University of Sheffield

Exploring the Effectiveness of Gamification Beyond Traditional Mechanics in Cultivating Chinese International Postgraduate Students' Sense of Belonging in Programming Courses

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Declaration

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Abstract

Chinese international students often face significant challenges in adapting to programming courses, particularly in developing a sense of belonging, which is crucial for their academic success and integration. This study explores the potential of gamification as a tool to enhance the learning experiences and sense of belonging among these students in fundamental programming modules. Through a design-based research approach, the study identifies the primary challenges these students encounter, both socially and academically, and investigates how tailored gamification strategies can address these issues.

The research progresses from identifying these challenges to testing and refining gamification features, such as points, badges, leaderboards, and collaborative tasks, to determine their effectiveness in enhancing student engagement and belonging. The study focuses on how these gamification elements, when thoughtfully designed and implemented, can create a more inclusive and supportive learning environment for Chinese international students.

Findings from this study indicate that carefully adapted gamification, tailored to the specific learning contexts and challenges of students, significantly enhances their engagement and sense of belonging. The gamification strategies developed as part of this research have proven effective in fostering inclusive learning environments, particularly for international students navigating new academic landscapes.

This research contributes valuable insights to the field of educational technology, emphasizing the importance of context-specific gamification strategies in addressing the unique learning needs of diverse student populations. The study advocates for the continued refinement of these methods, particularly in programming education, and encourages their application across different academic disciplines and student groups. By highlighting the pivotal role of relevance and context in educational interventions, this research underscores the potential of gamification in fostering a more connected and engaging educational journey for international students.

Keywords: Higher education, sense of belonging, international students, gamification, learning experience design, programming education,

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[1]https://chatgpt.com/

Publications, invited talks and presentations

An updated list of peer-reviewed publications, invited talks and presentations arising from this thesis:

Peer-reviewed Publications

- C. Cao. Leveraging Large Language Model and Story-Based Gamification to Build Intelligent Tutoring System for introductory programming modules: A Design-Based Research Study. Doctoral Consortium. In Companion Proceedings of the 28th Annual Conference on Intelligent User Interfaces (IUI '23), March 2023, https://doi.org/10.1145/3581754.3584111 (contributed to Chapter 5)

- C. Cao, L. Sbaffi, X. Zhao, F. Hopfgartner. Using a narrative-based gamified teaching approach to improve international students' sense of belonging. Poster. In Proceedings of the 54th ACM Technical Symposium on Computer Science Education (SIGCSE'23), V. 2, March 2023, https://doi.org/10.1145/3545947.3576361 (contributed to Chapter 5)

- C. Cao, L. Sbaffi, X. Zhao, F. Hopfgartner. International students in academic transition: needs and experiences of Chinese students in British higher education. Poster. In Proceedings of 2022 Society for Research into Higher Education International Conference, Mobilities In Higher Education (SRHE'22) (contributed to Chapter 4)

- C. Cao, X. Zhao, F. Hopfgartner. Gamification Improves Students' Intrinsic Motivation and Engagement in programming module. In Proceedings of the 14th International Conference on Education Technology and Computers (ICETC'22), October 2022, https://doi.org/10.1145/3572549.3572551 (contributed to Chapter 5)

Invited talks and presentations

- Game The Way to Programming Mastery: Using GPT model and Gamification to Revolutionize Programming Education. Invited talk in the Institute for Web Science and Technologies (WeST), Universitat Koblenz, Germany, April 2023

- Level Up Your Programming Skills: How AI and Gamification Can Supercharge Your Learning Experience. Invited talk in 7th Educational Data Mining in Computer Science Education (CSEDM) Workshop at 13th International Learning Analytics and Knowledge Conference (LAK'23), Arlington, TX, USA, March 2023

- Leveraging Large Language Model and Story-Based Gamification to Build Intelligent Tutoring System for introductory programming modules: A Design-Based Research

Study. Doctoral consortium and poster presentation in the 28th Annual Conference on Intelligent User Interfaces (IUI'23), Sydney, Australia, March 2023

- Challenges and Opportunities of Using GPT-3 Powered Intelligent Tutoring System in Data Science Courses at Higher Education. Invited talk in the School of Computer Science, Carnegie Mellon University, USA, November 2022.

- Gamification Improves Students' Intrinsic Motivation and Engagement in programming module. In. 2022 International Conference on Education Technology and Computers (ICETC'22), Barcelona, Spain, October 2022

- Unlocking the potential of AI-enhanced gamification in higher education. Invited talk in the Information Retrieval Research Group at the University of Sheffield, UK, October 2022 Implementing Gamification to Enhance Chinese STEM Students' Sense of Belonging in transition to British Universities. Presentation at Ischool PGR Consortium 2022, the University of Sheffield, UK, July 2022

- Implementing Gamification to Enhance Chinese STEM Students' Sense of Belonging in Transition to British Universities. Presentation at Ischool PGR Consortium 2022, the University of Sheffield, UK, July 2022

Awards

- ICETC Best Paper Presenter Award: selected as the best presenter from all presenters in ICETC'22 conference

- Publication Scholarship Award: £4500 (approx.) stipend at the standard UKRI rate for three months provided by the University of Sheffield

- SPLICE Travel Fund: $285 towards travel and accommodation costs for presenting and participating at CSEDM at LAK'23, Arlington, TX, US, March 2023.

Chapter 1

Introduction

This chapter introduces the overall research project and provides an overview of the research background, research rationale, research aims, key research questions, research design, and methodology, and expected contributions of the study.

1.1   Research background

Computing and technology are increasingly ubiquitous and have become a necessary part of many educational paths, professional opportunities, and industries (Pedro et al., 2019). Consequently, the importance of programming knowledge and coding skills has grown significantly in recent years. Introductory programming modules, often referred to as 'Computer Science 1' (introductory programming) courses are designed to introduce students to the fundamentals of programming and coding (Becker and Quille, 2019). However, these courses can be challenging for many international students, who may lack prior programming expertise and are confronted with language and cultural barriers (Khanal and Gaulee, 2019).

Chinese international students are among the fastest-growing population of international students, yet they often struggle to adjust to the educational system of the hosting country and feel a disconnect from their peers, programmes and the local culture (de Wit and Altbach, 2021). This can lead to feelings of isolation, alienation and an unsmooth academic transition. In programming modules, Chinese international students also face hardship due to a lack of prior exposure to coding concepts and language (Alaofi and Russell, 2022). As a result, they are more likely to experience anxiety and a feeling of estrangement. However, previous research showed bias and stereotypes when describing Chinese students' learning behaviours in global higher education (Heng, 2018). Chinese international students are often perceived as passive and reluctant learners when adapting to British educational systems (Zhu and O'Sullivan, 2022). This stereotype, however, fails to take into account the cultural and educational factors driving these behaviours.

One key factor that has been identified as contributing to Chinese international students' unsmooth academic transition experiences is a lack of belonging. Higher education can be a time of great uncertainty for students as they engage in social, cultural, and academic changes (Araujo et al., 2014). A sense of belonging is key to student success during this time. Belonging in higher education has been widely studied within transition pedagogy. Sense of belonging is an important factor influencing academic success and transition, and also an im-

portant human need that promotes intrinsic motivation (Hausmann et al., 2007; Master and Meltzoff, 2020; Karimi and Sotoodeh, 2020). The sense of belonging is multi-dimensional, referring to the feeling of being accepted, valued and supported by a group (Strayhorn, 2018; Ahn and Davis, 2020; Osterman, 2000). Araujo et al. (2014) proposed a three-tiered model to support the development of belonging over the student lifecycle, identifying three types of belonging for students: belonging to the cohort at the programme level; within an interdisciplinary learning environment at the department level; and global intercultural network linked to their subject or profession. The findings of the survey indicated that because of cultural differences, knowledge background, language abilities, and academic abilities, Chinese students were not able to adapt well to local teaching methods, did not receive enough attention and support from teachers and classmates, and lacked a sense of belonging to the subject.

At the same time, gamification has seen a surge in popularity in the educational sector. It has been used as a tool to engage students and encourage learning in a range of contexts (Welbers et al., 2019). This presents an opportunity to investigate the potential of gamification to scaffold coding learning and increase the sense of belonging among Chinese international students in introductory programming modules. Additionally, the use of educational technologies has been growing steadily in recent years, as an increasing number of educators recognise the potential of this approach to engage and motivate learners (Szymkowiak et al., 2021). An AI-enhanced gamification design is particularly attractive due to its ability to personalise the learning experience, offering tailored activities to meet the needs of diverse learners (Shemshack and Spector, 2020). In addition, an AI-enhanced gamification design can provide feedback in a timely and effective manner, offering learners the opportunity to improve their skills in a supportive and engaging environment (Alshaikh and Hewahi, 2021).

The research background of this thesis is rooted in the idea that gamification can be used to scaffold learning and increase belonging among Chinese international students in introductory programming modules. Gamification combines the use of gamification techniques with educational technologies to create a personalised learning experience. This approach encourages learners to engage in the learning process and offers them the opportunity to practise and improve their coding skills in a supportive and engaging environment. This thesis investigates the potential of gamification to bridge the gap between Chinese international students' prior knowledge and experience in coding and the expectations of introductory programming modules. It also explores how this approach can increase the sense of belonging among Chinese international students in these courses.

1.2 Research motivation

This research is motivated by the need to bridge the gaps in programming knowledge between Chinese international students and their domestic peers. It is also driven by the urgent need to create an inclusive learning environment that is accessible and welcoming to all students. The research findings could have a considerable impact on the teaching and learning of programming for Chinese international students. The study has the potential to provide insight into how gamification can be used to make the learning process easier and more effective for these students, as well as to foster a sense of belonging. The findings could inform lecturers, administrators, and policymakers of the most effective strategies for teaching and learning to

program for this population. This study can also be expanded to support other underrepresented student groups, such as female students majoring in Science, Technology, Engineering, and Mathematics (STEM) subjects and international students from other countries, who also need a sense of belonging to their peers, faculty, and subject-related careers.

This research is timely, important and relevant because the number of international students coming to the UK to study programming modules has increased significantly in recent years. However, many of these students arrive with limited computing science knowledge and language skills, which can create a sense of isolation and impede their academic success. Large language models (LLM), such as GPT-3, which has great potential in assisting programming education, are also rapidly iterated. By leveraging LLM and gamification, this research will provide insight into how these tools can be used to scaffold learning, improve language skills, and create a sense of belonging among Chinese international students during their transition to UK universities. This research will also contribute to the broader body of research on technology-enhanced learning and a sense of belonging in international students.

1.3 Research aim and objectives

The main focus of this research project is to explore the potential of gamification to scaffold coding learning and increase belonging among Chinese international students in introductory programming modules. Specifically, the focus will be on designing, evaluating, and refining the use of gamification to improve learning outcomes and increase motivation among Chinese international students in introductory programming modules.

The research project is framed within the context of design-based research, which emphasises the importance of designing, implementing, and evaluating a learning environment, with the goal of optimising the learning experience. The research project is guided by three research questions:

- **(RQ1)** What are the primary challenges that Chinese international students face in developing a sense of belonging in fundamental programming modules, and how do these challenges affect their learning outcomes?

- **(RQ2)** How effective is gamification in enhancing the learning experiences and sense of belonging for Chinese international students in fundamental programming modules, and what specific gamification features are most impactful?

- **(RQ3)** (exploratory) How can AI-enhanced gamification design be optimally designed to support the unique learning needs of Chinese international students in programming courses, particularly in fostering a sense of belonging and improving academic outcomes?

1.4 Research design and methodology

This research project applies design-based research (DBR) as its methodological approach. DBR is an iterative process that emphasizes the importance of designing, implementing, and evaluating educational technology to optimize the learning experience. This approach has

been widely used in educational settings to investigate the effectiveness of new technologies and approaches in engaging and motivating learners.

The language of instruction and support for this study will be English, concerning that English is the medium of instruction in British universities, where these Chinese international students are enrolled. Consequently, it is essential for the learning interventions to be in English to align with their overall educational environment. Additionally, proficiency in English is a prerequisite for Chinese students studying abroad, indicating that they possess a basic level of English necessary for understanding course materials. Using English also supports the improvement of their language skills, which is crucial for academic success and future career opportunities in global contexts.

The research is divided into three phases: 1) a survey to identify Chinese students' needs and the challenges they meet regarding the development of a sense of belonging and their learning experience in introductory programming modules; 2) a design probe with a story-based gamification prototype to increase Chinese students' sense of belonging and improve their learning experience in introductory programming modules with user evaluation; 3) the exploration of an AI-enhanced gamification design leveraging large language model and gamification features for introductory programming modules.

The study used a mixed-methods approach, incorporating both quantitative and qualitative data. The quantitative data were collected through a survey measuring students' sense of belonging, academic performance, and academic emotions, and a computer simulation study evaluating the performances of the gamification design. Qualitative data were collected through participatory observations and focus group interviews to explore students' experiences and perceptions in more depth. The data were analysed using descriptive statistics, thematic analysis, and natural language processing (NLP) analysis.

1.5 Thesis structure

The thesis begins with a comprehensive literature review in Chapter 2, covering key areas such as Chinese students' academic transition, their sense of belonging, gamification, and programming education. Chapter 3 outlines the research methodology, detailing and justifying the methods employed throughout the project. Chapters 4 and 5 present the results of the iterative design-based research conducted in two studies, which examine the application of gamification in introductory programming modules at the University of Sheffield. Chapter 6 introduces an exploratory study involving the use of large language models (LLMs), sharing initial findings from this investigation. Finally, Chapter 7 discusses the broader implications of the research findings and provides recommendations for future studies in this area.

Chapter 2

LITERATURE REVIEW

2.1 Overview

This research is situated within the larger context of educational technology and gamification. The use of technology in education has become increasingly popular, with a growing number of educators recognizing the potential of this approach to engage and motivate learners (Szymkowiak et al., 2021). This study specifically focuses on the application of gamification to scaffold coding learning among Chinese international students. The research problem being addressed is the need for Chinese international students to successfully learn to code while experiencing a sense of belonging during their academic transition in a foreign educational setting.

This review explores how gamification can address these two issues and examines relevant research on this topic. It critically evaluates existing studies on Chinese international students in the UK, focusing on their sense of belonging, the challenges they face in introductory programming modules, and the potential use of gamification to improve their learning experience and sense of belonging. The review aims to identify knowledge gaps, provide a solid foundation for the proposed research, and make recommendations for future research.

The chapter begins by providing an overview of Chinese students in the UK in section 2.3. It then explores the concept of belonging in higher education in section 2.4. Section 2.5 demonstrates the challenges in teaching and learning in introductory programming modules and their implications for the learning experience design (LXD). Section 2.6 discusses how gamification can increase Chinese international students' sense of belonging and improve their learning experience in introductory programming modules. Finally, section 2.7 synthesizes the literature review by identifying theoretical and practical gaps and proposing research questions.

2.2 Search strategy

The literature review was conducted using multiple databases, including Scopus, ScienceDirect, and Web of Science, to make sure that as much relevant literature as possible was retrieved. Scopus, ScienceDirect, and Web of Science were selected as they are all renowned academic databases that cover a wide range of disciplines. They are also all accessible through the University library, which makes searching for relevant literature easier.The inclusion crite-

ria were that the articles were peer-reviewed and published in English. The University library catalog Starplus and Google Scholar, which include grey literature such as conference proceedings, dissertations, and government reports, were also searched for more inclusive results. Additionally, manual searches of reference lists were conducted to identify any additional relevant articles. The rationale for including different databases in the literature search was that they cover a broad range of disciplines, including educational psychology, gamification and human-computer interaction (HCI). This literature review consisted of two main phases. An initial phase of the review was conducted in 2020, which involved a comprehensive search of the databases mentioned above to identify all relevant studies. In the first phase of the review, the background and orientation of the subject were presented, gaps in the research were identified, and it was ensured that no similar studies had been undertaken. The second phase consisted of a more focused search of the same databases, in which the information was updated, especially for information related to the rapidly changing field of information. The researcher has been constantly performing literature search activities between the two phases and until the submission of this thesis to keep abreast of developments in the field. Throughout the discussion that follows, literature gathered from both phases is used.

There were four strategies used in searching the literature, including (1) a keyword-based search; (2) hand searching of key journals; (3) snowballing from key authors and (4) reference mining from included studies. A detailed description of each strategy is provided below.

1. A keyword-based search was conducted in the Scopus, ScienceDirect and Web of Science databases using a range of terms associated with the research topic. The keywords used were "international students" OR "Chinese students" AND "higher education" OR "British universities" AND "introductory programming modules" OR "introductory programming modules" AND "sense of belonging" AND "gamification" OR "gamified learning"AND "intelligent tutoring system" OR "ITS". The search was limited to articles published in English.

2. In addition to the keyword-based search, a hand search of key journals and conferences was conducted to identify any relevant studies that may have been missed. The journals searched were "The Journal of Educational Computing Research", "International Journal of Artificial Intelligence in Education", "IEEE Transactions on Learning Technologies", "Journal of Computer Assisted Learning", "International Conference on Learning Analytics and Knowledge (LAK)", "International Conference on Artificial Intelligence in Education (AIED)", "International Conference on Educational Data Mining (EDM)" These publications cover topics such as educational technology, artificial intelligence in education, computer-supported education, and learning analytics, and were considered as key venue of the field of educational technologies.

3. A snowballing technique was used to identify any key authors who had published extensively on the topic. The authors chosen were those who had published extensively on the topic of the review and who were considered to be experts in the field (e.g. Juho Hamari who is the expert in the field of gamification, Chris Dede who is the expert in the field of in design-based research, Paul A. Kirschner who is the expert in the field of in educational technologies). The studies authored by these experts were then examined to see if they cited any other relevant studies. These authors were then searched for in the Web of Science and Scopus databases to identify any additional relevant studies.

4. Finally, a reference mining technique was used to identify any relevant studies that had been missed in the previous stage. This was done by manually searching the reference lists of all included studies for any additional studies that may be relevant. Studies that were cited by two or more included studies were considered to be relevant and were then included in the review.

2.3 Chinese students in the UK higher education

International students have become an integral part of the higher education landscape, and Chinese international students, in particular, represent a large population that is growing in size and importance. With the increasing number of Chinese international students enrolling in British universities, it is essential to understand the ways in which they transition academically to their new environment. This section first introduces the increasing diversity of Chinese students studying in the UK, then provides an overview of the Chinese education system and its unique features. It also discusses the studies that have been conducted on Chinese students' learning experiences in the UK, highlighting the theoretical and empirical gaps in the current literature.

2.3.1 The increasing diversity of Chinese students studying in the UK

Among all international students, Chinese students constitute the biggest portion of any other nationalities (Yu and Moskal, 2019). According to the latest data provided by HESA (Higher Education Statistics Agency, 2022), 33% of first-year non-UK domiciled students in the academic year of 20/21 came from China, and the number is still steadily growing. This influx of Chinese international students has led to them becoming the largest group of international students in the UK.

The increase in the number of Chinese students pursuing higher education in the UK has been accompanied by a significant shift in the educational profile of these students. In the past, most Chinese students came from elite backgrounds and had already completed a rigorous educational programme in China before coming to the UK. However, in recent years there has been a growing number of students from a more diverse range of backgrounds, including students from less wealthy families and students who have not previously studied overseas (Varga et al., 2021). The increase in the number of Chinese international students can be attributed to a number of factors, including the reforms of the Chinese higher education system, the globalisation of the Chinese economy, the UK's policy of welcoming international students, the UK's reputation as a world-leading education destination, the attractiveness of the UK's research environment and the availability of scholarships and financial aid. Additionally, the global recession of 2008 led many Chinese students to believe that it would be difficult to find a good job in China, and studying abroad became an attractive option (Ahmad and Shah, 2018).

The increasing diversity of Chinese students has had a number of implications for UK higher education. One of the most significant ones has been the need to provide more support for these students during their academic transition to the UK. This is particularly true for students studying STEM (science, technology, engineering and mathematics) subjects, where the language and cultural barriers can be particularly pronounced.

2.3.2 The uniqueness of Chinese students' educational background

The Chinese education system has some unique features that may impact Chinese students' academic transition to British universities (Yu and Moskal, 2019). In China, the education system is focused on rote learning and memorisation, which does not encourage independent thinking or creativity (Xu, 2022). As a result, Chinese students can find it difficult to adjust to the more creative and open-ended learning style of British universities. The Chinese education system is also well-known to be exam-focused, and students are under a lot of pressure to perform well during exams (Xu, 2022; Shieh, 2017). This may lead to Chinese students feeling overwhelmed and stressed when they start university, as they are not used to having to manage their own time and workload (Vasileiou et al., 2019). Another feature of the Chinese education system is that it is very competitive, and students are used to being graded in comparison to their peers. Therefore, Chinese students are more likely to feel isolated and alone at university, as they are not used to being in an environment where everyone is working towards their own individual goals (Liu, 2022).

Additionally, the Chinese education system is very hierarchical, and students are used to being told what to do by their teachers (Bear et al., 2018). The academic environment in China is very different to that in the UK. Chinese students are used to a more teacher-centred approach, where they are spoon-fed information and are not expected to think critically or independently (Cheng and Ding, 2021; Cheng et al., 2023). In contrast, the UK academic system places a greater emphasis on independent learning, critical thinking and student-centred learning (Schweisfurth, 2019). This may lead to Chinese students feeling lost and confused, as they are not used to being in an environment where they have to take responsibility for their own learning (Ding and Curtis, 2021).

The cultural differences between China and the UK also represent another important factor affecting Chinese international students' transitional experience. In China, the cultural emphasis is on collectivism, where the needs of the group are placed above the needs of the individual (Rumbley, 2020; Chen and Zhou, 2019). This collectivist orientation also affects Chinese students' learning styles, in which rote memorisation is often used to learn information (Lin and Gao, 2020). A collectivistic approach to learning is deeply rooted in the cultural values of collectivism, which emphasizes the importance of the group over the individual (Hwang et al., 2003). In educational contexts, this approach manifests in several ways. Students are encouraged to work together harmoniously, with an emphasis on group cohesion and cooperation (Grothaus and Richter, 2020). Individual achievements are often viewed in the context of their contribution to the group's success. There is a strong sense of shared responsibility among students, who are expected to support and assist each other to achieve collective goals (Kunwar, 2021). Respect for teachers and authority figures is paramount, with students less likely to challenge or question their teachers and more likely to accept the information and instructions provided without critical scrutiny (Littlewood, 2000). To maintain group harmony, open disagreement or conflict is often avoided, which can lead to less participation in classroom discussions where differing opinions might be expressed. Communication tends to be indirect, emphasizing maintaining face and avoiding embarrassment for oneself and others, which can result in students being less likely to speak up or ask questions in class.

This contrasts with the Western approach to critical thinking and analysis. In the UK, cultural emphasis is on individualism, where the needs of the individual are placed above the

needs of the group (Stentiford and Koutsouris, 2021). This can be a challenge for Chinese international students, who may be used to a more collectivistic approach to learning. This need for belonging in a community can sometimes make Chinese students feel isolated in a Western classroom setting (Tian et al., 2021; Tan et al., 2021). They may be more passive in class, and may not be used to participating in discussions, which is also different from their Western counterparts (Cao et al., 2021). Therefore, it is important to be aware of the uniqueness of the educational background to support Chinese students in their academic transition and studies.

2.3.3 Challenges faced by Chinese students

Studies have shown that Chinese students face distinct challenges compared to other international students when transitioning to British universities. The challenges faced by Chinese students are particularly significant due to the language, cultural, and educational differences between China and the UK. This section will explore these challenges in more detail, focusing on language barriers, cultural differences, educational background, and identity-related issues.

Language Barriers

One of the most significant challenges for Chinese international students is the language barrier. Many Chinese students struggle with understanding and using English effectively in academic settings. This difficulty can impact their ability to comprehend teaching materials, participate in class discussions, and complete assignments(Yu and Moskal, 2019). citealharbi2018review found that language problems were a primary difficulty for Chinese students transitioning to universities in English-speaking countries. Similarly, Holliman et al. (2023) highlighted that these language barriers often lead to feelings of isolation and a lack of belonging in the UK academic environment.

Cultural Differences

Cultural differences between China and the UK significantly impact Chinese students' experiences in British universities. Chinese students often find it challenging to adapt to British cultural behaviors and norms, which can lead to feelings of isolation and alienation(Yu and Moskal, 2019). The lack of cultural awareness and understanding among both Chinese students and their peers can exacerbate these feelings. Holliman et al. (2023) noted that cultural barriers contribute to the challenges Chinese students face, including difficulty in social integration and establishing a sense of belonging.

Educational Background

Chinese international students often experience unique challenges related to their educational background. The Chinese education system is known for its emphasis on rote learning and memorisation, contrasting sharply with the independent and critical thinking-based learning environment in British universities. Many Chinese students are accustomed to studying in large groups with real-time feedback from teachers, whereas Western universities typically promote independent study and self-directed learning (Lin and Gao, 2020; Ali, 2020). This

transition can be difficult, leading to feelings of isolation and being overwhelmed by the new academic expectations. Additionally, Chinese students may lack experience in independent learning, critical thinking, and problem-solving skills, which are essential for success in Western academic settings (Badger, 2019).

Identity and Psychological Challenges

Chinese international students often face unique challenges related to their identity. They may struggle to reconcile their Chinese identity with their new British identity, resulting in feelings of alienation and disconnection (Yu and Moskal, 2019; Holliman et al., 2023). This identity conflict can lead to psychological distress and increased academic pressure. Chinese students often experience a heightened sense of pressure to succeed academically, which can contribute to anxiety and stress (Jiang et al., 2021). Moreover, the dual identity experienced by Chinese students can complicate their sense of belonging, which is crucial for their academic success and overall well-being (Strayhorn, 2018; Walton and Cohen, 2011).

Need for Belonging and Support

The feeling of not belonging is a critical challenge for Chinese students in British universities. This lack of belonging can stem from cultural and language barriers, as well as the differences in educational approaches and identity conflicts. Studies have shown that a sense of belonging is closely linked to academic achievement and overall satisfaction in the university experience (Strayhorn, 2018; Walton and Cohen, 2011). Therefore, it is essential to provide appropriate support to Chinese students to address these challenges. Interventions that are culturally sensitive and tailored to the needs of Chinese students can help increase their sense of belonging.

Overall, the literature highlights the unique challenges that Chinese international students face when transitioning to British universities. These challenges are related to language, culture, and educational background, and can significantly impact students' sense of belonging and academic success.

2.4   Sense of belonging in education

2.4.1   Definition and theoretical framework of sense of belonging

The concept of sense of belonging are complex and multi-dimensional (Okolie et al., 2021). It refers to the emotional attachment to a person or group, which makes people feel accepted and included in an environment (Gopalan and Brady, 2020). Sense of belonging is a psychological phenomenon related to social identity and self-esteem and includes various components such as feeling accepted, respected, appreciated and socially connected in the academic environment (Chen and Zhou, 2019). In higher education, it has been widely studied in relation to student retention and success (Strayhorn, 2018; Gillen-O'Neel, 2021). For example, an early study conducted by Goodenow and Grady (1993) examined the relationship between school belonging and academic motivation among urban adolescent students. They found that students who felt a greater sense of belonging to their school were more motivated to learn and academically. Their study highlights the importance of school belonging

in fostering academic success.

There are various aspects of the research in sense of belonging in higher education, including the understanding of belonging, factors contributing to belonging, and strategies for fostering belonging. Previous research has explored various dimensions to understand students' sense of belonging in higher education. Ahn and Davis (2020) identified four domains of students' sense of belonging to the university: academic, social, cultural, and institutional. They found that students with a high sense of belonging in all four domains were likelier to persist in their studies and complete their degrees. This study highlights the importance of addressing all four domains of sense of belonging in order to foster student success. Another study conducted by Kahu et al. (2022) explored the complexity of first-year students belonging in higher education. They identified three types of belonging: familiarity, interpersonal, and academic. They found that students who had a strong sense of familiarity with the university, positive interpersonal relationships, and a sense of academic belonging were more likely to feel a sense of overall belonging and to persist in their studies. Similarly, Thomas (2012) suggested that belonging is linked to the psychological and sociological aspects of students, where they feel a sense of purpose related to the subject they are studying or their career aspirations. Above all, Araujo et al. (2014) proposed a three-tiered model consisting of programme level, department/faculty level and global intercultural network to support the development of belonging among students throughout their university journey, which is known as the "Belonging Model".

The factors that contributed to a sense of belonging in higher education were also widely investigated. Soria and Stubblefield (2015) found that those who had greater awareness about their strengths and capabilities were more likely to feel like they belonged at university successfully. This idea is extended by Burke et al. (2016), who argued that capability must be recognised for one to belong; therefore it is deeply entwined with identity formation which occurs within different contexts such as family influences or travelling to foreign countries without knowing customs including the ways of speaking, interacting and behaving. More research investigating the factors impacting individual's sense of belonging will be expanded in Section 2.4.3.

Empirical research has been conducted to explore effective ways of fostering a sense of belonging in higher education. Palus and Drath (2001) proposed an approach to the dialogue called "putting something in the middle," which can enhance the sense of belonging in a group. By putting an object in the middle of a group and taking turns discussing it, participants can create a shared understanding and sense of connection. This approach can be used in higher education settings to facilitate communication and connection among students and between students and instructors. In recent educational practices, Wilson et al. (2018) presented a grassroots, practical response to student belonging through learning and teaching experiences. They developed a program that includes community-building activities, student engagement initiatives, and faculty development workshops. Besides, Lim et al. (2022) presented a study on the use of learning design and personalized feedback to amplify teacher presence and belonging at scale. They found that personalised feedback and learning design can help to create a sense of connection between instructors and students, leading to a greater sense of belonging and higher levels of engagement.

Overall, the literature review above highlights the importance of a sense of belonging in higher education and its relationship with student success, retention, and overall well-being.

One key finding is that sense of belonging is a multidimensional construct that includes academic, social, cultural, and institutional domains. Ahn and Davis (2020) identified these four domains and found that students who had a high sense of belonging in all four domains were more likely to persist in their studies and complete their degrees, while Kahu et al. (2022) found that students who had a strong sense of familiarity with the university, positive interpersonal relationships, and a sense of academic belonging were more likely to feel a sense of overall belonging and to persist in their studies. This highlights the importance of creating a supportive environment that fosters interpersonal connections and a sense of academic belonging and suggests that institutions should be aware of the four domains in order to foster student success. The literature also provides strategies for fostering belonging in higher education, including the use of community-building activities, student engagement initiatives, and faculty development workshops (Wilson et al., 2018). The program has been successful in increasing student retention rates and improving overall student satisfaction. Besides, personalised feedback and learning design can help to create a sense of connection between instructors and students, leading to a greater sense of belonging and higher levels of engagement (Lim et al., 2022).

While the literature reviewed provides important insights into the concept of a sense of belonging in higher education, it is important to consider some limitations and future directions for research. Firstly, the studies reviewed were conducted in different contexts and settings, which may limit the generalizability of the findings. Further research is needed to explore the effectiveness of different strategies for fostering belonging in different contexts. Additionally, while previous studies provide evidence of the importance of belonging for student success, the mechanisms through which belonging leads to success are not well understood. Further research is needed to better understand the processes underlying the relationship between belonging and success.

To conclude, it is evident from the literature that a sense of belonging plays an important role in determining whether students stay on track during their studies or withdraw from university prematurely. It is also clear that there are many factors influencing how strong one's sense of belonging might be upon entering higher education - ranging from personal disposition to institutional structures and cultures. However, the research on international students' sense of belonging is still in its early stages, and more work is needed to understand the complex factors that contribute to this experience. Nevertheless, the existing research provides valuable insights into the importance of belonging for international students and the ways in which universities can support their transition to university life.

2.4.2 Chinese international students need to belong

Chinese students exhibit strong preferences to belong to social groups and work together with others. This phenomenon is largely attributed to the collectivist values encouraged in China, which emphasise the importance of group cohesion and cooperation. For Chinese international students, who often experience culture shock when studying abroad, having a strong sense of belonging can be particularly important for overcoming challenges and achieving academic success (Chen and Zhou, 2019). Studies have found that Chinese international students' sense of belonging to the host university and country is an important factor in their academic success (Strayhorn, 2018; Ching et al., 2017). In particular, a sense of community connectedness has been identified as one of the key aspects of students' well-being (Ching

et al., 2017). Tan et al. (2021) indicated that Chinese students show strong preferences to belong to social groups and working together with others, which is greatly affected by the collectivist values encouraged in China. Similarly, Chen and Zhou (2019) found that Chinese students were more likely to prefer cooperative learning over individual learning, even when given the option to work alone. Additionally, Heng (2019) found that Chinese international students who felt a sense of belonging were more likely to report a higher level of satisfaction with their university experience. A sense of belonging can help Chinese international students overcome these challenges by providing them with a sense of social support and inclusion. As such, understanding how to promote a sense of belonging among Chinese international students is essential for improving their learning outcomes.

2.4.3 Factors that contribute to a sense of belonging

Kift and Nelson (2005) reported that, in order to successfully manage the transition of students into higher education, institutions need to recognise student diversity and use a coherent approach with embedded 'transition pedagogy' across all aspects of curriculum delivery. More recently Gravett and Ajjawi (2022) proposed additional factors such as workload (university & paid employment), people within learning environments (including academic staff), and physical spaces as determinants in supporting or hindering feelings of development belonging and successful transition into HE. Burke et al. (2016) further argued that a sense of belonging is deeply entwined with identity formation and capability construction influenced by family, social interactions and cultural capital-suggesting lack thereof may pose particular challenges for first-generation university attendees making inclusionary practices key.

Instructor and peer support

One way to foster this sense of belonging is through instructor and peer support (Goodenow and Grady, 1993; Osterman, 2000). Instructors and peers can create a welcoming and supportive learning environment through regular check-ins, feedback, and open communication (Walton and Cohen, 2011). In addition, providing opportunities for students to engage with each other through group projects, class discussions, or other collaborative activities has been found to build a sense of community and belonging (Yeager and Walton, 2011). By promoting interaction and collaboration, instructors and peers can help students feel more connected to the classroom and to each other. As a result, students are more likely to persist in their studies, perform better academically, and have a more positive overall experience in the classroom (Yeager and Walton, 2011). By prioritising instructor and peer support and providing opportunities for students to interact and collaborate, educators can help create a learning environment that fosters a sense of belonging and promotes student success.

Classroom climate and culture

Classroom climate and culture play a vital role in fostering students' sense of belonging. Research has demonstrated that students are more likely to feel connected and invested in their learning when their classroom environment values diversity, respect, and inclusivity (Goodboy et al., 2020). To promote a positive classroom culture, instructors should set expectations for respectful behaviour and acknowledge and value diverse perspectives and experiences (Garibay, 2015). Recent studies have found that faculty who promote cultural

inclusivity and diversity in their curriculum and pedagogy create more inclusive learning environments, positively impacting students' sense of belongingness (Goodboy et al., 2020). It implied that the instructional design could implement inclusive, culturally responsive, and relevant curriculum and teaching practices to help students feel more connected and engaged in their learning.

Curriculum and pedagogy

Curriculum and pedagogy are crucial in shaping students' sense of belonging in higher education. The more relevant, engaging, and accessible the curriculum is, the more likely students are to feel motivated and invested in their learning (Kuh et al., 2008). Therefore, it is essential to ensure that the curriculum is up-to-date and reflective of current trends and practices. Furthermore, it has been found that varying teaching methods to accommodate different learning styles can increase students' engagement and motivation (Moussa, 2014). In a data science course, visual aids such as infographics and hands-on activities such as data analysis projects could be used to engage students with diverse learning styles. Additionally, experiential learning through internships or service learning projects can provide students with practical experience, increasing their motivation and engagement (Kong, 2021; Sze-Yeung Lai and Chi-leung Hui, 2021). To cater for the diverse needs of students, it is important to use a variety of teaching methods such as lectures, discussions, group work, and experiential learning (Ryan and Deci, 2017). In particular, group work has been found to be effective in promoting student engagement and collaborative learning in programming modules (Brown and Vaughan, 2018). By working on group projects, students can learn from one another and develop teamwork and communication skills.

Student characteristics

Student characteristics can significantly impact their sense of belonging in higher education (Pedler et al., 2022). For example, students who come from marginalised backgrounds or who have experienced discrimination may struggle to feel like they belong in their learning environments (Wang et al., 2020). Instructors can play a crucial role in helping students build their confidence by providing them with frequent feedback and constructive criticism (Wang et al., 2020). They can also encourage students to reflect on their progress and strengths and provide them with opportunities to develop self-efficacy (Thorpe, 2000).

It is important to note that a sense of belonging is not just about individual students; it is also influenced by the broader social and cultural contexts in which they are situated (Wang et al., 2020). For example, students who come from communities where higher education is not valued or who face financial insecurity may struggle to feel like they fit in on campus (Gopalan and Brady, 2020). Addressing these systemic issues requires a concerted effort from all members of the higher education community, including instructors, administrators, and policymakers (Gopalan and Brady, 2020; Pedler et al., 2022).

To promote a greater sense of belonging, instructors can incorporate inclusive teaching practices into their classrooms (Pedler et al., 2022). This can include using diverse course materials (Wang et al., 2020), creating a welcoming and safe environment for all students (Pedler et al., 2022), and actively engaging with students from different backgrounds (Gopalan and Brady, 2020). By doing so, instructors can help to create a more equitable and inclusive

learning environment that promotes student success.

Undiagnosed Conditions and Learner Needs

An important but often overlooked aspect is the impact of undiagnosed conditions on students' sense of belonging and academic performance. Undiagnosed learning disabilities, mental health issues, or other medical conditions can significantly hinder a student's ability to engage fully with their education (Lian and Wallace, 2018). These conditions can exacerbate feelings of isolation and disconnection, making it difficult for students to participate in classroom activities and build relationships with peers and instructors. Instructors should be aware of the signs of potential undiagnosed conditions and be prepared to offer support or direct students to appropriate resources (Kwon, 2009). Providing flexible learning options and accommodations can help ensure that all students, regardless of their health status, have the opportunity to succeed.

Overall, providing Chinese students with support during their academic transition is essential to their success. Research suggests that effective communication, a focus on student-centred learning, and a supportive environment are important for facilitating the transition of international students into university programmes. With the increasing portion of international students, their learning needs and the barriers they meet in the academic transitional period due to the conflicts of different educational and sociocultural systems should be given more attention. By understanding the challenges and expectations of these students, universities can provide the support needed to help them succeed.

2.5 Learning experience design in introductory programming modules

Programming modules in UK higher education institutions are known for their rigorous curriculum and demanding workload. Chinese international students may experience a sense of disconnection and isolation in these courses due to language barriers, cultural differences, and a lack of support from faculty and peers. However, research has shown that the use of active learning strategies, peer learning, and inclusive teaching practices can promote a positive sense of belonging among Chinese international students in programming modules. This section examines the existing literature on exploring the learning experience design for Chinese international students in introductory programming modules.

2.5.1 Definition of learning experience design

Learning experience design (LXD) is the process of creating engaging and effective educational experiences for learners by integrating principles from various disciplines, including instructional design, user experience design, and educational psychology. LXD focuses on understanding the needs, goals, and contexts of learners to design learning environments that are motivating, accessible, and conducive to learning. Schmidt and Huang (2022) define LXD as the practice of applying user-centered design principles to the development of educational experiences, ensuring that learning activities are both effective and enjoyable.

Theoretical frameworks of LXD, including Bloom's taxonomy, Flow Theory, Learning autonomy, Social learning, and Educational psychology, were found effective in designing

programming modules. Each of these theories provides insights into how programming modules can be more engaging and effective for learners. Understanding the needs and goals of students is the first step in designing an effective learning experience (Gulbahar and Guven, 2008). In an introductory programming module, students come from diverse backgrounds and have varying motivations for learning programming (Siong Hoe and Woods, 2010). To address this, LXD designers should create a challenging and engaging curriculum, which may include a mix of lectures, hands-on coding exercises, and collaborative projects (Siong Hoe and Woods, 2010). In addition, a supportive learning environment that encourages students to collaborate and ask questions is important (Monteiro et al., 2021; Le et al., 2018). The use of technology is another important aspect of LXD in an introductory programming module (Perera et al., 2021; Luxton-Reilly et al., 2018). Designers should choose tools and platforms that are user-friendly and accessible to students, such as online coding environments, interactive tutorials, and video lectures (Medeiros et al., 2018). Lastly, LXD designers should continuously evaluate and improve the learning experience based on feedback from students through surveys, focus groups, or individual interviews (Gulbahar and Guven, 2008). By incorporating feedback into the design process, designers can create a more effective and engaging learning experience for students (Monteiro et al., 2021).

