaviour implies educators' class-oriented actions with regards to classroom management and adaptive teaching (Maulana et al., 2017). Effective teaching behaviours significantly impact students' academic engagement, where disinterested students could play truant or behave disruptively in class. Following Creemers and Kyriakides's (2015) study on teaching effectiveness, teachers' classroom behaviour directly influenced students' learning outcomes. These educators may not have known how to improve their classroom behaviour despite reflecting positive teaching attitudes. Hence, teachers' professional development should enhance their teaching quality through optimal teaching skills. Teachers could then select behaviours that are palpably effective in the classroom context.

If the education systems are to improve schools for the 21st century, then they must increase the supply of teachers with strong working knowledge of their content and the pedagogical techniques necessary to link their content with real-world applications. Regarding the teacher behaviour-gamification link, knowledge, or familiarity with ICT tools enhances teachers' chances of utilising such instruments as part of their instruction: a crucial predictor of behaviour or behavioural intention (Sajinčič et al., 2022). Regardless, further research proves necessary to determine whether behavioural intention leads to the actual behaviour of incorporating technology into teaching. Much research on classroom behaviour and gamification involves students and their behavioural outcomes following the use of gamification in class (Tek et al., 2021).

1.7.3 Self-efficacy

Self-efficacy implies the development of teachers' beliefs in their ability to attain a specific level of accomplishment (Kent & Giles, 2017). High efficacy levels could influence the effectiveness of teachers, who could optimise their professional development and integrate new teaching strategies with their lessons. In Mahler et al. (2018), teachers' self-efficacy is connected to different teaching effectiveness elements: professional engagement, effective instructional strategies, and openness to difficult students. Teachers who are always aware of their student's needs will be able to provide appropriate and effective classroom support. Hence, it will allow the students to make the most learning progress. Therefore, attitude is important in measuring competence and must not be neglected.

Teachers with higher self-efficacy potentially generate better results in these elements for improved academic performance. Kent and Giles (2017) claimed that teachers with low self-efficacy seldom incorporate technological tools into their instruction. Although high self-efficacy in technology does not imply teachers' actual use of innovative tools in their teaching, it is an important element in technology integration. Tenório et al.'s (2020) research on the use of gamification in lessons revealed that teachers with high self-efficacy reflected positive reactions to the examined gamification tool. In this vein, teachers with high self-efficacy are inclined to integrate gamification with their lessons.

1.7.4 Psychological characteristics

Creemers and Kyriakides (2015) present the following psychological characteristics that determine an effective teacher: teacher personality, attitude, experience, and aptitude or achievement. Based on the Big Five personality domains of openness, conscientiousness, extraversion, agreeableness, and emotional stability examined in Kim et al.'s (2019) study, only agreeableness was not linked to students' academic outcomes. Furthermore, extraversion demonstrated a slightly stronger link to teaching effectiveness over conscientiousness. Although highly experienced teachers tend to facilitate student learning more effectively (Podolsky et al., 2019), their teaching effectiveness appears to wane after two or three decades. In addition, classroom management skills are important in allowing the students to learn in a conducive environment that is suitable for the students to perceive knowledge authentically.

Teachers' gamification-oriented attitudes must also be considered; negative attitudes towards technological tools potentially result in resistance to integrate technology with their lessons despite the availability of digital facilities (Islahi, 2019). Notably, teachers could be overwhelmed by such technology or hesitate to look incompetent in their students' eyes if they fail to resolve unforeseen issues. Technology competence based on teachers' aptitude in rapidly utilising novel technological tools or general knowledge of technology could also impact teachers' usage of gamification in their lessons (Uerz et al., 2018). Teachers who lack technological aptitude may need more time to understand and implement gamification in class.

1.7.5 Gamification

Gamification denotes the usage of game elements and design techniques in non-game settings (Flores, 2015). Teachers also tend to use and study gamification for online teaching and professional development in addition to classroom settings. Effectively-designed games could catalyse students' productivity and creativity and offer them a more effective learning experience. Nevertheless, teachers still lack the knowledge required to implement suitable gamification types in their teaching (Mee Mee et al., 2020). This conundrum indicates a correlation between gamification, TPACK, and teacher behaviour.

Among the barriers discussed in Mee Mee et al.'s (2020) study, teachers claimed that low self-efficacy levels and negative attitudes hindered them from incorporating gamification into their lessons. In gamification studies, game elements are frequently examined as a variable in relation to the study outcomes via mediators, such as psychological states and behaviours (Landers et al., 2018). Sailer and Sailer (2021) examined the effect of game design elements on student learning outcomes with learning process performance as a mediator in the flipped classroom context. Although gamification is commonly divided into different parts to investigate its association with the study outcomes, the use of gamification in mediating teacher variables and teaching effectiveness remains lacking in primary science education literature, despite the fact that gamification is frequently broken down into its component pieces to evaluate its association with research outcomes.

1.7.5.1 Gamification in Practice

The terms "gamification," "educational games," and "digital game-based learning" are not interchangeable. According to Hughes and Lacy (2016), students can use games as a means of practising, reviewing, and delving deeper into the concepts covered in class and other learning activities. According to Furdu et al. (2017), games' content can be changed to fit the game's story and rules. According to Becker and Nicholson (2016), loosely quantified games have elements such as rules, objectives, measurable progress, and a clear conclusion. According to So and Seo (2018), educational games highlight the game's inherent power and usefulness, going beyond just being an entertainment medium. The idea for educational games came from a place where people might use media and technology to have fun while learning new things. So and Seo (2018) noted that cognition and constructivism were subsequently incorporated to pique players' interest. Microworlds and simulations are common in today's games, drawing players in with a variety of senses (So & Seo, 2018). According to Kingssley and Grabner-Hagen (2017), one method of skill acquisition is through the use of games.

A new generation of students relies on digital gadgets for expression, communication, and understanding the world (Papanastastasiou et al., 2017), and serious games are a way to meet their educational and training demands by utilising emerging gaming technology. Unless the creator intended for it to be, gamification is not always associated with play, even though users may engage in play (Landers et al., 2018).

