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Developing a New Model for Achieving Flow State in STEAM Education: A Mixed-Method Investigation

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Abstract

The flow state is a mental state in which a person is fully immersed in an activity and experiences a sense of energized focus, full involvement, and enjoyment. It is a highly desirable state for learning, as it allows students to be more engaged and productive. However, achieving the flow state can be challenging, and there is no single method guaranteed to achieve all the conditions of this state. Additionally, this study argues that achieving the flow state is advantageous in STEAM education because it has the potential to increase student engagement and motivation, improve learning outcomes, promote creativity and problem-solving skills, and develop 21st-century skills such as collaboration and critical thinking. Therefore, this study aims to develop a new framework for achieving the flow state in STEAM education by investigating the implementation of a combined approach using impactful technology (ITU) and gamification (IGU). The framework combines impactful technology use (ITU) and impactful gamification use (IGU) to create activities that are challenging, have clear goals, provide immediate feedback, and promote action-awareness merging. A concurrent triangulation mixed-methodology research design was used, with data collected from teachers, students, and parents through questionnaires, interviews, and observations. The researcher used purposive sampling to determine the sample, which consisted of eighty-nine teachers, ten students, ten parents, and ten lesson observations. The study is significant because it is the first to propose a new model for achieving the flow state in STEAM education. The findings were used to develop the New Combined Flow Framework (NCFF), which supports achieving the conditions for the flow state in STEAM learning through the combined use of ITU and IGU. This new framework can be used by education professionals to practically achieve the flow state in STEAM classes. By understanding how to achieve the flow state, educators can create more engaging and effective learning experiences for their students, potentially revolutionizing STEAM education and making it more accessible to all students.

Keywords: Flow state, STEAM, ITU, IGU, ASMR, Educational Technology, Gamification.

Abstrak

Keadaan aliran ialah keadaan mental di mana seseorang terlibat sepenuhnya dalam aktiviti dan mengalami rasa fokus bertenaga, penglibatan penuh dan keseronokan. Ia adalah keadaan yang sangat diingini untuk pembelajaran kerana ia membolehkan pelajar menjadi lebih terlibat dan produktif. Walau bagaimanapun, mencapai keadaan aliran boleh menjadi mencabar dan tiada kaedah tunggal yang dijamin untuk mencapai semua syarat keadaan ini. Di samping itu, kajian ini berpendapat bahawa mencapai keadaan aliran adalah berfaedah dalam pendidikan STEAM kerana ia berpotensi untuk meningkatkan penglibatan dan motivasi pelajar, meningkatkan hasil pembelajaran, menggalakkan kreativiti dan kemahiran menyelesaikan masalah serta membangunkan kemahiran abad ke-21 seperti kolaborasi dan pemikiran kritis. Oleh itu, kajian ini bertujuan untuk membangunkan kerangka baharu untuk mencapai keadaan aliran dalam pendidikan STEAM dengan mengkaji pelaksanaan pendekatan gabungan menggunakan teknologi berimpak (ITU) dan gamifikasi (IGU). Kerangka ini menggabungkan penggunaan teknologi berkesan (ITU) dan penggunaan gamifikasi berimpak (IGU) untuk mencipta aktiviti yang mencabar, mempunyai matlamat yang jelas, memberikan maklum balas segera dan menggalakkan penggabungan kesedaran tindakan. Reka bentuk penyelidikan metodologi campuran triangulasi serentak telah digunakan dengan data dikumpul daripada guru, pelajar dan ibu bapa melalui soal selidik, temu bual dan pemerhatian. Pengkaji menggunakan persampelan bertujuan untuk menentukan sampel yang terdiri daripada lapan puluh sembilan orang guru, sepuluh orang murid, sepuluh orang ibu bapa dan sepuluh pemerhatian pengajaran. Kajian ini penting kerana kajian ini adalah yang pertama mencadangkan kerangka baharu untuk mencapai keadaan aliran dalam pendidikan STEAM. Penemuan ini digunakan untuk membangunkan Kerangka Aliran Gabungan Baharu (NCFF), yang menyokong pencapaian syarat untuk keadaan aliran dalam pembelajaran STEAM melalui gabungan ITU dan IGU. Kerangka baharu ini boleh digunakan oleh profesional pendidikan untuk mencapai keadaan aliran secara praktikal dalam kelas STEAM. Dengan memahami cara untuk mencapai keadaan aliran, pendidik boleh mencipta pengalaman pembelajaran yang lebih menarik dan berkesan untuk pelajar mereka yang berpotensi merevolusikan pendidikan STEAM dan menjadikannya lebih mudah diakses oleh semua pelajar.

Kata kunci: Keadaan aliran, STEAM, ITU, IGU, ASMR, Teknologi Pendidikan, Gamifikasi.

1.0 INTRODUCTION

There is a rising demand for Science, Technology, Engineering, Arts, and Math (STEAM) education in the classroom, and education experts consider STEAM an essential part of 21st-century education (Khine & Areepattamannil, 2019). Thus, STEAM is being adopted in educational systems around the world, with the UAE being a bright example. In order to increase and improve the success of STEAM programs, teachers need to motivate and engage their students. Facilitating students' deep engagement in learning activities is a primary goal of every teacher, and to achieve that, many researchers have turned to flow state research (Ferlazzo, 2013). The flow state is a state of optimal experience characterized by total absorption in the task at hand, a merging of action and awareness in which the individual loses track of time and self (Csikszentmihalyi, 1975). Moreover, flow is a natural state that can occur partially or fully in the classroom (Kiili, 2005). However, there were no practical methods teachers could use to systematically achieve all the flow state conditions in the classroom (Perttula et al., 2017).