2.5.2   Theoretical frameworks of learning experience deisgn

Learning experience design (LXD) is a rapidly evolving field that aims to create engaging and effective learning experiences. LXD involves the use of various theoretical frameworks to design and develop learning experiences that are effective, efficient, and engaging. This section discusses some of the most commonly used theoretical frameworks of LXD including Bloom's Taxonomy, and Social Learning Theory, which have been widely used in LXD to design learning experiences that target different levels of cognitive complexity and promote engagement and motivation.

Bloom's Taxonomy

Developed by Benjamin Bloom and colleagues, Bloom's taxonomy is a hierarchical model used to classify educational learning objectives into levels of complexity and specificity. The taxonomy consists of six levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. This framework helps educators design curriculum and assessments that promote higher-order thinking skills and ensure a comprehensive learning experience (Bloom and Krathwohl, 2020).

Bloom's Taxonomy has been used in LXD to design learning experiences that target different levels of cognitive complexity (Krathwohl, 2002). In an introductory programming module, Bloom's Taxonomy can be used to design learning objectives that range from basic syntax and commands (Remembering level) to creating complex programs that solve real-world problems (Creating level) (Bloom and Krathwohl, 2020). By targeting different levels of cognitive complexity, educators can ensure that students are not only able to memorise programming concepts but also apply them in real-world scenarios (Perera et al., 2021). In addition, incorporating LXD principles in programming modules can help students develop problem-solving skills and improve their ability to work collaboratively (Chang and Kuwata, 2020).

Experiential learning

Experiential learning is a teaching framework that emphasises the importance of hands-on experiences in the acquisition of knowledge. According to Kolb (2014), this approach involves a process of learning by doing, reflecting, and then applying the knowledge acquired. This allows learners to engage with the subject matter in a more holistic way, which traditional teaching methods may not always allow for. In fact, Kolb (2014) argues that experiential learning is a more effective way of facilitating learning because it allows learners to actively participate in the learning process.

In the field of Learning Experience Design (LXD), designers use the experiential learning framework to create immersive and interactive learning experiences that are focused on real-world applications. This approach has been found to be particularly effective in facilitating knowledge retention and application (Cheng and Tsai, 2016). LXD designers are able to use the experiential learning framework to design learning experiences that are tailored to the specific needs of learners, which allows for a more personalised and engaging learning experience.

Furthermore, the use of technology has revolutionised the field of experiential learning, enabling the development of more sophisticated and dynamic learning activities that simulate real-world scenarios and present challenges that learners may encounter in their future careers. As Bower et al. (2010) note, technology has enabled the creation of virtual and augmented reality learning experiences that provide learners with a more immersive and engaging learning environment. This not only increases the effectiveness of the learning experience but also allows for a more engaging and enjoyable learning experience.

Constructivism

Constructivism is a learning framework that emphasises the active role of the learner in the learning process (Land and Jonassen, 2012). This theory suggests that learners construct knowledge based on their experiences and that learning is most effective when learners are engaged in the process. LXD designers use this framework to design learning experiences that are interactive, collaborative, and reflective, and that help learners to develop critical thinking skills, problem-solving abilities, and a deeper understanding of the subject matter (Schunk, 2012).

One of the key aspects of constructivism is the idea that learners bring their own prior knowledge and experiences to the learning process. This means that every learner has a unique perspective on the subject matter and that they need to be able to make connections between their prior knowledge and the new information they are learning. LXD designers can use a variety of strategies to help learners make these connections, including providing opportunities for discussion and collaboration, encouraging learners to reflect on their learning, and providing feedback on their progress (Dabbagh and Kitsantas, 2012).

Another important aspect of constructivism is the idea that learners should be active participants in the learning process. This means that learners should be encouraged to ask questions, explore ideas, and engage in hands-on activities that allow them to apply what they are learning. LXD designers can use a variety of strategies to encourage active learning, such as creating interactive simulations, using gamification techniques, and designing activities that require learners to solve real-world problems (Papastergiou, 2009).

Overall, constructivism is a powerful framework for designing effective and engaging learning experiences. By placing the learner at the centre of the learning process, LXD designers can create experiences that are tailored to the needs and interests of each learner, and that help learners to develop the skills and knowledge they need to succeed in their studies and careers (Land and Jonassen, 2012).

Cognitive Load Theory

Cognitive load theory (CLT) is a widely used framework in the field of learning experience design (LXD) that explains how the human brain processes information (Sweller et al., 2011). According to CLT, the brain has a limited capacity for processing information, and when this capacity is exceeded, learning becomes difficult. CLT is based on the idea that there are three types of cognitive load: intrinsic, extraneous, and germane (Sweller, 2010). Intrinsic cognitive load refers to the inherent complexity of the material being learned, while extraneous cognitive load refers to the mental effort required to process information that is not relevant to the learning goal. Finally, germane cognitive load refers to the mental effort required to process information that is relevant to the learning goal.

One of the key applications of CLT in LXD is designing learning experiences that are cognitively efficient (Sweller et al., 2011). This means that LXD designers present information in a way that is easy to process and understand. To achieve this, designers use a variety of strategies such as separating information into smaller, digestible units, using visuals to support text, and minimising distractions that may cause cognitive overload. By taking these strategies into account, learners are able to better retain what they have learned, leading to a more effective and efficient learning experience.

The importance of CLT cannot be overstated, especially in today's information-rich world. With the rapid advancements in technology and the abundance of information available, learners are constantly bombarded with information from different sources. As a result, designing learning experiences that are cognitively efficient is crucial to ensure that learners can absorb and retain information effectively. LXD designers use CLT to create learning experiences that are tailored to the unique needs of learners, which makes it easier for them to understand, remember, and apply what they have learned.

Overall, CLT is a powerful framework that has been widely used in the field of LXD. It helps designers to understand how the human brain processes information and to design learning experiences that are cognitively efficient. By taking CLT into consideration, LXD designers can create learning experiences that are tailored to the needs and interests of learners, leading to more effective and engaging learning experiences.

Social learning

Social learning theory (SLT) is a widely used framework in learning experience design that explains how individuals learn through observation and interaction with others. According to SLT, learning is a social process that occurs through observation, imitation, and modelling (Bandura, 2019). This theory is rooted in the idea that people learn from one another, and that this learning can happen in a variety of settings, including educational institutions, workplaces, and social environments.

LXD designers use the principles of SLT to inform the design of learning experiences

that are collaborative, interactive, and focused on real-world applications. By leveraging the principles of SLT, designers are able to create learning experiences that are engaging and effective, while also promoting social interaction and collaboration among learners. These experiences can take many forms, from online courses and workshops to in-person training sessions and team-building exercises.

One key aspect of SLT is the role of observation and modelling in the learning process. By observing the behaviour and actions of others, individuals can learn new skills and behaviours that they can then apply in their own lives (Bandura, 2019). This is why LXD designers often incorporate video and other forms of media into their learning experiences, as these tools can be powerful tools for modelling and demonstrating new concepts and skills.

In addition to observation and modelling, SLT also emphasises the importance of feedback and reinforcement in the learning process. By providing learners with feedback on their performance, instructors can help them identify areas for improvement and encourage them to continue learning and developing their skills. Reinforcement, in the form of rewards and recognition, can also be a powerful motivator for learners, helping to keep them engaged and motivated throughout the learning process (Tricomi and DePasque, 2016; Wisniewski et al., 2020).

Overall, social learning theory provides a useful framework for understanding how individuals learn through interaction with others. By applying the principles of this theory, LXD designers can create learning experiences that are effective, engaging, and focused on real-world applications, while also promoting collaboration and social interaction among learners.

In summary, this section highlighted the theoretical frameworks that have been applied in learning experience design, including Bloom's Taxonomy, Flow Theory, Social Learning Theory, and Self-determination Theory. Table 2.1 summarizes the definition of the theories and their application on LXD. These frameworks have been used to design learning experiences that target different levels of cognitive complexity, promote engagement and motivation, and support individuals' psychological needs for autonomy, competence, and relatedness.

2.5.3   The needs and motivation for learning introductory programming modules

Studies have highlighted the importance of understanding the needs of international students in introductory programming modules. International students often feel a lack of confidence in their programming skills and a need for more intensive practice and feedback in order to succeed (Watson and Li, 2014). Additionally, international students may have difficulty establishing a sense of belonging in the classroom, which can lead to a lack of motivation and engagement (Chen and Zhou, 2019). In addition to academic needs, research has found that international students have unique social and cultural needs that must be addressed in order for them to succeed in introductory programming modules (Khanal and Gaulee, 2019). It is important to recognise the various needs of international students in order to create a supportive environment that will enable them to succeed in their programming module experience.

Motivating international students with unique needs is also a challenging and important aspect to be considered in the instructional design and teaching process. Learning motivation is an essential psychological concept linked to academic success and academic transition, as it has a great impact on students' learning behaviours, emotions and cognitions. It is reported

Name of Theory	Description	Implications on LXD
Bloom's Taxonomy	A hierarchical model classifying educational objectives into levels of complexity and specificity: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating.	Helps design curriculum and assessments promoting higher-order thinking skills. Enables the creation of learning objectives ranging from basic knowledge recall to complex problem-solving and creation, ensuring comprehensive learning experiences.
Experiential Learning	Emphasizes learning through hands-on experiences, reflection, and application of knowledge.	Facilitates knowledge retention and application by engaging learners in real-world applications. Enhances learning through immersive and interactive experiences, often using technology like virtual and augmented reality to simulate real-world scenarios.
Constructivism	Focuses on the active role of the learner in constructing knowledge based on their experiences.	Designs interactive, collaborative, and reflective learning experiences. Encourages active participation, critical thinking, and problem-solving. Strategies include discussions, hands-on activities, and gamification to enhance engagement and learning.
Cognitive Load Theory	Explains how the brain processes information, categorizing cognitive load into intrinsic, extraneous, and germane.	Aims to design cognitively efficient learning experiences. Techniques include breaking information into smaller units, using visuals to support text, and minimizing distractions, thereby enhancing information retention and learning effectiveness.
Social Learning Theory	Suggests that learning occurs through observation, imitation, and interaction with others.	Creates collaborative and interactive learning experiences. Utilizes observation, modeling, feedback, and reinforcement to teach new skills and behaviors. Encourages social interaction and collaboration among learners in both online and in-person settings.

Table 2.1: *Theoretical Frameworks of Learning Experience Design*

that a lack of intrinsic motivation can lead to a lack of engagement, which can lead to lower grades and a higher risk of dropping out (Telbis, 2013). According to Deci and Ryan (2008), intrinsic motivation is defined as the natural drive to engage in activities that are enjoyable and meaningful. Intrinsic motivation has been found to be a strong predictor of academic success (Vansteenkiste et al., 2009). When students are intrinsically motivated, they are more

likely to be engaged in their studies and persist in the face of difficulties. On the contrary, the lack of intrinsic motivation in an academic setting can lead to a number of challenges for international students, including feeling isolated and alone, feeling less confident in studying, and struggling to find a sense of belonging. In addition, a lack of intrinsic motivation can lead to stress and anxiety, which can further negatively affect academic performance (Al-Kumaim et al., 2021). This suggests that it is important for international students to feel supported in programming modules and have a positive attitude towards their studies with intrinsic motivations.

However, international students often lack intrinsic motivation for a number of reasons. Many international students come from cultures that value extrinsic rewards such as grades and degrees over intrinsic rewards such as personal satisfaction and enjoyment (Ryan and Deci, 2020). They often face language and cultural barriers that can make their studies more difficult and less enjoyable (Steinmayr et al., 2019). Nevertheless, international students may feel isolated and alone in their studies, which can lead to a lack of motivation (Andrade, 2006). These challenges can lead to a number of problems for international students such as feeling lost, feeling overwhelmed, and not being able to adjust to the new environment.

In summary, the literature has highlighted the unique needs of international students in introductory programming modules. International students may come from diverse backgrounds, have varying levels of experience with coding, and may have difficulty adjusting to the abstract nature of coding. Therefore, it is important to identify strategies and innovative approaches that can help international students learn to code. Additionally, they often lack intrinsic motivation due to their cultural background, language and cultural barriers, and feeling of isolation. It is essential to understand the unique needs and motivations of these students in order to support them and help them to succeed in programming learning.

2.5.4 Challenges of learning in introductory programming classes

Programming learning is difficult for novices and requires tremendous work and dedication. Teaching programming is also problematic if the instructional methods do not meet learners' needs and learning content. Tackling these challenges requires a multifaceted approach which involves understanding student needs, utilising innovative approaches, and adapting to the abstract nature of programming. The innovation of instructional design can be a valuable tool for helping students to adjust to the rigours of university-level study. In this section, strategies and innovative approaches for introductory programming modules in an international setting were explored by discussing the challenges associated with teaching coding to international students and examining different instructional approaches that can be used to support successful learning outcomes.

Programming is a complex task that requires a lot of skills and experience to master. Programming learning is often seen as dry and tedious (Grønli and Fagernes, 2020). This is partly due to the fact that most introductory programming textbooks tend to be quite formal and mathematical in their approach (Luxton-Reilly et al., 2018). Several factors contribute to the difficulty of programming learning, including the complexity of the concepts involved, the lack of prior experience, and the syntax of the language (Qian and Lehman, 2017). This can make the subject matter seem inaccessible to novices, who may feel that they lack the mathematical skills required to understand the material. This is especially challenging for international students from non-English speaking countries, such as China,

who face language and cultural barriers in addition to the complexity of the language itself. For Chinese international students, the programming modules are typically more theoretical and abstract than courses in China and may require a different way of thinking (Sun et al., 2021; Rattadilok, 2019). In addition, it can be difficult to find real-world applications for the concepts learned in a programming class (Anderson et al., 2014). These factors make it difficult for Chinese programming novices to understand the material and find real-world applications for the programming concepts they have learned.

Another difficulty of learning to program is due to the need to understand and apply multiple concepts simultaneously. For novice programmers, the learning curve can be steep and the task of becoming a proficient programmer can be daunting (Perera et al., 2021). Programming requires the understanding and application of multiple concepts simultaneously (Grover and Basu, 2017). These concepts include, but are not limited to, logical reasoning, problem-solving, and computer science principles. Each of these concepts is difficult to understand on its own, let alone in the context of programming (Wing, 2006). One of the main reasons for this difficulty is that learning about a computational concept involves learning its structural and functional uses (Moon et al., 2022). At its core, learning to program is about learning how to think computationally – that is, how to break down a problem into smaller parts, identify patterns, and create solutions (Sengupta et al., 2018). This can be a difficult task for novices, who often lack the necessary background knowledge and experience to understand these concepts.

In addition, the vast majority of novice programming students do not have any prior experience with coding or computer science. For instance, many novice programmers do not have a strong foundation in mathematics, which can make it difficult for them to understand the underlying concepts of programming (Robins et al., 2003; Allan and Kolesar, 1997). This lack of experience can make it difficult to understand the basic concepts of programming. Without a solid foundation in the basics, it is difficult to move on to more advanced concepts (Denning and Tedre, 2019). It is suggested that adaptive and immediate feedback can improve beginners' motivation and retention in programming learning (Marwan et al., 2020; Tricomi and DePasque, 2016).

The vastness of the programming field can also be overwhelming for those just starting with it. There are endless resources available, and it can be difficult to know where to find the right information. This can lead to frustration and discouragement and can make it difficult to progress in learning (López-Pernas et al., 2019). The sheer number of available programming languages is also confusing for beginners. While there are some similarities among languages, each one has its own unique syntax and semantics. The syntax of most programming languages is very different from the syntax of natural languages, which can make it difficult for novice programmers to read and write code.

The difficulty that novice programmers face in learning how to program is often compounded by the fact that they are typically not taught how to effectively use programming tools and techniques (Becker and Quille, 2019). For instance, many novice programmers are not taught how to debug programs or how to use programming libraries (Fitzgerald et al., 2008; Li et al., 2022; Robins et al., 2003). As a result, they often have to rely on trial and error in order to learn how to use these tools and techniques.

The challenges of learning programming can also be explained by the term 'double learning burden' (DLB), which has been identified as a significant factor in why novices find learning

programming difficult (Robins et al., 2003; Lister et al., 2009). In other words, students need to understand not only how a concept works, but also how it can be applied to solve problems. This can be a challenge, especially for those who are new to the field. The DLB has been shown to have negative consequences for novices, including reduced motivation, increased frustration and confusion, and lower achievement (Lister et al., 2009). One possibility is that it is simply a result of the nature of programming itself – that is, it is a complex task that requires a deep understanding of both structure and function in order to be executed effectively (Castro and Fisler, 2020). Another possibility is that the DLB arises from the way in which programming is typically taught – that is, by focusing on the syntax of the language rather than on the concepts that underlie the code (Hadwen-Bennett et al., 2018).

In conclusion, learning programming can be a difficult and intimidating task, especially for novice programmers. Programming requires the understanding and application of multiple concepts simultaneously, including logical reasoning, problem-solving, and computer science principles. Additionally, the lack of prior experience and the syntax of the language can make it difficult to understand the material and find real-world applications for the concepts learned in a programming class. Furthermore, the double learning burden associated with programming can lead to reduced motivation, increased frustration and confusion, and lower achievement among novices. Thus, it is important that introductory programming modules are designed in such a way as to provide students with a comprehensive understanding of the basics and allow them to apply these skills in a meaningful way.

2.5.5 Challenges of teaching in introductory programming classes

The instructional design of these courses can be difficult as they must be challenging enough to engage students, yet accessible enough to allow them to understand and apply the concepts. Programming education is currently undergoing a period of change and evolution. The traditional approach to teaching programming, which relies heavily on lecture-based instruction, is no longer as effective as it once was (Figueiredo and García-Peñalvo, 2020). In recent years, there has been a shift towards more active and engaging methods of instruction, such as problem-based and project-based learning. These methods are designed to provide students with an opportunity to explore the topic more deeply and develop a better understanding of coding principles. Furthermore, these approaches tend to be a more inclusive and foster collaboration between students (Hmelo-Silver, 2004; Dias and Brantley-Dias, 2017). They are also beneficial in facilitating greater student engagement and allowing students to learn through experimentation and exploration, which can be especially beneficial for novice programmers who need more time to explore, experiment, and ask questions (Barron and Darling-Hammond, 2008; Robins et al., 2003).

There is also a growing emphasis on teaching the fundamental concepts of programming rather than just focusing on the syntax and structure of the language itself. This is important since it allows students to develop an understanding of how programming works as a whole, instead of just learning specific commands or routines by rote. Additionally, teaching the fundamentals of programming helps students develop problem-solving skills that will serve them well in their future careers (Santos et al., 2020). Awareness of helping students develop soft skills such as communication, collaboration, and critical thinking were also raised among lecturers. While these skills may not seem directly related to programming, they are essential for successful programming projects and collaborative coding efforts (Gonzalez-

Barahona et al., 2022). Teaching soft skills can help students become better thinkers and communicators, which are invaluable assets in any professional field.

However, there is still much work to be done in terms of creating an effective teaching environment for introductory programming modules. Teachers must consider how to best meet the needs of their students while providing them with the tools and techniques they need to become proficient programmers. This may include adapting existing instructional strategies or introducing new ones that are tailored to the specific learning styles of the students. Additionally, teachers should seek out resources and materials that can help their students understand the underlying concepts behind programming and develop their problem-solving skills. Finally, lecturers should strive to create an atmosphere of openness and collaboration among their students so that they feel supported as they learn.

2.5.6   Examples of effective learning experience design strategies

Different strategies exist in the literature regarding programming learning, including the use of clear instructions, collaborative learning approaches, personalised and adaptive learning, culturally responsive teaching and digital technologies, which can be used to facilitate the effective learning and retention of coding concepts among international students.

Clear instructions

One strategy to help novices overcome these difficulties is to provide them with a clear and concise explanation of the concepts (Becker and Quille, 2019). This can be done through the use of tutorials, lectures, and other teaching materials (Medeiros et al., 2018). It is also important to provide novice programmers with opportunities to practise their skills (Luxton-Reilly et al., 2018). Many students struggle with the transition from reading about a concept to actually implementing it in code (Sun et al., 2022; Vaughn et al., 2012). Practice problems can help bridge this gap and help students to see the material in a more concrete way. It is suggested by the literature that, in order to overcome these challenges, it is important for introductory programming module lecturers to pay attention to the way in which they are presenting the material (Medeiros et al., 2018; Sobral, 2021). In particular, they should focus on helping novices to develop a deep understanding of the concepts that underlie the code, rather than simply on the memorisation of syntax (Barron and Darling-Hammond, 2008).

Collaborative and active learning

Collaborative and active learning are two interrelated learning strategies that can significantly enhance learning outcomes. Collaborative learning encourages learners to work together in groups to achieve a common goal, while active learning focuses on engaging learners in the learning process by involving them in activities that require their active participation (Freeman et al., 2014). Instructional techniques for collective learning and hands-on activities such as role-playing or problem-solving can also be used to allow international students to apply their coding knowledge in real-world situations. There are many different strategies of collaborative learning in higher education, but some common ones include using social media platforms to facilitate discussion and collaboration between students, designing group projects that require students to work together in order to complete the task, have students share their work with each other in an online forum or via email, encouraging students to

give feedback to each other on their work, using online tools such as Google Docs or Skype allows students to work together on assignments in real-time (Roselli, 2016).

Project-based learning can also be an effective active learning approach to teaching coding to international students. Project-based learning allows students to work on a specific project or challenge, which can help them to apply the coding concepts they have learned. It can help develop problem-solving skills, which can be beneficial for international students as they adjust to the abstract nature of coding (Kokotsaki et al., 2016; Maros et al., 2021). Additionally, a more student-centred approach to teaching programming has been shown to be more effective in engaging novice learners in active learning (Fields et al., 2021; de Carvalho and Bauters, 2021). This approach focuses on providing students with opportunities to explore and experiment with the material, rather than presenting them with a set of rules to memorise. Overall, collaborative and active learning has been shown to be more effective in helping students to understand and retain the material.

Personalised and adaptive learning

Personalised and adaptive learning strategies help cater to learners' individual needs and learning styles, which improves their engagement and motivation. Personalised learning involves tailoring the learning experience to the individual learner's needs, while adaptive learning adjusts the learning experience based on the learner's progress and performance (Peng et al., 2019). These strategies can be implemented using various technologies, such as learning management systems and artificial intelligence. One example of effective personalised and adaptive learning is the use of an intelligent tutoring system (ITS), which can analyse learners' performance data and provide personalised feedback and recommendations based on their strengths and weaknesses. This approach helps learners to focus on areas that require improvement and encourages them to take ownership of their learning (Tetzlaff et al., 2021; Xu and Ouyang, 2022). Research has shown that ITS can improve student performance and reduce cognitive load in programming modules. For example, Grenander et al. (Grenander et al., 2021) proposed an educational system that was designed to provide personalised feedback based on individual learners' needs and evaluated its effectiveness using deep discourse analysis. Similarly, Eguchi et al. (Eguchi et al., 2021) investigated the use of games to support STEM education for children with visual impairments. They found that the game had a positive impact on engagement and motivation among participants. Furthermore, ITS can provide personalised instruction and targeted remediation, which can be particularly beneficial for those who lack prior experience in programming.

Culturally responsive teaching

Culturally responsive teaching is a vital approach that recognizes and values the diverse cultural backgrounds of students. By incorporating the experiences of students into the learning process, this approach creates an inclusive and respectful environment that enhances learners' engagement and motivation (Zhang et al., 2012). However, culturally responsive teaching goes beyond creating a safe and respectful environment. It also promotes cultural awareness and understanding by incorporating cultural materials and examples into the curriculum, such as literature, music, and art from different cultures. This can help students appreciate and better understand different perspectives, improving their critical thinking and problem-solving

skills (Ladson-Billings, 2014). The benefits of culturally responsive teaching are particularly important for international students who may be unfamiliar with the higher education system and the norms and expectations of the classroom.

To ensure that students from diverse backgrounds feel included and valued, it is important for educators to be aware of and sensitive to the cultural differences and norms of their students. This can involve taking the time to get to know their students, asking about their cultural backgrounds and experiences, and actively seeking out ways to incorporate these perspectives into the curriculum. By doing so, educators can create a more inclusive and culturally responsive learning environment that meets the needs of all learners (Ladson-Billings, 2014).

2.5.7 Summary

The evidence presented in the sections above suggests that the instructional design of introductory programming modules should take into account the needs of the students, and the potential challenges of learning and teaching in programming modules and incorporate innovative approaches and digital technologies. The course should be designed to meet the objectives of the course, the level of the students, and the learning environment. Furthermore, the instruction should be tailored to the individual needs of the students, as some may require extra assistance or guidance. Additionally, the course should include problem-solving skills to help students better understand and solve the problems they encounter, as well as require students to regularly apply critical thinking. In terms of teaching methods, programming instruction can be incorporated into the course through a variety of activities, such as experiments, projects, case studies, and seminars, as well as training and workshops. Different strategies should be employed to accommodate different levels of ability, such as discussions, personalised learning, self-directed learning, and collaborative learning. In addition, various technology tools should be considered to support instruction, such as online learning, virtual reality environments, and virtual laboratories.

The theoretical frameworks also provide insights into how programming modules can be more engaging and effective for learners. For instance, Bloom's Taxonomy can be applied in designing programming tasks of different cognitive levels, while Flow Theory can be used to design gamified learning environments that promote student engagement and motivation. Learning autonomy has been proposed as a theoretical basis for implementing gamification in education, and Social learning theory suggests that gamification can be used to encourage students to learn by observing and imitating the behaviour of others. Educational psychology theories explain how gamification can be used to present information in a way that is more engaging and effective for learning.

Overall, the literature has highlighted the unique needs of international students in introductory programming modules. To address these needs, it is important to identify strategies and innovative approaches that can help international students learn to code. Additionally, it is important to recognise the various challenges that international students face when learning to program, such as the difficulty of understanding and applying multiple concepts simultaneously, the lack of prior experience, and a lack of intrinsic motivation. In conclusion, successful instructional design of introductory programming modules requires consideration of course content, teaching methods, and assessment design. Basic programming skills, problem-solving skills, and training on programming tools should be provided. Appropriate teaching strate-

gies should also be employed, with the support of technology tools, as well as appropriate feedback methods to measure student learning outcomes.

2.6 Gamification in education

With the rise of digital and mobile technologies, gamification has become increasingly prevalent in education. This section explores the use of gamification techniques in programming education and their potential to enhance the sense of belonging of Chinese international students in the UK. The review begins by defining gamification and exploring its application in programming education. It then discusses the advantages of using gamification in programming learning. The review also describes various gamification design frameworks, their strengths, and limitations in gamification design. Furthermore, the review examines several gamification techniques that can be effective in improving students' motivation, engagement, sense of belonging, and academic performance in programming modules. The review also presents successful gamification applications and their effectiveness in promoting engagement and collaboration among learners.

The table2.2 compares gamification with other educational methods, highlighting their definitions, advantages, and disadvantages. Gamification stands out for its ability to increase motivation, engagement, and a sense of belonging among students. However, it also presents challenges such as implementation time and the risk of overemphasis on rewards. In contrast, traditional lectures, project-based learning (PBL), and flipped classrooms offer their own unique benefits and limitations.

We chose gamification over other methods for several reasons. First, gamification's ability to significantly enhance student engagement and motivation aligns perfectly with our goal of creating a dynamic and interactive learning environment. Unlike traditional lectures, which often result in passive learning, gamification encourages active participation and sustained interest. Furthermore, the competitive and collaborative elements of gamification are particularly effective in fostering a sense of belonging and community among Chinese international students, which is crucial for their adaptation and success in a foreign educational setting. While project-based learning and flipped classrooms also promote active learning, they require extensive planning and resources, which can be challenging to implement consistently. Gamification, on the other hand, offers a flexible and scalable approach that can be seamlessly integrated into existing curricula, making it a practical and impactful choice for enhancing programming education

2.6.1 Definition of gamification

Gamification refers to applying game design components and mechanics in non-entertainment contexts to increase peoples' motivation and engagement, create an enjoyable experience and generate behavioural changes (Deterding et al., 2011a). Gamification has been implemented in a variety of domains such as business and health with the aim of improving motivation, engagement, and performance (Deterding et al., 2011a).

Gamification is also a popular technique in the field of education, particularly in programming and computer science (Deterding et al., 2011a; Kapp, 2012). Gamified learning is the incorporation of game-like elements, such as points, badges, and leaderboards, into

Method	Definition	Advantages	Disadvantages
Gamification	The application of game design elements in non-game contexts to enhance engagement and motivation.	Increases motivation and engagement Promotes a sense of belonging Enhances collaboration and competition Provides immediate feedback	Can be time-consuming to implement Risk of overemphasis on rewards May not appeal to all students
Traditional Lectures	A conventional method of teaching where the instructor delivers content verbally to a passive audience.	Structured and systematic delivery of content Efficient for large groups Cost-effective	Often passive and non-interactive Limited engagement and motivation Does not cater to individual learning needs
Project-Based Learning (PBL)	A student-centered pedagogy where students learn by actively engaging in real-world and personally meaningful projects.	Encourages critical thinking and problem-solving Provides real-world relevance Promotes teamwork and collaboration	Can be challenging to assess Time-consuming Requires careful planning and resources
Flipped Classroom	An instructional strategy where students review lecture materials at home and engage in interactive activities in class.	Promotes active learning Allows for personalized instruction Encourages student preparation and participation	Requires student self-discipline Dependent on technology access Increased preparation time for instructors

Table 2.2: *Comparison of Gamification with Other Educational Methods*

learning activities and assessments (Deterding et al., 2011a). The primary goal of gamification in education is to engage students and promote active learning, knowledge retention, problem-solving skills, creativity, competition, and collaboration among students (Hamari et al., 2014). Gamification has gained increasing attention from researchers and educators for its potential to enhance student learning and motivation (Koivisto and Hamari, 2019). Research has shown that gamification can improve student performance in areas such as learning engagement and understanding of the material (Koivisto and Hamari, 2019; de Marcos et al., 2014).

While the effectiveness of gamification for learning has been debated, recent research suggests that it can be an effective tool in certain contexts (Sailer and Homner, 2020; Dichev and Dicheva, 2017; Subhash and Cudney, 2018). Dichev & Dicheva (Dichev and Dicheva, 2017) found that gamification could improve engagement and motivation in learning, but that its effectiveness depended on the alignment between the game elements and the learning

objectives.

2.6.2   Advantages of using gamification in programming learning

Gamification has been increasingly used in various educational settings, including introductory programming modules, due to its potential advantages in enhancing student motivation, engagement, learning, and collaboration. In programming learning, gamification can help students learn complex coding concepts enjoyably and interactively (Bellotti et al., 2013). Gamification techniques, such as quests and challenges, narratives and storytelling, and game-like environments, provide students with a more immersive and engaging learning experience (Kapp, 2012).

According to Sailer and Homner (2020), gamification positively affects students' intrinsic motivation and engagement, as it provides them with a sense of autonomy, competence, and relatedness. This is consistent with previous studies that have found that gamification can increase student motivation and engagement (e.g., Dicheva et al. (2015); Hamari et al. (2014)). Gamification can also help address the issue of student disengagement and boredom, which can be major barriers to learning. By adding fun and interactive elements to educational activities, students are more likely to stay engaged and interested (Landers, 2014). This can lead to improved student attendance and participation in class, as well as higher levels of motivation and enthusiasm for learning.

In addition, gamification can be an effective way to teach programming concepts and skills. By utilising game-like elements, students can learn complex coding concepts in a more interactive and engaging way. This can help students develop a deeper understanding of programming concepts, as well as increase their interest in pursuing careers in technology (Koivisto and Hamari, 2019). Recent studies have even shown that gamification can have a positive impact on students' mental health and well-being. A study by Su (2016) found that gamification can reduce stress and anxiety levels among students, leading to better academic performance.

Moreover, gamification can promote active learning and knowledge retention by helping learners actively participate in the learning process and apply their knowledge in practical contexts (Kapp, 2012). As noted by Lee and Hammer (2011), gamification can also foster competition and collaboration among learners, which can improve their teamwork, communication, and problem-solving skills. However, it is important to note that the effectiveness of gamification depends on various factors, such as the design of the gamified system, the characteristics of the learners, and the learning context (Dicheva et al., 2015). Therefore, it is crucial to carefully design and implement gamification in educational settings based on the specific needs and preferences of the learners.

The current study aims to explore the potential of using gamification to increase Chinese international students' sense of belonging in the UK. While gamification has been widely used in various educational contexts to enhance motivation and engagement, its specific application to improving the sense of belonging among Chinese international students is less explored. This study seeks to fill this gap by examining how gamification can be tailored to meet the unique needs of this student group, thereby contributing to the existing body of research on gamification in education.

Overall, the literature suggests that gamification is a promising instructional design approach that can enhance various aspects of learning and collaboration. However, implement-

ing gamification in higher education poses its own set of challenges. These include the need for faculty support, appropriate technology, and assessment methods. Despite these challenges, the potential benefits of gamification in higher education make it a promising area of research.

2.6.3 Design frameworks of gamification in education

The development of effective gamification systems in education relies on established design frameworks. This section discusses several prominent frameworks: the 6D Gamification Design Framework, the MDA Framework, Werbach's Gamification Design Process, and the Octalysis Framework.

The 6D gamification design framework

The 6D gamification design framework omprises six components: define objectives, delineate target behaviours, describe the users, devise activity components, deploy the appropriate tools, and finally, determine the evaluation strategy (Dicheva et al., 2015). Each component plays a crucial role in designing a gamification system that effectively motivates and engages learners. The framework emphasises the importance of aligning gamification design with learning objectives and target behaviours, as well as considering the needs and characteristics of users. The 6D gamification design framework provides a comprehensive guideline for designing effective gamification systems.

MDA Framework

Similarly, the Mechanics, Dynamics, Aesthetics (MDA) framework has been used to analyse and design gamified systems (Hunicke et al., 2004). The MDA framework has become increasingly popular as a structured approach to gamification design that emphasises gameplay mechanics, which refer to the rules, methods, and interactions that define how a game operates and how players engage with it and user experiences (Hunicke et al., 2004). The MDA framework helps researchers focus on the core gameplay mechanics which ensures that the game is designed with a clear purpose and that the gameplay is engaging and enjoyable for the player (Hunicke et al., 2004). However, there are also limitations to using the MDA framework in gamification design. One of the main limitations is that it may not be suitable for all types of games or gamification projects, as it is primarily focused on gameplay mechanics (Hamari et al., 2014). For example, if a gamification project requires a strong narrative or storytelling component, the MDA framework may not be the best fit. Storytelling can be highly effective in educational settings as it enhances engagement, aids in memory retention, and provides context for learning. Narratives can make complex concepts more relatable and easier to understand by embedding them in a story, thereby fostering a deeper emotional connection and motivation among learners. Thus, while the MDA framework excels in designing the interactive and procedural aspects of a game, it may fall short in integrating compelling narratives that are essential for some educational gamification projects (Hamari et al., 2014). It may also not fully capture the nuances of users' behaviour and motivation, as it is based on a simplified model of user experience (Hamari et al., 2014). This can limit researchers' creativity and flexibility, as they may feel constrained by the framework's prescriptive approach (Hunicke et al., 2004).

Gamification Design Process

The gamification design process involves the phases of discovery, strategy, design, development, and deployment, and has been used to guide the development and implementation of gamified learning systems (Werbach et al., 2012). This framework emphasises the importance of understanding the target audience, defining goals and objectives, designing game elements, and evaluating the effectiveness of the system.

Framework	Advantages	Disadvantages
6D Gamification Design Framework	- Comprehensive guideline for design - Aligns with learning objectives - Considers user needs	- Can be complex and difficult to use in practice - Time-consuming to implement
MDA Framework	- Structured approach to design - Focuses on core game elements - Enhances engagement and enjoyment	- Not suitable for all types of gamification projects - Significant time and resource investment - May not capture nuances of user behavior
Octalysis Framework	- Holistic view of user motivation - Identifies and leverages different motivational drivers - Provides a meaningful gamification experience	- May be complex to implement - Requires understanding of diverse motivational drivers - Can be resource-intensive
Gamification Design Process	- Emphasizes understanding the target audience - Clear phases for development and implementation - Flexible and adaptable	- Can be broad and lacks clear guidelines for implementation - May require extensive planning and resources

Table 2.3: *Summary of Gamification Design Frameworks*

Despite the usefulness of these design frameworks (see Table 2.3) in the development of gamified learning systems, some of them have limitations that need to be addressed. For example, the gamified learning theory is criticised for being too broad and not providing clear guidelines for implementation. On the other hand, the 6D and MDA frameworks are criticised for being too complex and difficult to use in practice (Dichev and Dicheva, 2017; Subhash and Cudney, 2018). The literature implies that the effectiveness of gamification in education is dependent on the proper selection, implementation, and evaluation of game elements. It also suggests that a comprehensive and flexible design process is necessary to ensure that the gamified learning system is tailored to the target audience and their characteristics.

2.6.4 Psychological basis of the gamification design

The Flow Theory

The most commonly used psychological basis of gamification design is the Flow theory. Flow theory is a concept that describes a psychological state of complete absorption and engagement in an activity, characterised by a sense of control, loss of self-consciousness, and being in the present moment (Csikszentmihalyi and Larson, 2014). This state is achieved when individuals have a balance between the difficulty of the task and their own abilities, such that they are neither bored nor anxious (Csikszentmihalyi and Larson, 2014) Recent studies have continued to explore the concept of flow and its application in gamified learning. A study by Koivisto and Hamari (2019) found that gamification elements, such as points, badges, and leaderboards, were positively associated with flow and engagement in a learning context. The application of flow theory in gamified learning has also been explored in specific contexts, such as language learning. For example, one study (Özhan and Kocadere, 2020) found that a gamified language learning app improved learners' engagement and motivation, leading to a greater sense of flow and better learning outcomes.

Self-determination theory (SDT)

Self-determination theory (SDT) is a widely researched and applied theoretical framework that seeks to explain human motivation and behaviour. SDT posits that individuals have three innate psychological needs: autonomy, competence, and relatedness. These needs serve as the basis for intrinsic motivation and lead to greater satisfaction, engagement, and well-being. In this literature review, we will explore how SDT has been applied to learning experience design. SDT has been widely applied to education, including learning experience design. Research has shown that designing a learning experience that supports the psychological needs of autonomy, competence, and relatedness can lead to increased motivation, engagement, and learning outcomes (Guay, 2022; Niemiec and Ryan, 2009). For example, studies by Lee et al. (2015); Mendoza et al. (2023) found that incorporating autonomy-supportive strategies, such as offering choice and providing a rationale, into an online learning environment led to greater intrinsic motivation and engagement among college students. Another study by Vansteenkiste and colleagues (Vansteenkiste et al., 2020) examined the effects of autonomy-supportive teaching practices on students' learning outcomes and motivation. The researchers found that students who were taught in an autonomy-supportive manner had greater intrinsic motivation, a deeper understanding of the material, and better performance on tests compared to those who were taught in a controlling manner. Overall, SDT provides a valuable theoretical framework for learning experience design. Designing learning experiences that support individuals' psychological needs for autonomy, competence, and relatedness can lead to increased motivation, engagement, and learning outcomes.

Gamified learning theory

Gamified learning theory (Landers, 2014) offers a useful framework for understanding the potential of gamification in education, as well as the factors that can influence its effectiveness. Landers (2014) provides a comprehensive review of the research on gamification in education and proposes a theoretical framework for gamified learning that includes three components:

game elements, instructional design elements, and psychological mechanisms. Game elements include elements such as points, badges, and leaderboards, while instructional design elements include scaffolding and feedback. Psychological mechanisms include intrinsic motivation, goal-setting, and social influence. The authors argue that the effectiveness of gamification in education depends on the interaction between these three components. For example, game elements alone are not sufficient to promote learning. Instead, they must be integrated into an instructional design that is aligned with the learning objectives and that provides appropriate psychological support.