1.7.5.2 Gamification Elements

There are twenty-four game elements used in gamification, classified into five groups by Sitorus et al. (2017): activity, ability, money, status, and sharing. What constitutes activity inside a gamified system is engagement with its various components, such as objectives, stories, to-do lists, leagues, tournaments, and collaboration. Capacity encompasses strategy, constraint, and attentiveness; it emphasises user input and uniqueness under the system. Things like points, badges, virtual products, important features, actual rewards, and punishments are all forms of payment that users receive for their actions. Avatars, statistics, leaderboards, levels, progress, history, and social graphs are all examples of status data that describe participant action within the system. The term "sharing" refers to interactions between users and includes acts of charity and word-of-mouth advertising. Gamification has recently found a home in the academic world, joining other sectors where it has already found practical use, such as business. According to Becker and Nicholson (2016) and Fanfarelli (2018), badges have long been linked to scouting and similar activities. Anyone who possesses the emblem on their person can see the proof of achievement it contains (Lius, 2016). In 2011, the Mozilla Foundation and Peer to Peer University were the first to develop digital badges for non-gaming reasons (Corbeil et al., 2016). Signifier, completion logic, and reward are the three components of badges listed by Fanfarelli (2018).

A badge's signifier is the visual information it contains, its completion is the set of steps one must take to obtain it, and its reward is the end result of all of that work. Flexible goal setting, varying content and presentation delivery, and analysis

by experienced mentors all contribute to badges' ability to personalise. If badges are to serve as a tool for education, it is imperative that all parties involved, not just the users, are on board with their deployment (Jones et al., 2018). Furthermore, implementation necessitates deliberate planning, intentional execution, and harmonious incorporation into the overarching learning architecture (Fanfarelli, 2018). Benetti (2018), Bicen & Kocakoyun (2018), and Homer et al. (2018) all agree that students gain a sense of pride when they earn and display various badges in the classroom. Because of their prominent placement, badges can function as social indicators (Hamari, 2017).

Users are encouraged to try additional tasks when they can see what others have won, thanks to this public visibility. Digital badges can drive students to prepare for class by giving them a taste of the material before they even step foot in the classroom, according to research by Garnett and Button (2018). Students are engaged because badges serve as a type of formative assessment, improve their portfolio, and give them something to strive for (Benedetti, 2018; Smiderle et al., 2020). Badges are a great way for students to show what they've learnt, give teachers insight into student progress, and give quick criticism to students who aren't making the grade (Smiderle et al., 2020).

According to Chou and He (2017), badges are another tool that teachers can use to get students involved and talking to each other. According to research by Garnett and Button (2018), students who are driven by digital badges are more likely to be well-prepared for class when they arrive. The successful use of digital badges depends on instructors receiving professional development on the how and why of

their use (Jones et al., 2018). Despite the common association with video games, you can see leaderboards used outside of gaming in places like businesses to showcase sales records or classrooms to celebrate accomplishments (Becker & Nicholson, 2016). According to Nebel et al. (2017), there are pros and cons to using leaderboards, depending on how they are set up. Tasks for leaderboards, according to Landers and Landers (2015), should be time-bound, realistic, specific, measurable, and doable. One use of leaderboards is to highlight and reward top performers (Smiderle et al., 2020).

Having publicly viewable leaderboards—which can be seen as a status symbol or representation of accomplishment—may have the unintended consequence of making low achievers feel ashamed or anxious about their performance (Cheong et al., 2021). Leaderboards may also be aiming at the wrong thing, according to Nebel et al. (2016). In a tournament, for instance, the most essential metric is the amount of knowledge a player acquired using the gamified interface. According to Zhonggen (2019), serious games aim to inspire players to become more engaged in the gaming, which could lead to improved academic achievement. In their study with college students, Furdu et al. (2017) discovered that the addition of leaderboards reduced motivation. According to research by Armstrong and Landers (2017), narratives are stories that are told inside gamified educational contexts with the goal of improving instructional results.

According to Palomino, Toda, Oliveira et al. (2019), narratives and storytelling are thought to influence student participation within a gamified exercise. Starting with the title and any first interactions with mechanics, narratives

contain a succession of events that the player engages with (Palomino, Toda, Oliveira et al., 2019). According to Palomino, Toda, Oliveira et al. (2019), narratives are meant to lead students through the material by outlining it and controlling their engagement with it. An actor, a decision element, interaction, a series of events, a location, a date, an interaction time, and user experience are all essential components of a narrative-based gamified project (Palomino, Toda, Oliveira et al., 2019). According to Jagušt et al. (2018), students' interest was sustained after the first use and during numerous courses through the use of narratives in a gamified environment.

Reification and synapses were proposed by Mader et al. (2019) as tools for incorporating narrative into the classroom. The term "reification" describes the practice of representing development as an item in a landscape. The use of progress task rewards, which alter as the learner achieves certain goals, or atomic task rewards, which reward the learner with an object upon task completion, accomplishes this. While learning about ancient Egypt, for instance, a digital learning environment's landscapes or features may be pyramids that expanded as the learner accomplished tasks (Mader et al., 2019). Students can practise what they've learnt in class using Synapses, which are mind mapping tools. In order to aid in learning, this approach encourages students to think critically about the material and make connections. The teacher may also be able to detect where students are getting their information wrong.

1.7.5.3 Gamification in Education

According to Gabriela Kiryakova and Daniela Kozhuharova (2024) and the International Society for Technology in Education (2017), teachers should take part in creating real-life learning environments that foster digital competency. According to the U.S. Department of Education's Office of Educational Technology (2017), the National Education Technology Plan emphasised the importance of teachers utilising technology successfully in their classrooms to create real-world learning opportunities. Figure 1.1 illustrates the interactions between the six main standards in International Society for Technology in Education (ISTE).

Figure 1.2

The ISTE Standard for Educators

Adopted from U.S. Department of Education's Office of Educational Technology, 2017)

Under the ISTE an educator must determine tech skills where must learning with technology and transform learning with technology. With this knowledge, the educator can accomplish their goals in a variety of ways. While the National Education Technology Plan and the International Society for Technology in Education (ISTE) guidelines provide a foundation, they do nothing to consider educators' unique viewpoints and needs when developing these kinds of programs. If they want their students to feel like they have agency in their classrooms while also having a hand in the design process, teachers need to be involved from the beginning (Smiderle et al., 2020). Although the end result is less crucial than the process in developing a gamified system, high-quality design is still essential (Lefers & Birkenkrahe, 2016). According to Toda et al. (2019), the quantity of elements employed might also affect implementation, making the process difficult to manage.