It was proposed by Kiili (2005) that implementing educational technologies and gamification can facilitate the establishment of some flow state conditions. As stated by Vann and Tawfik (2020), implementing technology and gamification can facilitate the creation of a flow state in the classroom and positively impact student progress. Through technology and gamification, students are engaged, motivated, and use educational STEAM technologies in an impactful way. Due to this, many initiatives have been created to increase learning quality and motivate students to pursue learning by implementing educational technologies or gamification. Many of these initiatives have been implemented in STEAM programs and initiatives, as they normally encompass technology and/or gamification as proposed by Wang et al. (2022). However, these STEAM models are costly and time-consuming, as they typically require the use of many educational technologies and resources (Cohen, 2018). Furthermore, with the extensive use of educational technologies and gamification in education today, most classes do not achieve the flow state (Kiili, 2005), preventing students from reaching their full potential (Csikszentmihalyi, 1975) and maximizing the impact of using educational technologies and gamification. Additionally, as stated by Woodard (2019), many educators are reluctant or unprepared to integrate new educational technologies or gamification into their classrooms.

In previous research work, the authors have studied the level of teacher's maturity in Impactful Technology Use (ITU) in Abu Dhabi public schools (Hamash & Mohamed, 2023), and the level of teacher maturity in the Impactful Gamification Use (IGU) in Abu Dhabi public schools (Hamash & Mohamed, 2023). The findings of both studies indicate that STEM teachers in Abu Dhabi public schools have a high level of maturity when it comes to using educational technologies and gamification. This is attributed to several factors such as the Ministry of Education (MOE) in the United Arab Emirates emphasizing the importance of effective implementation of educational technologies, the provision of continuous professional development programs to teachers, the availability of educational technologies in every classroom and for every student, and the school inspection framework which gives significant importance to the use of educational technologies.

In this study, the researcher aims to develop a new combined flow framework for STEAM education. The purpose is to examine the impact of combining Impactful Technology Use (ITU) and Impactful Gamification Use (IGU) in the implementation of educational technologies in UAE public schools. The goal is to determine if this combination can facilitate the flow state for students. The research question being investigated is: What is an appropriate combined flow framework for STEAM education. Based on the findings, it can be concluded that while many STEAM classrooms are equipped with educational technology and gamification, it is not sufficient to enable the flow state and achieve significant improvements in student achievement. Other crucial factors such as human motivation, core drives and the conditions that foster the flow state in education play a significant role. Furthermore, emphasis should be placed on the role of teachers in accepting and effectively utilizing educational STEAM technology, as they play a crucial role in preparing students to do the same.

2.0 LITERATURE REVIEW

According to Csikszentmihalyi (1998), the highest state that students and teachers can achieve and utilize in the classroom is the state of flow. Various research, experiments, and historical references support the significance of the flow state (Buchanan & Csikszentmihalyi, 1991). Whalen and Csikszentmihalyi (1991) proposed that in the state of flow, students are fully absorbed in their learning tasks, and other activities do not distract them. The flow theory, also known as the optimal experience theory, is also linked to involvement and gamification, as discussed by Guo et al. (2016). Csikszentmihalyi (1975) described how individuals engage in activities and experience focus, interest, and enjoyment simultaneously. To further enhance leaners engagement, Csikszentmihalyi has identified nine dimensions of optimal flow performance that combine human-machine interaction with learning theory (Csikszentmihalyi, 1998). These dimensions include challenge-skills balance, action-awareness merging, clear goals, sense of control, transformation of time, autotelic experience, unambiguous feedback, concentration on the task at hand, and loss of self-consciousness.

According to Sharek and Wiebe (2011), the theory suggests three learning pathways: boredom, flow, and frustration. In learning a task, flow can be maintained when the difficulty level matches the level of skill development. Therefore, to understand the relationship between the flow state and STEAM education, The researcher highlights how flow directly applies to the way students engage with activities in STEAM classes, and how they move between the three pathways from boredom to frustration. Researchers have suggested that educators often experience the state of flow in STEAM education (Golland, 2015) so it is beneficial to break down lessons based on challenge level and skill level (Luxembourg, 2011), as this can assist in applying the flow state to the planning and implementation of STEAM activities for students in schools, and this an area where educational technologies can play a huge role (Albuquerque et al., 2017).

According to Kraiger (2003), there are three factors that influence learning. The first is the individual's motivation to participate in learning. The second is their ability to learn a new skill, which can be affected by various factors such as their personality. Lastly, the learning environment also plays a role, considering the individual characteristics of the learner. When students invest time and resources into learning, they can maximize their learning opportunities. Kraiger`s framework proposes that learning is a result of more than one factor. The researcher argues that this framework can guide achieving the conditions of the flow state through combining impactful use of technology and gamification to produce the three factors mentioned by Kraiger, which could result in also establishing the conditions of the flow state as presented in Figure 1. This combination is based on the idea that using technology and gamification can enhance motivation, improve learning ability, and create a conducive learning environment (Subhash & Cudney, 2018; Koivisto & Hamari, 2019). The framework also takes into consideration the principles of flow state, such as clear goals, immediate feedback, and a balance between challenge and skill, to facilitate the flow state during the learning process (Csikszentmihalyi, 1998).

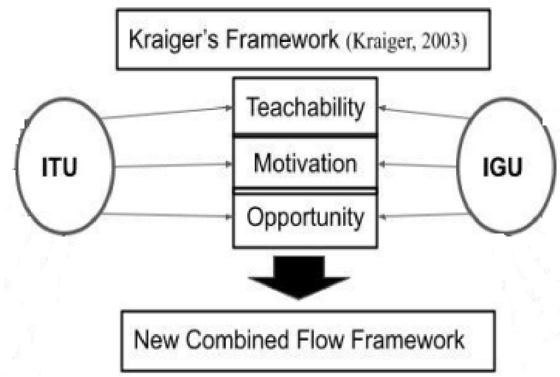

Figure 1. Kraiger`s Framework.