The psychological basis of the gamified learning course in the current research combines the major components of theories from Landers (2014) Gamified Learning Theory, the Belonging Model proposed by Araujo et al. (2014), the Self-determination Theory (SDT, (Ryan and Deci, 2000)) and the MDA Framework by Hunicke et al. (2004). The Gamified Learning Theory contributes to the understanding of the overall mechanisms of the gamification of learning. It indicates that game elements mediate learners' behaviours and attitudes by moderating learners' motivation, and eventually impact students' learning outcomes. The SDT theory explains the motivational changes and their impact on cognitions, behaviours as well as attitudes. It provides a framework for understanding the motivational factors that influence engagement in learning activities by emphasising the importance of intrinsic motivation and the three basic psychological needs of autonomy, relatedness, and competence. For the game attributes, the MDA framework is adopted to combine a series of game elements to achieve the expected mechanism and aesthetics. As the current study focuses on improving students' sense of belonging, the Belonging Model provides a three tiers framework to understand students' belonging in higher education, which is useful in aligning game attributes identified in the MDA framework accordingly to increase students' sense of belonging in different dimensions.

2.6.5 Gamification techniques in programming learning

Several game elements have been identified to increase students' motivation and sense of belonging in programming education, including badges, points, and leaderboards (BPL), narratives and storytelling, rapid feedback, role-play, quests and challenges, avatar customization, teamwork, and progress bars.

Badges, points, and leaderboards (BPL)

The badges, points and leaderboards, as known as BPL, are most commonly used to create a sense of competition and camaraderie among students (Kapp, 2012; Fischer et al., 2016). Badges are used to signify achievements or accomplishments, while rewards can be customised to the individual student's interests. Leaderboards add an element of social comparison, which can motivate students to compete with each other (Hamari et al., 2014). These elements help to create a sense of competition and camaraderie among students, which can lead to increased motivation and engagement in learning. Badges can be used to signify achievements or accomplishments and can be displayed on a leaderboard to add an element of competition (Zichermann and Linder, 2010). Rewards can be used to incentivise students to complete tasks or achieve goals and can be customised to the individual student's interests (Zichermann and Linder, 2010). By incorporating these elements into the learning process, students are

more likely to feel a sense of belonging and be motivated to succeed (Hamari et al., 2014; Kapp, 2012; Zichermann and Linder, 2010).

Narratives and storytelling

The use of narrative game elements and story-telling gamification elements has also been shown to be effective in improving student's learning experience and sense of belonging (Mader et al., 2019; Goshevski et al., 2017). Storytelling gamification design can provide a narrative context for the content and activities, which can help students understand the concepts being taught in the course. By immersing themselves in the stories, students can better understand how the concepts they are learning can be applied in real-world scenarios (Ibarra-Herrera et al., 2019). Storytelling can also provide an opportunity to interact with their peers and lecturers, which can help to create a sense of community and belonging. It also helps to engage students in the learning process and creates a sense of ownership and responsibility for their own learning (Ossiannilsson, 2018). The use of these elements has been shown to increase students' motivation and persistence in learning and to improve their academic performance (Moreira et al., 2013; National Academies of Sciences et al., 2018). The literature suggests that game elements and story-telling can be effective in improving student's learning experience and sense of belonging (Mader et al., 2019; Goshevski et al., 2017). However, there is a lack of research specifically investigating the use of these approaches in relation to Chinese students' sense of belonging at British universities and career interests in introductory programming modules.

Rapid feedback

Research has shown that rapid feedback can significantly improve students' learning experiences in gamified learning environments (Deterding et al., 2011b). Compared to traditional, summative feedback, rapid feedback has been found to be more effective in promoting learning (Dicheva et al., 2015). Rapid feedback has also been found to be effective in improving students' sense of belonging (Hattie and Timperley, 2007). More recent studies have supported these findings, such as a study by Cotner et al. (Cotner et al., 2008) which found that rapid feedback significantly improved students' engagement and learning outcomes. These studies suggest that rapid feedback is an effective strategy for promoting student learning and enhancing their sense of belonging in a gamified learning environment.

Role-play

Role-play is another gamification technique that is effective in promoting students' interest and engagement in programming modules. Role play is a type of simulation in which players assume the roles of characters in a fictional setting (Fine, 1983). It is a popular and effective way to learn new material, as it allows students to explore different aspects of a topic and experience the consequences of their choices (Danka, 2020). By assuming the roles of characters in a fictional setting, students can explore different aspects of a topic and experience the consequences of their choices. Role-play also helps to improve students' sense of belonging as they identify with the characters they are playing and feel a sense of ownership over the situation (Subhash and Cudney, 2018).

Quests and challenges

Quests and challenges are another popular gamification technique that can be used to motivate students to learn new programming concepts and skills, and can also reinforce previously learned material (Hamari and Koivisto, 2015). Quests are tasks or goals that learners have to complete in order to progress through levels or unlock new content (Subhash and Cudney, 2018; Alsawaier, 2018). Challenges are tests or problems that learners have to solve to demonstrate their skills or knowledge (Subhash and Cudney, 2018). Quests and challenges can be used in gamified programming learning by incorporating puzzle-solving, coding contests, practice opportunities, and leaderboards. These can help learners develop their programming skills, self-efficacy, intrinsic motivation, and engagement (Kapp, 2012). Quests and challenges can also help build a sense of competition and connection among students, which contributes to a positive learning environment (Kapp, 2012).

Avatar customisation

Avatar customisation is a popular feature in video games (Yee et al., 2009)and has also been used in gamification techniques for programming learning (Kapp, 2012). An avatar is a graphical representation of a person or a character in a gamified eLearning intervention. It can be used to enhance the level of engagement and emotional attachment between the learner and the gamified program (Wilton and Noël, 2011; Strmecki et al., 2015). There are different types of avatars, such as first-person or third-person perspectives, that can suit different learning objectives and preferences (Blake and Moseley, 2010). Personalising one's learning experience by creating an avatar has been shown to increase motivation and engagement in the learning process (Dicheva et al., 2015). Avatars can also serve as a progress tracker and reward system to provide a sense of accomplishment and encourage continued learning (Blake and Moseley, 2010).

Teamwork

Teamwork involves cooperation, collaboration, communication, and coordination among team members to achieve a common goal. In the context of programming modules, teamwork has been shown to enhance students' motivation, engagement, learning outcomes, and social skills (Tom, 2015; Lanza et al., 2008; Karl and Zender, 2022). Furthermore, recent studies have suggested that teamwork can also increase students' sense of belonging in programming modules because it provides opportunities for students to actively participate in a supportive and collaborative learning environment. (Mayfield et al., 2022; Moudgalya et al., 2021). This can lead to a greater sense of connection with peers and instructors, which in turn can increase students' motivation and engagement in the course (Mayfield et al., 2022; Stoytcheva, 2021; Zumbrunn et al., 2014).

Progress bar

A progress bar is a visual representation of a student's progress in completing a programming task, such as coding exercises or quizzes (Marwan et al., 2021). A progress bar is an effective tool for monitoring a student's progress in completing programming tasks and providing immediate feedback (Marwan et al., 2021; Nguyen et al., 2021). It can help students identify

areas where they need additional support and provide a sense of accomplishment, which motivates them to continue working towards their goals (Marwan et al., 2021). In gamified programming learning, progress bars can be used to show the number of coding exercises completed or points earned, which encourages students to continue learning (Ally and Prieto-Blázquez, 2014). By using progress bars, instructors can help students feel more connected to the course material and improve their motivation to learn.

In conclusion, previous research has shown gamification techniques, including badges, points, and leaderboards; narratives and storytelling; rapid feedback; role-play; quests and challenges; avatar customization; teamwork; and progress bars can be effective in improving students' motivation, engagement, sense of belonging and academic performance. However, there is a lack of research specifically investigating the use of these approaches in relation to Chinese international students' sense of belonging at British universities and their career interests related to the subjects. Therefore, there is a need for further research to determine the effectiveness of the individual and combination of the techniques in specific educational contexts for different users.

2.6.6 Successful implementation of gamification in programming learning

There are many successful gamification applications that create interactive classroom experiences, and programming languages that incorporate gamification techniques. The success of the gamification applications is inspiring for the gamification design of the current study.

One example of a successful implementation of gamification in programming learning is CodeCombat, an online platform that teaches programming through gamification. In this platform, users play the role of a wizard and complete coding challenges to progress through a fantasy world. The gamification techniques used in CodeCombat include points, badges, levels, and a leaderboard to encourage engagement and competition. CodeCombat was found effective in increasing students' motivation and knowledge retention compared to those who used traditional instructional methods (Kroustalli and Xinogalos, 2021). It was found that the gamification elements in CodeCombat were effective in promoting a growth mindset in students, as they were more likely to view coding challenges as opportunities to learn and improve (Kroustalli and Xinogalos, 2021).

Another example is Kahoot!, a game-based learning platform designed to create an interactive classroom experience. The gamification techniques used in Kahoot! include points, timers, and a leaderboard to promote engagement and competition (Jones et al., 2019; Cameron and Bizo, 2019; Plump and LaRosa, 2017). While Kahoot! is often used for general educational purposes, it can also be effectively utilized in programming education. Kahoot! can be used to quiz students on programming concepts, syntax, and problem-solving techniques. For example, instructors can create quizzes that test students' understanding of code snippets, debugging practices, or the application of specific algorithms. A study by Plump & LaRosa (Plump and LaRosa, 2017) found that Kahoot! led to increased learning outcomes and engagement among students. It showed that Kahoot! was effective in improving both cognitive and affective learning outcomes. In addition, the study found that Kahoot! was particularly effective in promoting a positive emotional state among students.

Scratch is another programming language and online community that enables users to create interactive stories, games, and animations using a drag-and-drop interface (Resnick et al., 2009). Scratch incorporates gamification techniques such as badges, a project gallery,

and a social network to promote engagement and collaboration (García-Gutierrez and Hijón-Neira, 2020). Studies have shown that Scratch is effective in increasing student motivation and creativity. A study by García-Gutierrez and Hijón-Neira (2020) found that Scratch encouraged students to continue programming outside of class and to be more satisfied with their programming projects. The use of Scratch has also been linked to improved computational thinking skills in students (Basawapatna et al., 2010). A study by Maloney et al. (2010) found that Scratch helped students develop skills in problem-solving, logical reasoning, and algorithmic thinking, and the use of gamification techniques such as badges, a project gallery, and a social network has been effective in promoting engagement and collaboration among learners.

There is also a trend of combining gamification with new technologies to scaffold learning, which also shows positive outcomes. The difference between 2.5D and 3D environments lies in their dimensionality and visual representation. A 3D environment provides a full three-dimensional space where users can navigate and interact with objects and other users from any angle, offering a more immersive experience. In contrast, a 2.5D environment uses three-dimensional models but presents them in a two-dimensional plane, creating an illusion of depth without full 3D navigation. This makes 2.5D environments simpler and often more accessible while still providing some level of spatial interaction. The study conducted by Zhang et al. (2022) aimed to explore the potential of 3D virtual environments in supporting the needs of Chinese learners in western education. A cross-cultural collaboration was set up between Chinese and western researchers to design and develop a 3D contextual interactive games (3DCIGs). The 'Wonderland' environment was designed to be culturally responsive and to promote cultural awareness, well-being and social inclusion with a set of interactive tools and collaborative gamification activities. The researchers found that the 'Wonderland' environment was effective in supporting the needs of Chinese learners and can help them to feel more included in the western education system and that it had the potential to promote positive outcomes such as increased motivation, engagement and socialisation. Similarly, Barata et al. (2013) designed a 2.5D virtual learning environment named AvatarWorld, enabling students to create their avatars and explore the learning content in the virtual world with rich interactions. The study indicated that gamification has a strong potential to motivate and engage students in courses requiring creative capabilities by enhancing their autonomy.

In conclusion, the literature suggests that gamification can be an effective tool to increase student engagement, motivation, and learning outcomes in programming modules. The reviewed platforms, including CodeCombat, Kahoot!, Scratch, 3DCIGs and AvatarWorld, have implemented various gamification techniques such as points, badges, levels, and leaderboards to promote engagement and collaboration among learners and are inspiring for the gamification design in the current study (see Table 2.4). The literature also highlights the importance of understanding the needs and interests of students and designing gamification elements that align with those needs. However, gamification is not a one-size-fits-all solution and the effectiveness of gamification may depend on various factors such as the course content, student demographics, and learning objectives. Thus, it is important for researchers to carefully consider the implementation of gamification in programming modules and to continually evaluate its effectiveness.

Tool/Game	Platform	Gamification Techniques	Key Features	Outcomes
Code Combat	Online	Points, Badges, Levels, Leaderboard	Fantasy-themed coding challenges, Role-playing	Increased motivation and knowledge retention, Promotes growth mindset
Kahoot!	Online	Points, Timers, Leaderboard	Interactive quizzes, Real-time feedback	Improved learning outcomes and engagement, Positive emotional state
Scratch	Online Community	Badges, Project Gallery, Social Network	Drag-and-drop interface for creating stories/games	Increased motivation and creativity, Improved computational thinking skills
3DCIGs (Wonderland)	3D Virtual Environment	Interactive Tools, Collaborative Activities	Culturally responsive design, Promotes social inclusion	Increased motivation, engagement, and socialization for Chinese learners
Avatar World	2.5D Virtual Environment	Avatars, Rich Interactions	Customizable avatars, Exploratory learning content	Enhanced autonomy, Motivation and engagement in creative courses

Table 2.4: *Comparison of Gamification Tools and Their Features*

2.6.7   Challenges and limitations of gamification in educational contexts

Despite the success of the gamified learning platforms and applications, and the promise of using gamification techniques to enhance programming learning by increasing students' engagement, sense of belonging and motivation, the implementation of gamification still faces challenges and limitations that must be addressed to maximise its effectiveness in educational practices.

One of the challenges of gamification is the over-reliance on extrinsic motivation (Hamari and Koivisto, 2013). Gamification often uses rewards such as badges, points, and leaderboards to motivate learners. While these rewards can be effective in the short term, they may not be sustainable in the long term. Learners may lose interest in the rewards or may become demotivated if they do not receive the rewards they were expecting (Sailer et al., 2017). Furthermore, learners may focus more on the rewards than on the learning itself, leading to a lack of intrinsic motivation, which is essential for long-term learning and retention (Deci et al., 1999).

Another limitation of gamification is the lack of customization and personalization (Hamari et al., 2014). Gamification often uses a one-size-fits-all approach, where all learners are given the same challenges and rewards. This approach can be problematic because learners have different needs, interests, and learning styles. A gamified system that is not customised or personalised may not be effective for all learners. For example, learners who are advanced may find the challenges too easy, while learners who are struggling may find the challenges

too difficult (Mekler et al., 2013).

Specific to programming education, one of the key challenges is the complexity of concepts and the need for problem-solving skills. Gamification might oversimplify these complexities, leading to a superficial understanding of programming principles. For instance, a game-based challenge might focus on syntax rather than deeper algorithmic thinking, which is crucial for mastering programming. Additionally, programming requires sustained concentration and logical thinking, which can be disrupted by frequent rewards and game mechanics that might encourage short-term engagement over long-term comprehension.

For Chinese learners, cultural factors can also play a significant role. Chinese students often come from educational backgrounds that emphasize rote memorization and high-stakes testing. This contrasts with the interactive and often informal nature of gamified learning environments. Consequently, Chinese learners might initially struggle with the transition to a gamified system that prioritizes creativity and exploration over traditional study methods. Moreover, the competitive aspect of gamification might exacerbate stress and anxiety, particularly in a highly competitive academic culture.

Gamification also has the potential for distraction and disengagement (Hanus and Fox, 2015). While games can be engaging, they can also be distracting. Learners may become so engrossed in the game that they lose sight of the learning objectives. Furthermore, learners may become disengaged if the gamified system is not well-designed or if the rewards are not meaningful. If learners do not see the relevance of the gamified system to their learning goals, they may become bored or disengaged (Hamari et al., 2014).

In conclusion, although gamification has the potential to increase students' engagement, sense of belonging, and motivation in programming modules, there are also several challenges that must be addressed to maximise its effectiveness. These challenges include the over-reliance on extrinsic motivation, the lack of customization and personalization, and the potential for distraction and disengagement. Specifically, in programming education, there is a risk of oversimplifying complex concepts and disrupting sustained concentration. For Chinese learners, cultural differences may impact the effectiveness of gamification. Gamification can be an effective strategy for increasing students' engagement and motivation, but it must be carefully designed and implemented to avoid the pitfalls identified in the literature. To maximise the effectiveness of gamification, researchers should consider using a combination of intrinsic and extrinsic motivation, customising and personalising the gamified system to meet the needs of individual learners, and ensuring that the rewards are meaningful and relevant to the learning objectives.

2.6.8 Conclusion

The review explores the potential of using gamification to increase Chinese international students' sense of belonging in the UK and discusses the advantages of using gamification in programming learning, including its potential to help students learn complex coding concepts in an enjoyable and interactive way, its ability to positively affect students' intrinsic motivation and engagement, its effectiveness in promoting active learning and knowledge retention, and its potential to improve students' mental health and well-being. It also presents a gamification design framework including the gamified learning theory, 6D framework, MDA framework and the gamification design process.Various gamification techniques have also been identified to increase students' motivation and engagement in programming education,

including badges, points, and leaderboards, narratives and storytelling, rapid feedback, role-play, quests and challenges, avatar customization, teamwork, and progress bars. Successful implementations of gamification in programming learning, such as CodeCombat, Kahoot!, and Scratch, are also discussed. These examples demonstrate how gamification can create interactive classroom experiences and programming languages that incorporate gamification techniques, which have been effective in increasing students' motivation, engagement, and knowledge retention.

Overall, the literature suggests that gamification can be an effective tool to increase student engagement, motivation, and learning outcomes in programming modules, and can contribute to improving Chinese international students' sense of belonging in the UK. However, the effectiveness of gamification depends on various factors, such as the design of the gamified system, the characteristics of the learners, and the learning context. Therefore, it is crucial to carefully design and implement gamification in educational settings based on the specific needs and preferences of the learners.

2.7 Discussion and implications

2.7.1 Synthesis of findings from the literature review

The literature highlights several significant challenges that Chinese international students face in developing a sense of belonging in fundamental programming modules. These challenges include language barriers, cultural differences, and the distinct educational background of Chinese students. Language barriers can impede students' ability to comprehend teaching materials and participate in class discussions, leading to feelings of isolation and a lack of academic confidence. Cultural differences, such as the collectivist orientation of Chinese students versus the individualistic approach prevalent in Western education, further exacerbate the sense of disconnection. Additionally, the rote learning and exam-focused nature of the Chinese education system contrasts sharply with the critical thinking and problem-solving emphasis in British universities, making the transition difficult for Chinese students.

These challenges significantly affect learning outcomes by reducing engagement, participation, and motivation. The lack of a sense of belonging can lead to increased stress, anxiety, and academic pressure, further hindering students' academic performance and overall well-being. Addressing these challenges is crucial for improving the learning experiences of Chinese international students in programming modules.

The literature also suggests that gamification can be an effective tool for enhancing the learning experiences and sense of belonging for Chinese international students. Gamification techniques, such as points, badges, leaderboards, and collaborative tasks, have been shown to increase motivation, engagement, and a sense of community among learners. By integrating game design elements into educational contexts, gamification provides immediate feedback, fosters healthy competition, and promotes collaborative learning, all of which are particularly beneficial for Chinese students who may feel isolated in a new educational environment.

However, the effectiveness of gamification depends on its alignment with the learning objectives and the specific needs of the learners. It is essential to carefully design gamification strategies that address the identified challenges and leverage the motivational drivers of Chinese students. For instance, incorporating storytelling and narrative elements can make

learning more relatable and engaging, while personalized gamification experiences can cater to individual learning preferences and levels of proficiency.

2.7.2 Addressing Theoretical and Empirical Gaps

The review identifies several theoretical and empirical gaps that need to be addressed. These include the need for more research on the biases and stereotypes affecting Chinese students, the specific factors influencing their learning experiences, and the practical application of gamification in real classroom settings. Moreover, there is a lack of empirical evidence on the actual performance of gamification in enhancing learning outcomes for Chinese international students.

Addressing these gaps requires a comprehensive approach that combines theoretical insights with practical interventions. The research should focus on developing and testing gamification strategies that are specifically tailored to the needs of Chinese students, involving understanding their cultural background, learning preferences, and the unique challenges they face in programming education. Additionally, longitudinal studies are needed to assess the long-term impact of gamification on students' sense of belonging and academic success.

In conclusion, the potential of using gamification to enhance Chinese students' sense of belonging and learning experience in programming education is promising. However, it is crucial to address the specific challenges faced by these students and design gamification strategies that are tailored to their needs. By integrating gamification into learning experience design, educators can create a more engaging, motivating, and supportive learning environment that promotes the academic success and well-being of Chinese international students.

2.7.3 Research aims and questions

The aim of the study is to explore the potential of using gamification to enhance Chinese students' sense of belonging and learning experience in programming education. The research questions (RQs) are:

- **(RQ1)** What are the primary challenges that Chinese international students face in developing a sense of belonging in fundamental programming modules, and how do these challenges affect their learning outcomes?

  This question establishes a foundational understanding of the specific difficulties these students encounter, both socially and academically. By identifying these challenges, the research can better tailor subsequent interventions aimed at improving their educational experiences.

- **(RQ2)** How effective is gamification in enhancing the learning experiences and sense of belonging for Chinese international students in fundamental programming modules, and what specific gamification features are most impactful?

  This question directly follows from RQ1, applying the insights gained about challenges to test and refine gamification strategies. It focuses on evaluating the impact of gamification and identifying which elements (e.g., points, badges, leaderboards, collaborative tasks) are particularly effective in addressing the challenges previously outlined.

- **(RQ3)** (exploratory) How can AI-enhanced gamification design be optimally designed to support the unique learning needs of Chinese international students in programming courses, particularly in fostering a sense of belonging and improving academic outcomes?

  This question advances the inquiry from gamification to the application of ITS, using the knowledge gained about effective gamification features to inform the design of ITS. It explores how ITS can be tailored to not only support academic learning but also enhance the sense of belonging, thereby providing a comprehensive support system for these students.

Each question builds logically on the findings of the previous one, creating a cumulative body of knowledge that supports a comprehensive understanding of the interventions being studied. By sequentially addressing the challenges, the effectiveness of gamification, and the potential of ITS, the research aims to systematically tackle both the immediate and extended needs of Chinese international students in programming courses. The research intends to ensure that the research outcomes are practically applicable, providing clear directives for educational technology development and curriculum design tailored to the needs of international students.

Chapter 3

Methodology

3.1 Introduction

The methodology of a research project serves as the structural framework, guiding the entire study by outlining the principles, methods, and practice employed by the researcher (Fetters et al., 2013). It encompasses the specific data collection and analysis techniques and the theoretical framework underpinning the research. A clear understanding of the methodology is crucial for grasping how the research was conducted and how its results were obtained, including considerations of validity, reliability, and overall quality.

In this study, we adopted a design-based approach (DBA) with mixed data collection methods and triangulation to explore the learning experiences of Chinese international students in programming modules. The research comprises three studies, each with two phases, employing a combination of questionnaires, focus groups, and participatory observations for data collection. Furthermore, we developed, prototyped, and evaluated an intelligent tutoring system that leverages AI and gamification techniques to scaffold programming modules and enhance the sense of belonging among the target student group.

The studies were conducted within the context of fundamental programming modules at the University of Sheffield, specifically the INF6027 'Introduction to Data Science' and INF6032 'Big Data Analytics' modules at the Information School. Participants included two cohorts of Chinese students enrolled in these modules during the 21/22 and 22/23 academic years. Figure 3.1 summarizes the sequential research design, outlining the research objectives and questions addressed in each study.

In the subsequent sections, we will discuss in detail the philosophical underpinnings, mixed methodology, research methods, research strategy, sequential research design, ethical considerations, and research quality of this study.

3.2 Research philosophy

Research philosophy underpins the methodological choices in a study, reflecting the researcher's beliefs and assumptions about the nature of knowledge (epistemology) and reality (ontology). This study adopts a pragmatist philosophy, which aligns with relational epistemology and non-singular ontology, as it best suits the research objectives and the complex nature of the phenomena being investigated.

3.2.1 Pragmatism

Pragmatism advocates for the practical application of research findings and the use of multiple methods to address research questions (Johnson et al., 2007). This philosophy is particularly suitable for this study, as it explores both the effectiveness of gamification mechanics (quantitative aspect) and the experiences of Chinese international students in British universities (qualitative aspect). Pragmatism's flexibility supports the mixed-methods approach of this research, enabling a comprehensive understanding of the impact of gamification on students' sense of belonging.

3.2.2 Relational epistemology

Relational epistemology posits that knowledge is constructed through interactions and relationships (Walsh et al., 2021). This perspective aligns with the study's focus on the social and relational aspects of students' sense of belonging and the interactive nature of the gamification interventions. It emphasizes the importance of understanding the participants' experiences and perspectives, acknowledging that knowledge is not static but dynamically co-constructed.

3.2.3 Non-Singular ontology

Non-singular ontology recognizes the existence of multiple realities and perspectives, challenging the notion of a single, objective truth (Hjørland, 2002). This ontological stance is relevant to the study as it acknowledges the diversity of student's experiences and the complexity of their sense of belonging. It supports the exploration of various interpretations and experiences, providing a more nuanced understanding of the phenomena under investigation.

3.2.4 Justification for the choice of philosophies

While other research philosophies such as positivism, interpretivism, or critical realism could have been considered, pragmatism, relational epistemology, and non-singular ontology were chosen to align with the study's objectives and the nature of the research questions. Positivism, with its emphasis on objective measurement and quantifiable observations, would not adequately capture the subjective experiences and perceptions of the students. Interpretivism, although focused on understanding social phenomena from the participants' perspectives, might not sufficiently address the practical implications of the research findings. Critical realism, which seeks to uncover underlying mechanisms and structures, may not fully embrace the dynamic and context-dependent nature of students' sense of belonging.

In contrast, the chosen philosophies allow for a flexible and comprehensive approach, integrating both quantitative and qualitative methods to explore the practical consequences of gamification on students' sense of belonging. They emphasize the importance of context, the role of the researcher-participant interaction, and the recognition of multiple realities, which are crucial for understanding the complex dynamics of international students' experiences in higher education.

3.2.5   Implications for the current research

Adopting pragmatism, relational epistemology, and non-singular ontology has significant implications for the research design, data collection, and analysis. It necessitates a mixed-methods approach that combines quantitative measures of gamification effectiveness with qualitative exploration of students' experiences. It also requires a reflexive and adaptive research process, where the researcher engages with participants to co-construct knowledge and continually reassesses the research approach in light of emerging findings. Ultimately, this philosophical framework ensures that the research is grounded in a pragmatic and relational understanding of the social world, providing valuable insights into the impact of gamification on Chinese international students' sense of belonging in British universities.

3.3   Mixed methodology

Guided by the pragmatic philosophy and addressing practical research considerations, this study adopts a mixed methodology. Mixed methodology is identified as the most suitable approach for this research, allowing for an integrated analysis of both quantitative and qualitative data. This combination provides a deeper and more nuanced understanding of the research topic (Johnson et al., 2007). This section elucidates the quantitative and qualitative approaches and justifies adopting mixed methods in the current research context. The subsequent sections will detail the specific research methods employed within this mixed-method framework, including questionnaire surveys, focus group interviews, participatory observations, and computational analysis.

3.3.1   Quantitative approach

The quantitative approach, characterized by the collection and analysis of numerical data, is instrumental in identifying patterns and testing hypotheses across larger samples, thereby facilitating generalizations to the broader population. This method is particularly effective in quantifying variables and examining relationships at scale, supported by statistical tools and software like Python, SPSS, and R. Despite its strengths in providing systematic and extensive analyses, the quantitative approach has limitations. It may overlook the complexity of individual experiences and contextual nuances, relying heavily on statistical interpretation, which can introduce error or reductionism.

3.3.2   Qualitative approach

The qualitative approach focuses on understanding human behavior and experiences in their natural settings. It is well-suited for generating hypotheses and offers rich, detailed insights into specific phenomena through methods like interviews, focus groups, and observations. While qualitative research excels in contextual and exploratory inquiry, it faces challenges related to subjectivity, researcher bias, and the potential lack of generalizability. Nevertheless, its open-ended nature allows for a comprehensive exploration of complex social dynamics and rare phenomena (Merriam and Grenier, 2019).

3.3.3   Mixed methodology

Adopting a mixed methodology integrates the strengths of both qualitative and quantitative methods, addressing their respective weaknesses. It enables triangulation, enhancing validity and reliability, and facilitates a more holistic view of the phenomenon under study from multiple perspectives. Despite challenges such as increased complexity, time, and resource demands, mixed methodology remains invaluable for its comprehensive insights and ability to inform practical solutions (Caruth, 2013).

The mixed methodology is particularly apt for this study, as it aims to understand the multifaceted experiences of international students' sense of belonging and learning experiences. It combines quantitative data from questionnaires, offering objective insights into learning behaviors, with qualitative data from focus groups and observations, which reveal deeper emotional and experiential facets. This dual approach enables a nuanced understanding of the student's experiences, informing the development of a tailored AI and gamification-enhanced tutoring system.

In sum, the flexibility, comprehensiveness, and rigor of the mixed methodology align perfectly with the goals of this research, making it the ideal choice for exploring the complex phenomenon of international students' sense of belonging and enhancing their academic transition with technology.

3.4   Research strategy

Following the explanation of the mixed methodology, this section delves into the research strategy, which details the overall plan and procedures for data collection and analysis. This section ties together the mixed methodology and the specific research methods into a coherent strategy, explaining how these methods are structured and sequenced throughout the research. It includes the rationale for the sequence of studies, the integration of data sources, and the methodological justifications for the choices made.

The research was divided into three sequential studies, each of which had a specific research question and associated research strategies and methods. Study 1 aimed to identify Chinese students' needs and the challenges they met regarding their sense of belonging and learning experience in introductory programming modules through a survey with a questionnaire and a focus group. The outcome of the first study laid the foundation of the design objectives of the gamification invention in the second study. Study 2 designed two gamification classes through brainstorming sessions with the lecturer and conducted field studies to explore the effectiveness of various game elements in introductory programming modules to increase Chinese students' sense of belonging and improve their learning experience. The data in the second study were collected through questionnaires, focus groups and observations. The findings of the second study informed the development of the ITS in the third study. Study 3 adopted a design-based approach to design and prototype an intelligent tutoring system, and evaluated its performance in providing personalised and appropriate support to scaffold coding learning, as well as its potential to increase Chinese international students' sense of belonging through computer simulation. The third study was designed to address the issues in the introductory programming module identified in the first study and the weakness of the gamification design for the introductory programming module in the second study. The research design, including the input and output for each phase of the three studies, is

Study 1 | *Phase 1*: *A questionnaire survey*
Input: Literature review
Output: Gained basic understanding of the challenges Chinese students faced regarding sense of belonging and code learning in PGT data science programmes.

Study 1 | *Phase 2*: A focus group interview
Input: Questionnaire findings from Study 1 Phase 1
Output: Gained more in-depth understanding of the challenges Chinese students faced regarding sense of belonging and code learning in PGT data science programmes and adressed RQ1.

Study 2 | *Phase 1*: *Gamification design*
Input: Literature review and findings from Study 1
Output: Designed two gamification sessions for an introductory programming course (INF 6032) using a set of game elements and mechanisms to engage target students and increase their sense of belonging.

Study 2 | *Phase 2*: *Pilot studies*
Input: Gamification design from Study 2 Phase 1
Output: Implemented and evaluated the two gamification sessions; identified the effective gamfication elements for increasing students' sense of belonging and the areas of improvement in the design; addressed RQ2.

Study 3 | *Phase 1*: *Explorary prototype of ITS*
Input: Findings from Study 2
Output: Designed a LLM-enhanced ITS leveraging the gamification design piloted in Study 2 and added AI features to improve the effectiveness of the system in increasing students' sense of belonging; piloted and iterated the ITS with invited lecturers, TAs, experts and practitioners.

Study 3 | *Phase 2*: *Computer simulation study*
Input: ITS from Study 3 Phase 1
Output: Conducted a computer simulation study to evaluate the effectiveness and potential of the ITS in increasing students' sense of belonging by NLP analysis and human evaluation; addressed RQ3.

Figure 3.1: *Input and output of each phase of the studies in the current sequential research design.*

detailed in Figure 3.1. The timeline of each phase in the current research was illustrated in Figure 3.2.

3.4.1 Research settings

To conduct a composite and multifaceted investigation of the implementation of gamification in solving practical issues, the research focused on in-depth research of a specific educational scenario (i.e. Chinese postgraduate students enrolled in the introductory programming modules in the Information School at the University of Sheffield). There are several reasons for choosing the specific group for the research. Firstly, as one of the leading research universities in the UK with a global reputation for academic quality, the University of Sheffield, where the research is conducted, attracts a considerable and increasing amount of international enrollments, especially those from China. The internationalism and representativity of the University of Sheffield make it an appropriate location for investigating international students' academic transition. Moreover, as a top department in the university, the Information School is characterized by an international learning environment, interdisciplinary expertise, and distinctive research in information and digital technology. The diversity of students' academic backgrounds and the international excellence of gamification and human-computer

Gamification design

Date: 20th Feburary-14th March 2022
Duration: 1 month

| 1 | Study 1 | 2 | Study 2 Phase 1 | 3 | Study 2 Phase 2 |

Survey

Pilot studies

Questionnaire:
Date: 10th-17th Janurary 2022
Duration: 1 week

Focus group:
Date: 20th Janurary 2022
Duration: 2 hours

Implementation, observation and questionnaire:
Date: Between 14th-24th March 2022
Duration: 2 weeks

Focus groups (4):
Date: 24th-27th March 2022
Duration: 1 hour per focus group interview

Figure 3.2: *The timeline of each phase in the research, including the date and duration of each study.*

interaction research add assets to the investigation of gamified course design. The number of Chinese students in the introductory programming modules is relatively large compared to other programs in the Information School and the university, which makes it easier to access an adequate sample. In addition, many students did their undergraduate studies in diverse subjects, and thus, this research provides a good opportunity for increasing their sense of belonging in the current subject. Convenience is another important reason for choosing the introductory programming modules, including INF6027 Introduction to Data Science and INF6032 Big Data Analytics, to conduct research, as the researcher can access and be involved in the module design.

3.4.2 Study 1: Formative study

The first study aimed to address the first research question proposed in section 2.7.3 in Chapter 2:

RQ1: What are the primary challenges that Chinese international students face in developing a sense of belonging in fundamental programming modules, and how do these challenges affect their learning outcomes?

Study 1, a formative study, adopted a mixed-methods strategy to ensure a comprehensive data collection process with extensive breadth. This method amalgamated quantitative and qualitative research techniques. The study unfolded in two distinct phases: an initial questionnaire survey aimed at discerning the challenges encountered by students and a subsequent series of focus group interviews designed for more profound exploration.

The first phase involved administering questionnaires to Chinese students at the Information School to gather quantitative data. This step specifically assessed students' sense of community and their perspectives on an introductory programming module (INF6027), a key component of the MSc in Data Science program at the University of Sheffield. The second

phase took a more nuanced approach, with in-depth focus group discussions involving a select group of students. These conversations aimed to glean qualitative insights into students' experiences, perceptions of their academic transition, and sense of belonging.

Data analysis was bifurcated according to the nature of the data; quantitative responses were evaluated through descriptive and inferential statistics, whereas qualitative feedback was interpreted through thematic analysis, as outlined by Braun and Clarke (2006). Insights derived from this initial study were anticipated to significantly shape the intelligent tutoring system's design and refinement in subsequent research endeavors. Detailed accounts of the question construction, participant recruitment strategies, sampling methodologies, and data analysis techniques employed in each phase of Study 1 follow in the ensuing sections.

Phase I of Study 1: A questionnaire survey

Questionnaire design

Questionnaire surveys are a staple in social science research, offering a quick and cost-effective means to collect data from a large sample (Nayak and Narayan, 2019). They can gather both quantitative and qualitative information, making them versatile for diverse research questions (Almalki, 2016). However, their reliance on self-reporting can introduce biases, such as social desirability, and designing valid and reliable questionnaires can be challenging.

The questionnaire in the current study was composed of three sections, specifically student background, the extent of sense of belonging, challenges and barriers (see Appendix A). The first section regarding students' background included their gender, age, perceived language skills, communication skills and academic skills, previous educational experiences, needs or motives for studying in the UK and current work/future plans after graduation. The questions regarding background information were designed to investigate students' academic preparation, performance capability and motivation, which are useful in analysing the factors affecting students' sense of belonging. In the second section of the questionnaire, the extent of the sense of belonging was measured by the Belonging Model by Araujo et al. (2014). The Belonging Model has been used and cited by a considerable number of researchers in the field and has been proven valid and efficient in measuring the sense of belonging of different ethnic groups of students in higher education (Strayhorn, 2018). In the third section, the challenges and barriers students' met in coding learning and their academic transition were asked to understand the problems students are facing.

Participants recruitment and sampling methods for the questionnaire survey
The questionnaire was administered online to a sample of Chinese students who enrolled in the MSc in Data Science at the University of Sheffield in the 21/22 academic year. The sampling method was purposive. Purposive sampling is a type of non-probability sampling which involves selecting units (e.g. people, organisations, texts) for inclusion in a study based on specific criteria relevant to the research question. This method is often used when the researcher has a clear idea of the type of cases they are looking for and wants to maximise the chances of finding these cases in the population under study. There were several reasons why purposive sampling was particularly well-suited to the study. As Chinese students were a relatively small and under-researched population within the wider field of international students, purposive sampling allowed the researcher to focus on this specific sub-group. Besides, given the dynamic and rapidly changing nature of the Chinese higher education system, a

purposive approach allowed the researcher to target students who had recently made the transition to studying in the UK, and who were therefore likely to be able to provide the most up-to-date and relevant information. Finally, as the research question was focused on students' subjective experiences, a purposive approach allowed the researcher to select cases which are most likely to provide rich and detailed data on this topic.

There were some potential disadvantages of using purposive sampling which were also taken into account. There was a risk that the sample may not be representative of the population under study because the selection of cases is based on specific criteria rather than being random. This could lead to findings which cannot be generalised to the wider population of Chinese students in the UK. Moreover, as the researcher was likely to have some prior knowledge or assumptions about the cases they are looking for, there was a risk of bias or preconceptions influencing the selection of cases and the interpretation of data. To address the potential drawbacks, purposive sampling was used in combination with interviews and focus groups, which helped to build a detailed and nuanced understanding of this complex and under-researched topic.

Data analysis of questionnaire survey The questionnaire data were anonymised by removing all personally identifiable information from the dataset. This included stripping out any information that could be used to identify an individual respondent, such as name, contact details, and any other unique identifying characteristics. In addition, any identifying characteristics of the responses needed to be obscured, such as timestamps, IP addresses, or other unique identifiers. The anonymised dataset was used for analysis and reporting purposes.

The main data analysis method of the questionnaire survey was descriptive statistics. Descriptive statistics is a powerful tool for understanding data, which can be used to summarise data, make comparisons, and investigate relationships. In the current study, descriptive statistics were used to understand the data in terms of the student's background, and their responses to the 5-likert questions regarding sense of belonging and learning experience.

A number of actions were taken to ensure the reliability and validity of the questionnaire. The reliability and validity of a questionnaire are important considerations in the design and implementation of a survey. The reliability of a questionnaire refers to the consistency of the results that are obtained from the instrument (Taherdoost, 2016). A reliable questionnaire should produce consistent results when administered to the same group of respondents on different occasions. The validity of a questionnaire refers to the accuracy of the results that are obtained from the instrument. A valid questionnaire should produce results that accurately reflect the opinions, attitudes, or behaviours of the target population.

In this study, the Pearson Chi-square test and Cronbach's alpha were deployed to assess the validity of the participant's responses to the questionnaires. Pearson Chi-square test refines the accuracy of the results by finding a correlation between the two variables, while Cronbach's alpha is a statistical measure that indicates the reliability of the questionnaire by measuring the internal consistency among the items. The questionnaire was also piloted with a small group (n=5) of respondents, who were not included in the final sample of the questionnaire, to test for clarity and to identify any problems with the questions. The questions were revised several times based on their feedback to ensure it was clear and concise and were worded in such a way that they can be understood by all respondents. Additionally, the researcher was also trained to administer the questionnaire and is familiar with the

procedures for administering and collecting questionnaire data.