According to Landers and Landers (2015), while creating gamified learning, effort and motivation, not aptitude, should determine success. In their exploratory study on higher education, Martí-Parreño et al. (2016) identified an attitude use gap as the problem. Teachers in their study had a favourable impression of gamification but were hesitant to implement it in their lessons. One question that this exploratory study raised for future research is why, given the good attitude towards gamification among professors, it isn't being used more. Teachers in a related study by Loague et al. (2018) felt that students benefited from using technology in the classroom, although they felt that teachers needed help implementing the technology. Incorporating technological research and practice into preservice programs' teaching cycles is crucial, according to Levitt and Piro (2014), if we want teachers to be learning managers rather than knowledge dispensers.

According to Akcaoglu and Kale (2016), it is recommended that preservice teachers learn about game design and problem solving as part of their curricular decisions. After researching the Gamification User sorts Hexad Scales, Tondello et al. (2019) concluded that they may be used to confirm the impact of gamification on different sorts of players' user types and to identify the ways in which different user types reflect different types of interactions. Using the philanthropist, socialiser, achiever, free spirit, player, and disruptor models, Tondello et al. (2019) conducted their study. Charity and a sense of purpose motivate philanthropists. For socialisers, the most important things are relatedness and the desire to make new friends.

The satisfaction that comes from accomplishing goals and rising to the challenge is what motivates achievers. Those with a free spirit and a thirst for adventure will find plenty of room to express themselves in the gamified system. Extrinsic benefits are what drive this type of gamer. The disruptive element enjoys triggering change and pushing the gamified system to its limits. Researchers discovered a correlation between Hexad user types and personality qualities, and they want to study this correlation in future studies. They also observed that there was some overlap between the user types (Tondello et al., 2019). Lopez and Tucker (2019) looked into how different kinds of players affected their results. The significance of designing a user-specific gamified learning environment is underscored by the researchers' discovery of a correlation between individual perceptions of game aspects, performance, and player type. Players' interactions with various strategies are impacted by their user types (Orji et al., 2018). Players are driven by various factors, including competitiveness, making comparisons, working together, and the promise of reward (Orji et al., 2018).

Punishment, goal-setting, simulation, or self-monitoring do not motivate disruptors. In terms of susceptibility to persuasion, socialisers rank highest. The four user categories that characterise genuinely motivated online behavior—socializer, free spirit, achiever, and philanthropist—were identified by the majority of learners, according to Bovermann and Bastiaens (2020). This led to the claim that students taking classes online are diverse and so necessitate individualised lesson plans based on their strengths and interests. Perceptions by students encompass a desire for social engagement, alleviation of boredom, and feedback (Cheong et al., 2014). Students in high school were able to draw from a wider range of resources because of the autonomy they had in their learning and skill development, according to research by Pitura and Dagmara (2017). When looking to maximise academic engagement, Sánchez et al., (2020) discovered that high school pupils preferred activities with voluntary autonomy and variety when it came to gamification. Another reason students weren't interested in the gamified app was because they thought some of the designs, including the avatars, were too childish or old-fashioned (Mert & Samur, 2018).

The final goal of design thinking, according to Simões et al. (2013), is to boost student engagement without utilising any particular game. It is the process, not the product, that should be the centre of attention in design, according to Lefers and Birkenkrahe (2016). There needs to be a behavioural outcome, a psychological outcome, and motivational affordances for an activity to be considered gamified (Hamari et al., 2017). When dealing with students who have language impairments, it is important to use simple language, there should be no reliance on a single modality for essential information, and there should not be a lot of small or

overlapping interactive elements (Nicole Costley, 2022; Smiderle et al., 2020). In order to inspire students to study and help them apply what they've learnt in different contexts, educators should think about developing interdisciplinary projects (Pitura & Dagmara, 2017). The following components should be included in meaningful gamification experiences: quests, challenges, clear goals, feedback, visible status, onboarding time restrictions, new identities, new roles, badges, points, levels, and avatars, cooperation, competition, and freedom of choice.

According to Homer (2018) and Hill and Brunvan (2018), learners are given some control over their learning experience through the use of signalling and a tutorial that helps with focus and program navigation. Pitura and Dagmara (2017) and Ukala and Agabi (2017) state that in designing gamification, it is important to ensure that the gamified components align with the current assessment regime, the targeted learning objectives, and the demands of stakeholders. Saggah et al. (2020) note that in order to increase teacher engagement in the design process of gamified learning, it is crucial to establish a collaborative strategy between game creators and educators. In addition, Sánchez-Mena and Martí-Parreño (2017) contended that gamification had to be crafted in a way that students perceive its educational worth and are inspired to participate actively, rather than merely experiencing it as a game. According to Huang (2016) and Pitura and Dagmara (2017), gamification can only be effective when designers and design technology are utilised.

The development of intentional social learning environments that foster shared objectives and collective pride is another means by which enrichment can take place (Gleason et al., 2018). Furthermore, teachers should exercise caution to

avoid demotivating their students by focusing too heavily on rewards (Kopcha et al., 2016). varied gamification design structures result in varied motivational and behavioural consequences, according to Morschheuser et al. (2019), and gamification that is cooperative instead than competitive will boost engagement and enjoyment. Overall, older players valued opportunities for teamwork and socialisation more than competition, according to Simperl et al. (2018), but younger players were more engrossed when competition was presented. Incentives and gamification will appeal to learners for different reasons. (Biles & Homer, 2018; Cheong et al., 2014) As stated by Gleason et al. (2018), it is crucial to comprehend the various types of learners, establish a clear aim for the audience, and tailor the game features to the intended user before implementing. To be successful with gamified pedagogies, students need to be able to commit to the process, take risks, and be actively involved in order to feel like they have accomplished something (Biles & Homer, 2018; Clements et al., 2017). Development requires consideration of both the mechanics, such as leaderboards, rewards, and badges, and the game dynamics, which include factors like the presentation of mechanics and when they are used (SánchezMena et al., 2016; Gleason et al., 2018). Components, defined as particular kinds of mechanics or dynamics, and mechanics as processes that advance actions, are the third category added to Gleason et al. (2018), list by Cheong et al. (2014).