Combining educational technology and gamification to achieve the flow state is not a new concept, especially in education. In 1996, Moneta and Csikszentmihalyi proposed the idea of the flow state in conjunction with gamified methods, which focus on setting goals and creating actionable objectives to reach those goals. A well-designed game, for example, can promote a flow state as it offers a rewarding and goal-oriented activity that leads to a win-win outcome. The research on implementing serious games in education for knowledge transfer can provide valuable lessons for utilizing impactful gamification with educational technology. According to Wang et al. (2017), a well-designed serious game should have mechanics and dynamics that contribute to perceived usefulness, ease of use, and clear objectives, leading to increased concentration and enjoyment for the user. Vann and Tawfik (2020) found that participants are more engaged and involved in an activity if it is exciting and engaging.

To capitalize on this practical aspect, many studies have explored how impactful gamification use (IGU) can improve learning outcomes in education. Yu-Kai Chou developed the Octalysis framework, a human-centered gamification design that explains the eight core motivations for humans. As Chou (2014) stated, there can be no motivation or behavior without core drives. Most games appeal to one or more of these core drives, motivating players to make decisions and engage in activities. The eight core drives identified in the framework are significant factors in making learning more enjoyable and positive through gamification. Gamification also allows learners to take ownership of their learning. Buckley and Doyle's study (2017) showed a correlation between engagement and gamification elements, resulting in an empowered flow state. While the literature shows that creating a gamified educational automated system can be complex and even have some adverse effects, such as stereotype threats that disrupt the intended flow state (Albuquerque et al., 2017), it is still a valuable approach to promoting the flow state.

In conclusion, the potential of integrating the concept of flow state in STEAM education is immense. The combination of educational technology and gamification has been proven to enhance motivation and improve learning ability. Studies have shown that this approach can promote the flow state, enabling learners to take charge of their own learning. In general, this method is a valuable and worthwhile way of achieving the flow state in STEAM education. Furthermore, upon reviewing several studies and theories on flow state, gamification, and educational technologies, it can be inferred that a framework that integrates both educational technologies and gamification can effectively foster conditions for the flow state. This can ultimately boost motivation, enhance learning ability, and establish a favorable learning atmosphere in STEAM education.

■3.0 METHODOLOGY

In this study, the researcher used a mixed methodology with a concurrent triangulation method design. This approach was chosen as it is considered the most suitable method for research that involves collecting both quantitative and qualitative data simultaneously (Edmonds & Kennedy, 2017). In complex systems like education, it is essential to use both types of data to gain a deep understanding of the topic. The researcher adopted a pragmatic approach and worldview, further supporting the use of the concurrent triangulation design.

The four steps of the concurrent triangulation design are as follows: data collection, data analysis and presentation, triangulation, and interpretation. During the first step, both qualitative and quantitative data are collected separately, but at the same time. The second step involved analyzing the data and presenting the results separately for each type of data. In the third step, the results from both arms of data collection are triangulated together to reveal any convergence, complementarity, or dissonance related to the research questions. Finally, in the interpretation step, the researcher interprets the results from the previous step to reach the final findings.

3.1. Sampling

The population for the quantitative part of this research is math and science public school teachers in Al Dhafra region, Abu Dhabi, who are teaching using educational technologies. The total number of teachers in the research population is 435, with a division between math and science subjects. It is important to note that teacher characteristics, skill levels, training, and education levels are similar for all teachers in the ministry of education. This is because the ministry of education has the same terms of employment, onboarding process, and training provided to all teachers, and teachers are expected to adhere to the same code of conduct. Additionally, all teachers use the same educational curriculum and technologies, and the ministry equips all schools with the same level of infrastructure and equipment. As a result, we can consider the teacher population to be compatible.

The researcher used a non-probability purposive sampling method. This means that the sample was deliberately chosen for their specific qualities. It is a non-random technique, and researchers determine what information they need and then seek out individuals who possess the necessary knowledge and experience to provide that information (Tongco, 2007). For this research, science and math public school teachers in Al Dhafra region in Abu Dhabi, with a minimum of two years' experience using educational technologies in the classroom and those who are well-trained in the instructional use of educational technologies, were selected. These criteria led to identifying 89 teachers. The teacher questionnaire was sent to all the selected teachers.

The sample size for the qualitative research was determined by following a set of guidelines based on Dworkin (2012). According to Dworkin, for a qualitative research study to effectively describe a phenomenon and answer the research question, the sample size should be large enough. However, a large sample size can result in repetitive data. Therefore, qualitative researchers should aim for saturation. Additionally, several publications recommend a range of five to fifty respondents as appropriate (Dworkin, 2012). Shetty (2022) also affirms that studies have shown that a sample size of just ten can yield applicable results. Of course, this is only achievable with careful selection of participants.

For this research, the initial sample size for interviewing teachers, students, and parents was set at ten. This number could be increased if the research does not reach a point of diminishing returns and saturation of information. The teachers were identified with the assistance of school leadership teams, according to the purposive criteria set in the sampling method. The same process was followed for selecting students, parents, and experts. Age classification was not considered for the teacher sample, as the current situation in UAE indicates that teachers of all ages are capable of using educational technology effectively. This was confirmed by the school leaders. However, the researcher ensured a balance between female and male teachers, as UAE has separate schools for boys and girls.

The researcher obtained consent from all participants before conducting any research activities. This included obtaining written consent from teachers and guardians of minor students. The purpose of the study was explained, and participants were assured that their personal information would be kept confidential. They were also given the option to withdraw from the study at any time without consequence. As the research involved the use of human participants and their personal information, ethical considerations related to consent and privacy were followed. The researcher ensured that all participants were fully aware of their rights and that their participation was voluntary. Measures were taken to protect the privacy of the participants, such as using pseudonyms and storing data in a secure location. The responsibility to use the data ethically and report findings accurately was acknowledged by the researcher. Furthermore, no information was collected that could identify the participants, such as names or school names, as it would not add value to the research results and to maintain the participants' privacy. Any information collected was presented in a way that ensured anonymity and confidentiality. The researcher also sought approval from relevant ethical committees before starting the research, to ensure that all ethical considerations were taken into account.