Phase II of Study 1: A focus group interview

Focus groups are particularly effective in fostering a dynamic environment that encourages participants to interact with each other. This interaction often leads to spontaneous discussions and the emergence of ideas that might not surface in the more controlled setting of one-on-one interviews (Galletta, 2013). In our study, this dynamic was invaluable for observing how students expressed and negotiated their opinions on gamification and learning experiences in a social context, which closely mirrors the natural group dynamics they experience in educational settings.

Moreover, the group setting can feel more natural and less intimidating for international students from collectivist cultures, like many from China, compared to one-on-one interactions with a researcher. This cultural familiarity often leads to more open and authentic expressions of their views and experiences, providing richer and more genuine data for our analysis.

Focus groups also allow for the observation of group synergy, where participants build on each other's responses (Stewart and Shamdasani, 2014). This aspect was particularly beneficial in our study as it helped uncover complex layers of students' perceptions and experiences. Participants often validated each other's experiences and collectively articulated common challenges and preferences, providing a comprehensive view of the issues at hand.

Additionally, focus groups are more time-efficient in gathering a broad spectrum of opinions and experiences from multiple participants within the same timeframe than conducting multiple one-on-one interviews. This efficiency was a practical consideration in our study, enabling us to efficiently gather significant data from the student population.

Development of the focus group interview topic guide The interview questions were based on the questionnaire from phase but, with these, the researcher went deeper into the students' experiences and feelings. The interviews were semi-structured, allowing for some flexibility and openness to explore the participants' experiences. The interviews were conducted with a small group of international students in the UK to understand their experiences of academic transition and sense of belonging. The interview questions were divided into three sections. The first section was about students' background, the second section was about their sense of belonging and the third section was about the challenges and barriers they encountered in their academic transition. In the first section, students were asked to share their background information, such as their age, gender, language skills and academic experience. The second section was used to explore the extent of their sense, the way they gained a sense of belonging in the class and the aspects that hindered their belonging. The last section was designed to understand students' learning experiences in introductory programming modules, including the expectations they had and the difficulties they met.

Participants recruitment for the focus group interview Nine participants were recruited from the respondents of the questionnaire. The students were contacted by email as recorded in the questionnaire and invited to participate in a focus group interview about their learning experience and sense of belonging in more depth. The focus group interviews were conducted in the discussion room at the Diamond library at the University of Sheffield, which is quiet and private and has enough space for all of the participants to sit comfortably.

The focus group lasted for approximately 90 minutes and was conducted in the afternoon on 20th January 2022.

Transcription and anonymisation The audio-recorded data were transcribed verbatim and anonymised to protect the participants' identities. All identifying information such as names, locations, and other personal information were removed or replaced with pseudonyms.

Data analysis of focus group interview The data analysis of the focus group interview involved the examination of participants' verbal responses to gain insight into the topic being discussed. This included listening to the audio recordings of the interviews and transcribing them into a written form. The transcripts were analysed to identify patterns, themes, and meanings expressed by the participants as they relate to the topic in question. It allowed for the examination of how the participants perceive and understand the topic, as well as how their experiences and beliefs shape their views.

The data were analysed using thematic analysis, an approach to analysing data that involves coding, categorising, and summarising the data to identify themes related to the research topic (Braun and Clarke, 2006). It is a useful tool for understanding the experiences of participants in a focus group interview, as it allows for the examination of how the participants perceive and understand the topic in question. Data familiarisation is the process before coding to become familiar with the data collected in the focus group interview. In the study, data familiarisation involved reading the transcripts of the interviews, as well as listening to the audio recordings. During this process, the researcher looked for patterns and themes in the data, as well as any emerging ideas or topics that may be relevant to the research topic. This process also involved looking for any potential biases in the data, such as any preconceived notions that may have been expressed by the participants. The data were then coded based on the topics discussed in the focus group interview and were organised into categories and themes.

The validity and reliability of the focus group results were assessed in several ways. Firstly, the researcher conducted an audit trail, which included making notes on any potential biases that were observed in the focus group data. This allowed for the identification of any potential issues with the data that may have impacted the reliability or validity of the results. The results were also validated by comparing the responses of the focus group interview with the responses of the questionnaire survey to identify any discrepancies between the two sets of data, which provided further evidence for the validity of the focus group interview.

3.4.3 Study 2: A field study of the gamification design

Research aim

The second study aimed to address the second research question proposed in section 2.7.3 in Chapter 2:

RQ2: How effective is gamification in enhancing the learning experiences and sense of belonging for Chinese international students in fundamental programming modules, and what specific gamification features are most impactful?

The outcome of the first study laid the foundation for the design objectives of the gamification course in the second study. To address the problems identified in Study 1, the second study proposed a gamification design and explored the effectiveness of various game elements in introductory programming modules to increase Chinese students' sense of belonging and

improve their learning experience. The second study was composed of two phases: the design of the gamified course and an accompanying evaluation taking the form of a field pilot study. The first phase of the study was the design and development of a gamification intervention for two practical sessions in the INF6032 module at the Information School of the University of Sheffield. The design of the gamified course was based on the findings of the first study, literature review and advice of the lecturers. The gamification design was deployed on Blackboard, the learning management system (LMS) adopted by the University.

The evaluation of the gamification design in the second phase of study 2 used a mixed-methods approach, incorporating both quantitative and qualitative data. The quantitative data were collected through a survey (see Appendix B) measuring students' sense of belonging, academic performance, and academic emotions. The qualitative data were collected through participatory observations and focus group interviews to explore their experiences and perceptions in more depth. The data were analysed using descriptive statistics and thematic analysis.

Empirical settings

The study was conducted in the sixth and seventh week of the spring semester of the 21/22 academic year. The gamification study was performed in four practical sessions in two teaching weeks (two practical sessions per week) of the Big Data Analytics module (INF6032), which is one of the core modules of the MSc Data Science programme at the University of Sheffield in the UK. The first two gamified sessions were conducted on 17th March (week 6), and the other two sessions were conducted on 24th March (week 7). The selected practical sessions provide introductory knowledge and hands-on experience in using Python programming in PySpark on Databricks to process big data analytics. Databricks is a cloud-based collaborative platform where users can use programming languages, such as Python, SQL, and R, to perform data analytics. PySpark is an open-source application programming interface (API) to support the collaboration of Python and the computational engine Apache Spark. A variety of learning activities regarding PySpark are also provided in the module to develop students' ability to identify questions and find solutions accordingly.

Theoretical basis

The limitations and complexity of the existing theories and frameworks highlight the gaps that justify the need for a new theoretical framework for the current educational research. Based on the literature review, the GAME Framework is proposed as a simplified version of a gamification design process that consists of four steps: Goals, Actions, Mechanics, and Evaluation (see Figure 3.3). The GAME framework was developed based on the existing theories and frameworks in the fields of educational psychology, learning experience design, gamification techniques and HCI research. It aimed to provide an instructional guideline to create a gamification learning design without getting overwhelmed by too many details or options.

The first component, Goals, should be meaningful and enjoyable for the players. The first step was inspired by User experience (UX) design research, which is the process of creating products that provide meaningful and relevant experiences to users. It involves understanding the needs, preferences and behaviour of the target audience, as well as designing solutions

G   **A**   **M**   **E**

Goals   **Actions**   **Mechanics** **Evaluation**

Learning &   Learning   Gamificaiton   Prototyping,
Social goals experience   design   piloting & iteration
              design (LXD)

| Belonging Model | Bloom's taxonomy | 6D framework | Cognitive Walkthrough |

| SDT theory | Experimental learning | MDA framework | User-centered design |

| Gamified learning theory | Constructivism | | Usability heuristic evaluation |

| | Cognitive load theory | | |

| | Social learning | | |

Figure 3.3: *The application of the GAME framework and associated theoretical basis of each step in the current research.*

that solve their problems and satisfy their goals (Dotson, 2016). Gamified learning is not just adding game elements to a non-game context, but also understanding the psychology and motivation of users. Therefore, it is important to identify the learning and social needs of the students to inform the gamification design. In higher education, gamification has been used to promote collaboration and social interaction among students, while also enhancing their knowledge and understanding of a particular subject (Papastergiou, 2009).

The second component, Actions, refers to the learning activities that could be gamified to engage and tailor the goals. In higher education, the learning activities could include completing assignments, participating in group discussions, and exploring a virtual environment (Marcelo et al., 2014). The second step draws on the learning experience design frameworks and strategies, with the aim of designing the learning objectives and tasks to be gamified that fits the diverse student population, foster active learning, and enhance students' comprehensive skills.

Mechanics is the combination of gamification techniques to support the goals of the game and facilitate the desired actions (Kapp, 2012). The Mechanics step involves selecting and designing game techniques and mechanisms that support the learning objectives and engage students, such as progression, feedback, and customisation to create a personalised and adaptive learning experience for each student. In the current research, the step also includes using mechanics such as social interaction, narrative, and aesthetics to create a sense of community and belonging among students.

The evaluation phase is a critical stage in gamification design, where the design is tested through prototyping, piloting, user studies, and iteration. During prototyping, the design is transformed into a tangible product that users can interact with (Vasilevski and Birt, 2021). In the piloting phase, a small group of users is selected to test the product in a controlled environment, allowing for the identification of any issues or improvements that need to be made before the product is released (Zichermann and Cunningham, 2011). User studies are then conducted to gather data on how users interact with the product and what they find enjoyable or frustrating (Hamari et al., 2014). The data is used to iteratively refine the gamification design, resulting in a final product that is engaging and effective (Werbach et al., 2012). The evaluation phase of gamification design is closely related to the user-centred design approach, which emphasises involving users throughout the design process (Norman and Draper, 1988). Additionally, the evaluation phase draws on usability testing techniques, which are used to assess the ease of use and learnability of a product (Nielsen, 1994). The iterative nature of the evaluation phase also aligns with the agile development methodology, which emphasises flexibility and collaboration throughout the development process.

The GAME framework proposed is designed to be flexible and adaptable to different courses and contexts, while also providing a systematic and evidence-based approach to gamification design in education. Although existing frameworks have their own strengths and limitations, the GAME Framework is used as the primary framework in the current study because it considers the context and stakeholders in the design process, which is crucial in designing gamification elements that are culturally sensitive and relevant to the target audience (Seaborn and Fels, 2015). By breaking down the process into four components, researchers can focus on creating meaningful goals, tailoring learning activities, selecting appropriate gamification mechanics, and evaluating the effectiveness of the design. It also emphasises the importance of emotions in the design process, which is critical in creating

engaging and motivating gamification elements to increase students' sense of belonging in the current study. Besides, it provides a clear and simple structure for the design process, making it easy for the researcher to follow and implement. Above all, the GAME Framework is flexible enough to be applied to a variety of different contexts and types of gamification projects, while still providing a solid foundation for effective design.

Overall, the proposed GAME Framework provides a simplified yet comprehensive approach to gamification design for educational research. By focusing on Goals, Actions, Mechanics, and Evaluation, it allows for a streamlined design process that takes into account the needs and motivations of students. The framework provides a useful tool for researchers looking to incorporate gamification into teaching and learning strategies. The strengths of the GAME Framework make it an ideal choice for the gamification design process in the current study, as it provides a practical and effective approach to designing culturally sensitive and relevant gamification elements. The framework can also be used as a starting point for designers and can be adapted to fit the specific needs of different educational contexts and student populations. By using the GAME framework, this study aims to contribute to the literature on gamification design and its implications for enhancing Chinese international students' sense of belonging in UK higher education. The framework will be tested and validated through a series of studies and iterations in the current research, with a focus on evaluating its effectiveness in enhancing Chinese international students' sense of belonging in introductory programming modules.

Phase I of Study 2: The gamification design

The gamification design was aimed to improve Chinese international students' sense of belonging in the introductory programming module INF6027. The outcome of the first study informed the design objectives and development of the gamification and ITS design in the following studies. Section 2.6.5 has identified a number of gamification elements that have the potential to make students feel more engaged and motivated in the course and increase their sense of belonging. These elements include storytelling with a focus on characters and plot, challenges, experiment points, level-up, leaderboards and rewards.

Specifically, two story-based gamified courses for two practical sessions of the INF6027 module were going to be deployed on Blackboard. The design process began with a brainstorming session between the teaching team of the practical sessions of the INF6027 module and the researcher to come up with a number of possible game elements that could be used in the gamified course. The brainstorming session took the form of face-to-face meetings in the lecturer's office. After the brainstorming session, the lecturer and the researcher identified the game elements that were most suitable for the course and the selected game elements were then incorporated by the researcher into the design of the gamified course. The gamification design was embedded in the Blackboard by using the Wiki feature, which is a collaborative tool of Blackboard that allows users to create and edit content. The Wiki feature allowed the researcher to quickly create and edit webpages without having to use HTML or other web technologies. The prototype of the gamification design was also piloted with three teaching assistants who taught the INF6027 module to ensure usability before its implementation in the practical sessions.

The theoretical framework for designing the gamified learning course and evaluating its impact on students' sense of belonging and learning experience (Figure 3.4) combines the
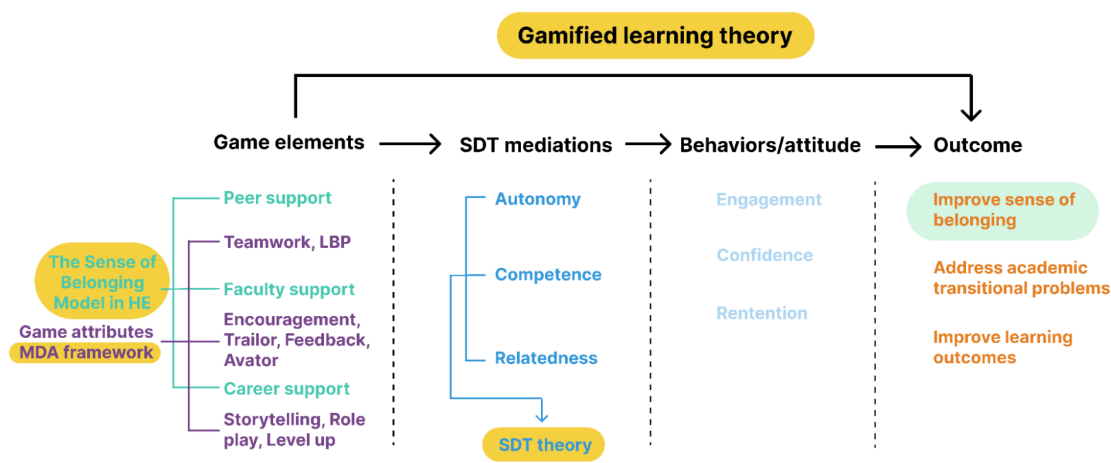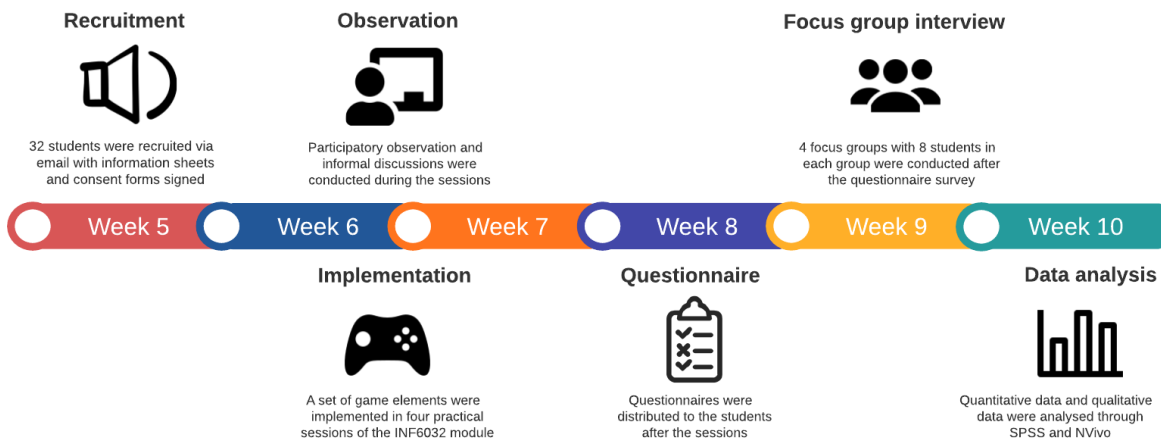
Figure 3.4: *The gamification for students' sense of belonging in higher education framework.*

major components of theories from Landers (2014) Gamified Learning Theory, the Belonging Model proposed by Araujo et al. (2014), the Self-determination Theory (SDT, (Ryan and Deci, 2000)) and the MDA Framework by Hunicke et al. (2004). The Gamified Learning Theory contributes to the understanding of the overall mechanisms of the gamification of learning. It indicates that game elements mediate learners' behaviours and attitudes by moderating learners' motivation, and eventually impact students' learning outcomes. The SDT theory explains the motivational changes and their impact on cognitions, behaviours as well as attitudes as discussed in Section 2.6.4. It provides a framework for understanding the motivational factors that influence engagement in learning activities by emphasising the importance of intrinsic motivation and the three basic psychological needs of autonomy, relatedness, and competence. For the game attributes, the MDA framework is adopted to combine a series of game elements to achieve the expected mechanism and aesthetics. As the current study focuses on improving students' sense of belonging, the Belonging Model provides a three tiers framework to understand students' belonging in higher education, which is useful in aligning game attributes identified in the MDA framework accordingly to increase students' sense of belonging in different dimensions. The integration and adaptation of the above theories in the current research was illustrated in Figure 3.4.

Phase II of Study 2: The field study

The aim of this research was to evaluate the gamification design in the introductory programming module at a British University from the perspective of Chinese students' sense of belonging. In order to obtain in-depth and comprehensive data, this study used a mixed-methods approach. The evaluation framework of the study consisted of three parts: a questionnaire, focus group interviews and participatory observations in order to triangulate the data and obtain a more holistic understanding of the research topic. A questionnaire survey was used to collect data on the student's demographic information, their prior experience with programming, their satisfaction with the course, and their sense of belonging (see Appendix B). Focus group interviews were conducted after the questionnaire to explore the

Recruitment

32 students were recruited via email with information sheets and consent forms signed

Observation

Participatory observation and informal discussions were conducted during the sessions

Focus group interview

4 focus groups with 8 students in each group were conducted after the questionnaire survey

| Week 5 | Week 6 | Week 7 | Week 8 | Week 9 | Week 10 |

Implementation

A set of game elements were implemented in four practical sessions of the INF6032 module

Questionnaire

Questionnaires were distributed to the students after the sessions

Data analysis

Quantitative data and qualitative data were analysed through SPSS and NVivo

Figure 3.5: *The timeline of the second study, including the participant recruitment, implementation and evaluation of the gamification.*

students' experiences with the course in more depth and to understand how the course has impacted their sense of belonging. Participatory observations were also adopted to observe the students' interactions with each other and with the course material, in order to better understand the dynamics of the course. The questionnaire was used to quantitatively collect data on Chinese students' perceptions of the gamification design in the introductory programming module. The focus group interviews and participatory observations, on the other hand, were used to qualitatively explore Chinese students' views and experiences in detail. The timeline of phase II of study 2 was illustrated in Figure 3.5.

Sampling and recruitment The participants' demographic features in the second study were consistent with those in the first study. This consistency was intentional, as all participants were recruited from the same cohort of students. Such continuity ensures that any observed differences in study outcomes can more reliably be attributed to the interventions and variables being tested rather than differences in the participant pool.

The researcher recruited 32 participants by approaching Chinese students at the Information School of the University of Sheffield who enrolled in the INF6032 Big Data Analytics module in the spring semester of the 21/22 academic year and invited them to participate in the study. The approach was face-to-face in the lecture room and via email. The researcher explained that the study would involve participating in gamified learning activities that would be used to improve students' sense of belonging in the introductory programming module INF6032, being observed during their participation, completing questionnaires and attending focus group interviews. Besides, the researcher explained that participation in the study was anonymous and voluntary and that the students could withdraw from the study at any time. The researchers used a purposive sampling method to select participants for the study. All of the participants participated in both questionnaires and focus group interviews, agreed to be observed during the implementation of gamification, and allowed online behavioral data to be collected for learning analytics.

Online questionnaire The questionnaire used in this study was used to measure students' sense of belonging after the implementation of the gamification design and compared

with the questionnaire findings in the first study before the gamification intervention with the same set of students. It consisted of four sections, including personal information, sense of belonging, academic emotions and gamified learning experience. Students' demographic information, such as gender, level of programming skills, study abroad experience, and undergraduate educational background, was asked in the first section (See Appendix B).

The second section measures participants' sense of belonging at different levels based on the instrument from the sense of belonging scale questionnaire proposed by Hoffman et al. (2002) (see Appendix F): 1)Peer Level: Questions assessed comfort in discussing class materials, engagement, sense of community, and the impact of gamification on peer-level belonging; 2)Departmental Level: Items evaluated recognition by faculty, approachability of instructors, integration into the educational culture, and departmental pride; 3)Subject-related Career Level: Questions gauged interest in data science, application of knowledge, career aspirations, confidence in tackling projects, and the influence of gamification on career-related belonging.The items were rated on a 5-point scale, with 1 indicating strong agreement and 5 indicating strong disagreement. A higher score on this scale indicates a stronger sense of belonging.

The questions in the third section explored participants' emotional responses to the learning session using a 5-point Likert scale, including questions about motivation, focus, relaxation, satisfaction with the learning and teaching process, enjoyment, and negative emotions (e.g., boredom, hopelessness, anxiety, anger). These items were adapted from the Academic Emotions Questionnaire (AEQ) developed by Pekrun Pekrun et al. (2002)(see table 3.1). The fourth and final section asked participants' experiences with the gamified system through a 5-point Likert scale and an open-ended question: 1)Interface Design: Smoothness of experience, ease of access, and clarity of instructions; 2) Game Elements: Ratings for various elements like an alternative reality, points and leaderboards and rewards; 3)Open-ended Feedback: Space for participants to provide suggestions or comments. These questions were designed based on existing literature on user experience and gamification elements in educational contexts (Deterding et al., 2011a).

Table 3.1: *Academic Emotions Questionnaire: Reliability of the Trait Scales Pekrun et al. (2002)*

Scales Emotion	Learning-Related Emotions		Class-Related Emotions		Test Emotions	
	α	Items	α	Items	α	Items
Enjoyment	.90	14	.89	15	.90	23
Hope	.86	9	.84	9	.89	16
Pride	.84	9	.86	9	.92	16
Relief	—	—	—	—	.89	14
Anger	.89	14	.85	11	.89	17
Anxiety	.92	18	.89	13	.94	31
Hopelessness	.93	13	.88	10	.94	21
Shame	.90	14	.91	15	.93	19
Boredom	.93	17	.93	14	—	—

Focus group interviews After conducting the questionnaire survey, 4 focus group interviews with 32 participants were conducted in the week after the implementation of gamifi-

cation, further to explore the students' opinions on the gamification design. Each focus group consisted of 8 participants. Criteria for Grouping Participants include: 1) Homogeneity in Academic Experience: Participants were grouped based on similar levels of prior exposure to programming; 2) Diversity in Backgrounds: Within each focus group, we aimed to mix participants with different undergraduate backgrounds, even if their current program was the same; 3) Volunteer Availability: Grouping was also influenced by the availability of participants to attend the sessions, ensuring maximum participation without disrupting their regular academic schedules.

The focus group interviews explored the students' experiences and opinions on the design elements used in gamification. Questions regarding students' sense of belonging to the class, school, and university and how the gamification design had impacted these perceptions were also asked. The significance of using focus group interviews in this context is that it provides a more in-depth understanding of Chinese students' perceptions and experiences of the gamification design, which can help improve the design in the following study. In addition, focus group interviews can also help to identify any potential problems with the gamification design that may not be apparent from questionnaire data alone.

The focus group interviews were conducted in the discussion room at the Diamond library at the University of Sheffield, which is quiet and private and has enough space for all of the participants to sit comfortably. Each of the interviews lasted for approximately one hour and was conducted between 24th and 27th March 2022.

During the interviews, the researcher started by introducing the topic of discussion, and then encouraged the participants to share their opinions and experiences. The focus group interviews began with a general question about the participant's experiences in the course. The researcher then asked more specific questions about the participants' perceptions of the gamification design, such as what they thought about the use of points, story-telling, and leaderboards in the course. The researcher also asked the participants whether they thought the gamification design had helped them to feel a sense of belonging in the course. Throughout the focus group interview, the participants were encouraged to share their experiences and thoughts openly and honestly. The discussion was allowed to flow freely, and the interviewer tried to avoid interruption or steering the conversation in a particular direction. A research assistant was employed to assist with the recordings and note takings.

Participatory observations Observations as a research method were primarily chosen for their ability to provide real-time, unmediated data on the behavior and interactions of students within the educational environment Denzin and Lincoln (2005). This method allows for an authentic glimpse into the everyday dynamics of the classroom and other learning settings, which is often impossible through other data collection methods that rely on self-reported data Marshall and Rossman (2016).

One of the main advantages of using observations is the ability to gather nuanced information about non-verbal cues, interactions, and environmental contexts that influence learning and social integration Kawulich (2005). Observing students in real classroom settings, during group work, or in social settings on campus provided insights into their engagement, participation levels, and the informal learning practice that occur naturally among students Angrosino (2007).

Furthermore, observations allowed us to verify and complement findings from other qualitative methods such as focus groups and interviews Silverman (2010). For example, if students

reported feeling isolated or highly integrated in focus groups, observation provided a way to corroborate these claims by visually assessing the student's integration and interaction with peers and faculty Creswell (2014). This methodological triangulation enhances the validity and reliability of our findings by providing multiple data points on the same phenomena.

Additionally, observations were instrumental in understanding the physical and cultural context of the learning environment, which can significantly affect the sense of belonging and academic success of international students Zhao and Frank (2011). Details such as the layout of classrooms, the accessibility of learning resources, and the informal interactions that occur before and after class were all aspects that observations uniquely captured.

In summary, the use of the observation method provided a comprehensive and detailed view of the behaviors and interactions of students, offering invaluable insights that complemented the data gathered from other methods. This approach ensured a richer, more rounded understanding of the factors influencing the learning experiences of Chinese international students in programming modules Patton (2015).

In the current study, the researcher took on the role of 'observer' and participated in the two practical sessions implementing the gamification approach to observe the Chinese students' experiences and behaviors. Observational data were collected during the session through note-taking, classroom observation, and informal discussions. The rubrics of the observational notes were based on the SDT theory, recording students' emotional and behavioral changes. The researcher's position as an outsider was acknowledged and considered during the research. To mitigate this, the researchers worked closely with the programming module teaching staff.

3.4.4 Study 3: EXPLORATORY PROTOTYPING GAMIFIED ITS

The third study aimed to address the exploratory research question proposed in section 2.7.3 in Chapter 2:

RQ3: How can AI-enhanced gamification design be optimally designed to support the unique learning needs of Chinese international students in programming courses, particularly in fostering a sense of belonging and improving academic outcomes?

Based on the findings from the first and second studies, the researcher designed, developed, prototyped, and evaluated an intelligent tutoring system to address the issues in the introductory programming module identified in the first study and the weakness of the gamification design for the introductory programming module in the second study. Design-based research (DBR) was employed to iterative develop and modify the system by gaining feedback from different stakeholders and experts. The feedback form from the meetings with stakeholders and experts was analyzed using a process-oriented approach to improve the design of the story-based ITS. A simulation study was also conducted to test the performance of the ITS with various simulated potential interactions from the diverse class population following Bloom's taxonomy (Krathwohl, 2002) generated by machine learning techniques. A set of natural language processing analysis methods, along with human evaluation methods, were applied to evaluate the dataset generated in the simulation study.

Empirical settings

The ITS system was developed and evaluated in the setting of the Introduction to Data Science module (INF6027) distributed in the autumn semester of the 22/23 academic year. The instructional content of the ITS in the simulated study was designed for the two-hour-long practical sessions in the sixth and seventh teaching weeks in November 2022. INF6027 is a core module of the postgraduate programme in Data Science at the Information School of the University of Sheffield. The aim of the module is to give students a basic understanding of 'Data Science' and 'Big Data' and to introduce R programming basics. The module format is a combination of lectures, which teach theoretical knowledge, and practical sessions, which provide hands-on practice using R programming and R studio.

Phase I: Development of the system

The system was designed in collaboration with teachers and teaching assistants delivering the INF6027 module and experts as well as practitioners with various expertise in interface design, gamification design, educational technology human-computer interaction, etc. The design process included prototyping, meetings with teachers, teaching assistants, experts and practitioners, and simulation tests. The initial prototype of the ITS was developed based on findings from the previous two studies of the research. The game elements, including storytelling, challenges, level-up, avatar, experiment points, and animated trailer, proved to have positive impacts on international students' sense of belonging and learning experience, which was applied in the initial prototype. To address the problems identified in previous studies, the gamification design was deployed on a web-based application with a set of new functions enabled by large language models (LLMs). The new functions and the LLMs-enabled chatbots' performances in the ITS prototype were modified and improved after each of the meetings.

Advisors recruitment Lecturers, teaching assistants, experts and practitioners were invited to the prototyping pilot studies as advisors and provided feedback on the system's design. Three lecturers and four teaching assistants from the INF6027 module were invited via email. The system prototypes were also piloted by twelve experts and eight practitioners from the fields of gamification, human-computer interaction, artificial intelligence, education, etc., who were approached and invited via Linkedin and emails.

Design process The feedback and suggestions to improve the system were collected through meetings and pilot studies with advisors by note-taking. The notes were fully anonymized without any personal information collected. All of the advisors were introduced to the study and informed about the note-taking methods for feedback collection only and their rights to withdraw at any time.

Phase II: Simulation Study

Computational analysis focuses on evaluating the performance of educational technologies and instructional tools. This method is increasingly popular for investigating large educational contexts (Litwin and Stadnicka, 2019). Techniques such as topic modeling, similarity analysis, and sentiment analysis are employed to assess the efficacy of AI-enhanced chatbots and other advanced educational technologies (Farkhod et al., 2021).

Creation of the Simulated Dataset The dataset consisting of simulated student questions at different cognitive levels and corresponding chatbot responses was specifically designed to evaluate the efficacy of a large language model (GPT-3)-powered chatbot within an educational setting focused on programming. This simulation aimed to replicate a variety of realistic student inquiries that could occur during actual coursework to assess the chatbot's capacity to provide accurate and contextually appropriate answers.

A team of subject matter experts, including lecturers and teaching assistants (TAs) in the module, initially drafted a set of potential questions. These experts used their understanding of typical student challenges and curriculum standards to create questions that were representative of actual student needs and inquiries across the aforementioned cognitive levels.

Once the questions and answers were generated, they underwent a review process in which educational technology experts assessed them for accuracy, relevance, and educational value. Based on feedback, adjustments were made to ensure that the responses were correct and pedagogically effective and engaging.

The data of 1) GPT-3 generated **Q&A** responses were generated based on Bloom's taxonomy, which provides a framework for understanding the different levels of cognitive complexity in learning (Krathwohl, 2002). The three levels of Bloom's taxonomy were integrated into three categories (from low level to high level):

- remember-level (specific question on recalling knowledge, e.g. "What are the required inputs for the tm_map() function in R?"),

- practical-level (practical questions on how to apply knowledge, e.g. "What is the best way to clean up my raw textual data before I start the text mining process in R studio?"),

- synthesis-level (general and exploratory questions beyond the course materials, e.g., "What would be the best way to practice using the data analysis and visualization tools in R?").

This taxonomy helped ensure that the questions varied in complexity and type, mirroring the range of queries a student might pose in a real educational context.

The data of 2) GPT-3 generated code check and explanation were generated for three R programming questions of different complexity, each with one correct answer and four intended incorrect answers, and four rounds of feedback for each question-answer pair, resulting in 60 feedbacks. The model used was text-DaVinci-003, the up-to-date model of GPT-3 as of January 2023, with token count = 200 and temperature = 0.5.

The prompts for generating 1) and 2) are described below for reproducibility:

1. Prompts for GPT-3 generated Q&A responses: Please perform as a teaching assistant in a course teaching R programming for data science and answer questions from students. The student asks [question]?"

2. Prompts for GPT-3 generated code check and explanation: Please check whether the answer to the R programming question [data analysis question] is correct. Correct answer: [ground truth answer] Input answer: [test case] Whether the input answer is

> correct and complete, and why (please start with 'yes' or 'no' and then explain; do not release the correct answer)?

During the training phase, the chatbot was provided with contextual cues beyond the questions' text. These cues include the module topic, the complexity level of the question, and the typical student errors associated with each topic. Additionally, the responses generated by GPT-3 were rigorously evaluated and refined through multiple rounds of expert reviews to ensure they meet educational standards and are contextually relevant. This iterative refinement process is designed to simulate a more realistic interaction where the chatbot's responses are continually updated based on user feedback, similar to how a real-world educational chatbot would improve over time through interaction with students and instructors.

Data analysis The data collected from the simulated dataset were analyzed using natural language processing (NLP) techniques and human evaluation methods. The NLP analysis, including Automated Readability Index (ARI) analysis, topic modeling, similarity analysis, and sentiment analysis, was used to analyze the conversation in the generated dataset. The data were also analyzed through expert screening and research coding to gain better insights into the ITS's performance. Expert screening refers to the process of manually examining the data to identify salient information, while research coding is the process of assigning labels to the identified data to categorize it according to certain criteria. This analysis enabled the researchers to identify ITS performance patterns and areas for improvement.

Evaluation metrics To measure the quality of LLM-enhanced chatbot-generated responses, a measurement metric (Table 6.1) with five dimensions, including Accuracy, Fluency, Empathy, Engagement, and Relevance, was developed built on previous work (Peras, 2018; Deriu et al., 2021). The definition, evaluation methods for the Q&A and code check, and explanation of chatbot models along with examples as illustrated below:

Using the five-dimensional evaluation metrics to examine the GPT-3 enhanced chatbot's performance in introductory programming modules provides an effective and systematic way to measure the quality of the chatbot's responses. The metrics are designed to measure the most important aspects of a conversation, and allow researchers to more accurately assess the quality of the chatbot's responses and quickly identify areas for improvement. The metrics also allow for a detailed, comprehensive evaluation of the chatbot's performance, which can provide valuable insights into the chatbot's ability to effectively communicate with mixed-ability students in introductory programming modules. Furthermore, the metrics can be used to examine the performance of different chatbot models (for the Q&A and code check and explanation purposes) in order to better improve the model for diverse contexts.

Automated Readability Index (ARI) analysis Automated Readability Index (ARI) analysis was conducted using the Textstat library for the evaluation of fluency. ARI analysis was used to indicate the readers' educational level required to read a piece of text. ARI scores range from 0 to 14, with higher scores indicating a higher level of readability. The formula for calculating the automated readability index is 4.71 x (characters/words) + 0.5 x (words/sentences) – 21.43 (Senter and Smith, 1967). The table below illustrates the age and US grade level needed to comprehend text indicated by the ARI scores.

Topic modelling Topic modelling was used to identify the core topics covered by the chatbot to ensure that the chatbot was able to understand the student's queries and provide appropriate responses. The Natural Language Toolkit (NLTK) Python library was applied to extract the nouns from the chatbot conversations with students. The output of this process is

	Definition	Q & A	Code Check & Explanation
Accuracy	How closely the responses match correct answers	Expert Screening	Ground Truth Checking
Fluency	How natural and smooth the responses sound	Expert Screening & Automated Readability Index	Expert Screening & Automated Readability Index
Empathy	How well the chatbot is able to understand and respond to the emotions of the user	Researcher Coding & Correlation of Sentiment Analysis	Researcher Coding & Sentiment Analysis
Engagement	How well the chatbot is able to keep the user interested & engaged in the conversation	Researcher Coding & Word count	Researcher Coding
Relevance	How closely the responses are related to the topic of the conversation	Semantic Similarity & Topic Modelling	[Covered by Accuracy given the Ground Truth of Code Answers]

Table 3.2: *Measurement metric of five dimensions of GPT-3 generated Q&A and code check & explanation.*

Score	Age	Grade Level
1	5-6	Kindergarten
2	6-7	First/second grade
3	7-9	Third grade
4	9-10	Fourth grade
5	10-11	Fifth grade
6	11-12	Sixth grade
7	12-13	Seventh grade
8	13-14	Eighth grade
9	14-15	Ninth grade
10	15-16	Tenth grade
11	16-17	Eleventh grade
12	17-18	Twelfth grade
13	18-24	College student
14	24+	Professor

Table 3.3: *The age and US grade level needed to comprehend text is indicated by the ARI scores (Senter and Smith, 1967).*

a list of topics with the frequency of each topic. The main topics were identified by selecting the nouns that had the highest frequency and can be used to compare the chatbot's responses to the expected topics for the simulated student questions.

The NLTK library was chosen as it is an open-source library for natural language processing, and is widely used to extract nouns as well as calculate their frequency for text processing and analysis. It also allows the researcher to evaluate the topic relevance of the responses, identify the topics and keywords that are most commonly discussed by the chatbot and, more importantly, the topics that the chatbot is not discussing, helping to identify potential areas of improvement.

Semantic similarity analysis To understand the content relevance of the chatbot's response, similarity analysis was applied to measure the semantic similarity between the simulated questions and the correspondent responses using Sentence Transformers. Sentence Transformers is a library of algorithms that are used to measure the semantic similarity between two sentences, which has been developed based on the BERT transformer model.

Sentiment analysis Sentiment analysis is used to evaluate the emotional and social responses of the chatbot. To evaluate the sentiment of the chatbot's response, a sentiment analysis algorithm based on the Textblob Python library was used. Textblob is an open-source Python library for processing textual data and it is built on the NLTK library. It is able to provide a more accurate sentiment analysis than manual sentiment analysis as it is able to analyse large datasets quickly and accurately. The evaluation by sentiment analysis is conducted by measuring the polarity of the responses, which can be classified as positive, neutral, or negative. If the response has a positive sentiment, it shows that the chatbot has successfully understood the user's emotional state and responded appropriately.

To evaluate the empathy and engagement of the chatbots, the Pearson correlation coefficient was also applied to measure the similarity between the sentiment of the questions and the responses. If the correlation coefficient is high, it indicates that the chatbot has understood the user's emotions and responded with a similar sentiment.

Human evaluation In addition to the automated analysis, the generated dataset was also evaluated by the researcher and an invited expert with expertise in data science to gain better insights into the performance of the AI-enhanced ITS. The expert is a data scientist who is familiar with R programming and data science analysis and is qualified to evaluate the dataset. The expert used a screening method and binary code analysis to evaluate the accuracy and fluency of the generated dataset, while the researcher coded the dataset to evaluate empathy and engagement.

To evaluate the accuracy and fluency for Q&A and fluency of code check and explanation without ground truth, the expert proficient in R programming screened the first round of responses to all 60 questions, assuming the first round of responses can represent the performance of GPT-3. The expert screening was also applied to compare the ground truth with the responses for code check and explanation in the aspect of accuracy.

Empathy and engagement of the chatbot's responses were coded by the researcher. The coding process began with the researcher reading each response, and coding the response as either "positive" or "negative", based on whether the response was considered to be supportive and encouraging or not. To ensure the accuracy of the coding process, the researcher inter-coded the responses of the generated dataset.

The human evaluation method helps to understand the chatbot's performance in terms

of subjective aspects such as empathy and engagement, which are difficult to measure using automated analysis. It also provides an additional layer of accuracy and reliability to the evaluation process, which is not achievable using automated analysis.

The validity of the proposed evaluation metrics was assessed by comparing the results of the automated analysis and human evaluation. To ensure the reliability of the evaluation metrics, the researcher inter-coded the responses of the generated dataset. The responses were coded twice and compared to identify any discrepancies. The discrepancies were resolved by discussing and reaching a consensus between the researcher and the invited expert. These processes ensured the validity and reliability of the proposed evaluation metrics.

3.5 Ethics concerns

Ethical considerations play an important role in conducting high-quality research. The primary principles for ethical research in a universal code are a combination of "rigour, respect and responsibility" (Vanclay et al., 2013). This concise summary indicates that researchers should keep professional codes of practice, show respect to the participants, and take responsibility for the research. Following the guideline from The University of Sheffield's Policy on Good Research And Innovation Practices (the GRIP Policy), several aspects of the study are taken into ethical concern, including the informed consent and participant recruitment procedure, the anonymity and confidentiality of the participants and data integrity.

All participants were sent a consent form outlining all detailed information about the research, the role and responsibilities they would take and any potential harms they might face throughout the whole process. The data being collected was entirely anonymous to ensure the confidentiality of participants. All information was stored securely and safely at the University of Sheffield during the study and was only used for research purposes. When the research finished, any identifiable information related to the participants was deleted. Detailed data management plans for each study were developed for the research (See Appendix D). The researcher applied for three ethical approvals from the School before collecting any data (See Appendix E).