1.7.5.4 Effects of Gamification

Student interest and competitive spirit were improved, better behaviour was stimulated, good homework habits were revived, student motivation was enhanced, and student engagement was better as a result of gamification (Mohammed & Ozdamli, 2021; Buckley et al., 2017; Homer et al., 2018; Özer et al., 2018; Tan & Hew, 2018). Participation by students served as a social incentive since they wanted other students to join in so they could earn cooperation badges (da Rocha Seixas et al., 2016). When the core features of games were coupled with a feeling of worth, (Swacha, 2021) discovered that gamification increased engagement in many circumstances. (Homer et al., 2018) Gamification's use boosts intrinsic motivation. Reading post-test results were not significantly improved, nevertheless, according to Homer et al. (2018). Clements et al. (2017) found that group activities enhance the motivating aspect of gamification. According to research by Chen et al. (2018), gamification increases student involvement in collaborative reading and encourages them to make more contributions to the learning system.

Fadhli et al. (2020) conducted a meta-analysis and found that gamification strategies can increase children's cognitive, social-emotional, health, attitude, and linguistic abilities as well as their attitude and health. People who are engaged in task mastery apart from others and in competition, or performance orientated, who are interested in achieving better than others, may be more drawn to gamified activities, according to Tan and Hew (2016). The study's participants expressed the belief that, in time, physical incentives would be preferred over virtual ones (Tan & Hew, 2016). The uniqueness of gamification, which incorporates competition and incentives, was

found to improve engagement and student motivation, according to an undergraduate study by Buckley et al. (2017). Students did react positively to the incorporation of gamification based teaching approaches, however gamified courses did not lead to a change in attitude towards the lesson, according to a postsecondary study by Yildrim (2017), which also made the reference to this high level of dynamic. The implementation of gamification in the classroom was determined by Araújo and Carvalho (2022) to be somewhat labour-intensive, leading to different degrees of student enthusiasm and, at times, making its continuous usage more difficult and necessitating revisions and reformulations. According to Sánchez-Rivas and Ruiz-Palmero (2019), gamification can lead to a little more happiness for teachers. Making and using classrooms that are more like games gives kids a chance to enjoy learning, which can improve their attitude towards school (Sanchez et al., 2017).

Gamified assessments encourage students to keep learning even after class is over by giving them challenges to complete at home (Sánchez- Rivas & Ruiz-Palmero, 2019). The use of gamified assessments in the iterative correction process allowed teachers in the study by Sánchez-Rivas and Ruiz-Palmero (2019) to keep students engaged in learning. Students reported less frustration and despair and more pleasure in the learning process when they could fix their mistakes and improve their scores whenever it was convenient for them (Rayner & Tan, 2021). The results presented by Najmeh (2020) suggest that including gamified components into students' leisure time at home, where they may be supervised by their parents, could lead to a more successful and viable implementation. Students were motivated to write significantly more messages when game mechanics were used, according to Aldalur (2023), who conducted a study on enhancing

argumentative writing. The use of digital gamification improved classroom management, according to Smiderle et al., 2020 research on writing skill development, because it got all students involved in the creative process of solving problems through writing. Phase two of the research by Bushra et al. (2024) examined whether students' learning would be improved when they integrated the student-favored features into a learning tool.

Graphics, challenges, and feedback all worked together to boost learning outcomes. Providers were able to better control the learning curve, scaffold new information, and augment users' intrinsic motivation when they used narrative and game-based learning components, according to a pilot study by Saridaki and Shopland (2016) of young adults with intellectual disabilities. The question of whether design effects are innately or extrinsically motivating was addressed by Hamari (2021) in his research on goal foci. Some critics of gamification contend that the incentives provided by badges, social status, and performance qualifications are superficial and do not actually motivate users to change their behaviour (Hamari, 2021). He posited that outcome-focused users may be more interested in these rewards.

Aldemir et al. (2018) found that students' responses to the game's story, leaderboards, challenges, badges, teams, points, and awards all revealed underlying themes. Issues of significance, dialogue, and personality were discussed in the narrative. Topics covered by the leaderboard included teams, reputation, participation, and competition. Emotional arousal, distraction, engagement, teamwork, competitiveness, collective intelligence, self-evaluation, reinforcement,

challenge type, timing, frequency, and repetition were the subthemes within challenge. Among the many features of the badges were the ability to self-evaluate, have fun, and progress through a system of levels.

Among the many subthemes that made up the teams category were teamwork, camaraderie, and communication. Distributed points, clarity, transparency, accessibility, and self-evaluation were the subthemes within the points. According to Aldemir et al. (2018), there were four types of rewards: participation, privilege, narration, and tangible. Participation in a gamified learning environment was found to result in the development of soft skills, such as teamwork, collaboration, and decision making, according to students in the study by Smiderle et al., (2020). Additionally, these pupils gained the ability to take calculated risks and make better decisions. Failing in a virtual setting is not perceived as a personal attack, but rather as a chance to learn from one's mistakes and try again (Alsawaier, 2018). Tomcho et al. (2019) discovered that gamification can yield results, but that it requires careful preparation before deployment to achieve those objectives. As long as the activities and learning objectives are well-aligned, gamification strategies focused on competition and rewards can be effective in improving performance in the classroom. According to Cuesta García et al (2022), teachers had more chances to cohesively incorporate gamification aspects when they used narrative with a tale as the foundation. At the same time, it has motive and aesthetics were the primary factors that drew students.

Opportunities for critical thinking, teamwork, and cooperative practice beckoned to students as they got into the game. According to Gooch et al. (2016),

the process of badge development involves both students and teachers. According to Gooch et al. (2016), students' metacognitive awareness may be enhanced when they are involved in creating their own badges. A potential avenue for future research was suggested by Hsu and Wang (2018), who discovered that students might occasionally select easier puzzles to get points. Using game mechanics and student-generated question methods in the production of online games and activities has positive benefits on the learning of algorithmic thinking skills, according to Hsu and Wang (2018). Students in the group that used game mechanics to create their artefacts outperformed those in the control group, according to research by Hew et al. (2016).