3.2. Data Collection

The quantitative data collection procedure used two instruments to collect data: the teacher questionnaire and lesson observation rubric. The lesson observation rubric has a four-point Likert scale with nine items. It measures the frequency of flow state conditions in the teacher's classroom, which results in the creation of the flow state. The digital teacher questionnaire has a six-point Likert scale with nine items. It measures the frequency of flow state conditions, and is adapted from the work of Csikszentmihalyi (1998) and Oliveira et al. (2020).

The qualitative data collection procedure involved two methods: lesson observations and interviews with teachers, students, parents, and experts. The lesson observations were carried out in the school environment, following the regulations of the ministry of education. The interviews were conducted in a semi-planned manner with the respective parties.

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■4.0 DATA ANALYSIS AND RESULTS

The study aimed to investigate the effectiveness of combining ITU and IGU in educational programs to induce a flow state in students in UAE public schools. Descriptive statistics were used to analyze the data collected from the teacher questionnaire and the quantitative section of the observation rubric. Table 1 presents the frequency and percentage of each flow state scale.

Table 1 The Flow state scale frequency and Percentage

Statements of Scale Flow	Never F (%)	Rarely F (%)	Sometimes F (%)	Often F (%)	Usually F (%)	Always F (%)
Challenge-skill balance.	1 (1.1)	2 (2.2)	10 (11.2)	14 (15.7)	36 (40.4)	26 (29.2)
Clear Goals	0 (0)	2 (2.2)	5 (5.6)	12 (13.5)	27 (30.3)	43 (48.3)
Unambiguous and immediate feedback.	1 (1.1)	0 (0)	8 (9)	11 (12.4)	38 (42.7)	31 (34.8)
Action-awareness merging	1 (1.1)	1 (1.1)	5 (5.6)	17 (19.1)	44 (49.4)	21 (23.6)
Total concentration on the task on Hand.	0 (0)	1 (1.1)	5 (5.6)	23 (25.8)	31 (34.8)	29 32
Sense of potential control.	1 (1.1)	1 (1.1)	8 (9)	19 (21.3)	33 (37.1)	27 (30.3)
Loss of selfconsciousness.	1 (1.1)	11 (12.4.)	24 (27)	19 (21.3)	24 (27)	10 (11.2)
Transformation of time (the sense of time becomes distorted)	1 (1.1)	10 (11.2)	20 (22.5)	19 (21.3)	26 (29.2)	13 (14.6)
Autotelic experience (The experience becomes rewarding by its reward)	0 (0)	2 (2.2)	11 (12.4)	17 (19.1)	36 (40.4)	23 (25.8)

The overall findings indicate that the flow state is frequently achieved through the use of available educational technologies and gamification in UAE public schools. According to teachers' responses, the conditions of lack of self-consciousness and distortion of time are the least commonly experienced in these programs. Furthermore, the results demonstrate similar percentages for the occurrence of all other conditions. Table 2 presents the results from lesson observations.

Table 2 Flow state conditions frequency

Statements flow	1 (To a small extent)		2 (To some extent)		3 (To a large extent)		4 (To a very large extent)	
	F	%	F	%	F	%	F	%
Challenge-skill balance.	0	0%	0	0%	2	20%	8	80%
Clear Goals	0	0%	0	0%	0	0%	10	100%
Unambiguous and immediate feedback.	0	0%	0	0%	0	0%	10	100%
Action-awareness merging	0	0%	0	0%	9	90%	1	10%
Total concentration on the task on Hand.	0	0%	0	0%	9	90%	1	10%
Sense of potential control.	0	0%	0	0%	0	0%	10	100%
Loss of selfconsciousness.	0	0%	0	0%	10	100%	0	0%
Transformation of time (the sense of time becomes distorted)	0	0%	0	0%	4	40%	6	60%
Autotelic experience (The experience becomes rewarding by its reward)	0	0%	0	0%	5	50%	5	50%

The results of the teacher questionnaire indicate that the educational programs effectively achieve flow state conditions. However, some conditions are covered more extensively than others. For example, clear goals, immediate and unambiguous feedback, challenge and skill level, and a sense of control and autotelic experience are all emphasized. Other elements, such as balance, a combination of action and awareness, total concentration on the current task, loss of self-consciousness, and the transformation of time, are also utilized but to a lesser extent.

The researcher collected various suggestions and improvement points from the teachers during the interview and their answers to previous questions. Suggestions for Impactful Technology Use (ITU) included providing more engaging elements for students, opportunities for teamwork, and creating more social interaction on the platform. Some teachers also mentioned the need for improved student collaboration options, as they want their students to work together during lessons and even when completing homework at home. Communication between students and their peers, as well as students and their teachers, was also highlighted by some teachers. On the topic of student engagement, teachers noted that while they observe their students being engaged, there is room for improvement and the addition of more features to keep students engaged throughout the lesson and beyond. In terms of content and question difficulty, teachers felt that in some cases, the level of difficulty and instructional language could be demotivating and lead to less engagement. Suggestions for Impactful Gamification Use (IGU) included improving the social features of the program to provide more ways for socializing, allowing students to customize their profile appearance, and implementing team competitions through the platform's team feature. Some teachers also suggested connecting gamified elements in a system to increase their effectiveness and providing unique awards that can be earned by the system or awarded by the teacher. These awards should be rare and not commonly seen by students. Flow state suggestions included incorporating a timer to help with lesson pacing and motivate students, as well as using more engaging visuals to capture students' attention. One teacher also suggested creating a flexible path to help students with challenges and keep them motivated, similar to the adaptive formative assessments in the English level tests.

