sustainability

MDPI

Article

Exploring Interest Formation in English Learning through XploreRAFE+: A Gamified AR Mobile App

Dan Wang, Mas Nida Md Khambari *, Su Luan Wong and Abu Bakar Razali

Faculty of Educational Studies, Universiti Putra Malaysia, Serdang 43400, Malaysia; gs52264@student.upm.edu.my (D.W.); suluan@upm.edu.my (S.L.W.); abmr_bakar@upm.edu.my (A.B.R.)
* Correspondence: khamasnida@upm.edu.my

Abstract: The use of gamification and AR technology is found to have the capacity to enhance students' interest. In this study, the researchers chose a class in a vocational college in China as a specific case that used the gamified AR mobile application, called XploreRAFE+. This study aimed to explore the use of XploreRAFE+ in the formation of learners' interest in order to answer the research question: What is the process of interest formation among vocational college students in a gamified AR environment, and how does it sustain students' motivation in learning English? The data for the study were collected via observations, interviews, and document analysis. The findings of the study indicated that in a gamified AR environment, vocational college students' interest was triggered by piquing curiosity. This then led to optimal learning experiences, where eventually the students began to have positive perceptions of English lessons and were motivated to extend learning experience on their own. These three components of interest formation formed a dynamic loop where interest formation was developed in a cyclical process. It is proposed that a cyclical formation of interest developed through a gamified AR environment over time could sustain learners' motivation.

Keywords: interest formation; gamification; augmented reality; vocational college students

Citation: Wang, D.; Md Khambari, M.N.; Wong, S.L.; Razali, A.B. Exploring Interest Formation in English Learning through XploreRAFE+: A Gamified AR Mobile App. *Sustainability* **2021**, *13*, 12792. https://doi.org/10.3390/su132212792

Academic Editors: Sara Catalán Gil and Jin Su Jeong

Received: 23 August 2021
Accepted: 12 November 2021
Published: 19 November 2021

1. Introduction

There has been an increasing focus in recent years on emerging contemporary approaches to learning, with gamification being among them [1]. Gamification incorporates game mechanics into learning design to create a fun and engaging learning atmosphere. All kinds of technical knowledge can be incorporated to make learning activities more enjoyable [2]. In the case of China, with the advent of the Fourth Industrial Revolution, in 2017, China's State Council issued the Notice on the Development Plan of the New Generation of Artificial Intelligence, which is a significant governmental document that emphasized the importance of artificial intelligence and relevant technologies, such as augmented reality (AR) technology, in various fields including education [3]. Subsequently, augmented reality (AR) technology has gradually been utilized with gamification to bring about a new digital learning experience among students. Past studies have shown that gamification, an innovative learning design compared to traditional education methods, can increase students' interest and motivation to learn [4–6]. Interest, as one of the strongest motivations in learning, has long been considered a primary factor influencing the learning process [7]. Learning interest has also been receiving much attention in vocational colleges in China [8].

In China, vocational colleges, commonly known as trade schools or trade colleges in western countries, are different from undergraduate universities in that they mainly emphasize the practical application of knowledge and seek to cultivate students' applied skills [9]. Vocational colleges are one of the post-secondary school institutions for students who have completed high school to further their studies, especially in the field of practical skills. The admission score required by vocational colleges is generally lower than that of undergraduate universities. It is a matter of concern that owing to outdated teaching

methods in vocational colleges in China and students' weak learning motivation and learning interest [10], almost 40% of students in vocational colleges have moderate or higher levels of learning burnout [8]. Evidently, vocational college students in China suffer a lack of interest in learning [8,11]. Although the benefit of gamification and AR technologies for enhancing learning interest and motivation have been well-documented, most vocational college teachers are not ready to gamify their lessons as they lack relevant technological knowledge. More specifically, they lack an understanding of how the application of gamification that uses AR technology could enhance learning interest [12]. This study, therefore, aimed to explore the process of interest formation among vocational college students in a gamified AR environment and understand how it could sustain students' motivation in learning English.

2. Literature Review

Gamification in education is characterized by competition which stimulates students' interest and participation in the learning process [13]. In games, students are required to beat rivals, become winners, and contribute their own effort to their teams. In higher education, commonly utilized incentives include points, badges, levels, and leader boards [1]. Many studies have been conducted on these elements and forms of gamification using samples comprising students in higher education [1]. Findings from such studies indicate that gamification can enhance learners' interest and motivation in learning [4–6]. For example, Bjaelde used levels in games that provided students with diverse challenges to learn in a quantum mechanics course, with different games representing different challenges in the course [14]. They conducted a pretest and a post-test to measure student motivation. The findings of the study revealed that gamification was a good way of boosting the students' motivation to study quantum mechanics. Similarly, in a study by Owens, the researcher evaluated the potential of inquiry-based and game-based learning styles to enhance students' motivation to learn about the evolutionary life history of plants [15]. In the study, one hundred and forty undergraduates were randomly allocated into one of four conditions: control, repeat-testing, leaderboard, and leaderboard with repeat-testing. The researchers found that game-based learning, including repeated testing and leaderboard elements, significantly increased students' motivation to learn biology, while leaderboards enhanced students' motivation, engagement, and interest in preparing for classes.

Many researchers have focused on the effect of gamification on language learning, finding, for example, that gamification, combined with other learning conditions, can effectively enhance students' learning motivation [16,17]. For instance, in support of learning the Italian language, James used an online language learning game, Duolingo, that used a variety of game-like methods, such as sentence and phrase translations, multiple-choice questions, and pictures, to teach languages [18]. Compared to traditional lessons involving one slideshow per day for seven lessons, students were found to be more motivated to play the game than to watch the slides. Duolingo's motivational and emotional benefits suggest that it is a promising alternative to motivate students to learn compared to traditional teaching methods.

A similar finding was also obtained in a study on English language learning. In a study by Zarzycka-Piskorz, an online game, Kahoot, was used to help students learn English grammar in a general English language course [19]. In this application, every user could adapt existing public tasks/tests to his or her own needs, as well as being able to share tasks/tests with other users. The researcher observed a group of university students during English classes conducted by their teachers and found that the use of online games increased their desire to learn grammar. Wichadee conducted a quasi-experimental study on two groups of students at a private university in Thailand [20]. The experimental group was taught English vocabulary and grammar using the digital game Kahoot, while the control group was taught using traditional methods. The researchers prepared 10 vocabulary quizzes and 5 grammar quizzes so that students in both groups

could review the lessons taught each time. The findings showed that the motivation of students in the experimental group was significantly higher than that of the control group.

Similarly, in Sartini's study, the use of Kahoot for learning maritime English was investigated [21]. In the study, two cycles of Kahoot were conducted. The pre-action Kahoot cycle aimed to confirm whether Kahoot as a vocabulary drill could support cadets' oral reproduction skills in the evaluation of early learning, whereas the post-action Kahoot cycle was utilized to assess improvement in learning outcomes. The results of the study showed that the Kahoot quiz had a significant influence on the mastery of vocabulary and terms in maritime English and supported the fluency and articulation of the cadets' speech. This improvement in intrinsic motivation was brought about by the students' ability to gain a better understanding of their lessons. Therefore, past studies have demonstrated that the use of gamification can effectively enhance students' interest and motivation [4–6].

AR technology refers to the technology of superimposing virtual objects in the real world to represent the real world [22]. AR technology can encourage students to interact with the real environment, a learning approach that was previously considered impossible [23]. AR technology can combine different forms of virtual materials, such as vivid animation, sound, and virtual figures, to build a real and virtual learning environment, thus enhancing learning motivation [24,25]. Furthermore, many studies have shown that AR technology can enhance students' interest [26,27]. For example, Chin adopted an augmented, reality-based, mobile touring system to promote learning interest in cultural heritage sites [28]. The findings of the study suggested that AR technology has the potential to increase students' learning interest. Additionally, AR technology can combine various forms of gamification to create an attractive learning environment [29]. For instance, in a study by Bressler, the researchers used a vision-based AR game in a school environment with sixty-eight middle school, student participants [26]; the findings indicated much potential for mobile AR science games to increase learning interest in science.

Interest is an important component in a technology-supported learning process [30]. When students' interest is triggered during learning, they can become immersed in the learning process and their interest can be extended to new learning [30]. There are many studies which focus on situational or individual interest in the investigation of interest formation in various contexts [31,32]. Rotgans investigated the development process of situational interest in an active learning environment [33]. In this study, sixty-nine polytechnic students in a problem-based learning session were evaluated to find out how situational interest would develop during a one-day experimental study. The results showed that situational interest was significantly enhanced because of the problem stimulus provided. Subsequently, situational interest gradually decreased but increased again at the end of the day. Korsun investigated the transformation, when learning physics, from situational interest to personal interest in the context of sustainable development of education [34]. In the study, the sequence of interest formation was analysed in terms of multiple steps, including curiosity, active curiosity, trying to understand, gathering strong knowledge, and conducting scientific research. The process represents the transition from situational interest to individual interest. The study revealed that active training and active learning methods, such as heuristic conversation and the creation of problematic situations, increased the level of motivation in the learning of physics. In these studies, the theory of interest development [35] and the scheme for the formation of learners' interest [36] were used as frameworks, which both assume that the development of interest formation occurs linearly. But is this so in all learning environments?

According to the Interest-Driven Creator (IDC) Theory, interest is regarded as a crucial component of learning and can be sustained during the whole learning process under technology-supported circumstances. The IDC theory highlights three anchored concepts, interest (Figure 1), creation (Figure 2), and habit (Figure 3), each of which undergoes a coherent learning process, forming a cycle.

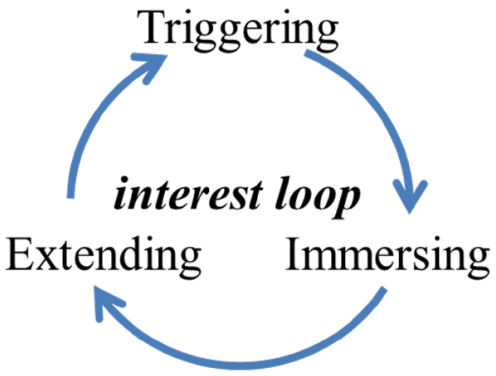

Figure 1. The interest loop (Chan et al., 2018, p. 442).