Students were able to practise with their family and classmates at home thanks to the competition format and the game's inclusion in the classroom home/school communication (Sánchez-Rivas and Ruiz-Palmero, 2019). In terms of learning performance, de-Marcos et al. (2016) found that gamification combined with social networking produced greater results than gamification alone. Students were more receptive to the competitive aspect of the game when they had more say over the assignment they were given to complete, according to Nebel et al. (2016), who did not discover a statistically significant influence of the leaderboard throughout playing. The inclusion of leaderboards in the study conducted by Furdu et al. (2017) had a negative impact on motivation. Students were driven by the competitive character of the program Kahoot, according to Carrillo et al. (2019). According to Wang and Tahir's (2020) literature evaluation, Kahoot improved classroom dynamics, decreased student anxiety, increased instructor motivation, and had a favourable impact on learning.

Using game mechanics to enhance learning outcomes is known as gamification (Hamari et al., 2017; Kingsley & Grabner-Hagen, 2015). Two branches of gamification, according to Becker and Nicholson (2016), are reward-based gamification and meaningful gamification. The goal of providing additional depth with educational subjects through the use of game mechanics is known as meaningful gamification. To measure progress, reward based gamification uses prizes instead of or in addition to grades. One way this was accomplished was by incorporating aspects of gaming that contribute to player enjoyment into educational settings (Simões et al., 2018). The concept of gamification refers to the addition of a new dimension to an existing process or activity (Saleem & Özdamlı, 2022).

According to Furdu et al. (2017), in order for gamification to be effective, it must be able to grab and hold the attention of learners while also engaging, entertaining, challenging, and eaching them. Using game mechanics, such progressing through a quiz, competing, or receiving rapid feedback, is what gamification is all about (Garcias & Marin, 2020; Hamari et al., 2021;). Adopting loyalty points, virtual currency, and varied levels, in addition to recruiting members from a social network, might further enhance social gamification frameworks (Simões et al., 2018). Some have voiced concerns about the use of gamification in education, arguing that it can only be used in certain contexts to prevent unethical outcomes. These contexts include those where there is already an abundance of motivation, those that require simplicity, and those where game mechanics conflict with ethical principles.

According to Aguilar et al. (2018), when teachers don't back gamification initiatives, students see them as passing craze. Along with the potential negative effects on learning and the emergence of task problems, Hamari et al. (2021) discovered in their meta-analysis that increasing competition necessitates control over design elements for optimum benefit. Furthermore, according to Adam (2021) and SánchezMena & Martí-Parreño (2017), teachers may be discouraged from applying gamification due to the time and effort needed to do so. To get around the time limit, Carlson et al. (2017) recommended that teachers should collaborate and share resources so that they don't have to start from scratch every time a session or activity needs to be gamified.

The distinction between activities that a student can do on their own and those that need guidance is central to the constructivist approach to education (Vygotsky, 1978). When students actively participate in learning activities designed for the modern era, the burden of acquiring knowledge shifts from the teacher to other students and, maybe, remotely accessible resources. In this chapter, I have covered a lot of ground, including the latest academic studies on gamification, its practical applications, how to create gamified learning environments, the elements of gamification, and its use in education. To inspire, engage, and improve learning efforts, gamification uses gaming features. A total of twenty-four components, grouped into the following areas: action, ability, money, status, and sharing, make this possible in the game. The methods in which gamification has been researched in education in relation to individual programs and aspects were also covered.

This study fills a gap in the literature by investigating how gamification components function in primary classrooms and how instructors see these components as contributing to students' academic progress. The researchers surveyed teachers from primary to get their perspectives on the use of gamification and its individual components. The United States Department of Education and the International Society for Technology in Education (ISTE) have put up the idea that teachers should create and implement real-world learning activities that build students' digital competences by making use of resources and tools appropriate to the digital age. Various types of learners and their preferred methods of learning, as well as students' perspectives on the components, were the subjects of the research presented in this chapter. Considering motivational affordances, keeping the end goal in mind, defining expectations, structuring learning environments, and developing an awareness of incentive emphasis are essential considerations in determining the design of gamified learning. Research shows that gamification can boost teachers' interest, engagement, self-efficacy, behaviour, work habits, motivation, and competitive spirit.

1.7.6 Teaching effectiveness

Students are more likely to actively share their knowledge while simultaneously considering and integrating the expertise of their classmates in cooperative learning, according to Johnson and Johnson (2018). All members of the group benefit from the group's increased knowledge and understanding as a result of this mutually beneficial flow of ideas and information. Research has shown that in a cooperative learning setting, the individual contributions of each student have an effect on the group's performance and the results of their education. By holding each other and the group to account, students highlight how important it is for everyone to contribute to the group's success (Johnson & Johnson, 2018). Furthermore, Sarfo et al. (2017) illustrated how students might aid in group learning by imparting their skills and expertise to their classmates. Conversely, in cooperative learning settings, exploitation may occur due to a lack of individual responsibility.

According to Abu-Hammad and Hamtini (2023), schools can also help pupils develop self-assurance and problem-solving skills by using creative gamification-based teaching approaches. This finding lends credence to Vygotsky's social constructivist theory of mathematics education, which proposes that gamification techniques can aid in the growth of students' problem-solving abilities. Mathematics teachers can captivate their students' interest and motivate them to solve problems by integrating gamification elements into the classroom. Gamified learning environments encourage students to actively engage and persist in solving mathematical problems, which helps to develop their problem-solving skills. In support of the finding, Smiderle et al., (2020) defined gamification as an

instructional strategy that employs games or interactive visualisations to teach students specific abilities. All during the course of their education, this method pushes students to engage in activities that require them to think critically and solve problems.