Analyzing the experts' interview answers provided the researcher with various suggestions and points of improvement that the experts raised during the interviews. Impactful Technology Use (ITU) points included providing more tools and features to facilitate collaboration between students and help them build their collaboration skills using educational technologies. In regard to the communication condition, program experts stated that this point needs to be improved. One program expert mentioned, “If this program can help provide a direct tool where students can directly communicate with each other and with their teachers, and if they can share directly with their peers and teams created, other experts also shared similar points. It was also clear that they have many recommendations, and their agreement with this point emphasizes improving it. Regarding creativity and innovation skills, there were some suggestions from the experts as well. They suggested that these programs give students a chance to create and innovate. They also suggested that programs provide students with school projects that they can use to improve their creativity and innovation skills.

Impactful Gamification Use (IGU) points included some suggestions connected with gamification elements, such as providing more performance graphs, teammates (real players or virtual non-players), and more competition. Other points are connected to Bartle's player types. These points show that there is a need for improvement in engaging the socializer player type, as stated by the program experts. They noted that this type of student is not fully engaged and that there are not many features and tools to engage the socializer type of students. Other suggestions include adding more features to engage the extreme achievers (the killers) type of students. Regarding the Octalysis gamification framework and its core drives for human motivation, experts stated that epic meaning's core drive is present in this program. However, it could be improved to higher levels to drive students' and teachers' motivation. For the social influence core drive, experts found it to be present in this program, but not to a large extent. They suggested that it could be improved to higher levels to drive students' and teachers' motivation. As for the unpredictability of core drive, program experts noted that it is present but not to a large extent. One expert even stated that it is mostly predictable. They suggested that it could be improved to higher levels to drive students' and teachers' motivation. Moving on to the flow state framework and its central conditions, experts stated that there is a clear need for improvement in achieving the loss of self-consciousness condition. They also noted that the total concentration on the task at hand condition needs to be improved, even though it is present in the program. Other points mentioned by experts include the professional development and instructional coaching provided by these programs for teachers and school leadership teams. These programs offer well-structured training and PLC sessions with coaching follow-up, and their trainers are experts in this program who can deliver constructive feedback. This greatly impacts teachers' ability to use educational technologies and gamification in an impactful way. Overall, the responses collected from program experts were consistent, and there was a clear harmony between all the statements. The experts also feel that the programs provided by UAE public schools are achieving these goals.

Analysing the parent interview answers provided the researcher with various suggestions and points of improvement. ITU points included reducing the time needed to complete lessons, especially when students are asked to complete them at home, which adds extra workload and impacts their performance in math and science due to the level of instructional language. Parents expressed that their children are underperforming in these subjects not because they do not understand the material, but because of their level of English proficiency. Some parents also mentioned the difficulty level of questions and how even underperforming students are still given challenging questions. Parents also requested more feedback and reports through the parent app. Impactful Gamification Use (IGU) points included parents asking for more engagement to increase students' focus and improve their performance in programs. Other parents suggested adding more competition options and opportunities for teamwork. Flow state conditions could be enhanced by implementing a more flexible schedule for students, giving them more choices and control over their learning pace. Some parents also requested tools to help their children stay focused.

Analyzing the student interview answers provided the researcher with various suggestions and points of improvement. Impactful Technology Use (ITU) points included giving students more control over their work and pacing, as well as incorporating time management features to promote focus and productivity. Other students expressed the need for bilingual options to support their learning journey, since they are expected to study math and science in English even when their English proficiency is not at the required level. Some students noted that certain lessons are longer than others, which can affect their engagement with the platform. Impactful Gamification Use (IGU) points included having personalized avatars and the ability for students to customize their profile. They also requested more games and competitions with their peers during and after classes and expressed interest in unique badges and rewards that they can collect. Some students mentioned feeling demotivated by the scarcity of points, stars, and grades, and wished for more opportunities to redo or retry lessons. Flow state conditions points included giving students more options and flexibility in their learning paths. They also requested tools to help them focus on one platform during learning, as well as in general, as they sometimes struggle with staying focused on learning activities. Several students also commented on the difficulty level of some questions, stating that it can be demotivating.

■5.0 DISCUSSION AND RECOMMENDATION

Discussion of the suitable combined flow framework for STEAM education starts with the triangulation of results from both research arms. The outcome of this process can be summarized to demonstrate a clear convergence, supporting the notion that this research will aid in creating a new combined flow framework. The convergence of both quantitative and qualitative data leads to main points that contribute to achieving a stronger state of flow. The triangulation distinctly highlights the correlation between the strength of ITU and IGU in relation to the flow state conditions (refer Figure 2). The results indicate that when programs and teachers consistently prioritize ITU conditions, such as student agency, critical thinking, and frequency and proficiency, there is a direct effect on achieving IGU conditions of empowerment, ownership, accomplishment, and frequency and proficiency. The researcher affirms that these triangulation results reveal a connection between these conditions.

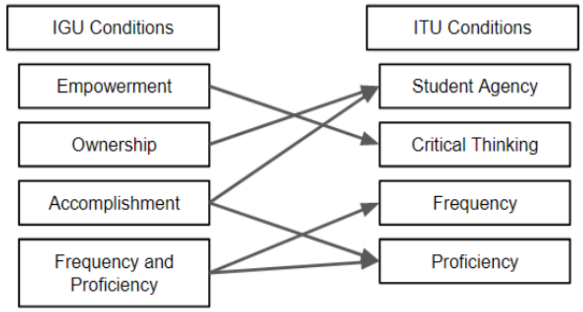

Figure 2. Relationship between the most achieved IGU and ITU conditions

Moreover, the identified areas for improvement in the ITU conditions, including collaboration, communication, choice, creativity, and innovation, align with the main core drives in IGU that were also identified as needing improvement, such as epic meaning, unpredictability, avoidance, and social influence scarcity (refer Figure 3). These triangulation results further demonstrate the correlation between these conditions.