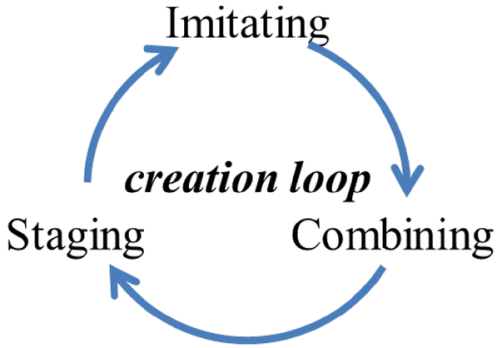

Figure 2. The creation loop (Chan et al., 2018, p. 443).

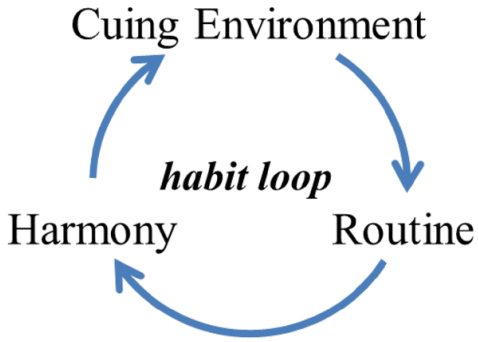

Figure 3. The habit loop (Chan et al., 2018, p. 443).

This study mainly considered the interest loop of the IDC theory, which includes triggering interest, immersing interest, and extending interest (Figure 1) to answer the question, "What is the process of interest formation among vocational college students in a gamified AR environment and how does it sustain students' motivation in learning English?". The IDC theory proposes that suitable learning strategies can nurture interest. These strategies can be characterized by three key words: "curiosity" that triggers interest, "flow" that immerses interest, and "meaning" that extends interest. In the context of IDC theory, the "interest loop" starts by tapping students' curiosity to trigger their situational interest and retain their interest by immersing them in relevant learning activities. Finally, emergent individual interest is nurtured when students discover areas of study that are truly meaningful to them. Chan proposed that the interest loop of the IDC theory is a dynamic and cyclical process [30]. In this study, the researchers theorized that the continuous feeling of curiosity, flow, and meaning cultivate sustained motivation in learning.

IDC theory has been applied and explored in different fields, such as program design [37], and robotics education [38]. Furthermore, some studies have applied IDC theory in gamified contexts [39,40]. For example, in Yeh's study, the researcher used IDC theory to

explain the findings of the study regarding the use of a game-based learning system, named "Math-Island" in mathematics learning [39]. In the study, an experiment was conducted with 215 elementary students for two years; the findings of the study were that the top students and the lower students in the experimental school both maintained a high-level of interest in mathematics through use of the system. Liu used the interest loop of IDC theory as the fundamental design of a gamified learning system named Character Monster [40]. Specifically, their research was focused on learning engagement among fifth graders by making learning Chinese characters a joyful experience with the support of a game-based mobile technology application. However, findings regarding the effect of this system on Chinese character learning interest and motivation were not explored in their study.

The present study employed a different approach to previous studies by utilizing the interest loop as a theoretical basis to explore the process of interest formation in a gamified AR environment, positing that interest formation occurs as a continuous, cyclical process that can foster motivation. Given problems faced by vocational college students and developmental trends in education in China, it is important to explore how students' learning interest and motivation can be engaged in a gamified AR environment. The study can help to inform understanding of the issue of a lack of learning interest among students of vocational colleges [8], and can help address the research gap regarding interest formation and sustainability of learning motivation.

3. Research Method

This study employed a qualitative case study methodology and focused on a particular group of students to provide an in-depth description and analysis of a bounded system [41]. Case studies do not depend on a single method to collect data, and a major strength of the case study methodology is its use of many different sources of evidence [42]. The methods used were observations, interviews, and document analysis. Prior to the study, approval from the Ethics Committee for Research Involving Human Subjects (JKEUPM) was obtained on August 13, 2020 (JKEUPM-2020-086). The JKEUPM stance and decisions are based on the principles expressed in the Declaration of Helsinki (2008). All the participants gave their informed consent for inclusion before they participated in the study.

A class in a vocational college in China was selected as a specific case that used the gamified AR app XploreRAFE+ to learn English. The researchers began by building rapport with the vocational college management staff, through whom a lecturer's English class was identified as a suitable case. The lecturer was then recruited and trained to use XploreRAFE+ so that she could conduct English lessons by employing the mobile application to create gamified AR environments. Thirty-eight naïve students from her English class then became the participants of the study and were trained to use XploreRAFE+. The training was provided for both the lecturer and the students so that they could familiarize themselves with the mobile application, and so that interest formation and learning motivation could be observed and understood without disruption caused by lack of familiarity with the technology. Of the 38 students involved, two were males, and 36 were females, aged between 18 and 20. The students were majoring in preschool education at the time of the study. Based on the college entrance examination data (Table 1), the majority of the students received relatively poor English scores in the college entrance examination. In China's college entrance examination, the maximum mark for English is one hundred and fifty, and the pass mark is ninety. The table shows that only seven students in this class passed the college entrance examination in English, while the remaining thirty-one students had low scores or had failed.

Table 1. Participants' English scores for college entrance examination.

English Scores	The Number of Students
110 > scores > 100	4
100 > scores > 90	3
90 > scores > 80	5
80 > scores > 70	10
70 > scores > 60	5
60 > scores > 50	9
50 > scores > 40	1
40 > scores > 30	1

All students willingly participated in this study. Their role in the study was explained and they were given guidance on how to use and familiarize themselves with the XploreRAFE+ mobile application prior to the first round of data collection. Once the lecturer and her students were comfortable with the mobile application, the data collection commenced. Figure 4 illustrates the process of participants' recruitment.

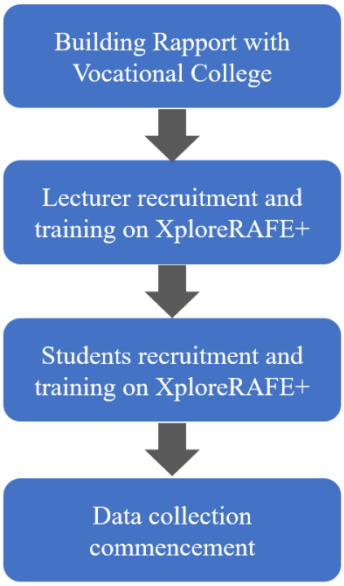

Figure 4. The process of participants' recruitment prior to data collection.

The researchers took into consideration the selected vocational college's regulations and teaching situation. The teacher required four weeks to complete one new English unit, with English classes conducted on a weekly basis, with a class duration of 90 minutes, including a ten-minute break. The four-week duration to complete one unit was sufficient for the research design as it allowed the interest loop to continuously recur from the use of XploreRAFE+ each week. It was also sufficient to identify and observe learners' motivation each time XploreRAFE+ was used in the four-week course.

Observations of the 38 participating students were conducted four times for a duration of 90 minutes each time the English lesson was conducted. At every observation, the researchers jotted down field notes and wrote memos to record the important data from the actions of the participants [43,44]. These data included, how the students' interests were piqued, how immersed they were in the learning, how their learning extended to real life situations, and, finally, how the gamified AR environment sustained their learning motivation in English lessons each week.

To obtain a more in-depth understanding of the actions of the study participants and to enhance the credibility of this research, focus group interviews (FGIs) and individual interviews were conducted following each class.The FGIs were conducted with all participants to gain an understanding of their actions through interactions among themselves and

with the researchers. The participants were divided into smaller groups, with six learning groups interviewed at different points during the four-week lesson period. There were six to seven students in each focus group reflecting the number in each learning group in the class. This was consistent with Denscombe's recommendation that focus groups consist of a small group of people, ideally between six and nine, to ensure effective data collection [45]. The FGIs were conducted each week after the classes ended for between 60 and 90 minutes each.

Individual interviews were conducted with participants who had shown active participation in the lessons. The individual interviews provided the researchers with the opportunity to spend extended time with the targeted participants to gain a richer understanding of their experience. A total of nine students were involved in the individual interviews, with two students interviewed twice and the remainder once. Each interview session lasted for approximately 50 to 90 minutes. In addition, documents, such as students' video recordings and students' essays, were collected to support and triangulate against the other types of data collected. The process of data collection and the types of data collected within the four-week period is presented in Table 2.

Table 2. The process of data collection and types of data collected.

Type of Data Collected	Data Collection Process			
	Week 1	**Week 2**	**Week 3**	**Week 4**
Observational field notes	38 students Duration: 90 minutes Remarks: 6 scenes observed	38 students Duration: 90 minutes Remarks: 6 scenes observed	38 students Duration: 90 minutes Remarks: 6 scenes observed	38 students Duration: 90 minutes Remarks: 6 scenes observed
Focus group interview transcripts	Group 1 (7 students) Duration: 70 minutes Group 2 (7 students) Duration: 90 minutes	Group 3 (6 students) Duration: 90 minutes	Group 4 (6 students) Duration: 70 minutes	Group 5 (6 students) Duration: 90 minutes Group 6 (6 students) Duration: 60 minutes
Individual interview transcripts	Student ID: S15 Duration: 65 minutes Student ID: S30 Duration: 70 minutes	Student ID: S19 Duration: 70 minutes Student ID: S13 Duration: 50 minutes Student ID: S22 Duration: 90 minutes	Student ID: S36 Duration: 50 minutes Student ID: S11 Duration: 70 minutes Student ID: S2 Duration: 50 minutes Student ID: S1 Duration: 50 minutes	Student ID: S15 Duration: 90 minutes Remarks: 2nd interview Student ID: S2 Duration: 50 minutes Remarks: 2nd interview

Table 2. *Cont.*

Type of Data Collected	Data Collection Process			
	Week 1	**Week 2**	**Week 3**	**Week 4**
Documents	Students' video recording. Students' essays.	Students' video recording. Students' essays.	Students' video recording. Students' essays.	Students' video recording. Students' essays.

The observational field notes, interview transcripts, and documents were analyzed with the assistance of NVivo software. There were four stages to the data analysis. The first stage involved transcribing interviews into type-written transcripts and entering them into NVivo for further data analysis. The second stage involved reading the transcripts and field notes and reviewing documents several times for familiarization and to gain a sense of the data before categorisation, and the taking of notes of emergent ideas. The third stage involved coding and developing categories and themes. In the process, a constant comparative method informed by grounded theory [46] was utilized. The final stage involved developing a related set of interpretations, and composing interpretations of the formation of interest in English learning among vocational college students with use of a gamified AR environment. Further analyses were carried out to find out whether interest formation may have a follow-on impact on students' learning motivation. To respect individual confidentiality, serial numbers were assigned to each participant when describing the themes emerging from the data analysis.