Research by Kiili, Devlin, and Multisilta (2018) found that students' critical thinking and problem-solving skills can be greatly enhanced by gaming. Additionally, Verbruggen, Depaepe, and Torbeyns (2021) lent credence to the idea of using the gamification design framework for problem-solving exercises in the classroom. Games can improve students' thinking ability, conceptual knowledge, and problem-solving skills. According to Kiili, Devlin, and Multisilta (2018), gamification has a beneficial effect on student motivation, successes, and problem-solving skills, and it also motivates students to interact and think critically. Prior research by Udjaja, Guizot, and Chandra (2018) found that gamification enhanced mathematical learning for around 66.9% of students, leading to a notable 75.4% boost in arithmetic skills. Students' competence in solving mathematical problems was found to be substantially improved when gamification instructional materials were used (Ambarwarti, Febriana, Anggoro, and Putra, 2022). Pringsewu, Lampung, Indonesia, junior high school students had poorer mathematical problem-solving skills due to a lack of active learning, according to the researchers.

As a measure of job performance in the teaching profession, teaching effectiveness does not reflect a consensual definition but is frequently measured using student evaluation, classroom observation, and student academic achievement (Kim et al., 2019). Different measurement types provide a clear depiction of teaching

effectiveness. The independent variables of TPACK, teacher behaviour, self-efficacy, and psychological characteristics in this study would be selected based on the integration of Falloon's (2020) teacher digital competence framework, Stronge's (2018) qualities of effective teachers, and Creemers and Kyriakides's (2015) TER to frame the dynamic model of educational effectiveness.

Falloon's (2020) teacher digital competence framework is selected to study gamification as a mediator between teacher variables and teaching effectiveness. This broad framework generally sections teacher digital competence into TPACK, personal-ethical competencies, and personal-professional competencies. Meanwhile, Stronge's (2018) qualities of effective teachers entail eight factors of effective teachers: the teacher as a person; classroom management and organisation; organising and orienting for instruction, implementing instruction, monitoring student progress and potential, and professionalism. Creemers and Kyriakides's (2015) TER divides teacher effectiveness works into psychological characteristics (personality, attitude, experience, and aptitude or achievement), teacher behaviour, and beyond-classroom behaviour (subject knowledge, pedagogical knowledge, teacher beliefs, and teacher self-efficacy). Table 1.1 presents the variable categorisation based on all three frameworks.

Table 1.1

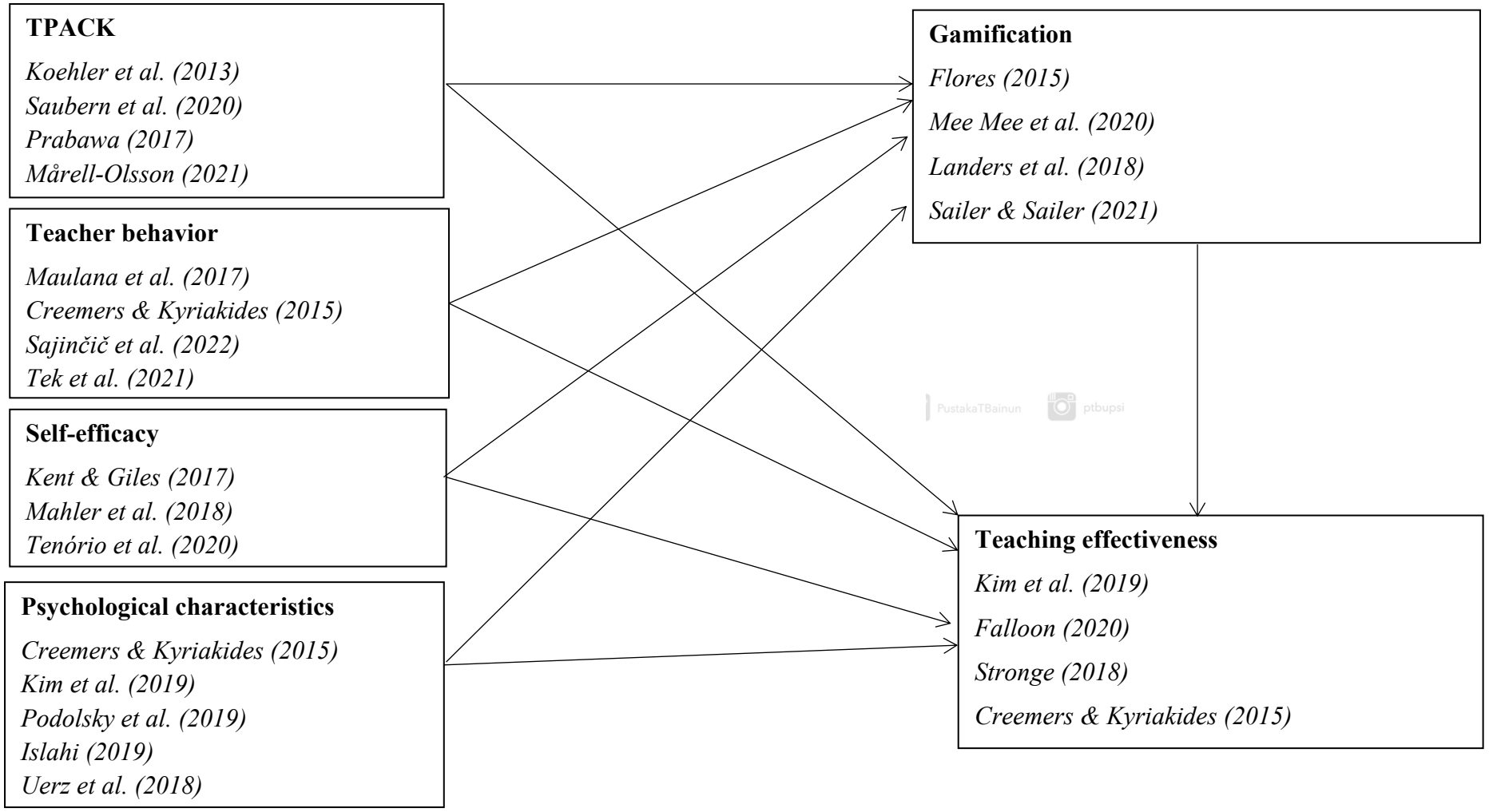
Categorisation of variables based on three frameworks

	Teacher digital competence framework	**Qualities of effective teachers**	**Teacher effectiveness research**
TPACK	personal-professional competencies	classroom management and organisation; organising and orienting for instruction, implementing instruction, monitoring student progress, and potential, professionalism teacher as a person	subject knowledge and pedagogical knowledge teacher behaviour
Teacher behaviour			
Self-efficacy	personal-ethical competencies		teacher beliefs and teacher self-efficacy
Psychological characteristics			psychological characteristics

The four variables of TPACK, teacher behaviour, self-efficacy, and psychological characteristics would be determined by combining similar aspects of teaching effectiveness frameworks with a digital counterpart. Notably, these variables have been studied in connection to gamification or technology competence but not as a mediator in teaching effectiveness.