3.6 Quality of the research

This section elucidates the methodological rigor and interdisciplinary approach underpinning this research. The study embarked on a sequenced exploration of gamification within educational settings, meticulously designed to unravel the intricacies of gamification's impact on the learning experience, particularly focusing on the cultivation of a sense of belonging among students.

3.6.1 Methodological rigor and interdisciplinary approach

The investigation was partitioned into three distinct yet interrelated studies, each serving a unique purpose and collectively scaffolding a comprehensive understanding of gamification's educational potential. The initial study laid the theoretical groundwork, exploring gamification's capacity to engage and motivate students across diverse backgrounds. This theoretical exploration was pivotal, setting the stage for the subsequent empirical inquiries.

Studies 2 and 3 transitioned from theory to application, rigorously testing the gamification framework developed from Study 1's insights. This progression from conceptual foundations to practical applications underscored the study's methodological rigor, ensuring that the theoretical models were not only sound but also applicable in real-world educational contexts.

3.6.2 Statistical analysis for empirical validation

A critical component of this research was the robust statistical analysis conducted to validate the hypothesis that gamification positively influences students' sense of belonging. To this end, we employed a suite of statistical tests to rigorously examine the data collected from Studies 2 and 3. The choice of statistical tests was guided by the nature of the data and the specific research questions at hand. Specifically, we employed Pearson correlation analysis to examine the relationship between gamification usage and the sense of belonging scores among students. This choice was predicated on the continuous nature of the variables and the interest in assessing the strength and direction of their linear relationship (Schober et al., 2018).

Prior to conducting the analysis, the following assumptions were verified to ensure the reliability and validity of the correlation results:

Normality: The data for both variables were checked for normal distribution using visual inspections of histograms and Q-Q plots, as well as Shapiro-Wilk tests, which confirmed that there were no significant deviations from normality.

Linearity: The linear relationship between the two variables was assessed through scatterplots, which indicated a linear trend in the data points.

Homoscedasticity: The constancy of variance of the residuals across all levels of the independent variable was examined through scatterplots of the residuals, ensuring no evident patterns indicating heteroscedasticity.

These checks were crucial to ensure the reliability and validity of the correlation results. The findings from the Pearson correlation analysis were insightful, which not only supported our hypothesis but also provided a quantifiable measure of the strength of this relationship, emphasizing the potential of gamification to foster a more inclusive and connected learning environment.

3.6.3 Synthesis of theoretical insights and empirical evidence

Integrating theoretical insights from Study 1 with the empirical evidence from Studies 2 and 3 represents a significant contribution to educational technology. This research has bridged the gap between theoretical speculation and empirical validation, demonstrating the tangible benefits of gamification in fostering an inclusive and engaging learning environment.

In conclusion, this research adheres to the highest standards of methodological rigour, employing a thoughtful mix of qualitative and quantitative analyses to explore the multifaceted impact of gamification. The systematic approach, coupled with meticulous statistical analysis, underscores the study's contribution to advancing our understanding of gamification's role in enhancing the educational experience.

3.7 Rationale for the within-subjects design approach

The methodological framework of this research was meticulously crafted, with a conscious decision to employ a within-subjects design over a traditional baseline comparison. The same cohort of students were recruited and participated in all of the studies. This choice was driven by a desire to align the study's design with its overarching research objectives, ensuring methodological soundness and maintaining pedagogical integrity. This section delves into the multifaceted rationale behind this decision, exploring its theoretical underpinnings, assumptions underlying the experimental work, methodological advantages, ethical considerations, and implications for educational research.

3.7.1 Theoretical underpinnings and methodological advantages

The pedagogical interventions under scrutiny in this thesis are grounded in sophisticated theoretical frameworks that hypothesize substantial intra-individual variability in response to educational technology tools. This theoretical perspective necessitated a within-subjects design to accurately capture the nuanced effects of these interventions on learning outcomes. This design choice offered several methodological advantages:

Control of inter-participant variability: Utilizing the same cohort of students across both studies minimized variability attributable to individual differences, thereby providing a clearer lens through which to assess the interventions' effectiveness.

Enhanced statistical power: The within-subjects design inherently requires fewer participants to achieve comparable statistical power to a between-subjects design, enhancing the efficiency of the study, especially in contexts where participant recruitment presents challenges (Montoya, 2022).

Direct comparison of intervention effects: This approach facilitated a direct comparison of the two pedagogical strategies on the same individuals, yielding insights into the relative effectiveness of each intervention without the confounding noise of differing group dynamics. For instance, Dunlosky and Rawson (2015) employed a within-subjects design to directly compare the effects of different spaced learning schedules on students' retention of scientific concepts, demonstrating the utility of this approach in isolating the impact of specific instructional strategies.

3.7.2 Assumptions underlying the experimental work

The experimental work in this study is based on several assumptions about the target learner population and the expected impact of the intervention:

Assumption 1: Heterogeneity in Background: It is assumed that the Chinese international student population is heterogeneous, with varying levels of English proficiency, programming experience, and cultural adaptation.

Assumption 2: Impact of Gamification: The intervention, which involves the integration of gamification elements into the programming modules, is assumed to enhance engagement, motivation, and ultimately, the sense of belonging among the students.

Assumption 3: Responsiveness to Intervention: It is assumed that the learners was responsive to the gamified intervention, with observable improvements in their learning outcomes and sense of belonging.

Assumption 4: Generalizability of Findings: While the study focuses on Chinese international students, it is assumed that the findings may be generalizable to other international student populations facing similar challenges in programming education.

These assumptions guide the experimental design and the interpretation of the study's findings. They also highlight the need for a tailored approach to address the specific challenges faced by Chinese international students in introductory programming modules.

3.7.3 Ethical considerations and practical constraints

The ethical dimension played a critical role in shaping the research design. In educational research, employing control groups often involves withholding potentially beneficial interventions from certain participants(Taber, 2019). In this study, denying a control group access to gamification elements could have unfairly disadvantaged those students, impacting their learning experience and sense of belonging. Such a strategy was deemed ethically untenable, as it conflicted with the principle of ensuring equitable learning opportunities for all participants.

Additionally, practical constraints influenced the decision to eschew a traditional control group design. Implementing a control group in an authentic educational setting poses logistical challenges, including ensuring comparable learning conditions and isolating the intervention's effects from other variables (Handley et al., 2018). Given these hurdles, the study opted for a design that prioritized realistic and ethical implementation of gamification in educational settings.

3.7.4 Alternative approaches

The selection of an approach is contingent upon the research questions posed, the nature of the intervention under scrutiny, and the outcomes sought. This discussion contrasts the chosen approach with alternative methodologies, with a focus on task-based evaluations.

The within-subjects design is characterized by its ability to facilitate a direct comparison of different interventions, such as gamification elements, within the same group of participants (Greenwald, 1976). This design effectively controls for individual differences, which is crucial in educational research where variability in learner characteristics can significantly influence outcomes. The mixed-methods evaluation complements this by providing a holistic understanding of the intervention's impact. It combines quantitative measures, such as test scores and engagement metrics, with qualitative insights obtained from student feedback and perceptions.

One of the strengths of this approach is its applicability to task-based evaluations. It is particularly adept at measuring the impact of gamification on specific learning tasks, such as coding exercises, while also capturing students' experiences and challenges in completing these tasks. However, this approach is not without limitations. The potential for carryover effects between conditions and the requirement for more complex statistical analysis are notable concerns. Additionally, the mixed-methods approach necessitates careful integration of diverse data types and can be time-consuming.

Alternative Approaches includes,

Between-subjects design: This approach involves comparing different groups of participants exposed to distinct interventions. Its strengths lie in reducing the risk of carryover

effects and simplifying statistical analysis (Thompson and Campbell, 2004). However, it requires a larger sample size to achieve the same statistical power as a within-subjects design, and individual differences between groups can confound the results. In the context of task-based evaluations, this design is suitable for assessing the overall effectiveness of an intervention on learning outcomes but is less effective for understanding intra-individual variability in response to the intervention.

Quasi-experimental design: This approach compares groups that are not randomly assigned, such as students in different classes or schools (Handley et al., 2018). It is more feasible in real-world educational settings where random assignment is not possible. The main limitations include a greater risk of confounding variables and selection bias, making it harder to establish causal relationships. For task-based evaluations, this design is useful for exploring the impact of gamification in naturalistic settings, but findings may be less generalizable due to the lack of random assignment.

Single-case experimental design: This approach involves an in-depth analysis of individual participants or a small group, often using repeated measures over time (Rassafiani and Sahaf, 2010). It allows for a detailed examination of the intervention's effects on individual learning trajectories. However, it has limited generalizability to a broader population and faces challenges in isolating the intervention's effects from other factors. In task-based evaluations, this design is ideal for studying the nuanced effects of gamification on individual students' task performance and learning processes.

In conclusion, the chosen approach of a within-subjects design with mixed-methods evaluation offers a comprehensive and nuanced framework for assessing the impact of gamification on programming education. It provides a balanced integration of experimental control and qualitative depth, making it particularly suited for task-based evaluations that aim to understand both the quantitative outcomes and the qualitative experiences of learners.

3.7.5 Pedagogical and eesearch implications

The methodological decision to forgo a baseline comparison in favor of a within-subjects design was made carefully considering the study's theoretical foundations, the nature of the interventions, and the research objectives. While this approach presents certain limitations, it provides a focused lens through which to examine the nuanced effects of educational technology interventions on learning outcomes. Furthermore, studies like that of Rittle-Johnson and Star (2007), which used a within-subjects design to investigate the effects of comparison on students' understanding of mathematical concepts, provide evidence of the value of this design in educational research, where the complexity of learning processes often necessitates innovative approaches to study design.

In conclusion, this thesis's absence of a baseline comparison is a deliberate methodological choice justified by the theoretical and pedagogical considerations outlined above. Future research could further elucidate the impact of these interventions by incorporating additional comparison groups or exploring alternative methodological frameworks, as suggested by the work of Koedinger et al. (2010), who used a within-subjects design to evaluate the effectiveness of intelligent tutoring systems in mathematics education.

3.7.6 Reflection on related work

In the context of this research, a within-subjects design with mixed-methods evaluation was chosen to assess the impact of gamification in programming education. This approach builds upon existing methods in educational technology research that emphasize the importance of controlled studies and user-centric evaluations Kazdin, 2017; Kelly, 2009. Unlike traditional between-subjects designs, the within-subjects approach allows for a more nuanced understanding of how individual learners respond to different interventions, aligning with the task-based evaluation framework suggested by Ellis (2003).

However, this research differs from previous studies by integrating qualitative insights with quantitative measures to provide a more holistic view of the learning experience. This mixed-methods approach is supported by the evaluation frameworks of Kirkpatrick and Kirkpatrick (2006), which advocate for assessing not only learning outcomes but also learners' reactions and behavioral changes.

The findings of this research contribute to the broader field of educational technology by highlighting the potential of gamification to enhance learning in programming education. The use of a within-subjects design with mixed-methods evaluation offers a template for future research in this area, particularly for studies focused on task-based learning. However, potential limitations include the challenge of controlling for carryover effects in within-subjects designs and the need for further research to explore the long-term impact of gamification on learning outcomes. Future studies could address these limitations by incorporating additional comparison groups or exploring alternative methodological frameworks.

3.8 Conclusion

The chapter described the methodology adopted in the research project to conduct a comprehensive exploration of the sense of belonging and learning experience of Chinese international students in introductory programming modules. The primary philosophical assumption of this research is that of pragmatism, which advocates a relational epistemology and non-singular ontology. Following the philosophy underlying the research, a mixed methodology was adopted to gain a comprehensive understanding of the educational scenario and provide solutions. The methodology was based on a survey and a design-based approach, leveraging a combination of questionnaires, focus groups and participatory observation to triangulate the data collection. This approach enabled the researcher to not only gain insights into the learning experiences of Chinese international students but also to identify the problems and challenges they encountered and take action to improve their learning experience through the aid of gamification. The research was divided into three sequential studies with each addressing a specific research question and with associated research strategies and methods and informing the following research.

Chapter 4

STUDY 1: FORMATIVE STUDY

4.1 Introduction

The study aimed to address the first research question identified in Section 2.7.3, which was:

> **RQ1** What are the primary challenges that Chinese international students face in developing a sense of belonging in fundamental programming modules, and how do these challenges affect their learning outcomes?

To achieve this aim, a survey was conducted with a group of Chinese students studying an introductory programming module at the University of Sheffield in the 21/22 academic year. The survey collected data on the participants' motivations and learning needs, the factors contributing to their sense of belonging, and their learning experience in the programming module through a questionnaire and a focus group interview. The study's findings were expected to provide evidence to develop more inclusive and effective supporting strategies that would improve teaching practices and instructional design to support Chinese international students' sense of belonging and academic success. The understanding of the educational experience of the Chinese international students gained from this study also informed the design and implementation of effective strategies leveraging gamification in the following studies.

In the rest of the chapter, the study sample is described in terms of the recruitment procedure, the recruitment rates, the participant's socio-demographic details, learning background, and anonymization. The findings are then presented in three main sections following the research objectives: motivation and learning needs, the factors contributing to students' sense of belonging, and the learning experience in the programming module. After reporting the findings under each theme, the researcher discusses the findings with the knowledge and gaps identified in the literature, offers critical insights, and discusses the implications for the following studies.

4.2 Description of the sample

4.2.1 Participants recruitment

The questionnaire and focus group invitation emails, along with information sheets and consent forms, were sent to Chinese students enrolled (n=68) in the introductory programming module INF6027 Introduction to Data Science at the University of Sheffield in the 21/22 academic year.

4.2.2 Recruitment rates

Among the 68 Chinese students enrolled in the Data Science program, 57 students responded to the questionnaire (80% completion rate), and nine attended the focus group interview. The nine Chinese students who participated in the focus group interview were randomly selected from the 26 students who responded to the invitation email for the focus group. The data from the questionnaire were collected over two weeks at the end of the autumn semester in January 2022, while the focus group was conducted on 20th January and lasted two hours.

4.2.3 Focus group interview site

The focus group interview took place in a seminar room at the Diamond Library at the University of Sheffield, a comfortable and quiet space where Chinese students could feel relaxed and free to share their experiences and thoughts about their learning experiences. The interviewer (the researcher herself) was seated at a table in the middle of the room, with the Chinese students seated around the table. There was a whiteboard at the front of the room where the interviewer could write down key points emerging from the interview.

4.2.4 Sociodemographic details

Sociodemographic details of the participants to the questionnaire

A total of 57 Chinese students studying the MSc Data Science at the Information School, University of Sheffield, were surveyed regarding their learning experience in the INF6027 module as part of their academic transition. The first section of the questionnaire asked about participants' socio-demographic details. The majority (94.7%) of the participants were aged 22-25, with 54.4% being female and 45.6% being male. 33.3% of the participants studied STEM courses in undergraduate study, while the other 66.7% studied various other disciplines. All participants had taken the introductory programming module (INF6027 Introduction to Data Science) during their first semester at the University in the 21/22 academic year. The sociodemographic details can be found in Figure 4.1.

Sociodemographic details of the participants attending the focus group interview

There were nine participants attending the focus group interview. Participants were asked to complete a short questionnaire before the interview about their gender, age, subject of the undergraduate degree, and study abroad experience. Their socio-demographic details are presented in Table 2. 56% (n=5) of the participants were female, and 44% (n=4) of the participants were male. All of the participants were aged between 22 and 25. Most of the
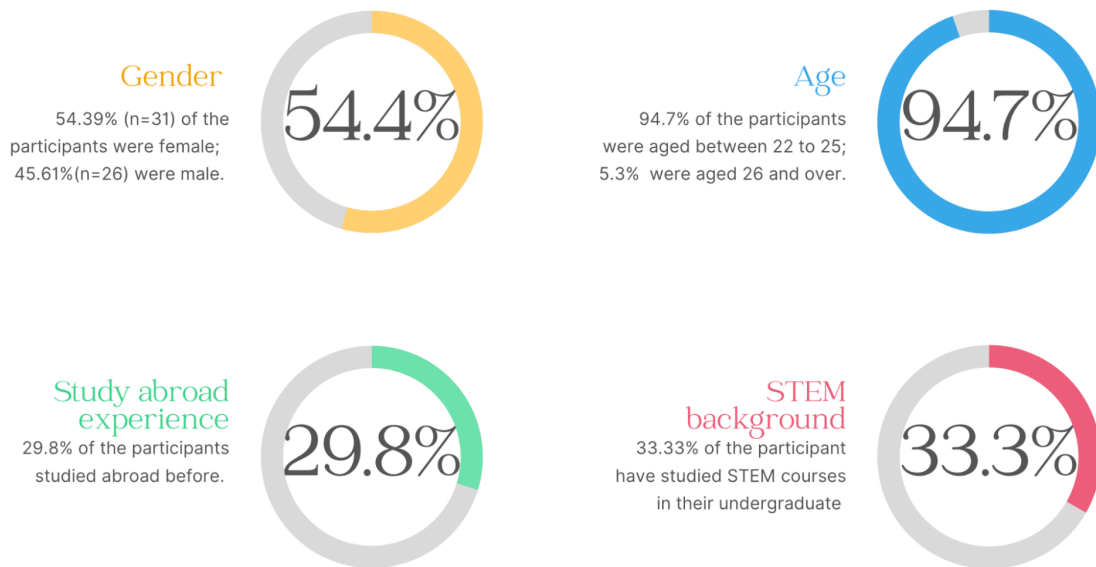
Figure 4.1: *Sociodemographic details of the participants in the survey of the current research.*

participants (78%, n=7) had not studied abroad before. Only three participants (33%) studied STEM-related subjects in their undergraduate course, while others' learning backgrounds ranged from business to arts. The data collected from the interviews helped corroborate the questionnaire's findings and provided a more in-depth picture of the sociodemographic groups under study.

To protect participants' identities, all identifying information was removed from the dataset. In addition, the dataset was randomly assigned a code so that the researcher would not be able to identify which responses belong to which participants. All participants were anonymized and assigned pseudonyms in P plus numbers (e.g., P1 indicated the first participant).

4.3 Themes emerged from the findings

This study aimed to gain a deeper understanding of Chinese international students' learning experience in introductory programming modules during their academic transition to British universities. A mixed research strategy was adopted, which included a questionnaire survey and a focus group interview. The results of the questionnaire and the focus group interview identified several key themes, namely, the motivation for learning, the difficulty of transitioning to the new curriculum, the difficulty of coding learning, and the lack of a sense of belonging. These themes were presented in Table 4.3 and were used in subsequent studies to develop gamification support mechanisms to increase Chinese international students' sense of belonging and help them succeed in programming learning.

PID	Gender	Age	Subject of bachelor degree	Study abroad
P1	Female	24	Construction electrical appliances	N/A
P2	Female	21	Business management	N/A
P3	Female	22	Arts	N/A
P4	Female	23	Arts	2 years in Germany
P5	Male	22	Computer science	4 years in the UK
P6	Male	23	Geography	N/A
P7	Male	21	E-commerce	N/A
P8	Male	25	English	N/A
P9	Female	22	Marketing	N/A

Table 4.1: *Sociodemographic details of the participants in the focus group interview of the current research.*

Theme	Subtheme
• Motivation for studying in the UK	Improve career prospects
	Gain high-quality learning experience
	Experience British culture
	Other motivations
• Challenges of transitioning to new curriculum	Unfamiliarity with course structure
	Cultural and language barriers
	Low academic confidence
• Difficulty of coding learning	Inadequate prior knowledge
	Difficulty in understanding
	Unclear feedback from lecturers
	Unfamiliar resources
• Lack of a sense of belonging	The feeling of isolation and loneliness
	Difficulties in forming relationships in class
	Disconnection from the programme
	Disconnection with job-market needs

Table 4.2: *Summary of themes emerged from the findings of the questionnaire and focus group interview.*
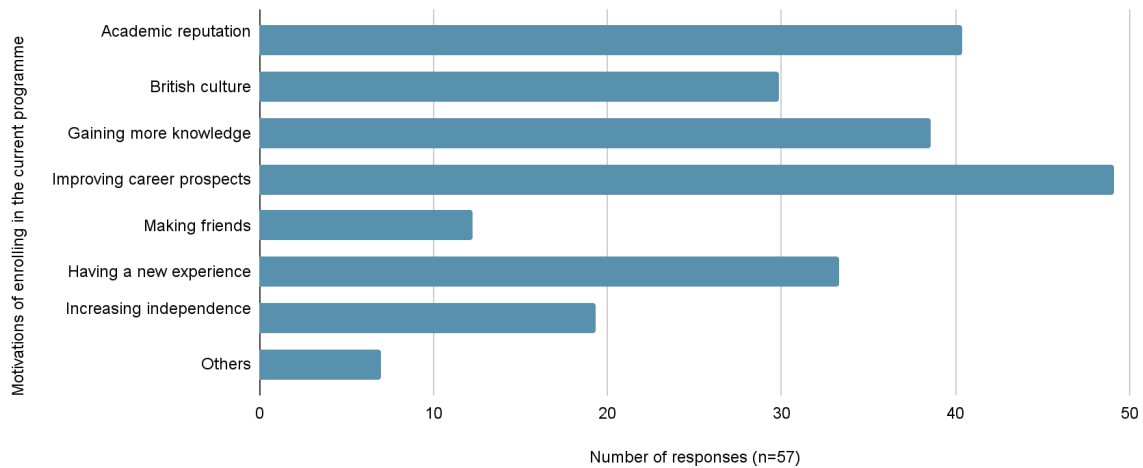
Figure 4.2: *Responses to the multiple choice question "What's your main motivation for studying learning programming-related courses in the UK?" in the questionnaire.*

4.3.1 Theme 1: Motivation for studying in the UK

The first theme identified from the survey was Chinese international students' motivation for learning programming at a British university. The students' main reasons for taking the introductory programming module included preparing for their future careers, gaining more knowledge and having a new experience in the UK.

It was found from the questionnaire that 49.1% (28/57) of the respondents were motivated to study in the UK by career motivation, which was the desire to improve their career prospects. The desire to gain a more internationally-recognised qualification was also associated with enhancing their career or academic prospects. The second dominant motivation for learning programming in their current course was to gain more knowledge. In addition, having a new academic experience and feeling the British culture was also influential to the participants' choice of study. On the contrary, fewer participants indicated that making friends and increasing independence was the primary motivation for their choice of study. The summary of responses to the question of students' motivation for learning programming in the UK in the questionnaire can be found in Figure 4.2.

The focus group interview also confirmed the findings from the questionnaire. Most of the participants (88.9%) in the focus group agreed that the main reasons for their choices were career-oriented. Their main concerns were the employability prospects of the courses and universities, and the academic reputation to be more competitive in the job markets. The findings of motivations for studying in the UK from the questionnaire and focus group were presented and discussed in the following sections to understand students' learning needs.

Improve career prospects

The majority (49.1%) of participants indicated in the questionnaire that they came to study in the UK in order to gain practical skills and improve their career prospects. This was borne

out in our focus group discussions with Chinese students studying in the UK, where 66.7% (6/9) of those who were interviewed indicated that this was their primary motivation for coming to study here. As P1 addressed:

> "I came to the UK to study because I wanted to gain practical skills that would give me an advantage in the job market back home."

P7 was also motivated by the career prospects and cited that:

> "I want to study here because I believe it will give me a better chance of getting a good job when I graduate."

The high reputation of the UK's education in the job market was also echoed by P3, who said:

> "I think that the education and skills I'll gain from studying in the UK will be highly valued by employers back in China."

Other participants also pointed out the motives of being more competitive in career prospects as data science graduates:

> "...I wanted to work in a data analysis position... Finding a data analysis position is more convenient if you have a master's degree from a British university." (P6)

> "My undergraduate major was not easy to find a job. So I transferred to the current programme for my future career." (P9)

Overall, the participants expressed a desire to gain practical skills and improve their career prospects and saw studying in the UK as the best way to achieve this. They believed that the UK education system would provide them with the necessary skills and knowledge to succeed in their chosen careers and that employers in China would value the UK qualification.

Gain high-quality learning experience

In addition, the UK's reputation for quality education and research was another key motivator for Chinese students. 40.35% of the participants in the questionnaire expressed that the quality of British universities was one of the main reasons for their choice of study in the UK. In the focus group interview, one student (P2) said:

> "I think the UK's reputation for quality education and research is one of the dominant motivations of Chinese students studying in the UK. I mean, when you talk to people in China, the UK is always presented as this gold standard, and I think that definitely played a role in my decision to come here."

Another student (P6) agreed and said:

> "the UK's reputation for excellence was a big factor in my decision to come here.
> I wanted to make sure I was getting the best education possible, and I knew that
> the UK would provide that."

The findings indicated that Chinese students felt that the UK offered a world-class education, with excellent research facilities and opportunities to work with leading academics in their field. They spoke highly of the UK's world-renowned universities and research facilities and felt that the UK would provide them with the best possible education and opportunities for future success.

Experience British culture

Gaining a new learning experience abroad from China, including embracing British culture and experiencing British campus culture is seen as one of the key motivators for studying in the UK according to the data from both the questionnaire and focus group interviews. The majority of the participants (77.78%) in the focus group indicated that they were interested in British culture and wanted to experience the British lifestyle. This was also supported by the questionnaire data, as 57.89% of the respondents reported that they were motivated to take the course due to the desire to experience a new learning environment.

In the focus group interview, it was explained that students from a variety of academic backgrounds can find a place to study in the UK, regardless of their previous academic achievements. This means that students who may not have had the opportunity to study abroad from China before can still take advantage of the UK's world-class education. As P2 mentioned:

> "The UK is not very strict about students' previous learning backgrounds. Hence,
> I decided to apply to British Universities to increase my success rate of getting
> [job] offers."

Another interviewee (P6) alluded to the fierce competition in the postgraduate entrance examination in the Chinese educational system:

> "I failed the Chinese postgraduate entrance examination because of the restrictions on my background. Then I tried to apply for the current programme in the
> UK, which has fewer restrictions on previous majors, and I succeeded."

There are also some external factors about the choice of studying in the UK:

> "I wanted to continue to study business, but the application was not very smooth
> at that time. I also applied for other majors at my university, and finally chose
> this major." (P2)

Similarly, P7 also expressed that studying in the UK was not visceral:

> "My choice of this major is actually my last resort.... I don't feel that there is
> any reason to want to study this major, only because I was rejected by others."

The findings showed that Chinese students were willing to study in the UK even though they might not have the same academic background as other students. It also indicated that students' choices in studying in the UK were influenced by universities' acceptance rate, limited choices in shifting majors, etc.

It was also evident from the focus group interview that the UK's multicultural environment is one of the dominant motivations of Chinese students studying in the UK. All Chinese students interviewed spoke highly of the UK's multiculturalism, with one participant (P3) going as far as saying that it was a key factor in their decision to study in the UK. They spoke of the UK's diversity as a strength, and as something that they felt would allow them to gain a more global perspective. They also felt that the UK's multicultural environment would provide them with opportunities to interact with people from a variety of backgrounds and learn about new cultures. As one of the participants (P9) addressed:

> "I want to feel what different academics are like, and most importantly, to study in new environments."

In addition, the Chinese students felt that the UK's multicultural environment would allow them to develop their own cultural identity. They felt that in China, they would be limited to only learning about Chinese culture and that they would not be exposed to the diversity of cultures that exists in the world.

Other motivations

The findings from the focus group interviews suggest that peer influence and timing are also motivations for Chinese students studying in the UK. In terms of peer influence, the students generally felt that their peers had a positive influence on their decision to study in the UK. For some students, their peers were the ones who first suggested studying in the UK and provided information about universities and the application process. Quotes from the participants include:

> "I think the main reason why I decided to study in the UK was because of my peers. At that time, most of my friends were studying abroad and they all encouraged me to do the same. They made it seem like it was a great experience and I would regret not taking the opportunity. I didn't want to miss out on what they were all doing, so I decided to go for it." (P1)

Others had friends who were already studying in the UK, and they were able to get first-hand information about what studying in the UK was like:

> "I feel that students' satisfaction rates were very high in British universities according to my friends, and the QS rankings were much better than the institutions I was eligible to apply to in China. So I choose to be here." (P5)

In general, the students felt that their peers had helped to support and encourage their decision to study in the UK. Based on the data collected from the focus group interview, it was found that for some students, the timing of their studies was an important consideration, as they wanted to complete their studies in a shorter timeframe than what would be possible in China.

Intrinsic motivation	n	% of total	Extrinsic motivation	n	% of total
Learn practical skills	6	66.7%	Low entry requirements	5	55.6%
			Peer influence	2	22.2%
			Improve career prospects	7	77.8%
			Experience new culture	2	22.2%
			Timing/cost	2	22.2%

Table 4.3: *The intrinsic and extrinsic motivation of students studying in the UK in the current study.*

Discussion

The results revealed that the most common motivation for Chinese international students to study the introductory programming module was to gain a deeper understanding of coding and improve their overall coding skills. Other motivations included the need to become more competitive in the job market, the desire to broaden their knowledge base, and the challenge of learning in a new environment. The findings indicate that the decision to pursue studies in the UK is a balancing act between personal development, future career, time length consideration, monetary investment, application requirements and inherent risks. From the comments, it can be seen that incoming overseas students were aware of the potential risks, which include job-seeking limitations of certain subjects, low university rankings considered by employers, the lack of practicability of knowledge, etc. The participants were more focused on the real benefits that the programme can bring to their future careers.

According to the SDT theory, it can be seen that students mostly choose the current programme in the UK because of extrinsic motivations. In the current study, learning practical skills was regarded as intrinsic motivation because it promotes the pursuit of studying in the UK for the sake of self-development. On the contrary, the other themes of motivation that emerged in the responses were more likely to be extrinsic motivation (See Table 4.3).

Though most of the interviewees indicated certain reasons for studying in the Data Science programme in the UK, it is apparent from their responses and description of their prior knowledge that there is a lack of solid subject knowledge for them to get started on the introductory programming modules. In many cases, studying abroad from China involves careful consideration of the potential benefits. This result may be explained by the fact that students were from diverse educational backgrounds, some of them very far away from the STEM fields. Students chose to enrol in the current programme in the UK given the increasingly popular belief in merchandising knowledge and the purpose of promoting career prospects (Altbach and Knight, 2007). The awareness and consideration of gaining practical skills for the job market could drive students to engage with introductory programming modules.

However, extrinsic motivations were associated with low resilience and other challenges during students' academic transition to unfamiliar subjects. The findings of the study are consistent with the work by Yu et al. (2018), which stated that Chinese students who were less self-determined in their learning were less likely to adapt to the UK learning environment and achieve academic success. The authors suggest that interventions to support Chinese

students' academic transition should focus on promoting their self-determination.

Understanding students' motivation for study and their learning needs is important for several reasons. As mentioned in the literature review, understanding learning motivation can help educators to design more effective teaching and learning strategies that address the needs of Chinese students, improve student retention and success rates and build a more positive and inclusive learning environment for all students (Yin, 2018; Chao et al., 2019; Wong and Luo, 2021).

Notably, the most interesting finding regarding the first theme identified was that Chinese international students are primarily driven by career-related factors, such as the need to develop employability skills and the need to increase their chances of getting a job. The finding highlighted the need for the instructional design to focus more on improving students' intrinsic motivation and meeting individual needs such as boosting their career-related skills to motivate and encourage them to succeed in their programming learning.

4.3.2 Theme 2: Challenges of transitioning to the new curriculum

Building on what motivates students to choose the UK as the destination for studying abroad from China, questions were asked about their transitional experience of studying in the INF6027 module and the challenges they met regarding the instructional design and learning and teaching methods. To investigate the factors affecting students' learning experience, questions such as 'how do you describe your learning experience of the first semester?' and 'why do you find it challenging or exciting?' were discussed in the focus group interview. The main challenges reported by the participants include their unfamiliarity with the course structure, cultural and language barriers, and low academic confidence.

Unfamiliarity with course structure

The participants reported a series of expectations toward the instructional design, including receiving rapid feedback on learning tasks, having a daily or weekly mandatory assessment that counts for the final grades, gradually increasing the level of difficulty throughout sessions, and learning useful skills to improve career prospects. As participant P8 stated:

> "I like to have a clear and fixed learning structure to push me to engage with the coursework regularly."

The further discussion showed that the expectations were closely in line with their previous learning experiences in China and their motivations for studying in the current programme. In Chinese higher educational institutions, students usually have tight schedules of classes with less independent study time and space, as explained by P1:

> "We used to go to classes at 7:30 am, and STEM courses such as Advanced Mathematics were delivered three times a week....It's almost like the frequency of having classes in high schools."

The Chinese students' expectations about their learning experiences in the UK suggested that they were not very spontaneously motivated to learn and were not prepared to face the challenges that they may encounter.

Several challenges were identified related to the difference in instructional design. Participants lacked a sense of accomplishment because there is no rapid feedback on completing tasks.

> "...we didn't know if we were doing it right or wrong, so we just went ahead in the mist with confusion and uncertainties." (P2)

Students are also less motivated to engage with quizzes and course materials which do not count for grades.

> "...practical sessions were useless. The attendance did not count for the final grades and there was not much difference compared to independent study at my apartment." (P5)

It can be seen that students feel disconnected from the programme and unclear about how to apply the knowledge, which decreases their learning interests.

Additionally, a common view among interviewees was that there was a suddenly increased difficulty with a large amount of unfamiliar knowledge in the programming module, without detailed explanations, which made them feel overwhelmed as P3 reported:

> "When the course went to the fifth week and the sixth week, it seemed the difficulty of both lectures and practical sessions had a 'qualitative leap'."

Another participant (P6) used an analogy to describe it:

> "I feel like we were learning basic maths but were suddenly asked to build an aircraft carrier."

A possible explanation for this might be that, given the programming module's introductory nature, the lecturers tried to include as much knowledge as possible to show students its power and effectiveness in processing big data analytics. However, the overload of knowledge without detailed explanations increased the difficulty for students to understand the content.

Another explanation for such problems might be that students came from diverse backgrounds, and most of them did not have adequate programming skills. As interviewee P4 put it:

> "I only have a few programming skills and am not familiar with the use of functions in this session. I will appreciate it if there are some brief introductions of functions before practising."

In this case, the learning content could be difficult for beginners. The diversity of background knowledge exacerbated the gap in learning paces among students, which was also the dominant reason for their negative academic emotions.

Cultural and language barriers

The language barrier was identified as a major challenge for Chinese students. All of the participants reported difficulties in understanding the lecturer and the materials due to their limited English proficiency. As P2 remarked:

> "Sometimes I feel like I'm just sitting there, but I don't understand anything."

The participants also reported feeling embarrassed to ask questions and preferring to keep their heads down during lectures.

> "Every time when I ask the teaching team questions, we actually don't understand what each other is talking about at all. . ." (P7)

The language barrier also affected their learning process outside of the classroom. P1 commented:

> "I always need to use Google translate to read the materials, which is a time-consuming process."

In addition, the cultural differences between China and the UK were also highlighted as a factor that influenced the learning experience. As P4 put it:

> "I think the UK education system is more focused on individual learning and independent thinking, whereas, in China, we tend to be focused on learning from the teacher."

The participants felt that the cultural differences led to problems in communication, such as their unfamiliarity with the independent learning style and their uneasiness in expressing opinions in English.

Low academic confidence

The participants reported that their lack of academic confidence was a major challenge that they faced in the first semester. P1 explained:

> "I feel like I am not good enough to compete with the other students, so I always keep myself in the corner."

The participants also reported feeling overwhelmed and helpless when they could not finish the worksheets before the practical session ended.

> "When I saw the solutions of other students, I was upset and felt I'm way behind my cohorts." (P7)

The participants also felt that their low academic confidence affected their ability to ask questions in class:

> "I think asking questions is one way to show your intelligence, but I don't feel like I have the confidence to do so." (P3)

The participants also reported that their low academic confidence was due to their lack of knowledge about the UK higher education system, which made it difficult for them to understand the course content and the assessment criteria:

> "I always felt like I was walking in the dark and could not see what was ahead of me." (P5)

They reported that they did not know how to seek help from their lecturers and peers, which further decreased their academic confidence:

> "I was afraid that if I asked too many questions, people would think that I was stupid." (P6)

The participants also felt that their limited English language proficiency and cultural differences between China and the UK made it difficult for them to build relationships with their lecturers and peers, which further decreased their academic confidence:

> "I felt like I was always an outsider, and people didn't want to help me." (P8)

Negative academic emotions affected students' learning interests and engagement in the coursework:

> "I felt like I was not capable of doing this, so I just gave up." (P2)

Above all, a series of motivational and engaging issues were reported due to unfamiliarity with the learning and teaching methods, as well as language and cultural barriers during students' transition to the new curriculum. These factors also led to students' low academic confidence in learning in the INF6027 module. The majority of the participants had expected to improve their practical programming skills during their academic transition to the University of Sheffield. However, they found that the learning and teaching approaches in the British universities did not meet their expectations in this respect. Participants also discussed the importance of developing problem-solving skills in the focus group interview and felt that the current learning and teaching practices in British universities did not adequately prepare them for solving real-world problems. The teaching quality in the UK was not as good as they had thought it would be. They felt that the teaching methods were not as interactive as they were used to and that the lecturers were not always well prepared.

In addition, some participants reported feeling overwhelmed by the volume of work required in the British universities and stated that the learning and teaching practices in the British universities did not adequately support them in managing their workload. As a result, they felt frustrated and disinterested in the course. Besides, the participants had difficulties adapting to the new learning environment. They found the academics, language, and culture to be quite different from what they were used to and had difficulty understanding the lectures and assignments. They also felt that the learning resources were not always accessible and that they had to spend a lot of time searching for information.

4.3.3 Theme 3: Difficulty of coding learning

The respondents reported that the practical sessions of the INF6027 module were a major challenge for them, with inadequate prior knowledge, difficulty in understanding, unclear feedback from lecturers, and unfamiliar resources.

Inadequate prior knowledge

The participants reported that they had inadequate knowledge of coding before the INF6027 module and found it difficult to learn the programming language. P7 commented:

> "It was hard for me to understand the syntax and the logic of programming, and I could not keep up with the pace of the class."

The participants also reported that they struggled to keep up with the pace of the programming module due to their lack of knowledge and experience:

> "It was like a race, and I was always behind." (P4)

Another student indicated that they found it difficult to understand the course materials and the lecture slides:

> "The materials and slides were too complicated, and it was difficult for me to figure out the purpose of the codes."

P3 also said that they did not have adequate knowledge of the software used in the programming module, which made it difficult for them to understand the course content:

> "I did not know how to use the software, and it was hard for me to figure out how to do the programming tasks."

The findings indicated that the participants encountered difficulties in learning the programming language due to inadequate prior knowledge. Despite their efforts, many of the participants struggled to keep up with the module's pace and found it difficult to understand the syntax and logic of programming.

Difficulty in understanding

Most of the participants had no previous coding experience, which made it difficult for them to understand the content and apply it in their assignments:

> "I feel like there is so much to learn and understand quickly." (P5)

Participants also reported that the focus of the lectures was mainly on the theory part of coding, which made it difficult for them to apply the concepts in practical tasks. P7 commented:

> "I feel like the lectures focus too much on the theory and not enough on the practical aspect. I don't know how to apply what I've learned in assignments."

The data suggest that the lack of practical experience and the focus of the lectures on theory can make it difficult for such individuals to understand the content and apply it in their assignments.

Unclear feedback from lecturers

In addition, participants reported that they felt they lacked clear feedback from their lecturers regarding their assignments, making it difficult for them to improve their coding skills. As P2 commented:

> "I feel like I'm not getting enough feedback from my lecturers. I don't know if I'm doing it right or wrong, so I just go ahead in the mist with confusion and uncertainties."

This was also echoed by P5, who stated that they did not have sufficient support and guidance from their lecturers and peers, which further decreased their confidence in coding:

> "I felt like I was alone in the class, and no one was there to help me."

Some participants also reported that they found it difficult to debug the codes they wrote and that they did not have sufficient guidance from their lecturers and peers on how to do that:

> "I did not know how to debug the codes and where to start." (P6)

The findings suggest that coding courses in higher education institutions need to be designed to provide adequate feedback and support to students, enabling them to develop their coding skills and confidence. Additionally, students need adequate guidance on how to debug codes, and a learning environment that encourages collaboration, peer learning, and support is needed.