The mobile application used in the class was a gamified augmented reality system named XploreRAFE+ developed by the researchers. XploreRAFE+ utilizes the linked concepts of exploration in a real (R) environment to promote active (A) participation among learners in a fun (F) and engaging (E) lesson using augmented reality (signified by the + symbol). The system provided an AR map for students to search for trigger images which were positioned at different locations so that students could learn English in a realistic environment. At each location, learners were able to activate the AR images and videos by scanning their mobile phones on the trigger images provided at that location area, to understand the situation at each scene and perform some tasks that could stimulate their learning of English language skills, such as writing, speaking, reading, and listening. In addition, a leader board and a timer were incorporated to generate competitiveness among learners who needed to correctly accomplish their tasks at each location. A timer enabled bonus points to be allocated to groups that completed the tasks in a shorter period of time. A section for the learners to input their reflections at the end of each lesson in the form of video recordings was included in the system to extend learners' interest and to sustain their motivation to practice their English language fluency by letting them relate to a real-life environment. The interface of the app is presented in Figure 5.

A library scene was selected as an example to present the gamified learning process in class. At the beginning of the English course, an AR map was provided, in which there were various learning scenarios, such as scenarios at a library, supermarket, clinic, dormitory, dining hall and gymnasium. The AR map was used as a course trigger marker. The students were divided into small learning groups. Each learning group used the application to scan the first scene they had selected in the AR map to obtain the sequence of learning scenarios. Once the students had received the reference books that provided an introduction to the app for the learning process in each scene with a basic description in English, the learning groups started the English lesson. The students would be "transported" to the scene of a library where they would first scan a marker, i.e., "AR English class," to obtain a video regarding learning requirements and tasks for the library scenarios. They scanned a library card to obtain a relevant introduction in English regarding the library, and 3D books and its relevant information would then be displayed. Then, the students would go to the bookshelves to look for and scan the real books which were presented when scanning the

library card. With each book that they scanned, they would be shown an AR image of the relevant content of the book; these would be the seed materials, including AR images, AR videos, AR audios, and a real physical environment. Figure 6 shows a student scanning the cover of a real book to acquire a relevant AR image in a library scene.

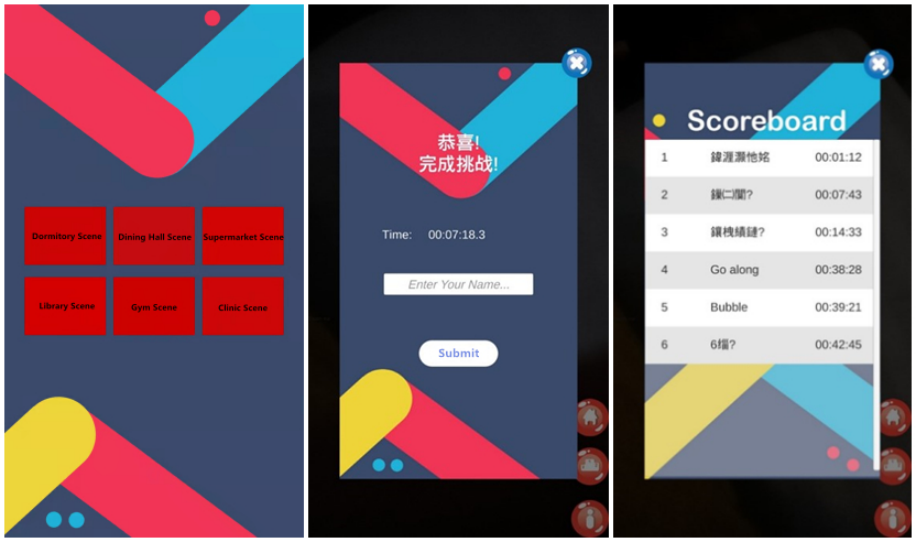

Figure 5. Scenes selection interface (**left**), submission interface (**middle**) and leaderboard interface (**right**).

Figure 6. A student scanning the cover of a real book with her smartphone and an AR video popped-up on the screen.

With the seed materials, the students were required to write a 100-word English essay related to the actual scene. Then, every team was required to video record themselves on XploreRAFE+ reading the short essay. Subsequently, they had to click "Submit." Immediately, the app would generate a ranking of times on the leader board. If a team was not satisfied with their recording or their essay write-up, they could make a revision by resubmitting the assignments. The learning time would then be recalculated so that bonus points could be given for each task. The essays were submitted to the course teacher after class for each team. The quality of the essays and recordings were to be assessed by their instructor. When the class was over, the students could revisit their video recording by scanning a trigger image titled "sharing." This feature allowed the students to share their assignments made for different scenarios with their classmates, thus facilitating discussions after class.

4. Results and Discussion

In order to validate the data, the researchers observed the class and triangulated the findings of the study. According to the analysis of data collected, the researchers found that three main themes emerged during interest formation, which were, (i) piquing curiosity, (ii) optimal experience, and (iii) experiencing meaningfulness. Furthermore, curiosity comprised three categories: perceptual curiosity, interest epistemic curiosity, and deprivation of epistemic curiosity. Optimal experience included the experience of pursuing the pleasure of looking for new information, the flow of balancing learning challenge with skills, and the experience of building positive relationships with fellow learners. With respect to experiencing meaningfulness, there were two categories, construction of knowledge and connection to real life. These themes emerged as a result of thinking about the process of interest formation and learning motivation among vocational college students in the gamified AR environment. The discussion of these themes sought to answer the research question: "What is the process of interest formation among vocational college students in a gamified AR environment, and how does it sustain students' motivation in learning English?".

4.1. Piquing Curiosity

As students were not familiar with this teaching technique, their teacher assembled them before starting the class for a briefing about the new learning method that used a gamified AR mobile application. The students were provided with reference books which provided information on the procedures in using the app and scenes in the app, together with basic English sentences about the scenes. After the briefing, the researchers observed six scenes at the beginning of the class and watched the video recording in each scene after the class. Table 3 presents the memo extracted from field notes, showing a summary of the main findings of the researchers' observations when students began to learn English in this environment.

Table 3. Summary of students' behaviors in the beginning of class.

Categories	Obvious Behaviors (OB)
Specific exploratory behavior	OB1. Students' eyes were attracted to the presented AR materials. The students looked as if they were trying to understand the content. OB2. After scanning the pictures, if the volume was found to be too low, the students would turn up the volume and they looked as if they were listening intently. OB3. Students touched the objects found in the scene and tried to interact with the real objects. OB4. Students referred to the reference book many times and viewed the relevant content of the scene. OB5. The students scanned the markers several times, focusing their eyes on the content presented and showing their desire to know more about the content. OB6. Students took screenshots of a specific sentence and they seemed to ponder about the meaning of the sentence.
Diversive exploratory behavior	OB7. The students walked very fast on their way to the scene. OB8. Students looked for markers around a scene with excited expressions on their faces.

Based on the observation results above, students' behaviors at the beginning of class could be divided into specific exploratory behaviors and diverse exploratory behaviors in the gamified AR environment. This finding was consistent with Berlyne's exploratory behaviors [47]. According to the IDC theory, specific–epistemic curiosity drives students' specific exploratory behaviors. Based on the data analysis of the observations of the students in the gamified AR environment, specific and diverse exploratory behaviors were evident. The initial data analysis of group interviews indicated that the two exploratory

behaviors were motivated by three kinds of curiosity, namely, perceptual curiosity (PC), interest epistemic curiosity (IEC), and deprivation epistemic curiosity (DEC).

4.1.1. Perceptual Curiosity

Perceptual curiosity refers to students' curiosity about the representation of AR technology and its features, such as superimposing virtual materials on real objects in the environment. Many students mentioned their curiosity about AR. For example, participant S9 said:

> *I think the AR technology is very cool. It can superimpose a lot of learning content on concrete objects. When I scanned objects, there would be videos, audios or 3D objects appearing. I found it fascinating and made me want to scan more objects. (FGI, 26 October 2020)*

Participant S11 and S14, who had similar views to S9, added:

> *When I scanned an object, I could also touch it. The feeling of holding it in my hand made me very curious about the object I was touching . . . I wanted to know more about it. In the past, what I learned in class was very abstract, it was all in my imagination. (FGI, S11, 26 October 2020)*

> *I thought this technology was very novel. When I scanned the first object at the scene, a video popped up. I thought it was so funny that I wanted to keep finding new AR objects and scanning them to see what was superimposed on them. (FGI, S14, 26 October 2020)*

The participants' statements indicated that perceptual curiosity was evoked by the variety of representations of AR technology and features that superimposed virtual materials on real objects. This finding echoed the observation by Berlyne that perceptual curiosity involves interest in and attention to novel perceptual stimulations [48,49]. The finding was also in line with Huang who pointed out that the gamified AR is better at capturing and retaining students' attention [50].

The researchers observed that when students explained their curiosity about the representations of AR technology and its features, the specific exploratory behaviors observed, such as OB1, OB2, and OB3 in Table 3 were close to perceptual curiosity. For example, participant S15's description of his feelings corresponded to OB1 in Table 3, i.e., that the students kept their eyes on the presented AR materials, as if they were trying to understand the content.

> *After I scanned the pictures, the 3D characters presented on the screen were very lovely; they caught my attention, and I was very curious about what we would learn. Then I read the content and tried to understand the AR content (Individual interview, S15, 26 October 2020).*

The students' perceptual curiosity was evoked by 3D characters presented on the screen, motivating him to read the specific AR content. As recorded in OB2, after scanning the pictures, if the volume was found to be too low, the students would turn up the volume as they wanted to listen attentively, as mentioned by S30:

> *When I scanned a picture, an AR video started with English subtitles and sounds. I thought the pronunciation was very standard and a little fast, but the presentation was very attractive. I became very curious to know what was happening, so I was all ears. (Individual interview, S30, 26 October 2020)*

The participants' description showed that perceptual curiosity, evoked by the variety of representations of AR technology and its features, motivated students' specific exploratory behavior. This finding echoed the findings of Berlyne's studies that perceptual curiosity involves interest in and attention to novel perceptual stimulations, thus motivating students to acquire new information [48,49].