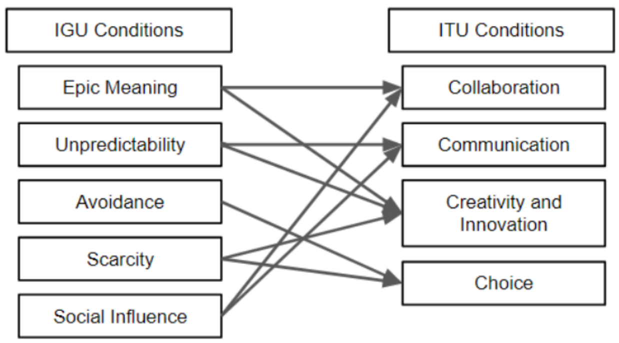

Figure 3. Relationship between the less achieved IGU and ITU conditions.

The triangulation process also yielded the following findings regarding the conditions of the flow state. Firstly, the combination of ITU and IGU within the used programs and their teachers has resulted in achieving some flow conditions, such as clear goals, a sense of control, challenge-skills balance, and unambiguous and immediate feedback. Secondly, the triangulation also highlighted some areas for improvement, including loss of self-consciousness, action-awareness merging, and concentration on the task at hand. The researcher organized these triangulation results from the previous research phase to reach a final interpretation. The convergence of both quantitative and qualitative data leads to main points that contribute to achieving a stronger state of flow. It is evident that the strength of ITU and IGU are connected to the conditions of the flow state. Additionally, the identified points for improvement in the ITU conditions align with the main core drives in IGU. Figure 4 illustrates the relationships between ITU and IGU conditions, as revealed through the triangulation process in the previous phase (research phase 3).

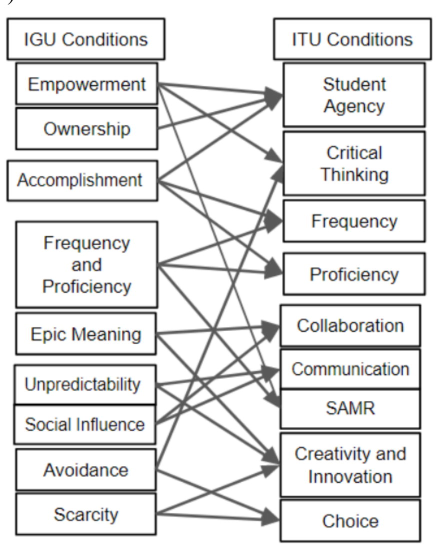

Figure 4. General relationship between IGU and ITU conditions

Based on the deep understanding of the conditions of both ITU and IGU gained through a thorough literature review, the researcher focused on identifying relationships and alignments between these conditions. The strongest relationships were highlighted through triangulation data. The results are illustrated in Figure 5.

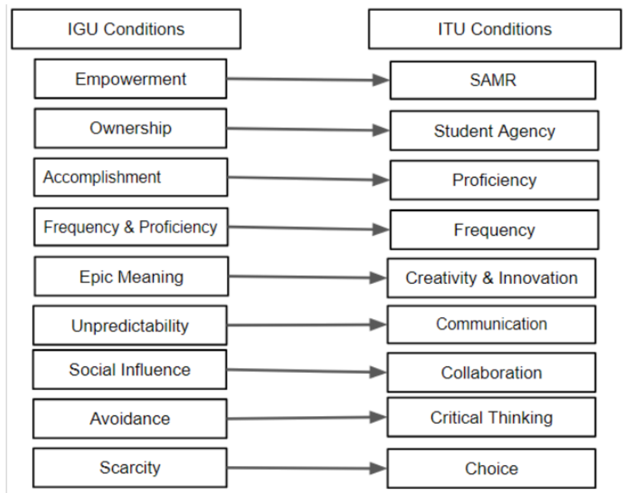

Figure 5. Direct Relationship between IGU and ITU conditions.

In creating the New Combined Flow Framework (NCFF), the researcher combined and aligned the six conditions of ITU, the SAMR Model, frequency, and effectiveness with the eight core drives of the Octalysis framework, also considering frequency and effectiveness, to align with flow state conditions. This alignment between flow state conditions and IGU can be seen in the following figure 6.

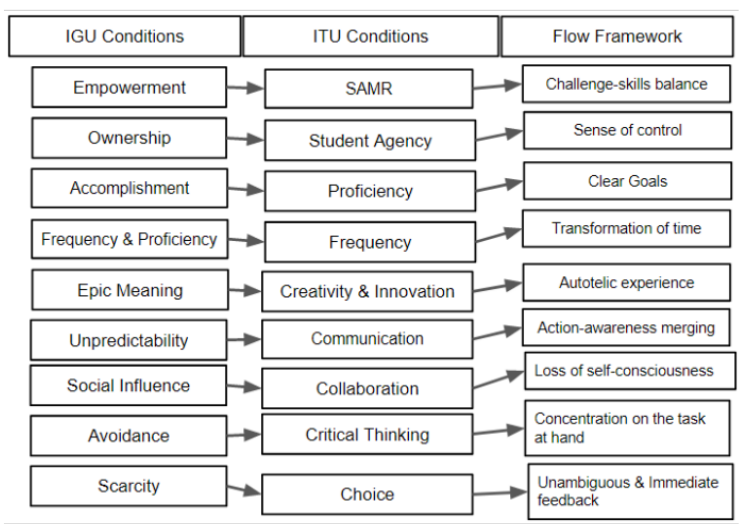

Figure 6. Alignment between IGU, ITU, and flow state conditions.