Unfamiliar resources

Participants reported that they felt that they were unfamiliar with the resources available to them to help them with the coding module. P1 commented:

> "I don't know where to seek help if I don't understand something. I think I need more guidance."

The participants also conveyed that they had limited access to resources in the programming module and did not receive sufficient support from their lecturers, which made it difficult for them to understand the course content:

> "We didn't have any materials to follow up, and no one was there to help us with the coding skills." (P7)

In conclusion, the study has revealed that the participants encountered various challenges in learning the programming language. Inadequate prior knowledge, difficulty in understanding, unclear feedback from lecturers, and unfamiliar resources were identified as major challenges that the students experienced. To help these students learn to code effectively, the teaching team should provide more resources and guidance, as well as create a learning environment that encourages collaboration and peer learning.

4.3.4 Theme 4: Lack of a sense of belonging

From the first theme identified, it was noted that one of the most common expectations among participants was the need to integrate into the new study environment and develop sound relationships with peers and lecturers. This assumption is based on the idea that receiving social and community support will lead to better learning outcomes (Philanthropies, 2010). It also aligns with the collectivist cultural values Chinese students perceive in their previous learning experiences. However, the reality is often different, leading to negative consequences. Therefore, the next sections concern students' sense of belonging in the introductory programming module.

The feeling of isolation and loneliness

In the study, participants explicitly reported feelings of isolation and loneliness, evident in both the questionnaire responses and during the focus group discussions. Many expressed that they were unprepared for the academic transition to British universities, finding the introductory programming modules particularly challenging. For instance, one student articulated this struggle by stating,

> "I felt so lost during my first programming module. It was so different from anything I had learned before, and I didn't have anyone to ask for help." (P6)

Another student shared similar sentiments,

> "I was afraid to ask questions in class because I didn't want to seem stupid. I felt like I was the only one struggling, and I was just too embarrassed to ask for help." (P3)

The quantitative data reinforced these qualitative accounts, with a significant proportion of the survey respondents indicating that they felt isolated and lonely within the course environment. The difficulty in understanding course content, coupled with teaching methods that did not align with their learning styles, exacerbated their feelings of disconnection. Additionally, many students reported a lack of confidence in their programming skills, which further contributed to their reluctance to engage actively in the learning process.

These pervasive feelings of isolation and loneliness not only negatively impacted the students' academic performance but also their overall well-being. The findings underscore the need for universities to enhance support systems for Chinese students, particularly during their transition into demanding academic programs. This includes training lecturers to be more attuned to these students' unique challenges in introductory programming modules, facilitating a more inclusive and supportive learning environment.

Difficulties in forming relationships in class

A common view among interviewees was that their relationships with classmates and teaching teams can be problematic. According to the participants, most of them went to class alone and did not have a chance to get to know each other. Their experience with teamwork was even worse. For example, one interviewee said:

	Expectations	Experience
Relationships with peers	Integrating into a learning community	Disrespect by other students; little interaction after classes; feeling out of place
Relationship with the teaching team	Patience and consistency	Multiple lecturers with dissimilar teaching styles, and it is not easy to pay attention to each student. The contrast of the teaching methods gave students an inconstant learning experience, which caused anxiety

Table 4.4: *Comparison of students' expectations regarding their sense of belonging and the challenges encountered.*

> "When doing group work, there are people who are willing to listen to others but do not want to listen to you, and that makes me feel disrespected. Just having this feeling will make you feel bad and even hate this course. When I went to seminars, I thought it was superfluous of me to sit here." (P4)

The feelings of marginalisation mismatched their expectation of integrating into a learning community. The results may be explained by the conflicts between different educational philosophies and ideologies. In individualistic countries, students are encouraged to engage and discuss in class activities and use critical thinking and tend to be more independent in their learning behaviours (Kornbluh et al., 2015; Ozer, 2017). On the contrary, Chinese students influenced by collectivism are more oriented toward keeping silent in the classroom and obeying teachers' arrangements. As a consequence, Chinese students' learning behaviours may be misunderstood in the host countries' educational settings as timid or less engaged (Liu and Littlewood, 1997; Rachel Zhou et al., 2005; Zhu and O'Sullivan, 2022).

There were some negative comments about their relationship with the teaching team as well. As one student stated:

> "...the teacher is not so attentive, and because he is teaching relatively difficult object-oriented programming, and at the same time, he is not so patient, and then the atmosphere in the classroom instantly went intensive. I'm starting to get anxious about the course." (P5)

It seems possible that the unsatisfying relationship with the teaching team is due to the teaching allocation. Multiple lecturers with diverse teaching styles were allocated to teach the same module, and it was not easy for them to pay attention to each student and know their needs well. The different teaching methods gave students an inconsistent learning experience, which caused anxiety. Table 4.4 compared students' expectations regarding their sense of belonging and the challenges they encountered.

Disconnection from the programme

The majority of the respondents felt a sense of disconnection from the programme and institution. They felt that the introductory programming module was not helpful in their academic

transition and that the program was not well organized. Most respondents also felt that the lecturers were not approachable and did not have enough time to complete the assignments.

The participants also said they longed to integrate into a 'learning community' or a group of international students where members warmly support each other. The occasional support from peers greatly impacts their sense of belonging during their academic transition. However, there was not much teamwork in the practical sessions of the introductory programming modules in the first semester. Consequently, it is rather difficult for students to communicate with classmates and receive support from others.

Participants reported several ways of obtaining a sense of belonging during their study in the first several months. The most mentioned aspect was the support from peers. As one interviewee (P7) put it:

> "I told them (the group members) at the time that I didn't quite understand what they were saying, and then there were classmates who comforted me after the class at the same time. That is those foreign classmates, saying that they understood your situation very well. I was very touched at the time. It's really warm."

Another participant (P2) also alluded that the help from classmates increased his sense of belonging during the rough time of the academic transition:

> "I asked my group members about the coursework at the weekend, and when I was confused about the instructions of the essay, I asked them, too. They worried about me and I was really moved."

The strong relationship and off-campus interactions with the group members made the participant feel accepted and supported.

Another way of gaining a sense of belonging is the support from the teaching team. Many interviewees mentioned that a good and responsible lecturer positively affected their learning experience and made them feel valued and respected. For example, interviewee P8 said:

> "... there was one teacher who was really nice and patient, and his teaching style was like the teacher in our high school (in China)... he demonstrates the application of the function (in programming) over and over again till he makes sure every student gets it, then he moves to the next one."

This view was echoed by other participants, who agreed that this teacher's teaching style matched and even exceeded their expectations. As one interviewee said:

> "...because in this programming module, I noticed that more than 90% of the students didn't learn to program before. So it's really lucky to have this teacher who pays attention to every student. He elaborated on the process step by step, which really impressed me. So I felt motivated and belonged to the module he taught." (P5)

The findings show that support from the teaching team is important to gain a sense of belonging for Chinese students. Many interviewees mentioned that a good and responsible lecturer positively affected their learning experience and made them feel valued and respected.

Disconnection with job-market needs

The participants on the whole demonstrated that their relatedness and perceived meaningfulness of the Data Science programme plays an essential role in gaining a sense of belonging. It was suggested that:

> "If there were updated cases used in the classes, it would make me feel more connected to the real world. In that case, I would be more motivated to learn." (P2)

Another interviewee also mentioned that:

> "There was an assessment that asked us to analyse cases under the Covid situation, and I really wanted to check if the trends I analysed were accurate after a certain period." (P7)

However, the data suggested that students may not see the relevance of the Data Science curriculum in the job market, leading to a disconnection between the curriculum and the job market needs. This was further evidenced by the lack of perceived value of the Data Science programme in terms of employability. The participants felt that the lack of resources and career guidance that can help bridge the gap between the Data Science curriculum and the job market needs are the primary causes of the disconnection:

> "The curriculum of the Data Science programme does not seem to be in tune with what the job market requires. It does not adequately prepare us for the job market." (P4)

The participants were also concerned with the lack of connection between the curriculum and the job market. They voiced their need to have more relevant skills and knowledge to prepare them for employment:

> "It would be great if the curriculum was more closely linked to the job market. That way we could learn more of the necessary skills to work in the industry." (P6)

The participants felt disconnected from the job market due to the lack of practical knowledge and skills acquired from the programme. They expressed the need for a more comprehensive understanding of the Data Science field and the ever-changing trends in the job market:

> "It feels like the knowledge we acquire from the Data Science programme is not enough to equip us for the job market. We need to learn more about the current trends in the industry and how to apply our skills." (P2)

The findings suggest that the participants felt a sense of belonging when they found the Data Science program to be related to their future careers and meaningful. It indicated that if updated cases were used in classes, participants would feel more connected to the real world and motivated to learn.

Discussion

The results of this study reveal that Chinese students have difficulties in finding a sense of belonging in British universities. Their primary difficulties are related to the lack of relationships with their peers, the teaching team, and the job market. The participants felt isolated and lonely in the classroom, as they found the course content difficult to understand and had little confidence in their programming skills. Furthermore, they felt disrespected and out of place in the team activities. Their relationships with the teaching team were unsatisfied due to the multiple lecturers with dissimilar teaching styles and the contrast of the teaching methods. In addition, the participants felt a sense of disconnection from the program and institution in the British universities and the job market due to the lack of resources and career guidance that can help bridge the gap between the Data Science curriculum and the job market needs. The participants also found some sources of gaining a sense of belonging during their study. The most mentioned aspect was the support from peers and the support from the teaching team. The participants felt valued and respected when they had a good and responsible lecturer. Additionally, the participants found the Data Science program to be related to their future careers and meaningful when updated cases were used in classes.

There are a number of implications for these findings. There is a need to provide more support for Chinese students during their academic transition, and lecturers should be mindful of the challenges that these students may face in introductory programming modules. Furthermore, the instructional design should provide more resources and career guidance that can help bridge the gap between the Data Science curriculum and the job market needs to help students better understand the job market. Finally, there should be more teamwork and peer collaboration in the classroom in order to help Chinese students integrate into the learning community.

4.4 Conclusion

This research has critically explored the academic and social challenges Chinese international master students face in programming modules at the University of Sheffield. The study was driven by the need to understand the specific barriers these students encounter as they transition into a UK higher education setting, particularly in a discipline that often requires a strong foundational knowledge of programming. By integrating responses from both Likert-scale survey questions and qualitative interviews, the study has provided a nuanced understanding of the student's academic and social experiences.

Analysis of these Likert-scale responses revealed significant trends: many students reported low levels of satisfaction with their integration into the classroom community and their interactions with peers and instructors. For instance, responses to statements such as 'I feel part of a learning community' and 'I feel connected to my peers' predominantly ranged from 'Disagree' to 'Strongly disagree.' These results underscore the lack of a supportive network, contributing to feelings of isolation among the students. Furthermore, the responses to Likert questions related to the accessibility of support services and the clarity of instruction indicated that many students did not feel adequately supported in their learning environments. This lack of support has a direct correlation to their sense of belonging, as students who feel unsupported are likely to feel detached from the academic community.

Interviews complemented these findings by providing deeper insights into the personal

experiences behind the numerical data. Students frequently discussed their struggles with adapting to teaching methods that did not accommodate their previous educational experiences and learning styles. For instance, many noted the fast pace of lectures and the lack of hands-on practice, which are not conducive to learning complex programming concepts for the first time.

The findings revealed that the participants, who come from varied educational backgrounds, with many having little to no prior programming experience, face significant hurdles. The programming learning curve is steep for beginners, especially those whose undergraduate studies did not involve similar analytical or technical coursework. This educational diversity contributes to difficulties in integrating new programming knowledge with their existing skill sets, thereby exacerbating the challenges of initial engagement and sustained progress in their studies.

Moreover, the social and cultural adaptation poses additional challenges. A notable insight from the study is the pronounced preference among Chinese students for a strong community feel, akin to their undergraduate experiences in China, which are often characterized by group-based learning and living arrangements. In contrast, the environment in British universities, compounded by language and cultural barriers, can lead to feelings of isolation and loneliness. These feelings are not trivial, as they directly impact the student's academic performance and overall well-being, highlighting a critical area for intervention.

The research question aimed to uncover the primary challenges these students face in developing a sense of belonging and how these challenges affect their learning outcomes. The survey and interview data collectively addressed this by illustrating how academic struggles are intertwined with social isolation. Students not only find programming inherently challenging due to their limited background in the subject but also feel alienated within their academic community, which compounds their learning difficulties.

The struggles with belongingness and academic integration observed in this study align with Self-Determination Theory (SDT), which emphasizes the importance of fulfilling the needs for autonomy, competence, and relatedness for optimal psychological development and academic achievement. Our findings resonate particularly with the need for relatedness, underscoring that Chinese students' academic and social integration is crucial for their success in foreign educational landscapes.

While this study provides insightful findings, it has limitations due to its focus on a single institution and a relatively small sample size, which may affect the generalizability of the results. Future research should expand to include multiple universities to explore whether these findings are consistent across different educational contexts. Longitudinal studies would also be beneficial in tracking changes and developments over time, providing deeper insights into the long-term effectiveness of proposed interventions.

Chapter 5

STUDY 2: FIELD STUDY OF THE GAMIFICATION DESIGN

5.1 Introduction

The results and insights of the first study vividly highlighted the multi-dimensional academic and social challenges, particularly the profound sense of alienation faced by Chinese international students in introductory programming modules at British universities. These findings reinforced previous studies like (Piwek and Savage, 2020) and underscored an urgent need for innovative interventions to enhance students' sense of belonging. This pivotal understanding set the stage for the subsequent research on employing a story-based gamification design to address that problem.

5.1.1 Research aim

This research was motivated by the need to address the sense of belonging of Chinese students in the introductory programming module at British Universities. The research question addressed in this study was:

RQ2: How effective is gamification in enhancing the learning experiences and sense of belonging for Chinese international students in fundamental programming modules, and what specific gamification features are most impactful?

The aim of the study was to investigate the effectiveness of using story-based gamification design to address the challenges Chinese students faced regarding a sense of belonging in introductory programming modules identified in Study 1. In particular, study 2 examines how different game-based elements (e.g., story, characters, tasks, rewards) identified in the literature can be used to improve Chinese students' sense of belonging and create a more supportive and inclusive learning environment in the INF6032 Big Data Analytics module. The study was conducted in two phases. In the first phase, the researcher identified the design objective based on the findings of Study 1 and brainstormed the gamification design with the teaching team of the INF6032 module. In the second phase, the gamification design was piloted and evaluated in the practical sessions of the INF6032 module, and a mixed-methods evaluation was used to assess the impact of the story-based gamification design on Chinese students' sense of belonging. The evaluation includes a survey, participatory observation,

and focus groups. Quantitative data were collected through a questionnaire and analyzed using SPSS. Qualitative data were collected through focus group interviews and participatory observations and analyzed using NVivo.

Study 2 was designed to propose and pilot a gamification approach to address the sense of belonging problems Chinese international students face in introductory programming modules, as identified in Study 1. It also provided evidence for the design and development of the AI-enhanced gamification system in study 3.

5.2 Phase I: The gamification design

The first phase of Study 2 was the design of the gamified sessions. The design process was based on the principles of GAME proposed in 2.6.3. The process involves identifying design objectives, including social objectives based on the findings from study 1 and the learning objectives of the current module (G); integrating the game elements identified in the literature review with the design objectives (A&M) and developing the prototypes of the gamification design for the target sessions in the sixth and seventh weeks of the INF6032 module (E).

5.2.1 The design objectives

The gamified sessions were implemented in the INF6032 module offered to postgraduate students in the MSc in Data Science program. The design objectives of the gamified sessions were twofold, as identified in the previous study, including addressing Chinese international students' social needs and learning needs.

Social needs

The sessions were aimed at addressing the sense of belonging issues previously identified in a study, as the lack of sense of belonging was the key barrier to their success in programming learning and academic transition reported by students. Study 1 has identified Chinese international students' career-oriented motivations for learning, challenges regarding academic transition, and lack of a sense of belonging due to the feeling of isolation and loneliness, difficulties in forming relationships in class, disconnection from the program, disconnection with job-market needs, etc.

Learning needs

The gamified sessions were designed to improve students' coding learning experience by incorporating the learning and teaching objectives of the module. The teaching and learning objectives of the selected sessions were to give students knowledge about big data analytics architectures and help them understand when and how to use such scalable data processing solutions appropriately. The selected practical sessions provide introductory knowledge and hands-on experience in using Python programming in PySpark on Databricks to process big data analytics. PySpark is an open-source application programming interface (API) to support the collaboration of Python and the computational engine Apache Spark. Databricks is a cloud-based collaborative platform where users can use programming languages like Python, SQL, and R to perform data analytics. Various learning activities regarding PySpark are also

provided in the module to develop students' ability to identify questions and find solutions accordingly.

After discussions with the teaching team in two face-to-face meetings on 21st February and 28th February, the design objectives of the gamified session were identified as follows.

1. to enhance the students' sense of belonging in class, school and career. The design included game elements such as story-telling, role play, and team-based challenges to motivate students to work together and support each other to solve real-life cases related to their future careers;

2. to improve students' coding learning experience by providing hands-on practice and feedback opportunities. The design included game elements such as quests, points, and leaderboards to incentivize students to engage in the learning activities and track their progress.

5.2.2   Gamification mechanics

A brainstorming session on gamification and instructional strategies to be incorporated in the practical sessions was conducted with the teaching team in a face-to-face meeting on 7th March. The emphasis of the design included inclusion, equity, and a focus on creating a personalized and culturally diverse learning environment. In addition, the gamification design also incorporated a sense of belonging framework, which is a key factor in promoting student engagement and motivation. The belonging model recognizes that students who feel a sense of belonging in their learning environment are more likely to be motivated and engaged in their studies. The prototype has been designed with this in mind, and the ideas discussed include (1) creating an interactive gamification interface that allows students to learn programming concepts while also learning about UK culture and customs; (2) incorporating personalized avatars that students can customize to represent themselves and their cultural background; (3) use a point system that rewards students for completing programming challenges and also for participating in team collaboration; (4) include leaderboards to encourage healthy competition among students and to showcase top performers; (5) add a chat feature that allows students to communicate with each other and with instructors in real-time; (6) create animated videos that incorporate real-world examples and culturally diverse scenarios to help students relate programming concepts to their own experiences.

The description and application of the game elements and their design objectives for increasing different levels of students' sense of belonging are demonstrated in Figure 5.1.

Game elements embedded to increase students' sense of belonging at the Class level

Teamwork The teamwork game element embedded into the programming module encourages students to work together to complete tasks and challenges. This element helps to improve students' sense of belonging based on self-determination theory by providing a sense of social connectedness and by promoting intrinsic motivation. The teamwork game element also helps improve students' sense of belonging based on the MDA gamification framework by providing a sense of purpose and challenge.

Game elements(Y) / Sense of belonging(X)	Class	School	Career
Teamwork	Students can assign tasks within the groups and decide which strategies to use.		Students are encouraged to collaberate to solve the tasks.
Points and leaderboards	Reward system with experiement points (XPs) for recognizing students' accomplishment and engagement in the teamwork.		
Levels and tasks	Dividing the practical materials into different levels with increasing team-based challenges and hands-on exercises.		
Avatar			Students can choose their preferred name and role as data scientists.
Narritive	The story-telling can help students connect the programming knowledge with real-world and related careers; a short animated video released before class introducing the learning activities in a fun and engaging way.		

Figure 5.1: *Descriptions of gamified elements incorporated into the gamified session and their potential effectiveness in enhancing students' sense of belonging in different levels based on the Belonging Model.*

Leaderboard The leaderboard game element is a ranking system that displays the top performers in the module. This encourages students to strive to improve their ranking and maintain their position on the leaderboard. It provides a way for students to see how they are doing in relation to other students in the course. This can help improve their sense of belonging by providing a sense of competition and a way to see their progress. Additionally, the leaderboards can give students a sense of accomplishment and recognition for their achievements.

Points The experience points game element is a simple points system that rewards students for completing tasks and participating in class. It is based on the self-determination theory, which states that humans have a natural tendency to seek out challenge and novelty and that this tendency leads to increased engagement and motivation. The MDA framework further states that games should be designed to provide a sense of agency, meaning that players should feel in control of their destinies. The experience points game element provides a sense of agency by allowing students to choose which tasks they want to complete and how many points they want to earn. This sense of agency leads to increased engagement and motivation, leading to an increased sense of belonging.

Game elements embedded to increase students' sense of belonging at the School level

Animated trailer The animated trailer introduces the learning activities of the programming module in a fun and engaging way. It shows the different challenges that students will face in the course and how they can overcome them. The trailer also highlights the programming module's importance of collaboration and teamwork. The effects of the animated trailer on improving students' sense of belonging are twofold. First, it helps students to see the course as a challenge to be overcome rather than a daunting task and encourages them to take on the challenge and persevere through the difficult parts. Second, it shows the importance of collaboration and teamwork in the course. This encourages students to work together and support each other, which leads to a stronger sense of belonging.

Feedback The feedback gamification element for the programming module is a system that allows students to see how well they are doing in the course and to receive feedback from the lecturer on their progress. This system is designed to improve students' sense of belonging by providing information relevant to their course progress and allowing them to see how their progress compares to that of other students. This system also allows students to receive feedback from the lecturer on their progress, which can help them to feel more connected to the course and to the lecturer.

Game elements embedded to increase students' sense of belonging at the subject/career level

Storytelling The programming module's story-telling/narrative gamification element is designed to help students improve their sense of belonging by providing a more engaging and immersive learning experience. It can help students to feel more connected to the course material and to the other students in the class. It can also provide a more motivating and inspiring learning experience. In addition, this approach can help students to better understand the concepts being taught and to see how they can be applied in real-world scenarios.

Role plays The role-playing element for the programming module is designed to help students improve their sense of belonging by allowing them to explore and experiment with the course material in a safe and supportive environment. Through role-play, students learn how to work together to solve problems and how to code in a collaborative way. This can help improve their self-determination, as they feel more capable and empowered to code in a team. Additionally, the role-play element allows students to socialize and interact with their classmates, which can help improve their sense of belonging.

Level up When students level up in the programming module, they unlock new content and features that were not available to them before. This gives them a sense of accomplishment and a sense of belonging within the course. The level-up element also provides students with a sense of autonomy and control over their learning experience. This allows them to feel more self-determined in their learning, ultimately leading to a more positive sense of belonging.

The design of the two courses is similar in structure but different in content and gamification mechanisms. The instructional materials of the two sessions were decomposed into different levels with instructions and tasks. Narrative storytelling of each session with real-life cases was set to make students feel more connected to the program. In both sessions, students were presented with a series of challenges in a specific story setting, which they must complete either individually or collaboratively to progress to the next level. Each challenge is associated with a point system, which allows students to accumulate points as they progress through the session. In addition, there is a leaderboard that shows the students' performance. The following sections illustrate each gamification session's description and mechanism.

5.2.3   The first prototype of the gamification design

The first gamification prototype was designed for the practical session in the sixth week of the INF6032 module. The gamification elements include an animated trailer, a narrative of simulated tasks, experience points (XPs), challenges, and quests. The original worksheets were divided into four leveling-up challenges, which provided a sense of progression and accomplishment. To be more specific, the worksheets of the session were divided into four leveling-up challenges with step-by-step instructions and hands-on activities. The challenges were labeled as 100xp, 200xp, 300xp, and 400xp, and students could earn XPs accordingly after successfully submitting each quiz. The challenges were challenging but achievable, which helped build students' confidence and self-efficacy. The challenges presented to the students were designed to test their critical thinking, analytical, and problem-solving skills. The leveling-up design aimed to suit different levels of difficulty, from easy to hard, to cater to the needs of students with varying levels of proficiency. The XP awards offered for each challenge were also designed to motivate the students to put in their best efforts. The use of XPs was a key feature of the prototype, which was used to incentivize students to complete the challenges and were awarded to students who successfully submitted each quiz. Using XPs provided a sense of achievement and progress, which helped keep students motivated and engaged throughout the learning process.

An evaluation questionnaire was administered at the end of the session to collect feedback from the students about their learning experiences and the gamification design and to seek their consent to use their personal data. The feedback collected was used to refine the gamification design further and to ensure that it meets the needs and expectations of the
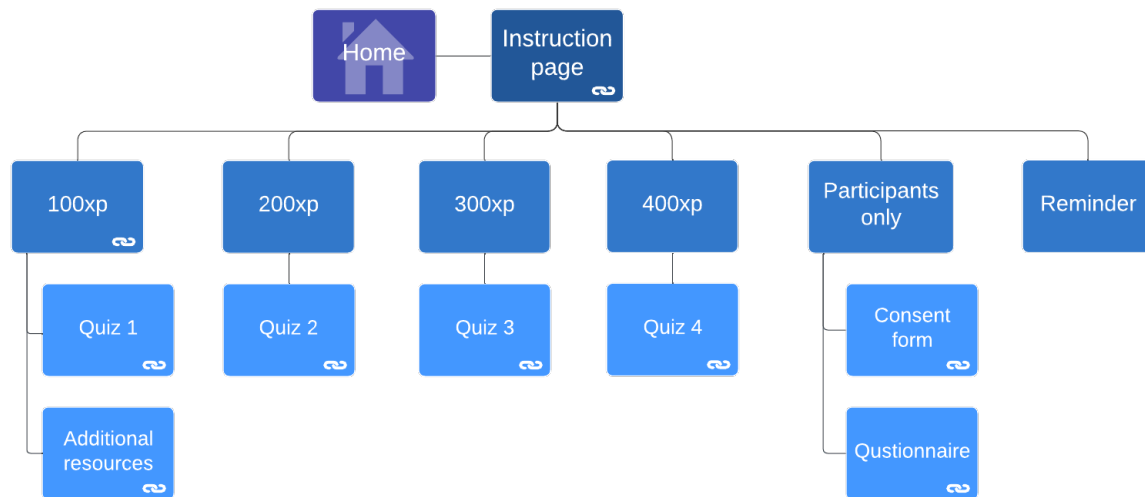
Figure 5.2: *Site map of the first gamification prototype.*

students. The design of the prototype was carefully crafted to ensure that it aligned with the learning objectives of the module and that it provided an effective and efficient way to learn the material. The site map of the first gamification design with the user flow from the top to the bottom and from the left to the right can be found in Figure 5.2.

The gamification design was deployed on Blackboard with authorization from the University of Sheffield, which entailed a rigorous process of ensuring that the design was aligned with the University's standards for online learning. Students were given access to the gamification task from the practical materials page of the INF6032 module on their Blackboard dashboard. This page displayed the session aims and objectives and provided a comprehensive introduction to the narratives of the simulated work task through an engaging animated video. The students were then directed to the entry point of the gamification task, which was designed to be intuitive and user-friendly. As part of the overall design, the practical materials page also served as the homepage of the gamification design, providing easy access to all the relevant resources (see Figure 5.3).

After clicking on the "Let's get started!" link, students were directed to the instruction page (see Figure 5.4). This page displayed the settings for the simulated work, provided entry to four challenges of varying difficulty levels, each with different XP awards, and included a link to an evaluation survey and a consent form. Additionally, instructions on submitting solutions to the quizzes were provided. The gamification design included a "Wiki" function, which allowed students to leave comments and collaboratively edit content in the textbox at the bottom of the page, to lead to a better understanding of the topics covered in the simulated work and foster a sense of community among the students.

The design of the different tasks followed the framework based on Bloom's taxonomy with leveling up challenges and associated quizzes as introduced in section 2.6.2.1. The '100xp' challenge page (see Figure 5.5) presents the starting setup of Databricks and preparation for data analysis in the following challenges with useful resources, which is the beginning task. While leaving up, the cognitive level of the instructions and quizzes for each challenge gets more complex, from the remembering level (200xp, see Figure 5.6) to the synthesis level

Figure 5.3: *The screenshot of the homepage of the gamified session for the first prototype designed for the practical session in the sixth week on Blackboard.*

Figure 5.4: *The screenshot of the instruction page of the gamified session for the practical session in the sixth week on Blackboard.*

Figure 5.5: *The screenshot of the '100xp' challenge page of the gamified session for the practical session in the sixth week on Blackboard.*

(300xp, see Figure 5.7) and finally to the practical level (400xp, see Figure 5.8).

5.2.4   Pilot study of the first prototype

The pilot study used an evaluation questionnaire to collect feedback from the students about their learning experiences and the gamification design. Sixteen students filled out the questionnaire (see Appendix B) after implementing the first prototype. Overall, the students reported a positive response to the gamified learning experience. 66.7% (12) of the participants in the questionnaire indicated that they were focused during the class (see Figure 5.9). Most participants agreed on all positive feelings and disagreements or neutral responses on all negative ones. Students reported that they were more willing to ask questions of the teaching team than in previous sessions. They were clearer about the learning structure and understood their tasks and roles in the activities. These results suggest that students' engagement was significantly improved during the gamified session.

200xp

Create Wiki Page

Wiki Instructions ⌃

👍 Congratulations! You've completed the first step!

🙌 Before we analyse the data of airports and flights connecting them, we need several steps to set the scene.

Loading essential libraries

First, let's load some of the packages that we will need for our analysis.

```python
from graphframes import *
import pandas as pd
from pyspark.sql.types import *
```

Read airports and flight connections into dataframes

Next, let's import the data into dataframes. We can directly download them from the web as follows:

```python
# load data into pandas dataframe
airportDF = pd.read_csv('http://ovus00.github.io/files/airports_us.csv')
flightsDF = pd.read_csv('http://ovus00.github.io/files/flights-airport.csv', skiprows = 1)
```

The data in the file flights-airport.csv contains a header. Using the argument *skiprows=1* will skip this header when importing the data.

Setting the schema matching airports and flight files

Before we can analyse the data we have to define what each column means. We can use PySpark's StructType class for this. The class defines column names, data type, and a Boolean to specify if a field can be nullable or not.

```python
airportSchema = StructType([ StructField("id", StringType(), True)\
                        ,StructField("name", StringType(), True)\
                        ,StructField("latitude", DoubleType(), True)\
                        ,StructField("longitude", DoubleType(), True)\
                        ,StructField("elevation", DoubleType(), True)\
                        ,StructField("type", StringType(), True) ])

flightSchema = StructType([ StructField("src", StringType(), True)\
                        ,StructField("dst", StringType(), True)\
                        ,StructField("count", IntegerType(), True)])
```

Loading files into vertices and edges dataframes

Now that we have defined a schema for our data we can use this to create vertices and edges dataframes.

```python
vertices = sqlContext.createDataFrame(airportDF,airportSchema)
edges = sqlContext.createDataFrame(flightsDF,flightSchema)
vertices.show()
edges.show()
```

The .show() command shows us what the dataframe looks like now.

Creating a graph

With everything sorted, we can now create a graph using the GraphFrame package.

```python
g = GraphFrame(vertices, edges)
```

Question   Edit Wiki Content

Created By 👤 Chen Cao
on Thursday, 10 March 2022 00:05:52 o'clock GMT
Last Modified by 👤 Frank Hopfgartner
on Tuesday, 15 March 2022 09:45:50 o'clock GMT

How would you check the datatypes of vertices? Please submit your output in the form here. (Hint: You have learned this in the practical of Week 4.)

https://forms.gle/kreN1QAxKMS5rwNX7

Comment

Figure 5.6: *The screenshot of the '200xp' challenge page of the gamified session for the practical session in the sixth week on Blackboard.*

Figure 5.7: *The screenshot of the '300xp' challenge page of the gamified session for the practical session in the sixth week on Blackboard.*

Figure 5.8: *The screenshot of the '400xp' challenge page of the gamified session for the practical session in the sixth week on Blackboard.*
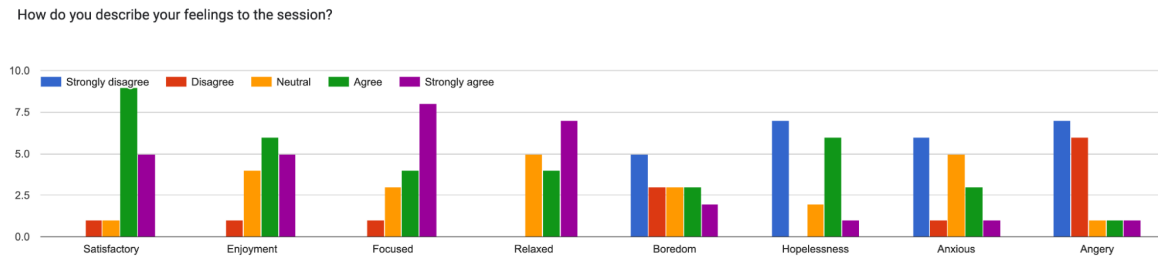
Figure 5.9: *The questionnaire responses to the question "How do you describe your feelings to the session?" in the pilot study evaluating the first gamification prototype.*

Regarding the effectiveness of the individual game elements, students indicated in the open questions of the questionnaire that they were impressed by the features of the "clear and lovely tutorial", "the different levels and different tasks dividing the long worksheets," "strongly relate to the real world," "the cute animation, pictures, and content interface are very cute," "every task of solving problems and responsibilities of data scientist," and "close to real-life examples."

Despite those successes, the first prototype had some limitations, as indicated by the participants in the questionnaire. The deficient in-time support and the scarce detailed explanation can cause frustration. Besides, the lack of rapid feedback and the inconsistent storyline can make it difficult to follow the course. Furthermore, the inadequate details in each story can make it difficult to understand the material. The participants also suggested ways to improve the course, such as organizing group discussions and adding task rewards. Additionally, participants suggested that more gradual instruction of new knowledge and more interactive activities would be beneficial and provide more introductions of programming functions for those with limited programming experience. As one response stated:

> "I only have a little bit of programming skills, and not familiar with the use of functions in this session. I will appreciate if there are some brief introductions of functions before practising."

Overall, the participants found the class to be interesting and engaging. They had positive comments, such as that the learning mode was interesting, and expressed eagerness for the next class.

5.2.5   The second prototype

The gamification design in the first prototype was refined and re-designed for the practical session of week 7. Building on students' feedback from the first prototype, the second prototype made several design changes to existing features, such as the storytelling of simulated work tasks, and added new gamification features, including team collaboration, leaderboards, and real-time feedback provided by the learning analytics of the quiz submissions powered by Blackboard. The following figures (Figure 5.10, Figure 5.11, Figure 5.12. Figure 5.12, Figure 5.13, Figure 5.14) present the screenshots of the homepage, instructional page, and

Figure 5.10: *The screenshot of the homepage of the gamified session for the second prototype designed for the practical session in the seventh week on Blackboard.*

pages of Level 1 and Level 2 of the gamified session for the second prototype designed for the practical session in the seventh week on Blackboard.

The team collaboration function is designed to bring students together to work on the material as a team (see Figure 5.15). By working collaboratively, students can exchange ideas, learn from each other, and develop important skills such as communication and problem-solving. By fostering teamwork, the prototype aims to create a sense of community within the learning environment, where students feel supported and encouraged to learn.

Another important feature of the second prototype is the learning analytics of the quiz function (see Figure 5.16 and Figure 5.17). Powered by Blackboard, the learning analytics of the quiz function enables teachers to capture valuable learning analytics data from students' quiz submissions. This data provides insights into how students are engaging with the material and areas where they may need more support. By using this feature, teachers can tailor their lessons to suit the needs of the students better, and ensure that students are making progress.

The leaderboard function is another exciting feature of the second prototype (see Figure 5.18). Students are encouraged to work harder and do better by providing an element of competition and motivation. As students compete with one another to improve their scores and climb the ranks, they are expected to be motivated to learn and engage with the material in a more meaningful way.

The second prototype is a marked improvement in gamification for this module. It boasts several new features that enhance the learning experience and promote student engagement, making it popular with students and teachers. The design of the prototype aimed to provide

Figure 5.11: *The screenshot of the instructional page of the gamified session for the second prototype designed for the practical session in the seventh week on Blackboard.*

Figure 5.12: *The screenshot of the "Preparation" page of the gamified session for the second prototype designed for the practical session in the seventh week on Blackboard.*

Level 1 - PySpark basics

Create Wiki Page

Wiki Instructions ⌃

Resilient Distributed Dataset

As explained in the lecture, data that can be accessed in Spark is transformed into Resilient Distributed Datasets (RDDs). RDDs allow apps to keep working sets in memory for efficient reuse. Further, it retains the properties of Map/Reduce.

```python
a = range(10)
```

Below code illustrates how to transform data to RDD. Let's start by creating a simple list.

This has created a list a containing the values 0-9. Next, let's perform the transformation to RDD as follows:

```python
rdd = sc.parallelize(a)  #lazy send to spark
rdd
```

Basic actions

Now that our data is transformed to RDD we can already perform basic actions and further transformations.

For example, let's look at the first element of our RDD.

```python
rdd.first()
```

If you want to see the entire RDDs content, you can use the *.collect()* action. This is the simplest operation and can be very helpful when analysing the data.

```python
rdd.collect()
```

Next, let's perform a basic Map/Reduce operation. Below example will first transform the data by multiplying each value by 10 in the mapping operation. The reduce operation will output the sum of all elements.

```python
rdd = rdd.map(lambda x: x*10)  #lazy! it return another rdd
rdd
```

```python
rdd.reduce(lambda x,y:x+y)  # not lazy (action)
```

We can also apply a filter to transform our RDD even further. Below example removes all elements that do not fulfil the condition.

```python
rdd = rdd.filter(lambda x: x>30)
rdd
```

Exercises   Edit Wiki Content

Created By 🧑 Chen Cao
on Thursday, 17 March 2022 11:25:04 o'clock GMT
Last Modified by 🧑 Chen Cao
on Wednesday, 23 March 2022 10:56:25 o'clock GMT

Now it's time to solve the first task! Please click the link below to see the question.

Please note only the leader of your group could submit the agreed answer for this level of the task.

Quiz

Comment

Figure 5.13: *The screenshot of the "Level 1" page of the gamified session for the second prototype designed for the practical session in the seventh week on Blackboard.*

Level 2 - Tuples and reduceByKey

Create Wiki Page

Wiki Instructions ⌃

Next, let's look at more complex concepts, namely tuples and the reduceByKey() operation.

First, let's create a new dataset data consisting of tuples such as 'Name', 'Age, 'Gender', 'Language'.

```
data = [['Alexandra','31','F','Python'],['Carla','25','F','C'],['Max','18','M','Scala'],['Tom','34','M','C'],['Philip','28','M','Python'],['Lucy','25','F','Scala'],['Al','18','M','Scala'],['Grace','34','F','Python']]
```

As before, we have to first transform data to RDD.

```
RDD = sc.parallelize(data)  #send data to spark
```

That was easy, wasn't it? Now let's use the .reduceByKey() operation to transform our data further.

Below example transforms the data by mapping all elements based on their 'gender' and sums them up.

```
sumByGender = RDD.map(lambda t: (t[2],1)).reduceByKey(lambda x,y: x+y)
sumByGender.collect()
```

Let's look at these two steps separately using another example. The .map() operation transforms the data by considering the elements stated in the operation.

```
languageAndAge = RDD.map(lambda t: (t[3],int(t[1])))
languageAndAge.collect()
```

The .reduceByKey() operation allows us to transform this data further. For example, we can sum up the same elements:

```
languageAndAge.reduceByKey(lambda x,y:x+y).collect()
```

Getting the average

Now, let's see how we can calculate the average of elements in the RDD. Again, we split this operation in a mapping phase and .reduceByKey().

```
temp = RDD.map(lambda t: (t[3],(int(t[1]),1)))
temp.collect()
```

```
temp2 = temp.reduceByKey(lambda x,y: (x[0]+y[0],x[1]+y[1]))
temp2.collect()
```

```
temp2.map(lambda x:(x[0],x[1][0]/x[1][1])).collect()
```

Exercises

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Created By Chen Cao
on Thursday, 17 March 2022 11:53:33 o'clock GMT
Last Modified by Chen Cao
on Wednesday, 23 March 2022 10:57:10 o'clock GMT

Now it's time to solve the second task! Please click the link below to see the question.

Please note only the leader of your group could submit the agreed answer for this level of the task.