Figure 1.3

Theroretical Framework



1.8 Conceptual Framework

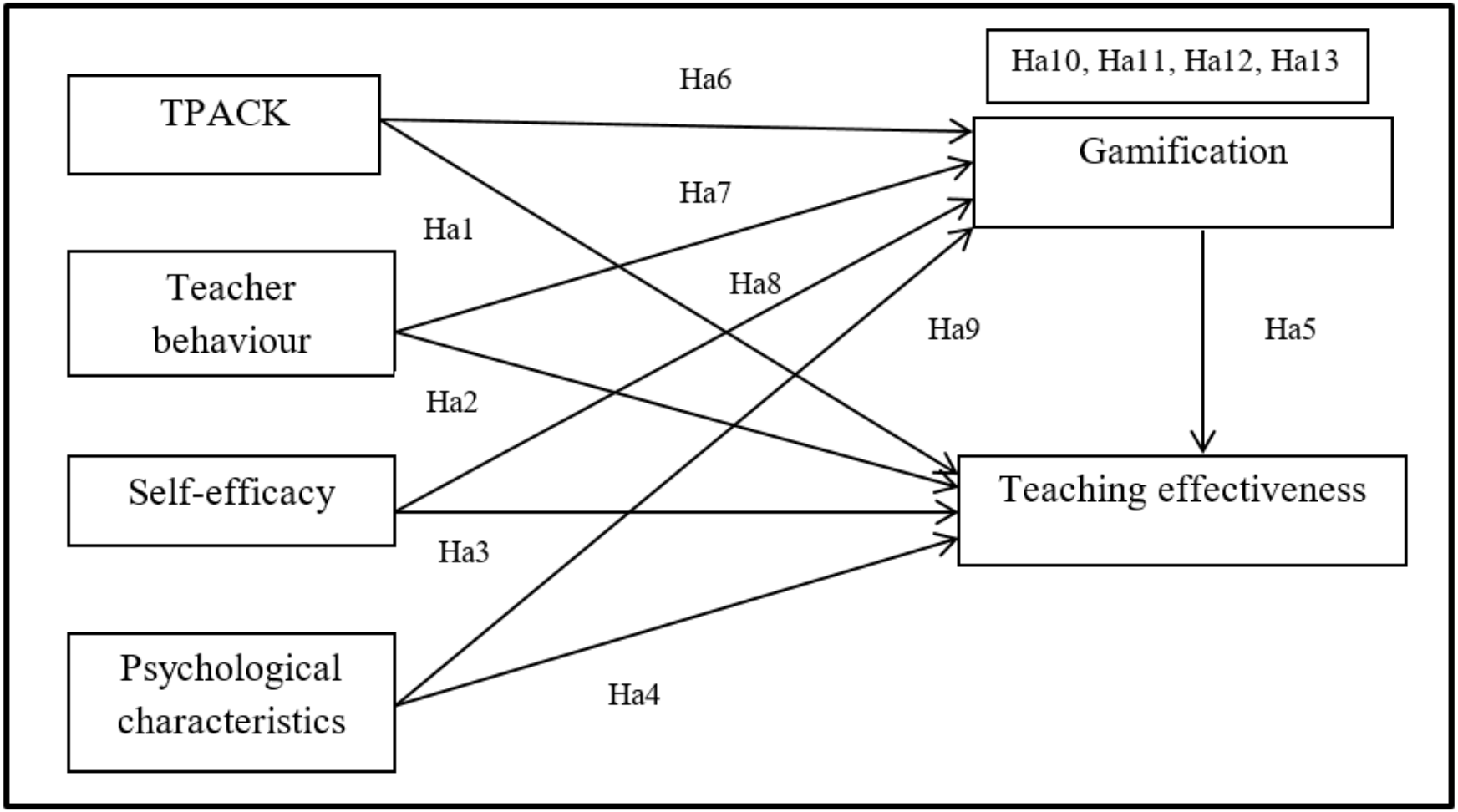
Swaen and George (2022) describe conceptual frameworks as practical tools that are a process and a product for organising and aligning all aspects of an inquiry. A conceptual framework can take different forms for different purposes but generally communicates the system of beliefs, assumptions, theories and concepts that support and inform (inquiry). Ravitch and Riggan (2017) suggest conceptual frameworks define the 'big ideas' associated with a particular inquiry and comprise a blend of personal beliefs, assumptions and experiential knowledge; topical research (knowledge relevant to the field of study); and theories generated from prior empirical work. The independent study variables are adapted from three frameworks: the teacher digital competence framework by Falloon (2020), the qualities of effective teachers by Stronge (2018), and TER by Creemers and Kyriakides (2015).

A combination of teacher and digital technology factors in the primary science education context would be investigated based on their effects towards teaching effectiveness as the dependent variable. Resultantly, four factors entailing TPACK, teacher behaviour, self-efficacy, and psychological characteristics would function as independent study variables. The conceptual framework converts these theoretical assumptions into a systematic model that delineates specific factors, their interrelations, and the function of gamification as a mediator. Concepts like as teacher behavior, self-efficacy, and psychological traits are based on the theoretical frameworks of TPACK and ZPD, emphasizing both instructor proficiency and student growth. The incorporation of gamification as a mediating variable signifies the amalgamation of theoretical concepts with modern educational practices, establishing gamification as a

technical instrument within the TPACK framework and a supportive mechanism inside the ZPD framework. The conceptual framework in Figure 1.4 depicts the possible variable relationships.

Figure 1.4

Conceptual Framework



1.9 Significance of the Study

This study enhances theory by contextualizing gamification within a comprehensive pedagogical and developmental framework, providing insights into how technology-mediated methods might augment teaching practices and student learning in foundational science education. This study tackles a significant gap in the literature, as most gamification research has focused on secondary or university education, leaving primary school insufficiently examined.