4.1.2. Interest Epistemic Curiosity

According to the data analysis, interest epistemic curiosity involved curiosity regarding the learning scenes in the environment. For example, participants said:

> *The AR map reminded me of a game map. It aroused my curiosity about the scenes and made me want to discover more unknown scenes. The exploratory process was fun and enjoyable. (FGI, S1, 26 October 2020)*

> *This was my first AR experience. I thought it was so cool. I was very curious about the AR content in each scene. I was also attracted by the cool map which reminded me of maps in the game called "Player Unknown's Battle Grounds" (PUBG). The way the course started made me feel as if I was about to play a game; I was very eager to explore all the scenes in the map. (FGI, S7, 26 October 2020)*

The students' statements showed that in this learning environment, the gamified AR map evoked students' curiosity regarding the learning scenes. In other words, interest epistemic curiosity can bring about stimulating pleasurable feelings of situational interest [51].

Moreover, interest epistemic curiosity explained the generation of the diverse behavior in Table 3; e.g., as recorded in OB 8, students walked very fast on their way to the scene and in OB 9, students looked for markers around a scene with excited expressions on their faces. Some of the students who expressed these behaviors had this to say:

> *I really wanted to go to the real scene and find new markers. I was curious about the scenes and markers, so I started walking fast because I wanted to start learning as soon as I could. (FGI, S5, 26 October 2020)*

> *The AR map was interesting and it looked like a game map that I usually play. It aroused my curiosity about the scenes and made me want to discover the map. (FGI, S6, 26 October 2020)*

The students' comments showed that interest epistemic curiosity, evoked by the gamified AR map, drove the students to search for new markers or information, i.e., interest epistemic curiosity motivated students' diverse behavior [52].

4.1.3. Deprivation of Epistemic Curiosity

The data analysis revealed the students' desire to discover the meanings of new English words and phrases to close the English knowledge gap. According to Litman, deprivation of epistemic curiosity reflects students' desire to understand new English knowledge to relieve the negative affective conditions of feeling deprived of knowledge [49]. For example, participant S30 said:

> *When I saw an English AR image (snacks) appearing on the screen, I was a little nervous that I might not understand the content because of my poor command of English. Nevertheless, I was curious and wanted to know what it said about the snacks. I didn't understand some words, so I just took a screenshot and went online to look up the definitions of the words. (Individual interview, 26 October 2020)*

The students' description of their actions and thoughts showed that the English knowledge gap created by the AR content stimulated students' desire to acquire new English knowledge. This finding was congruent with Chan who is of the view that creating information gaps would arouse students' curiosity for them to seek more information to build on what they already know as well as to find out what may happen [30].

The students also reported that, because they had to complete the learning task to attain a good ranking, they needed to understand the content. For example, student S2 said:

> *I was afraid that I could not write an essay about the scene. I wanted to write a good essay so that I could get a good ranking. So, I tried very hard to understand the English content in the scene. (FGI, 26 October 2020)*

From the students' comments and the researchers' observations, the AR English content and the gamification mechanism of competition provided by the leaderboard evoked the students' desire to understand new English words as well as the desire to eliminate the knowledge gap [52].

Deprivation epistemic curiosity also explains some students' specific exploratory behavior in Table 3, e.g., OB4: students referred to their reference books many times and viewed the relevant content of the scene; OB5: students scanned the real markers several times, focusing their eyes on the content presented and showing their desire to know more about the content; OB6: students took screenshots of specific sentences and they seemed to ponder the meaning of the sentence. The segments of interview transcripts that reflect these behaviors and feelings are as follows:

> *When I arrived at the gym, I did not know what suitable English phrases could be used to describe the scene (gym). As we all had a reference book that provided some basic English sentences about the gym, I constantly browsed through it to look for words and phrases that I could use to describe the scene. (FGI, S18, 2 November 2020)*

> *When I read the specific AR English materials, the content in English was superimposed on the real object. I really wanted to understand the English content. I was eager to know how to use appropriate English words to describe the specific object. So, I scanned the markers many times and took screenshots of specific sentences so that I could search for their meanings online. That was what I did to try to understand the meaning of the sentence. (FGI, S19, 2 November 2020)*

These descriptions showed that students tried to search for more specific English information to help them understand the content and to carry out the writing task. This is consistent with Berlyne who points out that deprivation epistemic curiosity motivates testing hypotheses or asking questions in order to gain knowledge [47].

The three categories of curiosity were evident through the data gathered from interviews and observations. These findings echo those of several studies which have found that the use of AR technology or gamification in learning could pique students' curiosity [53,54]. Moreover, they are congruent with Berlyne who postulated that curiosity reflects a desire for new information and stimulates exploratory behavior [47].

4.2. Optimal Learning Experience

According to IDC theory, students' interest could be maintained through "flow," i.e., the experience of intense emotional involvement when students are fully engaged in learning. The researchers observed that the students experienced intense emotional involvement at each of five points: when they were looking for markers, when learning AR materials, when discussing with their group members, when writing the essay, and when reading the essay. From the researchers' observations, there was a particularly interesting phenomenon in which students were very active and noisy while they were searching for markers, when they were involved in group discussions, and when they were reading their essays. However, students were relatively quiet when learning AR materials and writing their essays although these activities were often accompanied by discussion. After observing the students, the researchers conducted group interviews, during which the students mentioned some signs of flow experience in the five noted instances. Table 4 shows a summary of the main findings about the signs of flow experience based on field notes and interview transcripts.

Table 4. Summary of emotions during optimal experience.

When Flow Took Place	Main Emergent Feelings
Learning AR materials	a feeling of energized focus being unaware of the passage of time a loss of self-consciousness a sense of connection to the inner self a feeling of control over actions and environment
Reading the essay	a feeling of energized focus being unaware of the passage of time a loss of self-consciousness
Writing the essay	a feeling of energized focus being unaware of the passage of time a sense of connection to the inner self a feeling of control over actions and environment
Looking for markers	being unaware of the passage of time momentary loss of anxiety and constraint
Group discussion	being unaware of the passage of time momentary loss of anxiety and constraint a feeling of control over actions and environment

The following interview segments reflect the emotional states of the students during the five moments. For example, when the students described that they were learning AR materials:

I was able to be focused; I just concentrated on trying to understand the sentences in the AR materials. (FGI, S30, 16 November 2020)

We gave the AR materials full attention. We concentrated on the task of solving problems by going online to look for answers. (FGI, S8, 26 October 2020)

The students described how they felt when they were reading their essay:

When we shot the videos and practiced reading aloud, I felt time fly. (FGI, S30, 16 November 2020)

When I read aloud, I found that I had difficulty pronouncing some new words. After checking out their pronunciation, all my energy was focused on articulating the words correctly (FGI, S21, 16 November 2020).

The students described their feelings during essay-writing:

When I was writing my essay, I was absorbed in it because I had to think about how to use some new knowledge I had learned about the scene. I had to organize sentences and finish the composition. We tried our best as our group was eager to get a good ranking. (FGI, S8, 26 October 2020)

When I was writing, I was very involved in thinking about how to use the words and phrases correctly. (FGI, S15, 2 November 2020)

The students described how they felt while looking for markers:

When we were looking for markers, I did not realize the time passing us by as I was enjoying the process very much. (FGI, S11, 26 October 2020)

When I was looking for markers, I felt very relaxed and had fun. (FGI, S19, 2 November 2020)

Students described their feelings during group discussions:

When we were in a group discussion, I felt that time passed very quickly. We managed to solve our problems after having a good and enjoyable discussion. The atmosphere of the discussion was good. (FGI, S21, 9 November 2020)

I really enjoy group discussions. During a discussion, we can share ideas and discuss the content for our essays. It was very relaxing and fun. (FGI, S17, 2 November 2020).

In summary, according to the participants' descriptions of their feelings regarding learning English in the gamified environment, the researchers found that not only were they eager to solve the problems they encountered during learning AR materials, group discussion, writing the essay and reading the essay, but they also enjoyed themselves in looking for markers, so much so that they lost track of time. This finding was consistent with IDC theory which states, "When students experience flow, they seek out increasingly greater challenges while devoting more attention to stretch their skills to confront such challenges, resulting in personal development as well as feelings of efficacy ([55], p. 6)". Further analysis of the data showed that the students' experiences in the five moments can be categorized as: (1) pursuing the pleasure of looking for new information, (2) balancing the challenge with skills, (3) building positive relationships with other learners. The following section will further analyze these three experiences.

4.2.1. Pursuing the Pleasure of Looking for New Information

According to the data from the interviews, most students said that when they were looking for markers, they experienced a feeling of momentary loss of anxiety and constraint. The students mentioned this many times, indicating that that they enjoyed looking for new markers. They forgot the pressure and constraint of learning English. They enjoyed the process so much that they did not notice the passage of time. For example, participants S27 and S2 said:

There were many markers to explore in this environment, and each setting was different. Each learning task was full of new discoveries and we learned many different things. This process of exploration made me very happy and I didn't notice the passage of time. I like to discover things; there so many unknowns.

Meanwhile, since task completion time for each group was ranked, we didn't waste time on just having fun. I thought the process of exploration made learning enjoyable and effective. (Individual interview, S27, 16 November 2020)

We enjoyed searching for markers in each learning situation because it's a relaxing process. Nevertheless, when we were immersed in the process, because of the ranking and the tasks, we would remind each other not to spend too much time on it. (Individual interview, S2, 16 November 2020)

The students' responses showed that the gamified setting (looking for clues to learn) provided enjoyable learning experiences. Furthermore, a timer that provided bonus points for each remaining second gave the students a feeling of success in a non-penalizing fashion when they were able to solve the tasks within the given duration. The combined use of tasks and a timer created a sense of competitiveness amongst the students. This finding is consistent with that of Yu, i.e., that the timer can stimulate students to engage in learning [56].

Some students also mentioned that in the process of looking for clues, the unknown interactive AR materials also provided many pleasant surprises, thus enhancing their enjoyment of the learning experience, making them eager to pursue new information. For example, participants S36 and S22 said:

I enjoyed looking for markers in a setting, not only because I wanted to find new markers, but also because I could find so many different forms of AR content each time – it was like going on an exploration that was full of wonderful surprises. Meanwhile, I could also interact with the AR content. I really enjoyed the process of exploring. (Individual interview, S36, 9 November 2020)

I think AR materials were very cool, and I was very curious about how AR materials would be presented in every scene. I also enjoyed looking for markers in real surroundings. I had so much fun; time passed too fast. (Individual interview, S22, 3 November 2020)

These comments by the students showed that the gamified setting, coupled with unknown interactive AR materials, created an enjoyable learning experience and the students enjoyed looking for new information. This finding lends support to the view that gamified AR could promote enjoyment in learning [57].