Quiz

Comment

Figure 5.14: *The screenshot of the "Level 2" page of the gamified session for the second prototype designed for the practical session in the seventh week on Blackboard.*

Figure 5.15: *The screenshot of the links accessing the group work and team function for the second prototype designed for the practical session in the seventh week on Blackboard.*

Figure 5.16: *The screenshot of the learning analytics function for the quizzes submissions in the "Level 1" section of the second prototype designed for the practical session in the seventh week on Blackboard.*

Figure 5.17: *The screenshot of the learning analytics function for the quizzes submissions in the "Bonus" section of the second prototype designed for the practical session in the seventh week on Blackboard.*
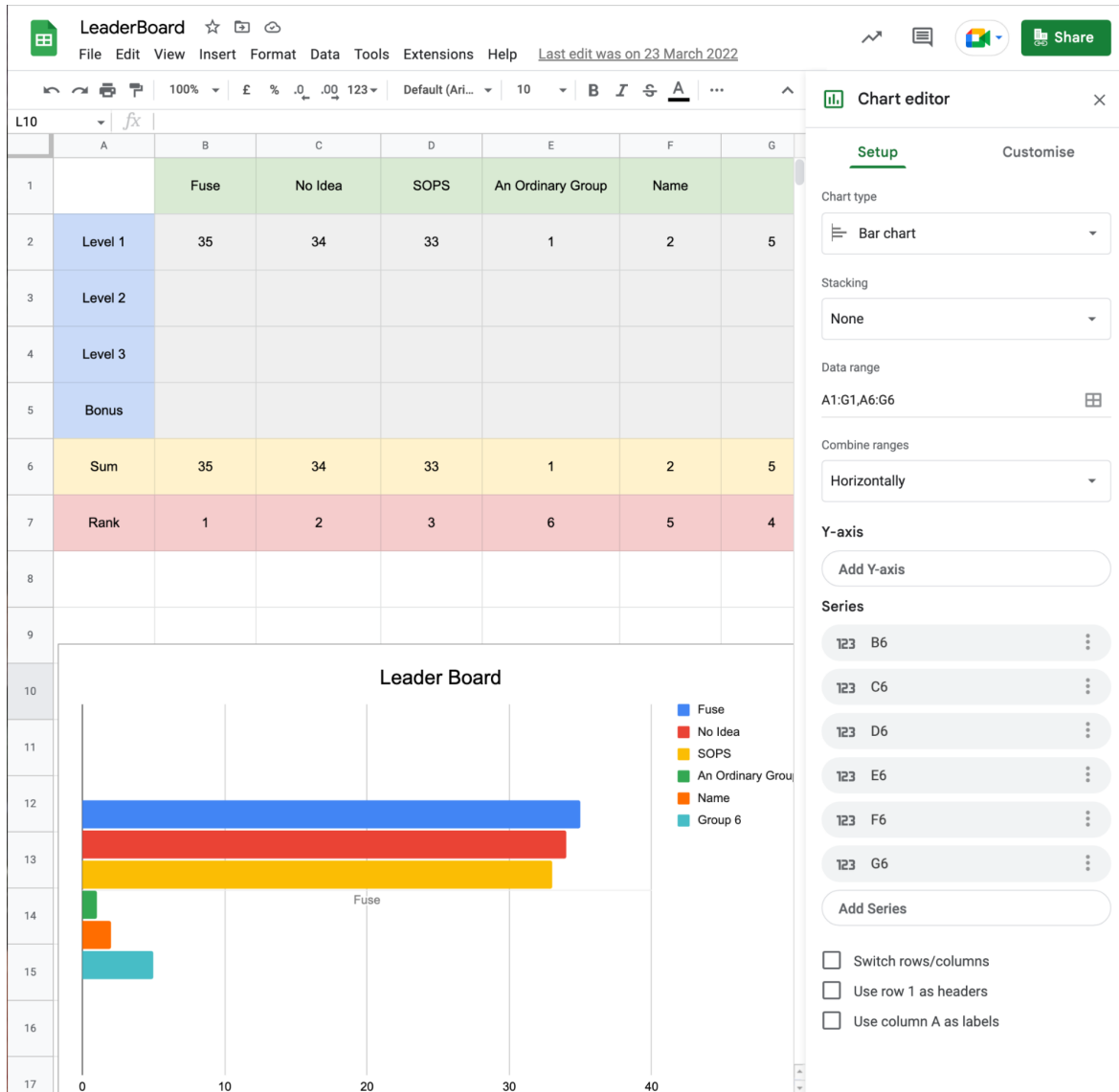
Figure 5.18: *The screenshot of the leaderboard function powered by the Google sheets in the second prototype designed for the practical session in the seventh week on Blackboard.*

a fun and engaging learning environment that fosters collaboration while also promoting exceptional learning outcomes. In conclusion, the second prototype of gamification for the INF6032 module represents a significant step forward in developing gamification for this module. With its team collaboration function, quiz function, and leaderboard function, the prototype is designed to create a learning environment that is engaging, motivating, and promotes learning outcomes.

5.3 Phase II: Field study

5.3.1 Description of the sample

32 participants were recruited from the Data Science Programme at the Information School by email invitation. All of the participants were from China, 15 of which were female and 17 were male. The dominance (72%) of the participants was at the beginner level of programming, and only 18.8% of the students studied abroad before. Their undergraduate backgrounds were quite diverse, ranging from Finance to English, among which 31.3% were STEM-related subjects. The demographic details of the participants are presented in Figure 5.19. The demographic feature of the participants was consistent with the one in the first study, as they were recruited from the same cohort of students. All of the participants participated in both questionnaires and focus group interviews, agreed to be observed during the implementation of gamification, and allowed online behavioral data to be collected for learning analytics.

5.3.2 Questionnaire findings

The effects of gamification in improving students' sense of belonging

The second section of the questionnaire consisted of five 5-Likert questions measuring the effectiveness of gamification in students' sense of belonging in terms of their relationship with classmates and lecturers within the learning community of the course, their relatedness to the faculty, and their connectedness with the subject related career based on the sense of belonging scale questionnaire proposed by Hoffman et al. (2002) and the Belonging Model by Araujo et al. (2014). The summary of questions is presented in Table 5.1.

When asked about their sense of belonging, the majority of respondents reported that they felt a strong sense of belonging to their course (70%), their university (60%), and their classmates (55%). Furthermore, nearly half of the respondents (45%) felt that the gamified learning experience had helped them to develop a stronger sense of belonging.

The average score for the question on the effects of gamification in improving students' sense of belonging was 3.9, which indicates that gamification positively affected students' sense of belonging. Table 5.2 presents the descriptive data (minimum, maximum, mean, standard deviations, Median) of the responses to the questions related to the evaluation of sense of belonging. The highest score was for the question on students' relationship with lecturers, with a score of 4.32. This indicates that gamification positively affected students' relationships with the teaching team. The lowest score was for the question on students' perceived loneliness, with a score of 3.56. This implies that the gamification approach was relatively less effective in reducing students' sense of loneliness. The other three questions had scores of 4.04 and 3.84, respectively, meaning that gamification positively affected stu-

Figure 5.19: *The sociodemographic profile of participants of the second study of the research.*

Table 5.1: *Survey Questions on the Impact of Gamification*

Question Number	Question	Question Type
SQ1	How would you rate the impact of gamification teaching on improving your relationship with your classmates?	5-Likert scale
SQ2	How would you rate the impact of gamification on bringing you closer to your teaching team?	5-Likert scale
SQ3	How would you rate the impact of gamified teaching on alleviating loneliness?	5-Likert scale
SQ4	How would you rate the impact of gamified teaching on making you more confident in your profession?	5-Likert scale
SQ5	How would you rate the impact of gamification on increasing your sense of belonging?	5-Likert scale

dents' sense of relatedness to peers and their connectedness with the subject-related career. These results are consistent with the literature on gamification and sense of belonging, which suggests that gamification can improve students' sense of belonging by increasing their social interactions and connection to the course content (Rivera and Garden, 2021; Ling, 2018). The results of this questionnaire show that gamification can positively affect students' sense of belonging, particularly in terms of their relationship with lecturers and their connectedness with the subject. However, the approach is relatively less effective regarding students' sense of relatedness to faculty. These results suggest that gamification can be useful in enhancing students' sense of belonging and engagement in the learning community.

According to the survey results, there was no significant difference in the sense of belonging between male and female students in the course. Table 5.3 indicated that both groups

Question codes	Number of responses	Min.	Max.	Mean	S.D.	Med.
SQ1	32	3	5	4.32	0.75	4
SQ2	32	2	5	4.04	0.98	4
SQ3	32	2	5	3.56	0.96	4
SQ4	32	2	5	3.84	0.90	4
SQ5	32	2	5	3.76	0.93	4

Table 5.2: *Descriptive data (minimum, maximum, mean, standard deviations, Median) of the responses to the questions related to the evaluation of sense of belonging.*

Question	Gender		Level		
	F (46.9%)	**M (53.1%)**	**Low(28%)**	**Med(48%)**	**High(24%)**
SQ1	4.41	4.13	4.25	4.43	4.33
SQ2	4.12	3.88	4.00	3.86	4.33
SQ3	3.94	3.38	3.58	4.00	3.83
SQ4	3.94	3.63	3.75	4.14	3.67
SQ5	3.77	3.13	3.17	4.00	3.83
Summary	4.04	3.63	4.09	3.75	4.00

Table 5.3: *Mean values of sense of belonging by gender and programming levels.*

reported similar levels of belonging, with female students having a mean score of 4.0 and male students having a mean score of 3.6. Additionally, there was no significant difference in the sense of belonging among students with different levels of programming expertise. Students with lower programming skills reported a sense of belonging with a mean score of 4.1, which was comparable to the mean score of 3.8 reported by students with higher programming skills. These findings indicate that the sense of belonging fostered by the course's gamification elements is consistent across gender and programming expertise levels, suggesting that the gamified teaching methods in the current study might effectively create an inclusive learning environment. However, it is important to acknowledge the limitation of the small sample size, which may affect the generalizability of these results.

	Non-standardized coefficients		Standardisation coefficients	t	p	VIF	R 2	F
	B	Standard error	Beta					
Constant	0.852	0.940	-	0.906	0.376	-	0.523	**F (4,20)=5.476, p=0.004**
SQ1	-0.123	0.317	-0.100	-0.389	0.701	2.751		
SQ2	0.169	0.181	0.179	0.936	0.360	1.530		
SQ3	0.475	0.322	0.461	1.473	0.156	4.095		
SQ4	0.263	0.215	0.273	1.222	0.236	2.088		

Table 5.4: *Linear regression analysis results. Dependent variables: SQ5. D-W value: 2.202. * $p < 0.05$ ** $p < 0.01$*

Codes	Questions	Question types
LQ1	Do you think gamified teaching has improved the atmosphere of the classroom?	5-Likert scale
LQ2	Do you think gamification has improved your engagement in the class?	5-Likert scale
LQ3	How would you rate the experience of taking computer classes in the sixth and seventh weeks? Sub-items: Happiness/focus/anxious/hopeless/sense of achievement/sense of meaningfulness/sense of engagement/sense of fulfilment	Matrix scale questions

Table 5.5: *The effectiveness of the gamification design in improving students' learning experience.*

The results of the linear regression analyses showed that, after controlling for gender and programming level, the Belonging Model factors (i.e. social connectedness, academic relatedness, and faculty relatedness) did not significantly predict a sense of belonging, $F(4,20)=5.476$, $p=.004$, $R2=.523$ (see Table 5.4). These correlations were quantified through p-values, with results showing significance at $p < 0.05$ levels, indicating a less than 5% likelihood that the observed relationships occurred by chance. The similar sense of belonging reported by students with different levels of programming expertise implies that gamification might efficiently bridge the gap between novices and more experienced students. However, it is important to note that the results of this study are based on a small sample of students. Therefore, these results should be interpreted cautiously and future research should focus on replicating these findings with a larger sample of students.

The effects of gamification in improving students' learning experience

When asked about their gamified learning experiences (see Table 5.5 for the question items), the majority of respondents reported that they found the experience to be enjoyable (70%), challenging (65%), and motivating (60%). Furthermore, nearly half of the respondents (45%) felt that the gamified learning experience helped them to better understand the course material.

On a 1-5 scale, with 1 being strongly disagreed and 5 strongly agree, the average responses to the questions were as follows in Table 5.6:

To evaluate the impact of gamification on students' sense of belonging, we conducted a Pearson correlation analysis. This test was chosen because our data met the assumptions of normality, linearity, and homoscedasticity, and we aimed to examine the strength and direction of the relationship between two continuous variables: gamification usage and sense of belonging scores.

The results revealed a significant positive correlation between gamification usage and students' sense of belonging ($r = 0.42$, $n = 120$, $p < 0.01$), indicating that higher levels of

Question codes	Number of responses	Min.	Max.	Mean	S.D.	Med.
LQ1	32	3	5	4.40	0.65	4
LQ2	32	3	5	4.44	0.65	5

Table 5.6: *Descriptive data (minimum, maximum, mean, standard deviations, Median) of the responses to the questions related to the evaluation of learning experience.*

gamification were associated with stronger feelings of belonging in the classroom. The effect size of this correlation suggests a moderate relationship, which is meaningful in the context of educational interventions.

These findings support our hypothesis that gamification can enhance students' sense of belonging, aligning with previous research that highlights the potential of gamification to foster engagement and social connectedness. The statistical significance of this result underscores the value of incorporating gamified elements into educational settings to promote a positive learning environment.

Overall, the vast majority of students who responded to the survey believe that gamification has positively impacted their academic-related emotions. In terms of the atmosphere of the classroom, the average score was 4.4, which indicated that respondents thought gamified teaching has improved the atmosphere of the classroom. This suggests that gamification has helped to create a more positive and enjoyable learning environment for students. Regarding student engagement, the average score was also 4.4, implying most participants think gamification has improved their engagement in class. This suggests that gamification has helped increase student interest and motivation in the class, leading to better academic performance. This is likely because gamification introduces an element of fun and competition into the learning process, which can motivate students to pay attention and participate more actively. Additionally, the social interaction that is often a part of gamified learning can help create a more supportive and positive classroom environment.

The radar graph in Figure 5.20 shows that gamification positively affected students' academic emotions. The mean score for the focus sub-item was the highest (4.2), followed by happiness (4.2), sense of engagement (4.0), sense of fulfilment (3.7), sense of achievement (3.6) and sense of meaningfulness (3.6). The mean score for the hopeless sub-item was the lowest (1.8).

Overall, the data shows that gamification can be an effective tool in improving students' academic emotions. The highest scores were seen in the focus and happiness sub-items, indicating that gamification can help students maintain their focus and interest in the learning process. The sense of engagement, achievement, and meaningfulness were also positively affected, implying that students feel more engaged and motivated when learning is presented in a game-like format. The results for the hopeless sub-item were less positive since the question was framed in a negative manner. The data suggest that gamification can improve students' focus, happiness, sense of engagement, sense of fulfillment, sense of achievement, and sense of meaningfulness and reduce students' feelings of hopelessness. Future research should explore the effects of gamification on academic emotions in more depth.
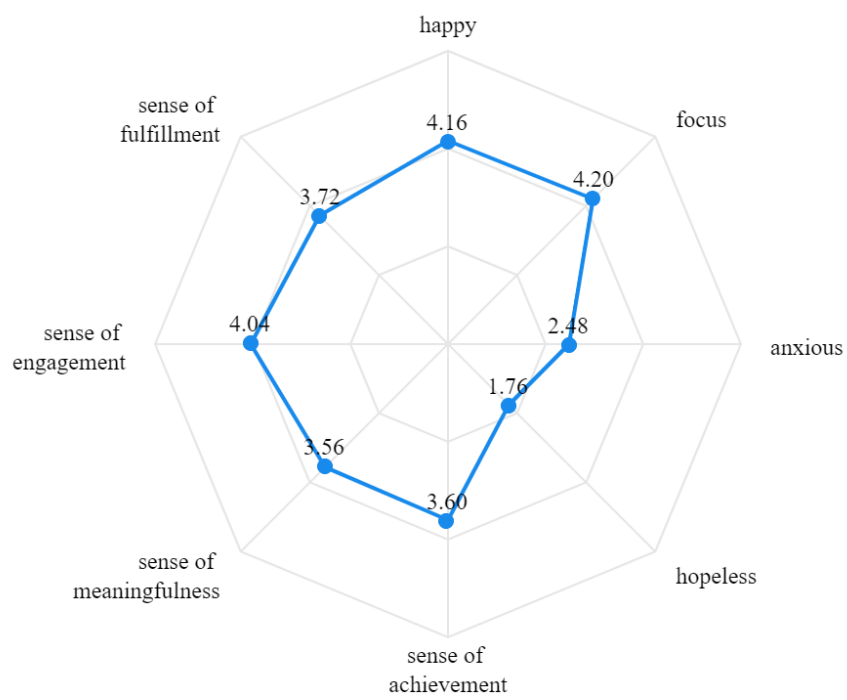
Figure 5.20: *Radar graph of the mean score of academic emotions responded to LQ3.*
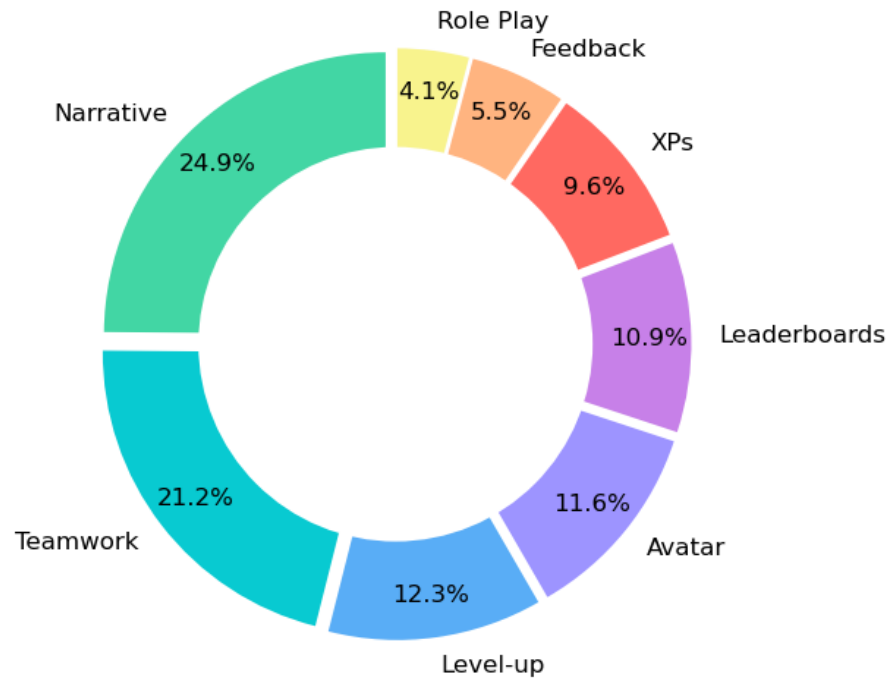
Figure 5.21: *Students' preference of each game element in the programming learning.*

Students' attitude towards the gamification design and each game element

Students' preferences and perceived effectiveness of each game element were evaluated in the questionnaire. The pie chart (Figure 5.21) illustrates students' responses to their perceived most effective game elements, increasing their intrinsic motivation to the programming module. The statistical analysis brought forward significant insights into how specific elements of gamification, namely Narrative, Level Up, and Teamwork, influence students' sense of belonging. These elements stood out for their substantial impact on the educational experience.

The use of storytelling or narrative in gamification profoundly impacted students' engagement and sense of belonging. The data indicated that students felt more connected to the learning material when they were engaged in a cohesive narrative. This connection was not merely academic; it fostered a deeper sense of being part of the story unfolding within their educational journey. The statistical significance of this finding was evidenced by a p-value below 0.05, underscoring the effectiveness of narrative as a tool for enhancing the educational experience.

The concept of 'Leveling Up' or progressing through different achievement stages also had a notable positive influence. This mechanism provided students with a clear sense of progression and achievement. As students advanced through levels, they reported increased feelings of accomplishment and belonging, underlining the motivational aspect of this gamification element. The statistical analysis confirmed the significance of these observations, indicating a strong correlation between level progression and students' sense of belonging.

Lastly, teamwork within the gamification framework significantly boosted students' sense

of community and belonging. Activities that promoted collaboration and peer interaction enhanced learning and played a crucial role in cultivating a supportive and inclusive educational environment. This was reflected in the statistical data, where the incorporation of teamwork in gamified learning showed a significant positive impact on students' sense of belonging, as demonstrated by the p-values obtained.

These results highlight the multifaceted impact of gamification in education. The elements of Narrative, Level Up, and Teamwork each cater to different but crucial aspects of the learning experience. Narrative engages students emotionally and cognitively, Level Up provides a tangible sense of progress and achievement, and Teamwork fosters social connections and collaboration. Together, these elements create a dynamic and inclusive learning environment that engages students and instills a strong sense of belonging and community.

The findings suggest that effectively integrating these gamification elements can significantly enhance the educational experience, especially in diverse educational settings where fostering a sense of belonging is essential for student success.

Finally, when asked about suggestions for improvement, most respondents suggested that the game should be more challenging (60%), and that more feedback should be provided (55%). Other suggestions included making the game more fun (45%), and providing more help and support (40%). Most respondents had suggestions for how gamified learning could be improved (70%), and the rest did not have any suggestions (30%). The most common suggestion was that gamified learning should be made more fun and engaging (50%), followed by the suggestion that it should be less time-consuming (30%).

Summary of questionnaire findings

Overall, the questionnaire results suggest that gamified learning experiences can be enjoyable, challenging, and motivating for Chinese students enrolled in the introductory programming module. Furthermore, the gamified learning experience can help Chinese students to understand the course material better and develop a stronger sense of belonging. Suggestions for improvement were mostly related to gameplay, with respondents requesting more clarity, support, and interest. A small minority of respondents suggested that gameplay be made easier, less frequent, or nonexistent.

The findings showed that Chinese students generally had positive attitudes towards gamified learning experiences and that these experiences improved their sense of belonging. These findings are consistent with previous research on gamification and its effects on students' sense of belonging (Zhang and Chen, 2021; Ling, 2018). However, there are some limitations to this study. First, the sample size is relatively small. Second, the questionnaire was self-reported and thus subject to potential biases. Future research should attempt to address these limitations.

These insights are a testament to the multifaceted role of gamification in education. Not only does gamification enhance engagement through interactive and motivational elements, but it also plays a pivotal role in fostering a sense of belonging among students. Each gamification element, from achievement badges to collaborative challenges, addresses different psychological and social needs of students, contributing to a more inclusive and connected learning experience.

The findings particularly emphasize the importance of recognition, progress tracking, and social interaction in the context of educational gamification, suggesting these are key areas

to focus on for future gamification designs. This is especially relevant in settings with diverse student bodies, including international students, where the sense of belonging can be crucial to academic success and personal well-being.

In conclusion, the detailed statistical analysis from this study provides substantial evidence of the positive impact of gamification on students' sense of belonging. This not only supports the implementation of gamification strategies in educational contexts but also provides valuable insights for the design and application of these techniques to create more inclusive and effective learning environments.

5.3.3 Focus group interview findings

A total of 32 Chinese students enrolled in the INF6032 module participated in the study. The students were divided into four focus groups, each consisting of eight students. The focus groups were conducted in Chinese and were audio-recorded. The recordings were transcribed and translated into English. The students were asked about their experiences and opinions on the design elements used in the gamification and the impact of the gamification design on their sense of belonging to the class, faculty, and subject. To ensure consistency, we used a detailed moderator guide was used for each session, which included the exact wording of questions and the order in which they were to be asked. After each focus group session, moderators debriefed to discuss the flow of the discussion and any deviations from the script. We also conducted the focus groups in Chinese to minimize misunderstandings and allow for richer, more nuanced responses. The transcripts were analyzed using thematic analysis using the NVivo software. Four themes were identified: a sense of belonging, learning experiences, and gamification elements, and suggestions for improvement. The codes of the four main themes and the sub-themes under each theme are presented in Table 5.7. The findings of the focus group interview will be reported following the themes.

Theme	Description	Sub-themes
A. Sense of belonging	Gamification impact on students' sense of belonging	• Relationships with classmates • Relatedness to the faculty • Connectedness to the subject and related career • Feeling of isolation • Additional aspects
B. Learning experience	Gamification impact on students' learning experience	• Learning motivation and engagement • Academic confidence • Learning retention • Playful experience • Additional aspects
C. Gamification elements	Students' preferences and attitudes towards each game elements	
D. Suggestions for improvement	Students' suggestions on the improvement of the gamification design	• Real-time feedbacks • In-time learning-support with high quality • Balance between entertainment and learning • Realistic storytelling • Autonomy in teamwork • Learning community for the class • Progress indication and clear instructions

Table 5.7: *The initial codes of the focus group interview transcripts.*

Theme A: Gamification's impact on students' sense of belonging

The main themes that emerged from the data were relationships with classmates, relationships with the teaching team, relatedness to the faculty, connectedness to the subject and related career, feeling of isolation, and additional aspects.

Theme A.1) Gamification impact on students' sense of belonging in the aspect of their relationships with classmates

The relationships with classmates sub-theme emerged as the most salient, with students reporting positive experiences of working with classmates in the context of the story-based gamification design. The focus group interviewees were unanimously positive about the potential of story-based gamification design to improve their sense of belonging at the peer level in class. They found that the game-based approach helped them to feel more comfortable and confident in interacting with their peers. They also felt that the game allowed them to interact with their peers in a more meaningful way. As one participant (P12) addressed:

> "You are provided chances to talk to your classmates, and then you can think more about how this thing (big data analytics) is working, and then you can share your ideas with others more, and you are more willing to communicate."

The students felt that the story-based design helped to create a more inclusive and supportive environment in the class and that it helped them to feel more connected to their classmates. The students also felt a stronger sense of belonging to the module community when story-based gamification design was used, and they were more likely to seek help from their peers when needed. As one interviewee (P16) mentioned:

> "...especially for me, who missed the induction week and didn't know anyone in the class. It [the gamification design] is a great help, which allows me to communicate with some classmates, and it's really good."

However, students also reported that the gamification design can improve the sense of belonging in a group setting but may not have as much of an impact on the sense of belonging in a larger class setting. As participants (P15) argued:

> "...when it comes to a group of several people, it is true that this [the impact of gamification] on the sense of belonging is very great, but for the class level, it's not so likely (to feel a stronger sense of belonging), I didn't have much chance to talk to the students outside my group."

Overall, the interviewees reported positive experiences of using story-based Gamification Design in the introductory programming module. They felt that the story-based gamification design helped them understand the course content better and feel more connected to their classmates. They also felt that story-based Gamification Design had improved their sense of belonging at the peer level.

Theme A.2) Gamification impact on students' sense of belonging in the aspect of their relatedness to the department

The relatedness to the faculty and institution sub-theme emerged as another important theme in the data. The students felt that the story-based gamification design helped them

feel more connected to the institution. The students reported feeling more supported and valued by the teaching team when story-based gamification design was used in the course. They also felt that the story-based gamification design had made the course more engaging and interesting and helped them understand the course content better. One interviewee (P30) said:

> "...I feel that this game-like design itself represents the college's and teachers' care for us. I can feel that the teachers and assistant teachers are working hard to make our learning more interesting, and they are doing their best for us to have a better learning experience. It's as if they are making our relationship with them closer."

Another interviewee added that:

> "I feel I was valued by the department because they care about Chinese students' learning experience. For this point, I feel a sense of belonging."

The findings suggest that story-based gamification design can help Chinese students feel more connected to the School and institution. However, the students also reported some negative experiences, such as difficulty getting timely responses and detailed feedback from the teaching team. The high ratio of students to teachers was also mentioned as a possible explanation for the difficulty. These findings suggest that there is room for improvement in the way story-based gamification design is implemented in order to help Chinese students to feel more connected to the School and institution.

Theme A.3) Gamification impact on students' sense of belonging in the aspect of their connectedness to the subject-related career

The students felt that using stories could help create a more personal connection between each other and the module material and that this could, in turn, lead to improved academic performance. Other participants echoed this sentiment, stating that the story-based gamification design made the course material more relatable and easily understood. They also noted that it helped them to feel more connected with the data science career. One participant (P8) said:

> "... I have not been exposed to the actual project before, and now I am asked how to solve a real problem that is the airline, and then how to reduce its budget, reduce costs, and then maximize the benefits. I think this makes me clearly understand what I can learn in the future, and have a clear awareness of my career planning."

Another interviewee also mentioned the following:

> "I also feel like I understand the material better because I can see how it applies to real-world scenarios." (P16)

Based on the findings above, it appears that story-based gamification design can be an effective way to improve Chinese students' sense of belonging by increasing their connectedness to the subject-related career. This is likely because story-based gamification makes the

module material more relatable and easier to understand and also helps students see how the material can be applied to real-world scenarios. Thus, this type of gamification design can help create a more personal connection between students and the module material, leading to improved academic performance.

Theme A.4) Gamification impact on students' sense of belonging in the aspect of their feeling of isolation

Most participants felt that the story-based gamification design had helped them feel less isolated in the module, as it provided a more supportive and collaborative learning environment. One student (P14) said:

> "I think it (story-based gamification design makes the class more like a community because we're all working on the same thing and trying to help each other out, rather than just feeling like we're all on our own."

Another interviewee (30) echoed this sentiment, stating that:

> "I think it's good that we can work together on the story because it makes me feel less alone in the class, and I can learn from other people's perspectives."

A few participants also felt that story-based gamification had helped them feel more connected with the lecturer, allowing for more interaction and communication. One student (P22) said:

> "I think the story-based gamification design has helped me feel more connected with the lecturer because we can talk about the story and the characters, and he can give us more help and guidance."

The findings suggest that story-based gamification design can help Chinese students feel less isolated in the course. This was because it created a more supportive and collaborative learning environment and helped to connect students with the lecturer.

The participants' sense of belonging was found to be significantly improved when story-based gamification design was implemented in the practical sessions of the INF6032 module. The students reported feeling more connected to their classmates, the teaching team, and the subject matter. They also felt less isolated and more motivated to succeed in the module. The study's results showed that using story-based gamification improved Chinese students' sense of belonging, motivation, engagement, and academic confidence.

The first theme emerging from the qualitative data helped explain the study's findings. First, the story-based game provided a context for learning, which was particularly beneficial for Chinese students who were struggling to adjust to the British university context. Second, the story-based game promoted social and emotional learning, which helped Chinese students to develop a sense of belonging. Third, the story-based game increased motivation and engagement, encouraging Chinese students to persist in adversity.

Theme B: Gamification's impact on students' learning experiences

It was found that the students felt more engaged and motivated to learn when story-based elements were incorporated into the course. In particular, students reported feeling more

motivated to work on the programming tasks and more invested in the course due to the story-based gamification design. Furthermore, the interviewees felt that the story-based gamification design made the course more enjoyable and less daunting. They also felt that the story-based approach could help reduce the isolation that some Chinese students can experience when studying in a foreign country. The participants discussed how the gamification design made the course more engaging and enjoyable.

Theme B. 1) Learning motivation and engagement

The participants reported feeling more motivated to work on the programming tasks due to the story-based gamification design. They felt that the story-based approach made the course more interesting and engaging, thus motivating them to work harder. One student (P30) said:

> "I think the story-based design makes the entire course more interesting, and thus I am more motivated to learn."

The students also reported feeling more invested in the course due to the story-based gamification design. They felt that the story-based approach enabled them to understand the course material better and see how it can be applied to real-world scenarios. As one participant (P14) said:

> "It (the gamification design) makes me more invested in the course since I can relate to the stories and understand the logic behind the problems, so I'm more motivated to learn."

The students also felt that the story-based approach helped to make the course more enjoyable and less daunting. They felt that the story-based approach was more engaging and made the course material more interesting. As one participant (P10) said:

> "... I think it (the story-based gamification design makes the course more enjoyable and less daunting because it allows us to have a more in-depth understanding of the course material, and it's more interesting."

Theme B. 2) Academic confidence

The participants discussed how the story-based gamification design helped them become more confident in their programming skills. The students felt that the story-based approach had allowed them to understand the course material better and to gain a deeper understanding of programming. They also felt that the story-based design had allowed them to develop a more meaningful connection with the course material and helped them become more confident in their programming skills. As one participant (P12) said:

> "I think this gamification design can help us gain a deeper level of understanding of the course. It's more interesting and engaging than just reading the text. We can really understand the material better."

The students also felt that the story-based gamification design had helped them to become more confident in their ability to solve real-world programming problems. As one participant (P19) noted:

"I think this gamification design has helped me to become more confident in my programming skills. I feel like I can now solve real-world programming problems more confidently."

The findings suggest that the story-based gamification design can help Chinese students to become more confident in their programming skills. The story-based approach encourages students to think more deeply about the course material and to develop a more meaningful connection with the course material. This, in turn, can lead to improved performance and increased confidence in their ability to solve real-world programming problems.

Theme B. 3) Persistence of learning

The participants felt that the story-based approach helped promote persistence, enabling them to see the tasks as part of a larger story. This, in turn, helped to maintain motivation and engagement. As one participant (P7) said:

"The story-based design helps us to connect the task to the whole story, so that we can persist and complete the task."

The interviewees also reported that the story-based design helped them to stay focused and motivated throughout the course. They felt that the story-based design provided them with a sense of purpose and that it helped to make the module more interesting and enjoyable. As one participant (P11) said:

"The story-based design helps us to stay focused, because we can see the big picture and understand why we need to do the tasks. We can connect the tasks to the story, so it makes us more motivated to complete the tasks."

The findings suggest that story-based gamification design can help to promote persistence, as it enables students to see the tasks as part of a larger story and helps to maintain motivation and engagement.

Theme B. 4) Playful experience

The students reported that the story-based gamification design enabled them to learn through a more playful and engaging experience. They felt that the story-based elements helped to break up the monotony of the course and that it made the course more enjoyable. One student (P15) said:

"I think the game-like design makes the course more interesting and enjoyable. It feels like a game, and it makes the learning process more engaging."

Another participant said that:

"I find this game-like design is really interesting and exciting. It makes it easier to understand the course content and I can learn more easily."

The students also reported feeling more motivated to work on the programming tasks, as they felt that the story-based approach helped to make the tasks more meaningful and engaging. As one participant (P2) pointed out:

> "I think the story-based design makes it easier for me to understand and remember the content. I feel more motivated to do the tasks because I know I'm helping to solve the problem in the story."

Overall, the interviewees reported positive experiences of using story-based gamification design in the introductory programming module. They felt that the story-based gamification design had helped to make the course more enjoyable and engaging, and that it had helped to motivate them to work on the programming tasks.

Theme C: Students' preferences and attitudes towards each game elements

The most effective gamification elements were narrative and teamwork according to students' perceptions. One participant (P10) commented:

> "The animated trailer was very cute and interesting, created an immersive atmosphere and stimulated my sense of mission and exploratory curiosity, which motivated me to learn related programming knowledge to solve questions addressed in the trailer."

This view was echoed by another student (P28) who commented:

> "The storyline of each session gave me a chance to know more about the role of data scientists and how to use data analytics to solve cases, which increased my sense of meaningfulness and interest in the course."

The interactive and play-based nature of the approach engages students and encourages them to participate. The social connectedness element promotes social interaction and connection, which are both important for a sense of belonging. The use of stories provides a culturally appropriate means of conveying information and promoting learning. Stories can engage learners emotionally, which may have helped the students form a stronger connection to the course material. Additionally, the story-based design may have helped the students feel more like they were part of a community, as they were working together to complete the course. The story-based gamification design can also create a sense of engagement by providing students with a clear purpose and goal. The story provides a context for the students to apply the programming concepts they are learning, and the challenges within the story give them a reason to persist in the face of difficulties. This sense of engagement can lead to a sense of belonging, as the students feel like they are part of something larger than themselves.

When it comes to the perceived effectiveness of teamwork, 73% of the participants indicated that this was one of the most important components triggering their intrinsic motivation. For example, one student said:

> "The teamwork elements made me feel like I'm not alone. I really like the moment we help each other and work out the problems together." (P5)

This was also recorded by the researcher's observations, which indicated that although the progress of each team varies due to their diverse learning and skill backgrounds, there were

not many negative emotions associated with failure on tasks or low rankings. Participants were helping each other and worked together to figure out the problems they met. They were also encouraging their team members to make more attempts on the quizzes.

Overall, narrative and teamwork emerged as the most effective gamification elements for improving students' intrinsic motivation, by giving them a sense of mission, meaningfulness, and belongingness. The fulfilment of such needs aligns with the basic psychological needs as addressed in the SDT theory (Ryan and Deci, 2000). The data collected by questionnaire, observation and learning analytics increased the cross-validation of the data.

Theme D: Students' suggestions on the improvement of the gamification design

There were a few areas that the participants felt could be improved. First, the participants felt that the game could be more informative, providing more information about the concepts that they were learning. Second, the gamification design could be more engaging, providing more opportunities for the player to interact with each other. One participant indicated that they would like there to be more collaboration opportunities so that everyone has a chance to learn and contribute. Another interviewee also believed that more interaction and communication among students can help them to get to know each other better and feel more motivated to learn together. Additionally, they express a desire for more resources to be available so that they can better prepare for each lesson. As one interviewee (P7) addressed:

> "I wanted to preview it in advance, but I didn't find anything, so I said that if the seventh week I just said the sixth week, in fact, the seventh week I think a lot of regrets are a lot of functions, for example, lambda Some people have not learned, they don't know its principle, and then you can only copy it."

Third, the gamification design could provide more rapid feedback, letting the player know how well they were doing and what they could do to improve. Besides, the participants felt that the gamification design could be more visually appealing.The interviewees also suggested that story-based gamification design could be further improved by making the stories more realistic and by making the stories more engaging.

One participant (P16) also suggested future gamification design to be more culturally sensitive:

> "I think it's important to consider the cultural context of the design. For example, if the game is going to be used in a different country, it should be designed in a way that is culturally appropriate for that country."

Finally, they felt that the current design did not sufficiently challenge them, and as a result, they were not motivated to do their best work. One interviewee said:

> "Each student has different learning abilities, so it is difficult to set a suitable time for everyone. The project should be designed to be completed over a period of time so that everyone has a chance to learn and understand the material."

Overall, students suggested that the gamification design of the introductory programming module could be improved by increasing the interaction between students, providing more individualised feedback, and making the tasks more challenging.

Summary of the focus group interview findings

From the data collected in the focus group interviews, it was found that the majority of students felt a sense of belonging to the subject, programme of study and university after participating in the story-based gamification design. They felt that the design made the module more enjoyable and engaging and that it helped them to better understand the concepts being taught.

The focus group interview yielded rich and detailed data about the participants' experiences with the gamification design in the course. The data revealed that the participants had mixed feelings about the use of different game elements. Some participants found these features helpful in motivating them to engage with the course content, while others found them to be confusing and unhelpful. However, overall, the participants felt that the gamification design had helped them to feel a sense of belonging in the course. They appreciated the fact that the gamification design encouraged them to interact with other students and to feel a part of the learning community.

Limitation of the findings

There were some limitations to the focus group interviews, including the small sample size and the lack of diversity in the sample. The method also did not investigate students' long-term perceptions of the gamification design or its impact on their sense of belonging. Future studies could address these limitations by including a larger and more diverse sample of students, and by investigating students' perceptions over a longer period of time.

5.3.4 Participatory observation findings

This section presents the findings from class observation on the impact of gamification design on students' sense of belonging and learning experience. The data was collected through observation of students during the gamified sessions and informal discussions after classes. The main themes that emerged from the observation were class atmosphere, peer interactions, and game elements preference.

Class atmosphere

The gamification design had an overall positive impact on students' sense of belonging and learning experience. Students enjoyed the gamification design and felt more related to the class and the role of data scientists in practice. Participants were immersed in the narrative settings, kept focused on the tasks, actively engaged with the course content, and spent extra time studying the materials after the session. One student stated in the informal discussions after the class:

> "I really enjoyed the gamification design. It made me feel like I was part of something bigger and more exciting than just a regular class."

Most students were quite clear on the session structure and understood their tasks and roles.

Peer interactions

Participants were helping each other and working together to figure out the problems they encountered. They were also encouraging their team members to make more attempts on the quizzes. One student noted:

> "I found it really helpful that we could work together as a team. It made the tasks more engaging and less stressful."

Although the progress of each team varied due to their diverse learning and skill backgrounds, there was not much negative emotion associated with failure on tasks or low rankings.

Game elements preference

The narrative trailers and the storytelling were observed as the most appealing elements of the gamification design. Participants were excited and curious when watching the trailer and revealing the rankings. As one student stated:

> "I really enjoyed the narrative trailers and the leaderboard. They made the class more fun and exciting, and motivated me to keep learning."

This also accords with the results of questionnaires, which showed that participants were interested in story-telling elements.