The study offers significant implications for politicians, educators, and academics. The findings can guide policymakers in curriculum creation and teacher professional development programs amid Malaysia's ongoing educational changes. On practical grounds, this study would be significant in supporting and developing primary science teachers' pedagogical and technical skills to upgrade primary-level science instruction and comprehend how gamification functions as an active learning tool in science classrooms. Educators may also get insights into the cultivation of digital competence, self-efficacy, and successful teaching behaviors essential for the integration of technology-driven pedagogies.

Policymakers acquire essential evidence for formulating national strategies, while researchers are afforded an avenue for additional academic inquiry. These stakeholders may utilize the insights obtained to enhance the quality of primary scientific education in Malaysia and worldwide, ensuring that children are adequately equipped with the skills and knowledge required for engagement in a fast expanding technology landscape.

Nevertheless, studies on gamification as a mediating role in teaching effectiveness remain lacking despite the prevalence of gamification models. These models enable teachers to internalise and optimise their professional development in fulfilling new-generation student needs. For example, teachers could offer science students intriguing and motivating technology-driven learning environments that could improve students' academic achievement. Such integrations could increase Malaysian science students' scores in the upcoming PISA.

This study would also expand the current body of knowledge on teaching effectiveness. A technological standpoint is incorporated into teaching effectiveness aspects to determine the significance of gamification in influencing teachers' teaching effectiveness. The empirical outcomes would facilitate teachers to self-upgrade upon understanding the different variables impacting their teaching effectiveness and develop their competence in lacking areas. This study would also emphasise teacher attributes in relation to gamification following relevant research on its effects towards student outcomes and motivation. The literature gap in gamification research and its influence on teachers must be addressed to holistically understand the implications of gamification in education. In this regard, the study findings would contribute to gamification research with a focus on its effect on teachers' teaching quality.

1.10 Limitations of the Study

This proposed study, which focuses on the implementation of gamification in primary science classes, is not without its limitations despite significant contributions to the education sector. Hence, outcome generalisation to other primary school subjects or school levels (preschool or secondary) would be impossible. Appropriate gamification types and levels may differ between different subjects and schooling levels. Overall, context specificity is crucial to identifying the degree to which gamification influences multiple contexts. This study is also limited in the sampling of teachers as it only includes primary science school teachers in the state of Perak.

Perak exemplifies a state characterized by varied socio-economic and educational environments, encompassing urban centres with reasonably developed infrastructure and rural regions that have limitations in resources and accessibility. This research on Perak aims to elucidate how gamification tactics may function in educational institutions with differing degrees of technology preparedness and teacher proficiency, which are critical factors influencing instructional efficacy. Although Perak serves as a significant case study owing to its socio-economic diversity and representation of both urban and rural educational contexts, the results cannot be entirely generalized to the national level.

A quantitative approach is proposed in this study to develop a model on gamification and teaching effectiveness for science school teachers and to ascertain the significance of relationships between teacher variables, gamification, and teaching effectiveness. Thus, future studies could incorporate qualitative or mixed-method

designs to strengthen the proposed study findings and offer a more comprehensive understanding of gamification and teachers' teaching effectiveness. Two types of gamification tools, Kahoot and Quizizz, were proposed in this study. These instruments are frequently used among Malaysia teachers, who are familiar with them. Nevertheless, the inclusion of multiple gamification types (through structural and content gamification) and tools may complicate the study owing to variances in structure and purpose.

1.11 Operational Definition

1.11.1 TPACK (Technological Pedagogical Content Knowledge)

The TPACK denotes a complex interaction of the three pillars of knowledge, technology, pedagogy, and content, which could generate the necessary knowledge required to incorporate technology into teaching (Koehler et al., 2013). In the proposed study, TPACK is the interaction between content, pedagogical, and technological knowledge to integrate gamification with primary-level science lessons.

1.11.2 Teacher behaviour

Teacher behaviour implies educators' actions in class, such as classroom management and adaptive teaching (Maulana et al., 2017). In the proposed study, teacher behaviour is discussed in the context of applying gamification to primary-level science lessons.

1.11.3 Self-efficacy

Self-efficacy is the development of teachers' beliefs in their ability to achieve a certain level of accomplishment (Kent & Giles, 2017). In the proposed study, self-efficacy refers to the development of primary science teachers' beliefs in their ability to successfully implement gamification in their lessons.

1.11.4 Psychological characteristics

As described by Creemers and Kyriakides (2015), psychological characteristics determine an effective teacher based on personality, attitude, experience, and aptitude or achievement. These attributes would be discussed in the study in terms of applying gamification to primary-level science lessons.

1.11.5 Gamification

Gamification, the meticulous application of game-thinking to resolve problems and encourage learning through appropriate game elements (action language, assessment, challenge, control, environment, game fiction, human interaction, immersion, and rules or goals), facilitates the learning process and its outcomes (Landers, 2014; Garone & Nesteriuk, 2019). It is. In the proposed study, gamification refers to the implementation of game elements to address issues and encourage primary science classroom learning. Two gamification tools, Kahoot and Quizizz, would be considered in this study.

1.11.6 Teaching effectiveness

Teaching effectiveness is a measure of job performance in the teaching profession that does not possess a consensual definition but can be measured through students, teachers or a combination of both (Kim et al., 2019). In this study, teaching effectiveness would be described in the context of applying gamification to primary-level science lessons. The measurement of teaching effectiveness will be done through classroom practices in the form of teachers' self-evaluation similarly to SKPMg2 (*Standard Kualiti Pendidikan Malaysia Gelombang 2*) and TER (Teacher effectiveness research).

1.12 Chapter Summary

This chapter provided an overview of the proposed study background and problem statement, which would facilitate the research process. The research objectives, questions, and hypotheses were also listed in the chapter. Both theoretical and conceptual frameworks were illustrated to understand the study context and output, followed by the research significance and limitations. Lastly, this chapter presented the operational definitions of TPACK, teacher behaviour, self-efficacy, psychological characteristics, gamification, and teaching effectiveness were explained.