4.2.2. Balancing Challenges with Skills

Many students said that when they were learning with AR materials, writing their essays, and reading the essays aloud, they experienced a feeling of energized focus, a suspension of time, a sense of connection to the inner self, a loss of self-consciousness, and a feeling of control over their actions and environment. The students said that during those moments, they were completely focused on trying to execute the learning task by themselves, balancing the challenges that the task posed, extending their abilities, and thus falling into the flow. The following interview segments described the emotional and mental states of students when they were completely engaged in learning the English language.

> *When I was writing, I was most focused. I kept recalling what I had learned in the scene and some sentences that I knew before, trying to figure out how to put them together. Then I would look up some new words that could be used in the essay and discussed them with my classmates. During the whole process of thinking about how to write, I was completely absorbed in my task. After I finished the composition, I began to practice reading aloud several times as I did not read well at the beginning. I would look up the pronunciation of difficult words and then read my essay again and again. (Individual interview, S13, 3 November 2020)*

> *My English foundation is not very good. So, when I came across unfamiliar words in learning the AR materials. I would go online to look up the definitions of these new words as I wanted to write a better essay. When writing, I wanted to incorporate what I had learned from the scene into my composition. When I was uncertain about my grammar and vocabulary, I would go online to check out the correct usage. After finishing the composition, I immediately began to practice reading aloud; I would practice many times. I felt totally immersed in the whole process, especially when I practiced reading the essay. I would find a quiet spot, lean against the wall and immerse myself in reading aloud. (Individual interview, S11, 10 November 2020).*

The participants' feedback showed that, stimulated by challenges that the task posed, they were completely immersed in learning with AR materials as they wrote and read aloud their essays. This finding highlighted the view that challenges can strengthen students' involvement, thus supporting Wong's claim [55].

Furthermore, in the process of data analysis, the researchers noted that the students always talked about task setting and the leaderboard when asked about challenges and skills. For example, participants S2 and S1 said:

> *I was curious about the whole AR content. I tried to understand it. When I came across some English sentences that I did not understand, I went online to search for their meanings. I was fully immersed in the learning process. Of course, I also wanted to understand the content so that I could write a better composition. (Individual interview, S2, 10 November 2020).*

> *When I scanned the AR content, I became very curious to find out more about it. I wanted to understand it so that I could write a better essay. So, I would read it a few times and then look up the meanings of the difficult words. After that, I would try to understand the whole English content. During this process, I was very focused on learning. I also wanted to get a good ranking. (Individual interview, S2, 10 November 2020)*

According to the feedback of the students, task setting and the use of the leaderboard in the learning environment further motivated students to be completely engaged in the learning process, thus enabling them to finish their tasks. This finding was consistent with that of Alomari who showed that the leaderboard could stimulate students' motivation

and sustain learning motivation by providing a sense of competitiveness in the learning process [1].

4.2.3. Building Positive Relationships

Initially, data analysis from the observations and interviews showed that students also tried to solve problems in group discussions. Just like turning to the Internet for help, they turned to their teammates. The students reported that in the process of communicating with others, they were unaware of the passage of time. They also experienced a feeling of momentary loss of anxiety and constraint. The group discussions were helpful in fostering positive relationships with fellow learners. Most students said that they formed good friendship among themselves through discussion, sharing of knowledge, solving problems together, and helping one another. Such positive relationship helped relieve anxiety and pressure that are usually present in the traditional classroom. For example, participant S15 said:

> *In our group discussions, we shared our own understanding of the AR content and what ideas we used for our composition. Although we sometimes had heated discussions and even felt that we were about to quarrel, it was not a real quarrel as we were very happy during most of the whole discussion. And we were unaware of the passage of time. We all felt very relaxed during the whole process and there was no sense of restraint, unlike in a traditional classroom. (Individual interview, S15, 17 November 2020).*

The student's comments showed that the gamified environment provided learners with opportunities to discuss and share knowledge of English, thus making them feel that they belonged to a group. The need to have teammates and group discussions, as required by the gamified environment, fostered relatedness [2]. This finding agreed with Wong's view that when flow activities are collaborative, engaging in such activities with immersing interest allows students to build positive social relations by benefiting others [55].

Based on the data analysis, in such a learning environment, students constantly experienced the pleasure of looking for new information as well as the flow of balancing the challenge of acquiring new skills, along with building positive relationships. This finding echoed some studies which have indicated that the use of gamification or AR technology could immerse students in learning [1,58].

4.3. Experience Meaningfulness of Learning English

From the data analysis, the researchers found that most of the students, having experienced revising and resubmitting their video recordings and watching the shared videos, thought that English language learning had become more meaningful.

The interview segments below reflect these sentiments:

> *When I realized that I had used some words wrongly, I discussed my mistakes with my teammates. After rectifying my mistakes, I resubmitted my work. This process made me feel that English learning had become more meaningful. I had a better understanding of the difficult words. (FGI, S38, 16 November 2020).*

> *Watching the shared videos motivated me to reflect on my own writing and reading aloud. Furthermore, it also stimulated me to think about how I could write a better essay and to have correct pronunciation for my video recording. I made more effort to preview the English content of the subsequent scene and practice my pronunciation after class. (Individual interview, S1, 10 November 2020)*

As shown in the above students' comments, the gamified mechanism of resubmission and the "sharing" video function provided opportunities for them to reflect on their learning content and to share their thoughts with their teammates. Through further data analysis, the researchers found that the students perceived the meaningfulness of English language learning when they submitted their video recordings and watched the shared videos. Perceived meaningfulness involved two aspects: (1) construction of English

knowledge, i.e., using new English vocabulary and phrases in sentences to describe scenes, and (2) a connection to real life.

4.3.1. Construction of English Knowledge

Some students mentioned that after submission of their videos, they went back to revise the content of the video and the corresponding essay repeatedly. In this process, they felt that they improved their English language knowledge. For example, Participant S19 said:

> *Since we could submit our videos many times, we would check whether there was any problem with the videos even after we submitted them. We focused mainly on the correctness of our pronunciation, the correct usage of words and construction of sentences. If there was any mistake in the video, we would discuss it with our teammates, rectify it and resubmit the video. However, if we did that, the submission time would be recalculated, and that would impact the ranking of our group in the leader board. Therefore, every time before we submitted our video, we would first check it carefully to make sure that our sentences were correctly constructed and that the pronunciation of difficult words was correct. We would try our best to make no mistakes. During this process, both my teammates and I had a deeper understanding of new words and phrases. In the process of revision, my group members sometimes helped me correct my mistakes in writing and pronunciation. (Individual interview, S19, 2 November 2020)*

According to the students' feedback, the gamified mechanism of resubmission combined with the timer provided them the opportunity to reflect on the learning content and to share their thoughts with their team members, thus reinforcing their mastery of new English knowledge.

In addition, some students mentioned that during the revision of the content of their videos, they recalled the AR English content they had learned. They thought that the AR English content was memorable because they could always relate to a specific real-life scene or objects when discussing new English words, phrases, or sentences. These real-life scenes or objects enhanced their understanding and improved their ability to remember new English words, phrases, and sentences. For example, participants S15 and S36 stated:

> *When I submitted my video, I would check what I had written. I tried to recall the learning scene. I found that I could remember the AR content superimposed on each marker very clearly because it always allowed me to relate to the object. At the same time, I was deeply impressed by the new English words, phrases and sentences in the AR content. I found that I could easily remember what I had learnt as they were meaningful. In the past, I always had problems remembering what I had learnt in my English class. (Individual interview, S15, 17 November 2020)*

> *The AR content for the English lesson had real-life scenes. This made the content of the lesson more meaningful as we could use the English content in these scenes in the future. At the same time, I expanded my English vocabulary quite extensively. (Individual interview, S36, 9 November 2020)*

The students' description showed that the AR technology feature which superimposed learning contents on the real objects in real-life scenes helped to enhance understanding of English content. This finding confirmed that AR games improved students' understanding of their learning materials [50] and echoed Sydorenko's point that AR games provide a useful background for English learning and are particularly helpful for collaborative deconstruction of the meaning of abstract concepts [59].

4.3.2. Connection to Real Life

There are two aspects to how the use of gamified AR exercise connects to real life, i.e., applying English language skills in real-life situations, and integrating English skills into topics depicting real scenes. Some students said that they might study abroad in the future. They used to think learning English was abstract and served little purpose, but now they

felt that the English content learned in this environment would be useful for their future daily life abroad. Participant S34 mentioned:

> *I may go abroad to study in the future. I think learning English in this environment will be very helpful for me in many aspects in the future. (FGI, S34, 16 November 2020)*

Because the students were majoring in preschool education, it is very beneficial for them to master the English language as it will be used in the teaching of young children in the future. Most students reported that the English content learned in this environment would be useful for their future careers. Participant S2 explained:

> *As we would use English in our future teaching career, what I have learned in these real-life situations would be useful when I start working. (FGI, S2, 2 October 2020)*

The students' remarks highlighted the relevance between their gamified AR English lessons and their needs in real life. They were aware that mastery of the English language would be beneficial for their careers, and that the gamified AR learning of English was meaningful, unlike the traditional way of learning English. The contextual learning motivated the students to link the learning material and new knowledge with real situations in the family and society [60]. This finding was consistent with Ho's study which indicated that the use of AR technology in the English class that combined learning and real-life events helped enliven the English learning experience [61].

In addition, many students mentioned that the gamified AR environment provided topics that integrated English language skills, such as reading, listening, writing, and speaking on topics with real-life scenes. The students felt that mastering English skills was meaningful and useful for them. They mentioned that integrating English skills with topics related to daily life made them feel that what they had learned was very meaningful and useful. Below are excerpts from the interviews.

> *When I learned English in a scene that depicted a real-life setting, I found that I could learn and practice English skills, such as speaking, reading, listening and writing on one topic. The learning materials were useful and meaningful. (FGI, S27, 16 November 2020)*

> *In the traditional English class, we would also learn English based on different topics. But the learning process was very boring and very abstract. We would all sit in the classroom and learned mechanically. But in this new environment, we acquired English language skills in an environment that simulated real-life settings. The learning content was very attractive and meaningful. The new environment allowed me to integrate what I had learned, and practiced the skills of listening, speaking, reading and writing for a specific scene. (FGI, S32, 16 November 2020)*

According to the students' comments above, the new environment integrated English language skills, such as reading, listening, writing, and speaking, with topics that were related to real life settings. This made the students realize the usefulness of learning the English language. Firstly, students noted that the thematic learning with specific topics helped them better understand the learning content, especially since the topics were related to daily life events and settings. In this regard the thematic learning in a real environment supported English language skills learning [60]. The data analysis also showed that integrating English skills in real-life scenes made English content more relevant and memorable, as pointed out by Liu who was of the view that thematic learning provides students with a framework to facilitate learning [62].