The end result is a three-interlocking nonagon framework, with Impactful Gamification Use (IGU) in the center, followed by Impactful Technology Use (ITU) on the second nonagon. Both are encompassed within the third nonagon, which represents the flow state. This newly combined framework is crucial for achieving the flow state and will lead to the desired results in the learning process. With a specific focus on human interaction design, this framework will empower educators to create learning systems that begin with motivation, as it is built on the central core drives of human motivation. This will engage and motivate students, ultimately driving progress and achievement. Additionally, the design will utilize educational technology in a meaningful way to enhance the learning experience. The impactful integration of technology can redefine how we approach learning, allowing both teachers and students to reach new levels of success. Furthermore, the Impactful Gamification Use (IGU) and Impactful Technology Use (ITU) will establish the ideal conditions for achieving the flow state. The new framework will place emphasis on creating the flow state from the initial design stage, rather than seeing it as a result only. The benefits of this framework are comprehensive and can be implemented in various educational systems, from large-scale implementations to individual lesson plans.

The researcher aims to create a new framework to assist 21st-century educators in effectively implementing educational technology and gamification to achieve the flow state, which has been shown in literature to significantly impact student learning. This goal was supported by research findings gathered through a variety of quantitative and qualitative research methods, including teacher interviews and lesson observations. The data was then analyzed and presented separately before conducting triangulation of the quantitative and qualitative data. The resulting interpretations led to key points for achieving a stronger flow state, as the identified strengths in ITU and IGU are directly related to the conditions of the flow state. Similarly, areas for improvement in ITU and IGU align with aspects of the flow state that require improvement. For example, the "sense of potential control", one of the nine flow state conditions, is directly related to "educational technology creating and facilitating student agency", a condition for Impactful Technology Use (ITU). This is also correlated with "ownership", a core drive from the Octalysis framework, starting with a sense of ownership will motivate students to use educational technology to gain agency over their learning, with support from well-trained and prepared program teachers following a well-structured educational system. This will contribute to achieving the sensation of potential-control, a flow state condition, and ultimately lead to the positive effects of the flow state, as stated by Mihaly Csikszentmihalyi (1990). Additionally, the researcher found that while some conditions of ITU, IGU, and the flow state are directly related, others are aligned and complement each other. For example, "clear goals", one of the flow state's nine conditions, can be achieved by integrating educational technology at a higher level through the "SAMR model", another condition for Impactful Technology Use (ITU), while also aligning with "epic meaning", a core drive from the Octalysis framework. Similarly, achieving goals is also related to the "frequency and proficiency" with which educational technology is used, as the framework is not practical without them.

Understanding the relationship between the Octalysis framework and Bartels player types is also crucial. The flow state, the first type of Bartels player type, represents the achievers, who are primarily motivated by left-brain core drives such as "development and accomplishment" and "scarcity". In contrast, the second type, explorers, are motivated by "unpredictability and curiosity" and are drawn to discovering new things. The third type, socializers, is motivated by "social influence" and values connections and collaborations with others. The fourth type, "extreme achievers" or "killers" as referred to in the text, have a combination of "development and accomplishment" and "social influence" core drives, as they strive for success and recognition from their peers. Understanding this relationship between the Octalysis framework and Bartels player types can help in better understanding how these factors can impact the learning process.

Now, let's examine the relationship between the Octalysis framework and flow state theory. Remember, at the highest level of anxiety, we have core drive eight (Loss and avoidance). As we move down a level, we reach core drive six (Scarcity and impatience), which can make it challenging for students. However, there is still a possibility for them to succeed. Moving further down, we have core drive two (Development and accomplishment). At this level, students will feel confident and capable of reaching their goals. In the center of the flow channel, we find core drive three (Empowerment of creativity and feedback). Here, students are utilizing their creativity, feeling in their element, and experiencing a sense of satisfaction. A level below that, we have core drive four (Ownership and possession), which motivates students to spend more time learning and collecting information, grades, stars, points, etc. Next is core drive five (Social influence and relatedness), which may not require a high level of skill but can still motivate students, particularly those who are more social. Finally, we have core drive seven (Unpredictability and curiosity), which can be utilized by teachers to make lessons more exciting and keep students engaged. What is noticeable here is the absence of core drive one, which can be addressed through the new combined framework. This highlights the need for a holistic approach in achieving the best results (refer Figure 7).

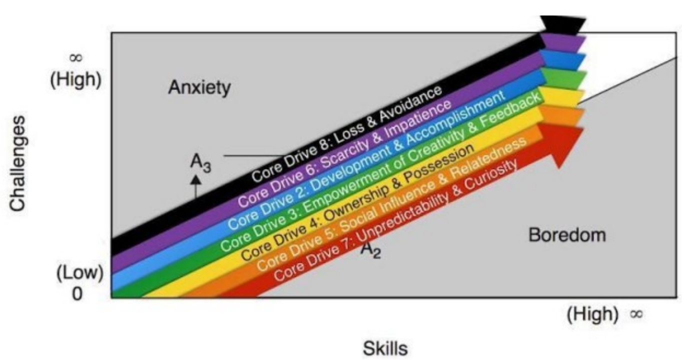

Figure 7. Flow state theory and Octalysis framework.

Therefore, the researcher has created the New Combined Flow Framework (NCFF) by combining and aligning the impactful technology use conditions (the six conditions of ITU, SAMR Model, frequency, and effectiveness (proficiency)) with the impactful gamification use conditions (the eight core drives of the Octalysis frameworks, frequency, and effectiveness (proficiency)). This framework should also be aligned with the conditions for entering a flow state. The result is a three-interlocking Nonagon framework with Impactful Gamification Use (IGU) in the center, surrounded by the Impactful Technology Use (ITU) Nonagon. These are both contained within the third Nonagon, which represents the flow state. The Figure 8 illustrates the New Combined Flow Framework (NCFF).