4.4. Interest Formation and Learning Motivation

As indicated by the students' reactions and comments regarding the gamified learning environment using AR technology, students' interest was developed through piquing curiosity, experiencing optimal learning experience, and perceiving meaningfulness.

With the constant circulation of the three elements of interest formation in the gamified AR environment, students' interest in learning English was enhanced, and students noted

their change from lacking interest in English learning to having the motivation to learn English. Most students mentioned that in the cyclical process, their autonomy was enhanced when they were experiencing optimal learning experience. For instance, participants S1, S27 and S24 mentioned that:

> *I used to feel very restricted in traditional classes, I often want to find some new content on my own, but it is not allowed in class. In this environment, even though we had markers we wanted to look at, but we didn't know where they were, we could wander around the locations to look for the markers. I really enjoy this sense of freedom. Besides, in the process of looking for the new markers, I also encountered other new contents that made me want to explore more in the future. (Prolonged interview, S1, 10 November 2020)*

> *We were pleasantly surprised and amused by the variety of AR content while looking for markers. These different presentation of AR content made the process of exploration became more interesting and made us enjoy the process more. Our group members were fully engaged in the process. (FGI, S27, 16 November 2020)*

> *I really hated English writing before because first I didn't know what I could write and writing was too abstract for me. Besides, the writing topics were always rigid and boring. But in this environment, we had a broad theme about this real scene and there were a lot of topics we can freely choose which were so close to us. The whole writing process made me feel happy, although I still have some difficulties in writing, I was fully engaged in the process of solving the problems and writing the essay and I no longer resist writing in English. (FGI, S24, 9 November 2020)*

Students' comments showed that the gamified setting, looking for clues to learn, provided students with a chance to play, allowing free exploration [63]. This way of facilitating exploration has been suggested to be a way of easing engagement in a required task, as Nicholson has claimed [64]. In this playful space, students were allowed to decide which exploration pathways they wanted to pursue [63] to enjoy the process of looking for new learning content. The finding also echoed Schrier's study which found that exploring a physical location also motivated participants to learn more and engaged them further in the game [65]. The participants especially enjoyed actively walking around and learning rather than sitting passively in a classroom. Moreover, the statement also showed that the AR presentations, which were initially unfamiliar to the students, enhanced the pleasure of exploration, thus immersing them in the pursuit of the pleasure of exploration. The finding also highlighted that the use of play combined with AR further enhanced the enjoyable atmosphere. This was, as Castañeda claimed, the fun ambiance provided by the gamified AR environment that keeps students motivated in using the tool for learning [66]. Meanwhile, the findings also showed that AR has the potential to engage students by seeing and understanding information in its context through which they can creatively explore the content by exploring scenarios through the lens of games [67]. Moreover, students' statements also showed that the gamified AR environment that provided choices enabled them to be more autonomous [68], which was significant for intrinsic motivation. This is because choices were closely related to the play, and the use of choice created a more playful ambience in the learning process [64].

Most students mentioned that in the cyclical process, their relatedness was enhanced when they had optimal learning experiences. The students expressed the view that, due to their past English learning experience, they were afraid to express their opinions in front of their classmates because they were not good at English, which made them nervous. However, now that they were very familiar with their group members and had developed a good relationship, they felt more confident. As the number of times the students shared their opinions increased, they were more open to share their thoughts in group discussions. For example, student S19 said that:

> *In the beginning, we were unfamiliar and not close with each other. But because we were learning English in this environment, our group members became familiar with each other, and that makes us became very active in the group discussion later. As we became*

familiar with each other, we dared to express our opinions in front of them. (Prolonged interview, S19, 2 November 2020)

Meanwhile, students also stated that their English competency improved when they perceived the meaningfulness of learning English. Student S1 stated:

The sharing videos motivated me to reflect my own writing and reading aloud. Meanwhile, it also stimulated me to think about how I can write a better essay and have a better pronunciation in the video in that real scene. I began to preview English content of the next scene and practice the pronunciation after class. (Individual interview, S1, 10 November 2020)

According to the students' feedback, the cyclical formation of interest that they experienced from the use of XploreRAFE+ for a duration of four weeks maintained their motivation. The researchers suggest that this process was analogous to the continuous energy produced from the oscillating charges of an electromagnetic field. Similarly, the continuous experience of interest formation from the use of XploreRAFE+ in four consecutive English lessons led to sustained motivation in learning English. This is because the students' psychological needs, namely competence, autonomy, and relatedness, were continuously satisfied in the cyclical process. This finding echoed Deci's claims that competence, autonomy, and relatedness are closely related to motivation [69]. The conceptualization of the findings of this study is illustrated in Figure 7.

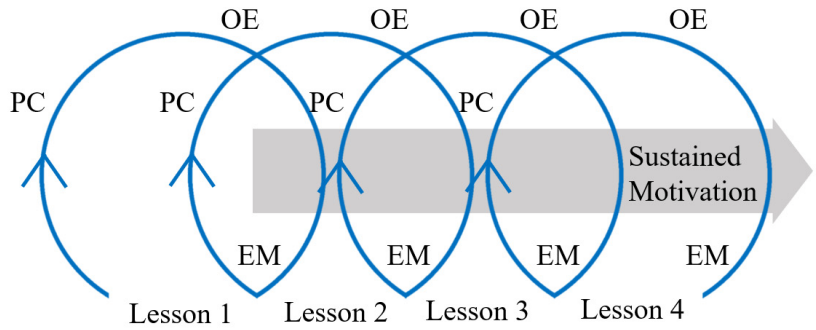

Figure 7. Continuous experience of interest formation (piquing curiosity, optimal experience, experience meaningfulness) from the use of XploreRAFE+ that leads to sustained motivation in learning English.

5. Limitations

There are some limitations to this study. The first limitation relates to the process of selection of participants. The selected vocational college where this study was conducted emphasized the use of emerging technology in teaching. This vocational college fully supports teachers in reforming teaching. Moreover, the college is relatively better equipped than general vocational colleges in Sichuan Province in terms of teaching facilities and environment. Therefore, the teaching and learning environment in this college is not representative of most ordinary vocational colleges. Furthermore, in this study, the researchers wanted to explore the use of gamified AR technology in interest formation among vocational college students, and therefore the choice of vocational college that uses gamified AR technology was an important factor guiding the researcher's choice. In the selection process, the researcher chose a class in this vocational college that used gamified AR technology to carry out teaching reform in English courses.

A second limitation relates to the potential for a Hawthorne effect such that students might have been behaving differently knowing that they were being studied. Before the course began, the teacher of this course had introduced the research to the class and informed them that a researcher would come to observe their learning process. Although the researchers did not participate in the course and did not affect the normal course

learning, when the researchers videotaped the learning processes, the researchers found that at the beginning of the course the students in the class were nervous. This might have affected their behaviors and, in turn, their behavioral assessments. Nevertheless, as the course progressed, the students became acclimatized to the observations and recording of videos. A third limitation concerns theoretical lenses. In this research, the researchers chose the interest loop of IDC theory as the theoretical basis and selected three components of it as an important means of explaining the formation of interest. The results might be different had the researchers chosen another theory. A fourth limitation relates to the research design. The study was conducted within four weeks—were the research to be conducted over a prolonged period the increase in duration might affect the findings obtained.

6. Conclusions

Using the framework provided by IDC theory, this study found that in the gamified AR environment, interest formation could be attributed to three themes, (i) piquing curiosity, (ii) optimal experience, and (iii) experiencing meaningfulness. Furthermore, curiosity comprised three categories, (1) perceptual curiosity, (2) interest epistemic curiosity, and (3) deprivation epistemic curiosity. Optimal learning experience could be categorized as: (1) pursuing the pleasure of looking for new information, (2) balancing the challenge with skills, and (3) the experience of building positive relationships. Experiencing meaningfulness of English language learning consisted of two aspects: (1) construction of English knowledge, and (2) connection to real life. This process is illustrated in Figure 8.

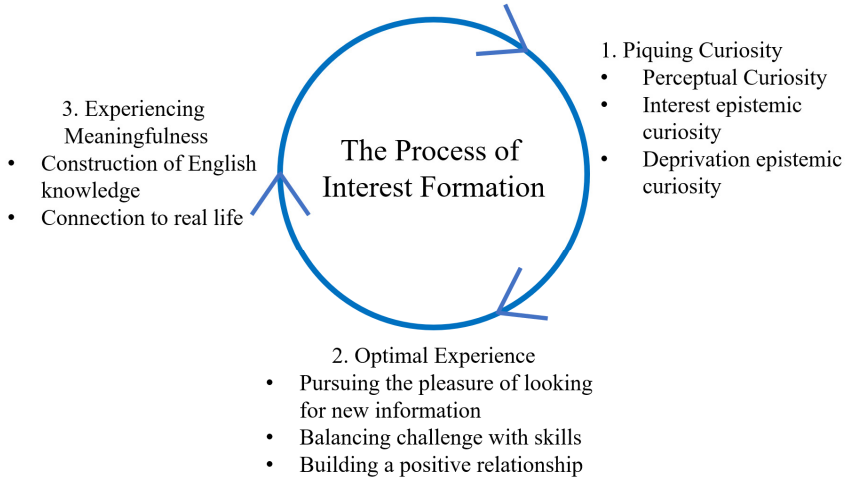

Figure 8. The Process of Interest Formation in a Gamified AR Environment.

The researchers found that interest formation in the gamified AR environment was a dynamic process. In the beginning, the students' curiosity was triggered by the variety of representations of AR technology and its features, including the gamified map, AR English content, and the mechanism of competition provided by the leaderboard. The three categories of curiosity motivated students' specific and diverse exploratory behavior. Exploratory behavior, the result of three categories of curiosity, was the basis of the students' optimal learning experience.

With the stimulation of the learning tasks and ranking provided by the leaderboard, students experienced the flow of balancing the challenges of practicing the skills when learning with AR materials, writing the essay, and reading it. In the gamified setting that required the students to look for clues while exploring the environment using unknown interactive AR materials, the students experienced the pleasure of looking for new information. Working as teammates in a gamified setting, the students built positive relationships with team members while discussing and sharing ideas.

After undergoing the optimal learning experience, the gamified mechanism of resubmission and the use of "sharing" videos provided the students with opportunities to

reflect on their learning content and to share their thoughts with teammates. The features of AR technology that superimposed learning content onto real objects in real-life scenes enhanced the understanding of English content and connection with real life situations, thus helping the students perceive the meaningfulness of learning the English language. With the circulation of interest loop in the gamified AR environment, students in a playful environment became more engaged in learning, developed good relationships with classmates, and were able to extend their English proficiency. In short, students' needs for competence, autonomy, and relatedness were satisfied. The cyclical formation of interest developed through gamified AR environments over time was able to sustain learners' motivation, analogously to the oscillating charges of an electromagnetic field producing continuous energy.

There are many studies on the positive effect of gamified AR on learning that show gamified AR can improve students' learning by enhancing students' learning motivation and interest [26,70], facilitating students' engagement, interaction and collaboration [26,67], enhancing enjoyable learning experience [57,71,72], boosting understanding of knowledge [71], and through experiencing flow [50,70]. However, very little is known about the process of interest formation in a gamified AR environment and how it could sustain learners' motivation. Within the theoretical framework of IDC theory, the study has filled some gaps in the literature as the findings of the study showed that interest formation includes piquing curiosity, experiencing optimal learning experience, and perceiving meaningfulness of learning. These stages occur in a perpetual loop that may further sustain learners' motivation in learning.

In existing studies on the formation of interest, the focus is usually on situational and individual interest. These research studies discuss the development process of situational interest in an active learning environment and factors affecting this, and the transition from situational interest to individual interest [33,34]. From these past studies the process of interest formation has been assumed to occur in a linear way. However, the findings of the current study indicate that, in the gamified AR environment, interest formation is a dynamic process. The "interest loop" starts by tapping students' three kinds of curiosity to trigger students' situational interest. Immersing students in English language learning helps maintain situational interest and allows them to have optimal learning experiences. Finally, emergent individual interest is nurtured when the students find that learning the English language is genuinely meaningful for them. When students constantly experience the "interest loop", they developed genuine interest in learning. Subsequently, sustained motivation in learning could be achieved by the continuous cyclical process of interest formation from the use of gamified AR mobile application for several weeks.

The researchers believe that there are opportunities to expand this study to other disciplines, such as science, mathematics and history, as well as to other levels of education, such as primary and secondary school students. This study employed a qualitative methodology, and a case study was used. The researchers recommend that other methods should also be used to validate the findings. Since this study is qualitative in nature, the findings of this study are not generalizable. However, it may be transferable to situations that are similar to the case under study. Additionally, this study can be used as an exploratory basis for subsequent research in quantifying the interest and motivation level of learners in a prolonged experimentation process.

Author Contributions: Conceptualization, D.W. and M.N.M.K.; methodology, D.W. and M.N.M.K.; software, D.W. and M.N.M.K.; validation, D.W., M.N.M.K., S.L.W. and A.B.R.; formal analysis, D.W. and M.N.M.K.; investigation, D.W. and M.N.M.K.; resources, D.W. and M.N.M.K.; data curation, D.W. and M.N.M.K.; writing—original draft preparation, D.W. and M.N.M.K.; writing—review and editing, D.W., M.N.M.K., S.L.W. and A.B.R.; visualization, D.W. and M.N.M.K.; supervision, M.N.M.K., S.L.W. and A.B.R.; project administration, M.N.M.K.; funding acquisition, M.N.M.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Research Incentive Grant for Teaching and Learning, Universiti Putra Malaysia [9323703] and the APC was funded by Universiti Putra Malaysia under the Research Management Centre.

Institutional Review Board Statement: Approval from the Ethics Committee for Research Involving Human Subjects (JKEUPM) was obtained on August 13, 2020 (JKEUPM-2020-086). The JKEUPM stance and decisions are based on the principles expressed in the Declaration of Helsinki (2008).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to human subject safeguarding practice.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Alomari, I.; Al-Samarraie, H.; Yousef, R. The Role of Gamification Techniques in Promoting Student Learning: A Review and Synthesis. *J. Inf. Technol. Educ. Res.* **2019**, *18*, 395–417. [CrossRef]
2. Subhash, S.; Cudney, E.A. Gamified learning in higher education: A systematic review of the literature. *Comput. Hum. Behav.* **2018**, *87*, 192–206. [CrossRef]
3. State Council of the People's Republic of China. Guo wu yuan guan yu yin fa xin yi dai ren gong zhi neng fa zhan gui hua de tong zhi [Notice of the State Council on Issuing the Development Plan on the New Generation of Artificial Intelligence]. Available online: http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm (accessed on 24 July 2021).
4. Fisher, D.J.; Beedle, J.; Rouse, S.E. Gamification: A study of business teacher educators' knowledge of, attitudes toward, and experiences with the gamification of activities in the classroom. *J. Res. Bus. Educ.* **2013**, *56*, 1.
5. Villagrasa, S.; Fonseca, D.; Redondo, E.; Duran, J. Teaching case of gamification and visual technologies for education. *J. Cases Inf. Technol.* **2014**, *16*, 38–57. [CrossRef]
6. Leaning, M. A study of the use of games and gamification to enhance student engagement, experience and achievement on a theory-based course of an undergraduate media degree. *J. Media Pract.* **2015**, *16*, 155–170. [CrossRef]
7. Amjah, D.Y.P.H. A study of teachers' strategies so develop students' interest towards learning English as a second language. *Procedia-Soc. Behav. Sci.* **2014**, *134*, 188–192. [CrossRef]
8. Zuo, Y.W. Gao zhi yuan xiao xue sheng xue xi juan dai xian zhuang daio cha yu dui ce fen xi [The Present Situation and Countermeasures of the Learning Burnout Problem of Higher Vocational Students]. *Vocat. Technol.* **2019**, *18*, 48–51. [CrossRef]
9. Lian, H.B.; Zhao, Y.Q. Xin shi dai zhong guo te se zhi ye ji shu da xue de te zheng ding wei yu shi jian zhi xiang [Orientation and practical orientation of Vocational and technical universities with Chinese characteristics in the new era]. *J. Heilongjiang Vocat. Inst. Ecol. Eng.* **2021**, 94–96.
10. Hao, D.Z.; Hu, K.Z. Tian jin shi gao zhi sheng xue xi juan dai xian zhuang yan jiu [Present situation of learning burnout of Higher Vocational Students in Tianjin]. *J. Tianjin Univ. Technol. Educ.* **2014**, *24*, 50-53,63.
11. Hao, D.Z. Tian jin shi gao zhi sheng xue xi dong ji yu xue xi juan dai de xian xiang ji qi guan xi yan jiu [On Learning Motivation and Learning Burnout in Vocational College Students of Tianjin]. *Stud. Theor. Policies* **2014**, *5*, 22–25. [CrossRef]
12. Liu, H.X. Zeng qiang xian shi ji shu zai gao zhi jiao yu de ying yong xian zhuan ji dui ce [The application of AR in higher vocational education and its countermeasures]. *Electron. Technol. Softw. Eng.* **2019**, *5*, 135.
13. Kim, E.; Rothrock, L.; Freivalds, A. The effects of Gamification on engineering lab activities. In Proceedings of the 2016 IEEE Frontiers in Education Conference (FIE), Erie, PA, USA, 12–15 October 2016; pp. 1–6.
14. Bjaelde, O.E.; Pedersen, M.K.; Sherson, J. Gamification of quantum mechanics teaching. In Proceedings of the E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, New Orleans, LA, USA, 27 October 2014; pp. 218–222.
15. Owens, D.C. Overcoming Motivational Barriers to Understanding and Accepting Evolution through Gameful Learning. In *Evolution Education Re-considered*; Harms, U., Reiss, M., Eds.; Springer: Cham, Germany, 2019; pp. 167–184. ISBN 978-3-030-14697-9.
16. Zhang, Q.; Qu, W.Q.; Zhou, C.L.; Lin, C.Y. Da xue ying yu you xi hua jiao xue de she ji yu shi jian [Design and practice of college English gamification teaching]. *Abil. Wisdom* **2013**, *27*, 66.
17. Yang, H.L.; An, L.J. Gao xiao ying yu ting li you xi hua jiao xue de she ji yu ying yong [Design and application of gamified teaching of college English listening]. *Sci. Technol. Inf.* **2019**, *17*, 120–122.
18. James, K.K.; Mayer, R.E. Learning a second language by playing a game. *Appl. Cogn. Psychol.* **2019**, *33*, 669–674. [CrossRef]
19. Zarzycka-Piskorz, E. Kahoot it or not? Can games be motivating in learning grammar? *Teach. Engl. Technol.* **2016**, *16*, 17–36.
20. Wichadee, S.; Pattanapichet, F. Enhancement of performance and motivation through application of digital games in an English language class. *Teach. Engl. Technol.* **2018**, *18*, 77–92.
21. Sartini, S. Kahoot in Maritime English Teaching: Its Impact on Nautical Science Cadet's Oral Reproduction and Vocabulary. *Engl. Lang. Educ. J.* **2020**, *3*, 41–51. [CrossRef]
22. Azuma, R.T. A survey of augmented reality. *Presence Teleoperators Virtual Environ.* **1997**, *6*, 355–385. [CrossRef]
23. Billinghurst, M. Augmented reality in education. *New Horiz. Learn.* **2002**, *12*, 1–5.