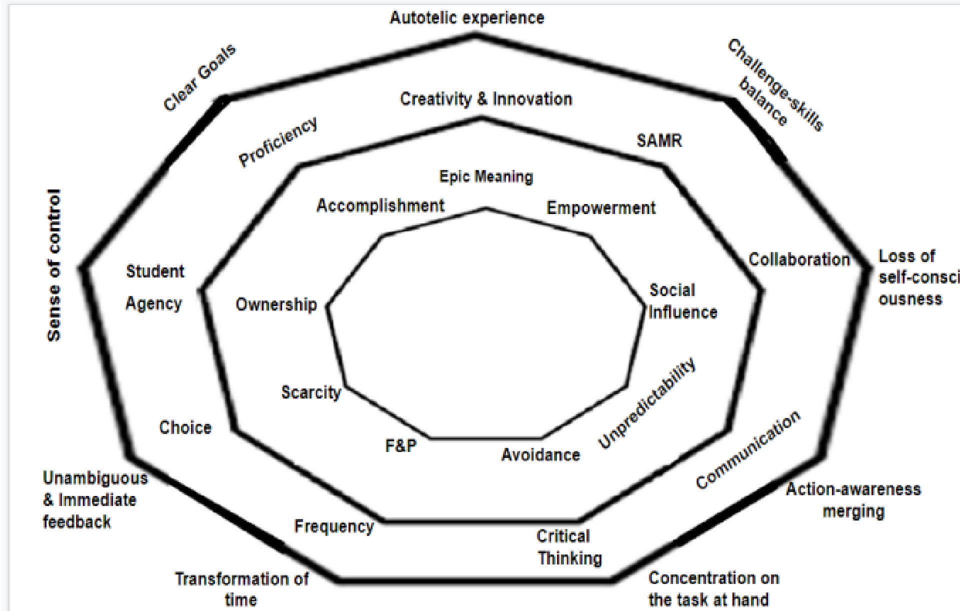

Figure 8. The New Combined Flow Framework (NCFF).

This new combined framework is important in achieving the flow state and will lead to the desired results in the learning process. With a focus on human interaction design, this framework enables educators to build learning systems centered on motivation, as it is based on the core drives of human motivation. This will engage and motivate students, driving their progress and achievement. The design also incorporates the impactful integration of technology to enhance the learning process, redefining it and allowing both teachers and students to reach new levels of attainment and progress. The Impactful Gamification Use (IGU) and Impactful Technology Use (ITU) will establish the necessary conditions for achieving the flow state. This framework prioritizes creating flow from the design stage rather than it being a mere result. Its benefits are extensive and can be implemented in large educational systems or even in individual lesson plans. The researcher concludes that the final findings strongly support the creation of the New Combined Flow Framework (NCFF). This framework empowers educators to build learning systems of various sizes and levels, establishing the ideal conditions for achieving the flow state and focusing on human interaction design. Its applications are vast and can alter the way teachers plan and conduct their lessons. Additionally, it can assist educational leaders, educational system managers, and instructional designers in designing and creating effective STEAM learning systems and programs, particularly those incorporating educational technologies and gamification elements.

■6.0 CONCLUSION

The combined effect of both the IGU and ITU enhances the establishment of other conditions, resulting in a strong flow state. This state can have numerous positive effects on the learning process. As observed in this research, the flow state in the UAE educational program environment led to improved student achievement and interest in STEAM subjects. Although the educational programs implemented in the UAE have been successful, this research has also highlighted the need for necessary improvements. As a result, these programs serve as valuable models for studying and analyzing them. However, further development of the newly created frameworks requires additional work and analysis of other successful programs. Ultimately, the new combined flow framework is the main added value and contribution of this research project to education systems and educators worldwide, especially those working in the STEAM learning environment. Future research on this framework will involve studying other learning systems and models until a format is developed that can be used by any teacher, with both ITU and IGU requiring minimum resources and being achievable through the NCFF, educators can now create a flow state by combining both. The practical implications of this research are significant for educators, as it offers a new framework, the NCFF, that can be applied in real classroom settings to enhance the learning experience for students. By combining the principles of IGU and ITU, the NCFF aims to create a strong flow state in the classroom, leading to improved student achievement and interest in STEAM subjects. The potential benefits of the NCFF for students are significant. By creating a flow state, students are more likely to fully engage in the learning process, resulting in improved academic achievement. This is particularly beneficial in STEAM subjects, where students may struggle to find interest or motivation. Additionally, the NCFF can help develop students' problem-solving and critical thinking skills, as they are fully engaged in the learning experience. In conclusion, the NCFF holds promise in providing substantial advantages to students. By inducing a state of flow, it can facilitate full engagement in the learning process, resulting in enhanced academic performance, particularly in STEAM subjects.

■7.0 LIMITATION

Some minor obstacles were faced, such as time management and communication issues due to internet connectivity problems. However, these challenges were resolved through the researcher's flexibility, problem-solving skills, and the cooperation of school leaders and teachers. Although the findings from researching the implemented programs have been largely positive in terms of establishing the new combined flow framework, the validity of this framework should not be limited to these programs or educational systems in the UAE. It is essential to validate this framework in STEAM educational systems that continuously have success in terms of student achievement and interest in STEAM education. One suggested STEAM program is the First League (FLL) program. Additionally, it is recommended to test this framework in non-STEAM programs and other learning models. It is crucial to create an educational system based on NCFF and test its effectiveness through an experimental approach. Creating a fully functional system based on the new combined flow framework guidelines will enable researchers to examine and gain a deeper understanding of the framework and its benefits. For future researchers using this framework, it is important to have customized assessment and research tools tailored to the NCFF guidelines and conditions. This step will help standardize research related to this framework and reduce the time needed for preparing research projects.

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