24. Liu, T.Y.; Tan, T.H.; Chu, Y.L. QR code and augmented reality-supported mobile English learning system. *Mob. Multimed. Process* **2010**, 7–52. [CrossRef]
25. Solak, E.; Cakir, R. Exploring the Effect of Materials Designed with Augmented Reality on Language Learners' Vocabulary Learning. *J. Educ. Online* **2015**, *12*, 50–72. [CrossRef]
26. Bressler, D.M.; Bodzin, A.M. A mixed methods assessment of students' flow experiences during a mobile augmented reality science game. *J. Comput. Assist. Learn.* **2013**, *29*, 505–517. [CrossRef]
27. Yu, S.J.; Sun, J.C.Y.; Chen, O.T.C. Effect of AR-based online wearable guides on university students' situational interest and learning performance. *Univers. Access Inf. Soc.* **2019**, *18*, 287–299. [CrossRef]
28. Chin, K.Y.; Wang, C.S. Effects of augmented reality technology in a mobile touring system on university students' learning performance and interest. *Australas. J. Educ. Technol.* **2021**, *37*, 27–42. [CrossRef]
29. Hao, K.C.; Lee, L.C. The development and evaluation of an educational game integrating augmented reality, ARCS model, and types of games for English experiment learning: An analysis of learning. *Interact. Learn. Env.* **2019**, *29*, 1–14. [CrossRef]
30. Chan, T.W.; Looi, C.K.; Chen, W.; Wong, L.H.; Chang, B.; Liao, C.C.; Cheng, H.; Chen, Z.H.; Liu, C.C.; Kong, S.C.; et al. Interest-driven creator theory: Towards a theory of learning design for Asia in the twenty-first century. *J. Comput. Educ.* **2018**, *5*, 435–461. [CrossRef]
31. Azevedo, F.S. An inquiry into the structure of situational interests. *Sci. Educ.* **2018**, *102*, 108–127. [CrossRef]
32. Lin, H.S.; Hong, Z.R.; Chen, Y.C. Exploring the development of college students' situational interest in learning science. *Int. J. Sci. Educ.* **2013**, *35*, 2152–2173. [CrossRef]
33. Rotgans, J.I.; Schmidt, H.G. Situational interest and academic achievement in the active-learning classroom. *Learn. Instr.* **2011**, *21*, 58–67. [CrossRef]
34. Korsun, I. The formation of learners' motivation to study physics in terms of sustainable development of education in Ukraine. *J. Teach. Educ. Sustain.* **2017**, *19*, 117–128. [CrossRef]
35. Hidi, S.; Renninger, K.A. The four-phase model of interest development. *Educ. Psychol.* **2006**, *41*, 111–127. [CrossRef]
36. Lanina, I.Y. *Formirovanie Poznavatelínykh Interesov Uchashchikhsia na Urokakh Fiziki [The Formation of Learnersí Cognitive Interest in Physics Lessons]*; Prosveshcheniye: Moscow, Russia, 1985. (In Russian)
37. Uzumcu, O.; Bay, E. The effect of computational thinking skill program design developed according to interest driven creator theory on prospective teachers. *Educ. Inf. Technol.* **2021**, *26*, 565–583. [CrossRef]
38. Kong, S.C.; Wang, Y.Q. Nurture interest-driven creators in programmable robotics education: An empirical investigation in primary school settings. *Res. Pract. Technol. Enhanc. Learn.* **2019**, *14*, 1–19. [CrossRef]
39. Yeh, Y.C. Math-Island: Design and Preliminary Evaluation of Interest-Driven Mathematics Learning System. Ph.D. Thesis, National Central University, TaoYuan, TaiWan, 2019.
40. Liu, W.Y.; Chen, Z.H. Developing digital game-based learning system for the acquisition of Chinese characters in primary education: An interest-driven creator (IDC) theory perspective. In Proceedings of the 27th International Conference on Computers in Education, ICCE 2019, Kenting, Taiwan, 2–6 December 2019; pp. 172–176.
41. Merriam, S.B.; Tisdell, E.J. *Qualitative Research: A Guide to Design and Implementation*; John Wiley & Sons: Hoboken, NJ, USA, 2015; ISBN 1119003601/9781119003601.
42. Yin, R.K. *Case Study Research and Applications: Design and Methods*; Sage Publications: Thousand Oaks, CA, USA, 2017; ISBN 1506336183/9781506336183.
43. Patton, M.Q. *Qualitative Evaluation and Research Methods*; Sage: Thousand Oaks, CA, USA, 2002; ISBN 0761919716/9780761919711.
44. Creswell, J.W.; Poth, C.N. *Qualitative Inquiry and Research Design: Choosing among Five Approaches*; Sage Publications: Thousand Oaks, CA, USA,, 2016; ISBN 1506330215/9781506330211.
45. Denscombe, M. *The Good Research Guide for Small-Scale Social Research Projects*; McGraw-Hill Education: London, UK, 2017; ISBN 9780335226863/0335226868.
46. Charmaz, K. *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*; Sage: London, UK, 2006; ISBN 761973524.
47. Berlyne, D.E. A theory of human curiosity. *Br. J. Psychol.* **1954**, *45*, 180–191. [CrossRef] [PubMed]
48. Berlyne, D.E. Determinants of human perceptual curiosity. *J. Exp. Psychol.* **1957**, *53*, 399–404. [CrossRef]
49. Berlyne, D.E. The influence of complexity and novelty in visual figures on orienting responses. *J. Exp. Psychol.* **1958**, *55*, 289–296. [CrossRef]
50. Huang, Y.M.; Lin, P.H. Evaluating Students' Learning Achievement and Flow Experience with Tablet PCs Based on AR and Tangible Technology in u-Learning. *Libr. Hi Tech.* **2017**, *35*, 602–614. [CrossRef]
51. Litman, J.A. Curiosity and the pleasures of learning: Wanting and liking new information. *Cogn. Emot.* **2005**, *19*, 793–814. [CrossRef]
52. Litman, J.A. Interest and deprivation dimensions of epistemic curiosity. *Personal. Individ. Differ.* **2008**, *44*, 1585–1595. [CrossRef]
53. Hong, J.C.; Hwang, M.Y.; Liu, Y.H.; Tai, K.H. Effects of gamifying questions on English grammar learning mediated by epistemic curiosity and language anxiety. *Comput. Assist. Lang. Learn.* **2020**, 1–25. [CrossRef]
54. Pamungkas, T.D. Android-based augmented reality media and the curiosity about mathematics. In Proceedings of the Journal of Physics: Conference Series, Semarang, Indonesia, 12–13 August 2020; p. 012016.
55. Wong, L.H.; Chan, T.W.; Chen, W.; Looi, C.K.; Chen, Z.H.; Liao, C.C.; King, R.B.; Wong, S.L. IDC theory: Interest and the interest loop. *Res. Pract. Technol. Enhanc. Learn.* **2020**, *15*, 1–16. [CrossRef]

56. Yu, F.; Wang, L.; Li, A.H.; Liu, Y.; Gong, S.L.; Li, B. Li Yong Chirality-2 jing xing you ji hua xue you xi hua jiao xue mo shi de shi shi [Using Chirality-2 to Implement the Game Teaching Mode of Organic Chemistry]. *Chin. J. Chem. Educ.* **2021**, *8*, 89–93.
57. Pombo, L.; Marques, M.M. The EduPARK Mobile Augmented Reality Game: Learning Value and Usability. In *Proceedings of the 14th International Conference Mobile Learning*; Lisbon, Portugal, 14–16 April 2018. Available online: https://eric.ed.gov/?id=ED590397 (accessed on 24 July 2021).
58. Giasiranis, S.; Sofos, L. Flow experience and educational effectiveness of teaching informatics using AR. *J. Educ. Technol. Soc.* **2017**, *20*, 78–88.
59. Sydorenko, T.; Hellermann, J.; Thorne, S.L.; Howe, V. Mobile augmented reality and language—Related episodes. *TESOL Q.* **2019**, *53*, 712–740. [CrossRef]
60. Marhamah, M.; Handayani, W.; Mukhaiyar, M.; Ramadhan, S. Integrated Thematic Context on Contextual Learning Based on English Learning Process in the Fifth Year at As Shofa Islamic Elementary School. In Proceedings of the International Conference on Language, Literature, and Education (ICLLE 2018), Padang, Indonesia, 19–20 July 2018; pp. 272–275.
61. Ho, S.C.; Hsieh, S.W.; Sun, P.C.; Chen, C.M. To activate English learning: Listen and speak in real life context with an AR featured u-learning system. *J. Educ. Technol. Soc.* **2017**, *20*, 176–187.
62. Liu, M.C.; Wang, J.Y. Investigating Knowledge Integration in Web-based Thematic Learning Using Concept Mapping Assessment. *Educ. Technol. Soc.* **2010**, *13*, 25–39.
63. Hung, A.C.Y. A critique and defense of gamification. *J. Interact. Online Learn.* **2017**, *15*, 57–72. Available online: http://www.ncolr.org/jiol/issues/pdf/15.1.4.pdf (accessed on 24 July 2021).
64. Nicholson, S. A recipe for meaningful gamification. In *Gamification in Education and Business*; Reiners, T., Wood, L., Eds.; Springer: Cham, Denmark, 2015; pp. 1–20. [CrossRef]
65. Schrier, K. Using augmented reality games to teach 21st century skills. In *ACM SIGGRAPH 2006 Educators Program, Proceedings of SIGGRAPH06: Special Interest Group on Computer Graphics and Interactive Techniques Conference, Boston, MA, USA, 30 July–3 August 2006*; Association for Computing Machinery: New York, NY, USA, 2006.
66. Castañeda, M.A.; Guerra, A.M.; Ferro, R. Analysis on the Gamification and Implementation of Leap Motion Controller in the IED Técnico Industrial de Tocancipá. *Interact. Technol. Smart Educ.* 2018. Available online: https://www.emerald.com/insight/content/doi/10.1108/ITSE-12-2017-0069/full/html (accessed on 24 July 2021).
67. Klopfer, E.; Sheldon, J. Augmenting your own reality: Student authoring of science-based augmented reality games. *New Dir. Youth Dev.* **2010**, *2010*, 85–94. [CrossRef]
68. Alsawaier, R.S. The effect of gamification on motivation and engagement. *Int. J. Inf. Learn. Technol.* **2018**, *35*, 56–79. [CrossRef]
69. Deci, E.L.; Ryan, R.M. *Intrinsic Motivation and Self-Determination in Human Behavior*; Plenum: New York, NY, USA, 1985; ISBN 978-1-4899-2271-7.
70. Iwata, T.; Yamabe, T.; Nakajima, T. Augmented reality go: Extending traditional game play with interactive self-learning support. In Proceedings of the 2011 IEEE 17th International Conference on Embedded and Real-Time Computing Systems and Applications, Toyama, Japan, 28 August 2011; pp. 105–114.
71. Eleftheria, C.A.; Charikleia, P.; Iason, C.G.; Athanasios, T.; Dimitrios, T. An innovative augmented reality educational platform using Gamification to enhance lifelong learning and cultural education. In Proceedings of the IISA, Piraeus, Greece, 10 July 2013; pp. 1–5.
72. Juan, M.C.; Carrizo, M.; Abad, F.; Giménez, M. Using an augmented reality game to find matching pairs. In Proceedings of the 19th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision, Plzen, Czech Republic, 31 January 2011; pp. 59–66.