In summary, the observation findings found that gamification design can have a positive impact on students' sense of belonging and learning experience in programming modules. The use of narrative settings was particularly effective in increasing students' engagement and motivation. The study also highlighted the importance of fostering peer interactions and providing a supportive learning environment.

Suggestions for improvements

Certain aspects of the design that could be improved were mentioned during the informal discussion with the students after the class. Firstly, the difficulty of the learning materials could be adjusted or divided into different levels adapting to students' learning backgrounds. Otherwise, students may find it too difficult to finish the task and thus perceive insufficient capacity for learning. Secondly, more interactive design could be added to the practical session, such as feedback on each task and enabling discussion boards. One participant suggested,

> "It would be great if we could get more feedback on our tasks and have a chance to discuss them with our peers. This would help us to learn more effectively and have a better understanding of the content."

5.4   Discussion

The study aimed to investigate the effectiveness of story-based gamification design in enhancing Chinese students' sense of belonging in the introductory programming module. The

findings suggested that the gamification design has overall positive effects in connecting students to the learning community and having a better understanding of applying programming skills in real-life cases. It also showed promising outcomes in motivating and engaging students in the practical session. These findings are consistent with previous research that has shown the positive impact of gamification on students' engagement and motivation (Dabbagh and Kitsantas, 2012; Huang and Soman, 2013).

The study demonstrated that a gamification design can increase students' intrinsic motivation in programming learning. The intrinsic motivation was mainly assessed by students' academic emotion, perceived academic confidence, relatedness, and autonomy, according to the SDT theory. The results showed a positive attitude towards the sessions, improved academic confidence, and a greater sense of belonging to the class. The gamification design was found to be related to the real world and strengthened the autonomy of programming learning. Furthermore, the study found that the gamification design significantly improved students' engagement during the gamified session, as they were immersed in the narrative settings, focused on the tasks, and actively engaged with classmates and the teaching team. However, the study only addressed the use of story-based gamification in an introductory programming module, and future research should aim to investigate its effectiveness in other courses.

In conclusion, the study provides valuable insights into using innovative instructional design to support international students' learning in introductory programming modules. The study contributes to the theoretical and practical improvement of using gamification to improve students' intrinsic motivation in educational contexts. The findings suggest that educators who are teaching introductory programming modules to Chinese students can use story-based gamification design to improve students' sense of belonging, engagement, and motivation. However, the gamification design should consider students' diverse needs and the balance between intrinsic and extrinsic motivation.

5.4.1 Limitations of the study

Although the study's findings are positive, it is important to note that it was conducted with a small number of students, so the results cannot be generalizable to all Chinese students. In addition, the study only looked at the use of story-based gamification in an introductory programming module, thus it is not possible to know whether the results would be the same in other courses. Future research should, therefore, aim to replicate the study with a larger number of students and investigate the use of story-based gamification in other courses.

The study concluded that although the gamification design can engage and motivate students in the learning process, it also has the potential to distract and demotivate them. The design should consider students' diverse needs and the balance between intrinsic and extrinsic motivation.

5.4.2 Implications for future work

Notwithstanding the relatively small sample, this work offers valuable insights into using innovative instructional design to support international students' learning in introductory programming modules. Aligning with the gamified learning theory (Landers, 2014) and the SDT theory (Ryan and Deci, 2000), the study contributes to the theoretical and practical

improvement of using gamification to improve students' intrinsic motivation in educational contexts.

The study provides strong evidence for the efficacy of story-based gamification design in improving Chinese students' sense of belonging in the introductory programming module at British universities. However, more research is needed to elucidate further the mechanisms underlying this effect. The study has also proposed suggestions on how to improve the current gamification design to enhance students' sense of belonging and gamified learning experience, which include:

1. Develop a more in-depth storyline and better sign-postings among different levels of tasks, to create a sense of connection and coherence for students.

2. Encourage collaboration and communication among students from different groups, to create opportunities for social interaction and support.

3. Design more comprehensive and in-time feedback mechanisms for quiz questions and learning tasks, to help students understand the mistakes and correct them in a timely manner.

4. Increase the level of interaction and support from lecturers or the learning systems, to create a sense of security and belonging for students.

Chapter 6

Study 3: EXPLORATORY PROTOTYPING GAMIFIED ITS

6.1 Research aim

This exploratory, work-in-progress prototyping aimed to develop an AI-enhanced gamification learning system for introductory programming modules. While the insights gained from this chapter contribute to the overall understanding of the potential of AI-enhanced gamification i increasing Chinese international students' sense of belonging, they do not directly answer the main research questions of this thesis. Instead, this chapter explores potential design solutions and their feasibility, providing a foundation for future, more conclusive studies. The research question was:

RQ3: How can AI-enhanced gamification design be optimally designed to support the unique learning needs of Chinese international students in programming courses, particularly in fostering a sense of belonging and improving academic outcomes?

6.2 System development

6.2.1 Design process

The design process involved modifying instructional objectives, learning materials, AI and gamification-enhanced features, and developing full-stack web-based applications grounded in theories. Following a design-based research approach, the design process was iterated based on advice from advisors across various fields. These advisors included three lecturers and four members from the teaching team of the INF6027 module at the University of Sheffield, as well as twelve experts and researchers in academia and eight practitioners in industry. Advisory meetings took various forms—online, face-to-face, group, and individual—and the feedback informed three iterations of the prototypes, covering instructional content, AI and gamification mechanisms, usability, accessibility, and interface aesthetics.

Overall, the ITS implementation was iterative, involving design, prototyping, and evaluation. The GAME framework allowed refinement based on feedback from lecturers, teaching assistants, experts, and practitioners, resulting in a system tailored to learners' needs. The
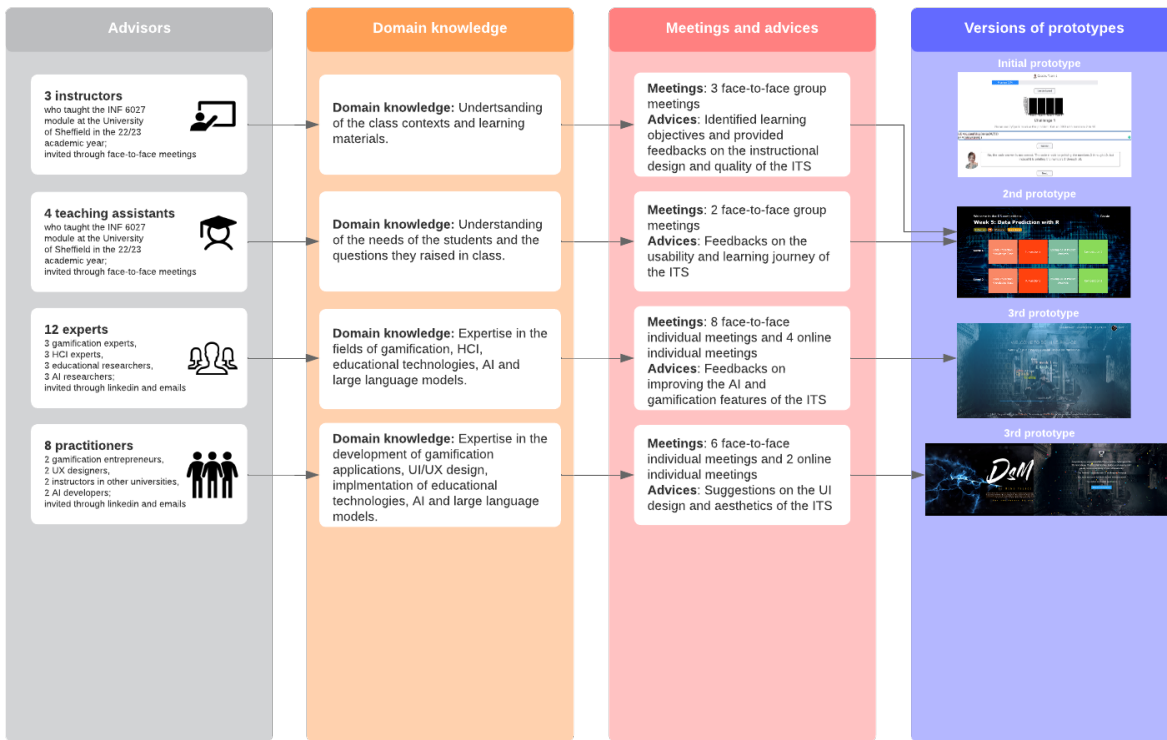
Figure 6.1: *Summary of the design process.*

final version includes a complete set of instructional content, GPT-3-enabled chatbots, gamification elements, and an accessible, user-friendly interface.

Interface design

The ITS interface design follows visual design and user experience (UX) design principles. The interface was designed to be inviting and visually appealing, with interactive elements like animations, videos, and a word cloud to encourage user engagement. The navigation bar is intuitive, and a progress bar visually represents user progress, motivating continued use. The chatbot provides personalized support and resources, such as external links and tutorials.

6.2.2 Gamification design

The gamification mechanism was designed to provide a fun and engaging learning experience and to improve students' sense of belonging in the levels of class, school and subject-related career. It consists of a set of gamification elements, including alternative reality, experience points, badges, personalised feedback and encouragements, levels and challenges, an avatar, progress bars on the instructional page and homepage and an exploratory word cloud. The description of game elements and the design principle to increase users' sense of belonging in different levels, autonomy and capacity was illustrated in Figure 6.2.

The alternative reality element inspired by the Sherlock universe bridges the gap between theoretical concepts and their practical application, allowing students to better envision their

Game elements(Y) / Sense of belonging(X)	Subject level	Faculty level	Peer level	Autonomy	Capacity
Alternative Reality (AR)	The Sherlock Holmes elements were integerated to provide a cultural specific and immersive learning experience and connect students with the DS career and British culture. An animated trailer introducing the story and learning tasks was distributed prior to the class.				
Points and badges		Reward system for recognizing students' accomplishment and engagement in the teamwork.			
Personalized feedback and encouragement	Personalized comments and suggestions were provided immediately after students finish each tasks and levels.			Personalized comments and suggestions were provided immediately after students finish each tasks and levels.	
Levels and challenges	Dividing the practical materials into different levels with increasing challenges.			Dividing the practical materials into different levels with increasing challenges.	
Avatar		Students can choose their preferred name and profile photo tol be shown on their page throughout the class.		Students can choose their preferred name and profile photo tol be shown on their page throughout the class.	
Progress bar		Progress bar can give students clear idea of the course structure and increase their retention.			Progress bar can give students clear idea of the course structure and increase their retention.
Additional resources			Word cloud of R on the home page to provide an overview of useful R functions for data science projects		

Figure 6.2: *Gamification mechanism of the DS Mind Palace gamification learning system.*
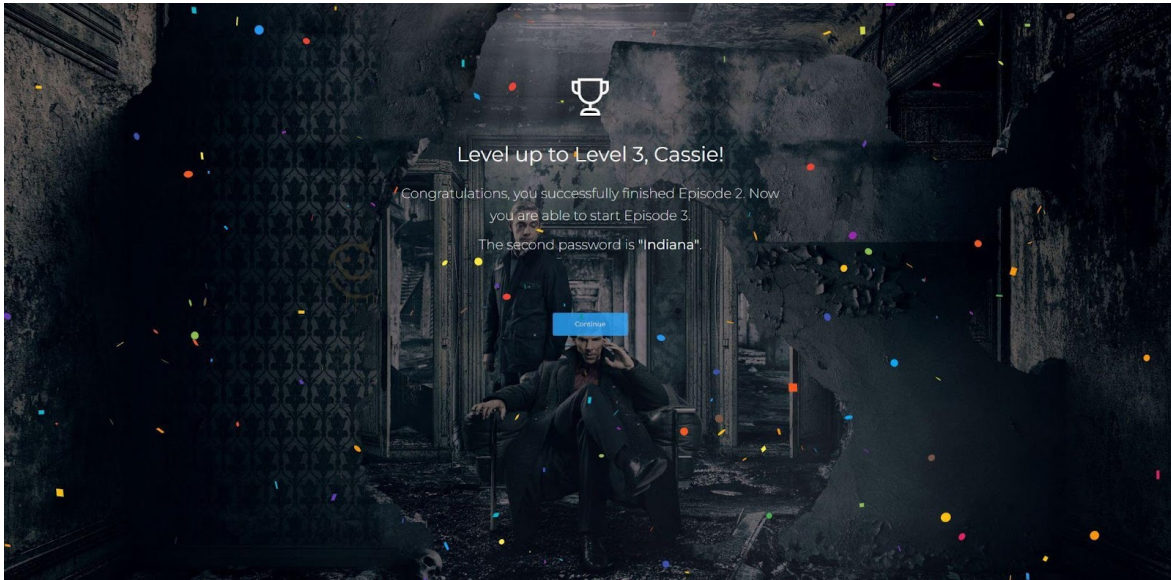
Figure 6.3: *Recognition badge of the DS Mind Palace gamification learning system.*

future as data scientists. The feedback elements were designed to provide immediate and personalized responses to students' questions or efforts, powered by GPT-3 to ensure accuracy. The avatar element further personalized the learning experience, as students will be able to choose their own name and profile photo and receive personalized welcome, encouragement, and feedback messages throughout the class. The level-up, points, progress bar, recognition page (see Figure 6.3), and learning report (see Figure 6.4) elements aimed to provide a sense of progress, rewarding students for their accomplishments and encouraging them to continually engage with the class. Additional resources were visualized and provided in the word cloud of R to increase the sense of exploration and foster active learning.

6.2.3 Web-state management

The ITS uses Redux.js for web-state management within React.js components, maintaining application state, and responding to user interactions. Redux.js allows efficient state updates and data access, facilitating complex user interfaces. In the ITS, Redux.js handles user profiles, questions and answers, code snippets, and gamification data, enabling responsive, state-aware application behavior.

6.2.4 AI algorithm

GPT-3 is an autoregressive large language model. In this project, GPT-3 is used for building an intelligent system for a programming module in a data science master program. The system is designed to provide in-time and personalised support to students during their learning process. The AI algorithm consists of two main components: the question-answering (Q&A) module and the code-explaining module. The question-answering module is responsible for answering user questions about programming concepts. The code-explaining module is re-
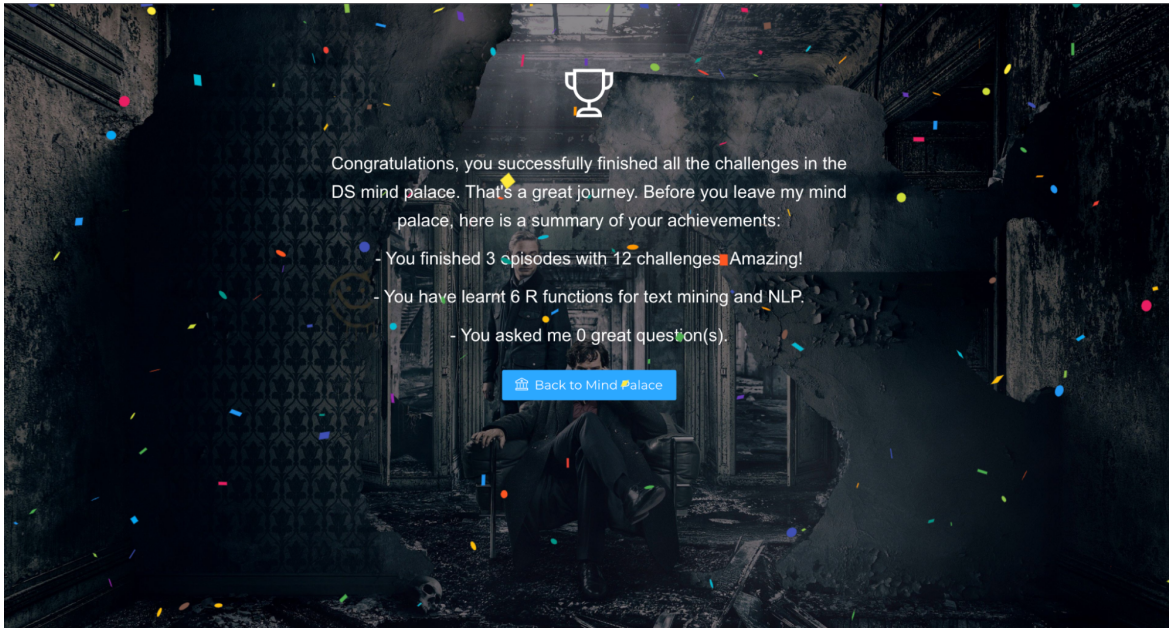
Figure 6.4: *Screenshot of the learning report summarising the learning journey of the system, including the number of episodes finished, challenges resolved, functions learned, and questions raised to the chatbots.*
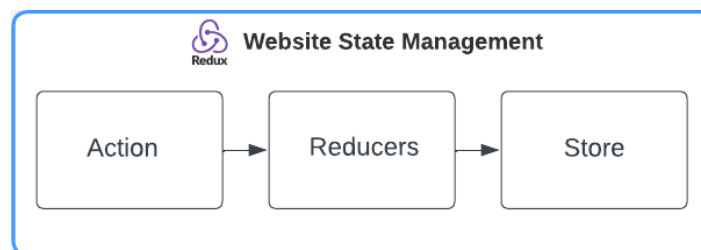
Figure 6.5: *The workflow of Redux for website state management.*
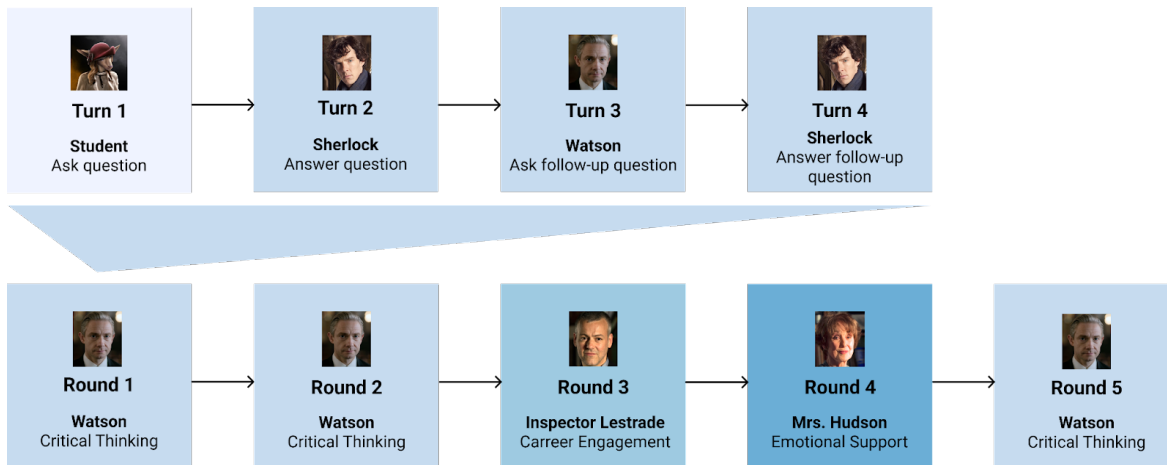
Figure 6.6: *Illustration of the workflow of the conversational agents.*

sponsible for providing explanations for the code snippets.

Question-answering module

The question-answering module uses the GPT-3 API to generate answers for the user questions. The API takes in a prompt containing strings of questions and pre-set contexts and returns a response. When the student asks a question, the intelligent tutoring bot Sherlock will answer it first. Then the critical thinking bot Watson (60% of appearance rate), career engagement bot Inspector Lestrade (20% of appearance rate) and emotion support bot Mrs Hudson (20% of appearance rate) will continue the conversation. The working flow of the conversational agents were illustrated in Figure 6.6. Examples of their conversations are provided in Figure 6.7 - Inspector Lestrade and Figure 6.8 - Mrs Hudson.

Code checking module

The code-explaining module also used the GPT-3 API to generate explanations for the code snippets. The code-explaining module first extracts the code snippet from the user input and then generates an explanation for the code snippet by calling the GPT-3 API with the code snippet and a prompt as input. The code-explaining module used a set of predefined prompts to generate explanations for the code snippets. The prompts are selected to cover a wide range of programming concepts.

The string of the prompts sending to the OPENAI API (text/Davinci003) are:

"Please check whether the answer of R programming question '"+question_list[i]+"' is correct. \n \n Correct answer:\n" + correct_answer_list[i] + "\n The input answer:\n" + correct_answer_list[i] + "\n \n Whether the input answer is correct and complete, and why (please start with 'yes' or 'no' and then explain, do not release the correct answer)? \n"

6.2.5   Back-end: Data storage and learning analytics

Firebase was used to store the data generated by the system, such as student questions, code snippets, and gamification data and provided the authentication, user management, and
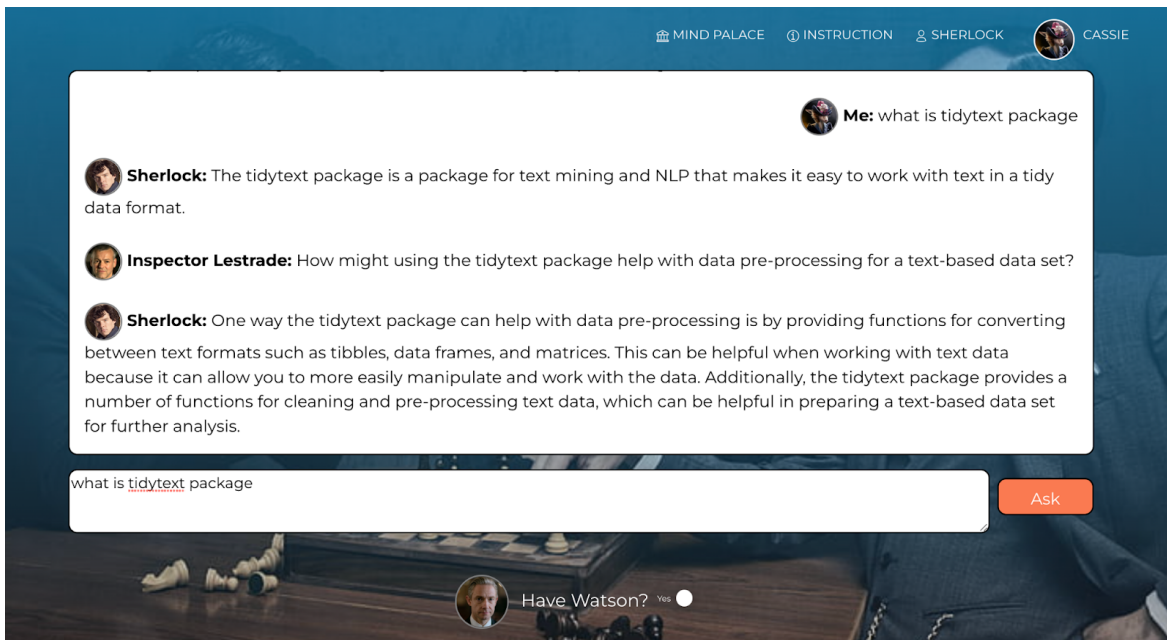
Figure 6.7: *In the third round of every five questions asked by students, Inspector Lestrade will replace Watson to ask a question related to career development, technology application or industry jobs, such as the question presented in the figure and "How could one use dplyr to manipulate and process large numerical datasets in data science industry jobs?"*

real-time database capabilities. Firebase is a cloud-hosted NoSQL database with powerful features such as data synchronisation, real-time event handling, and offline storage. It allows the web application to store and sync data with the Firebase Realtime Database, providing an efficient way to store and query data. The system was also equipped with a learning analytics system, which is used to collect and store the data from the students' interactions with the system. The data collected by this system will be used to analyse and improve the learning process. An example sequence analysis of simulated users' interaction with the system was shown in Figure 6.10 to demonstrate the learning analytics function of the system using the data collected by Firebase. The sequence analysis makes it easier for lecturers to understand students' engagement with the learning materials, the places where they most struggled with to provide more personalised support and better control the teaching process. By tracking how long students spend on each section of the learning materials, lecturers can identify which topics are engaging and which are not. For example, if students are spending a lot of time on gamified challenges but rushing through theoretical content, it may suggest a need to integrate more interactive elements into the theoretical sections to balance engagement. The analysis can also reveal how often students use gamification features such as badges, points, and progress bars. If students who engage more with these features show better learning outcomes, lecturers might consider enhancing these elements further or introducing new ones. Furthermore, if the sequence analysis shows that students frequently interact with the chatbot for specific types of questions, lecturers can assess whether the AI support is adequately addressing these queries or if there are patterns where the chatbot fails to provide
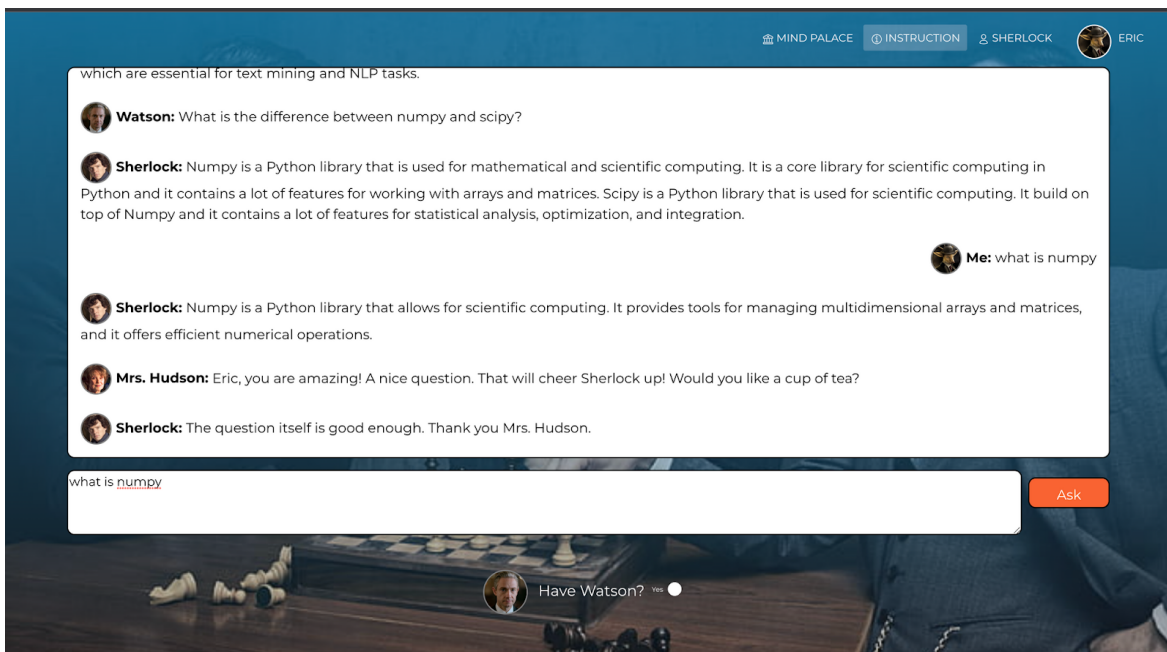
Figure 6.8: *In the fourth round of every five questions asked by students, Mrs Hudson will replace Watson to provide encouragement to the students with a variation of her famous quotes "A nice murder. That'll cheer you up." and "Would you like a cup of tea?". Then Sherlock will give a pre-set reply "The question itself is good enough. Thank you, Mrs Hudson."*

Figure 6.9: *Personalised feedback for correct (top) and incorrect (bottom) code submission.*

Figure 6.10: *Simulated sequence analysis of users' interaction with the system. The vertical axis represents the simulated users, while the horizontal axis represents the clicks from the simulated users on different pages. The clicks on the homepages were designated as blue squares, the clicks on the level-1 page in the first episode were symbolised as red triangles, the clicks on the level-2 page in the second episode were illustrated as yellow triangles, the clicks on the level-3 page in the final episode were symbolised as green crosses, and the clicks on the chatbot page were represented by purple squares.*

satisfactory answers. This insight can guide improvements in the AI's training data or prompt additional human support in these areas. By analyzing the paths taken by different students, lecturers can identify personalized learning patterns. For instance, some students might excel by starting with practical exercises before diving into theoretical explanations, while others might prefer the opposite. Understanding these preferences can help lecturers offer tailored learning paths or adaptive learning sequences. If the analysis shows that students who initially engage actively with the system suddenly stop interacting, this could be a sign of disengagement or frustration. Lecturers can then intervene early, reaching out to these students to understand and address their issues before they completely disengage from the course. By identifying which parts of the system are used most frequently, lecturers can prioritize updating and maintaining these areas. Conversely, resources can be reallocated from underused features to those that provide more value to students. Finally, if the analysis shows that students often use the system's peer-learning features, lecturers can encourage more collaborative activities. They might set up group projects or discussion forums based on the system's analytics on how students interact with each other.
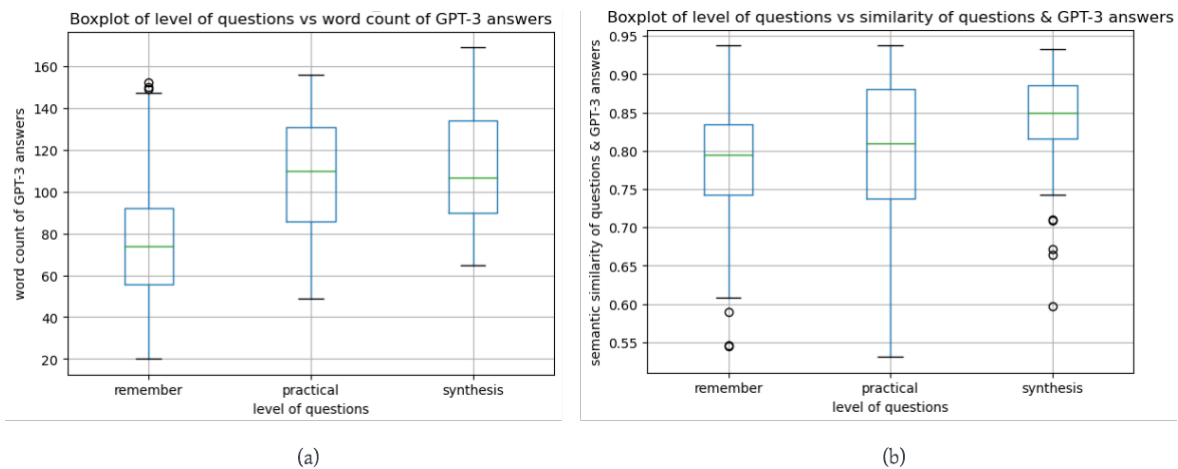
Figure 6.11: *(a) word count of the answers generated by GPT-3 enhanced for each cognitive level of the simulated questions and (b) boxplot of the semantic similarity*

6.3 Computer simulation study

This study aimed to evaluate the efficacy of the ITS in scaffolding the learning of R programming, as well as its ability to promote a sense of belonging among students. To evaluate the system, a simulation study was conducted to assess its accuracy, fluency, empathy, engagement and relevance in providing appropriate responses to a variety of questions in different cognitive levels and contexts, based on Bloom's Taxonomy. Results from the NLP analysis and human evaluation were centred on three themes: accuracy and fluency; empathy and engagement; and relevance.

6.3.1 Accuracy and fluency

The expert screening indicated 95% (57/60) of responses (the first response of each question) of Q&A met the accuracy requirement. The main reason for an inappropriate response was incompleteness, e.g., "...4. DataCamp - DataCamp is" due to the length limit. Those failures can be avoided by increasing the token budgets for the generated output while still reflecting that GPT-3 tends to generate over-detailed, even redundant responses. Building on this point, we checked the distributions of word count over three categories of questions as shown in Figure 6.11 (b). The length of responses to remember-level questions was significantly lower than the responses to the other two types (Kruskal-Wallis test between groups, $H - value = 60.03, p - value << 0.01$), which is as expected given that the questions in the other two types are more open-ended.

The results of expert screening for fluency indicated all responses were natural and human-like but the language was simple. The Automated Readability Index (ARI) was used to provide a quantitative measurement of the readability of the response. The ARI for three levels of Q&A responses, remember-level (Mean=12.86, std=3.37, Median=12.80), practical level (Mean=12.81, std=2.85, Median=12.55), synthesis level (Mean=12.76, std=3.24, Median=12.15), had similar distribution. According to the ARI reference chart, the output of
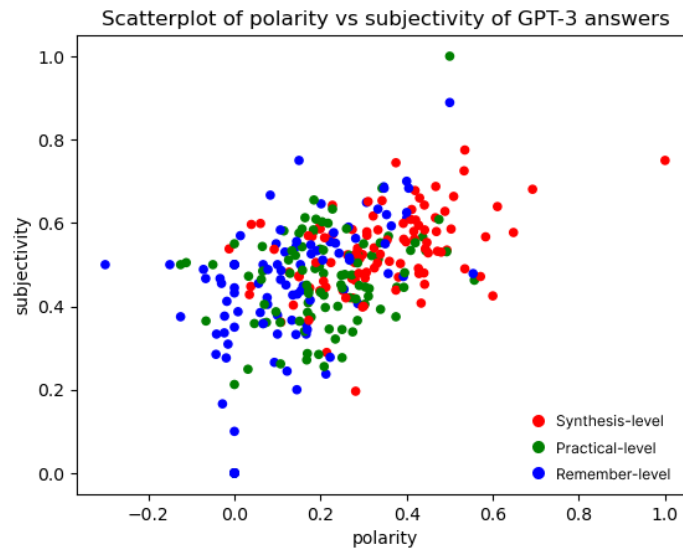
Figure 6.12: *Scatterplot of the polarity and subjectivity of GPT-3 answers to synthesis-level, practical-level and remember-level questions.*

GPT-3 was consistent and relatively easy to understand, with text complexity comparable to the readability of college students (18-24 years old). ARI for code explanation was slightly lower (Mean=11.49, std=3.87, Median=11.25), comparable to the readability of eleventh-grade to twelfth-grade students (17-18 years old).

The selected age and US grade level needed to comprehend text is indicated by the ARI scores (Senter and Smith, 1967).

6.3.2   Empathy and engagement

The empathy and engagement of the chatbot's responses were measured through sentiment analysis and human evaluation for triangulation.

Sentiment analysis findings

Results of the sentiment analysis with Textblob indicate that the GPT-3 enhanced chatbot generated largely neutral answers in terms of polarity for the remembering level, while the answers were relatively positive for the synthesis level (see Figure 6.12). In terms of subjectivity, the chatbot's answers were largely objective for the remembering level, while the answers were most subjective for the synthesis level. Pearson correlation coefficients between the sentiments for questions and corresponding answers were calculated reporting a positive correlation between the polarities of questions and corresponding answers ($Corr = 0.421, p-value << 0.01$) and a weaker positive correlation between subjectivities ($Corr = 0.290, p-value << 0.01$). This result suggests that the GPT-3 enhanced chatbot is capable of producing sentimentally equivalent or comparable answers to match questions at different levels of the learning curve.

6.3.3 Relevance

Relevance for Q&A responses was measured by semantic similarity between questions and corresponding responses and topic modeling (see Figure 6.13). The semantic similarity of Q&A was fairly high: remember level (Mean=0.79, std=0.08), practical level (Mean=0.80, std=0.09), synthesis level (Mean=0.84, std=0.06); which indicates that the responses were very relevant to the question. The semantic similarity of synthesis-level Q&A was significantly higher than those of the other two types (Kruskal-Wallis test between groups, H-value=26.00, p-value<0.01), presenting a higher relevance for response to more general questions. As shown in the results of topic modeling, the most common keywords in GPT-3 generated answers to synthesis-level questions (synthesis-level answers) are "code", "help", "way" and "practice", which are on a high level compared with common keywords in GPT-3 generated answers to remember-level and practical-level questions such as "text", "package", "mining", "analysis" and "function". "Https" is also one of the most common keywords in GPT-3 generated synthesis-level answers, indicating that those answers often refer to external resources such as R programming websites. Besides, the keywords in the synthesis-level answers are not as concentrated as answers to remember-level and practical-level questions and have wider coverage, as the count of the most common keywords in synthesis-level answers is 86 ("code") compared with 163 and 187 of most common keyword "text" in practical-level answers and practical-level answers. It aligns with the high-level nature of synthesis questions. The keywords in the practical-level answers and remember-level answers are similar, while "example" is more common in practical-level answers than remember-level answers, which implies that practical-level answers provide more examples as a part of the answers.

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6.4 Discussion and conclusion

This exploratory study aimed to develop an AI-enhanced gamification learning system tailored specifically for Chinese international students in introductory programming courses. The overarching goal was to address the unique challenges faced by these students in terms of both academic performance and social integration. By incorporating elements of intelligent tutoring systems (ITS), gamification, and AI, the study sought to enhance the learning experience, foster a sense of belonging, and improve academic outcomes. The findings from this study are particularly relevant within the broader context of the thesis, which explores the effectiveness of gamification beyond traditional mechanics in cultivating a sense of belonging among Chinese international postgraduate students in programming courses.

The system's design integrated AI capabilities, such as GPT-3 for question-answering and code explanation, with gamification elements inspired by narrative-driven contexts, such as the "Sherlock universe". This combination aimed to make learning more engaging and personalized. The use of AI provided immediate, contextually relevant support, while gamification elements were designed to increase motivation and a sense of progress. The simulation study demonstrated that the AI components could generate accurate, fluent, and relevant responses to students' queries. This indicates a strong potential for providing immediate and effective support during the learning process. The ability to deliver personalized responses, particularly through the empathetic and engaging nature of the AI-driven chatbots, suggests that students could receive tailored assistance that addresses both their cognitive and
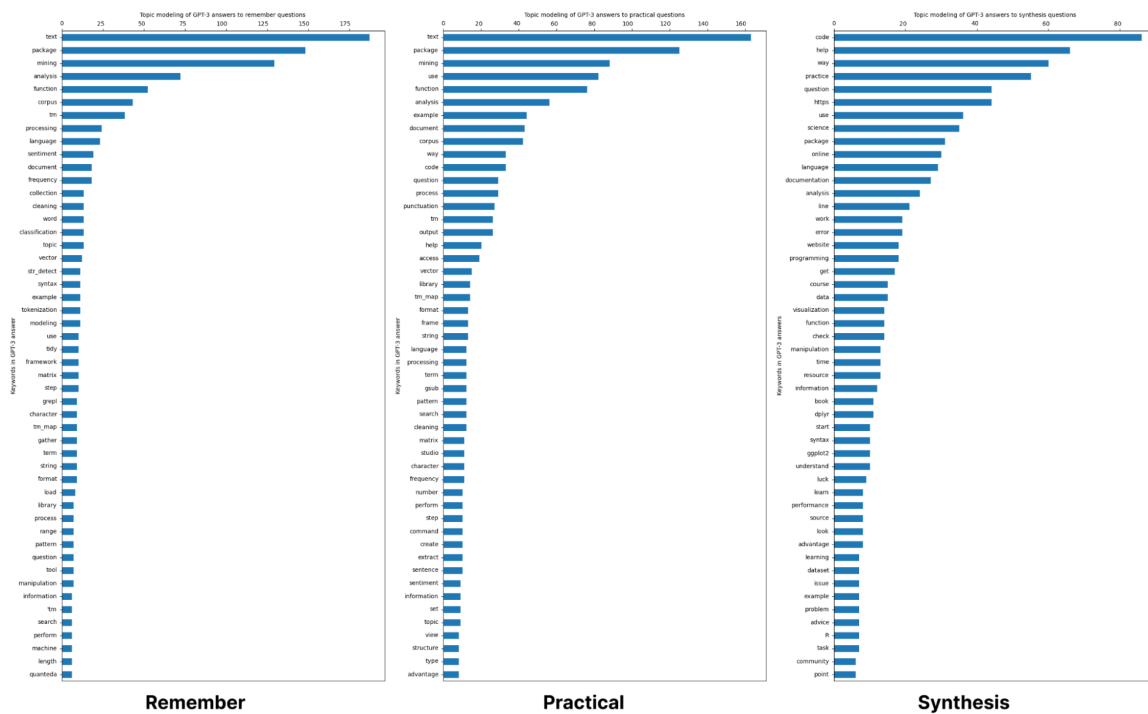
Figure 6.13: *Topic modeling results of GPT-3 answers to remember-level, practical-level and synthesis-level questions, respectively.*

emotional needs.

One of the core objectives of this study was to explore how gamification, beyond traditional mechanics, could cultivate a sense of belonging among Chinese international students. The gamification elements included alternative reality scenarios, progress tracking, personalized feedback, and avatar customization. These elements were designed not just to make learning fun but to create a community-like environment where students feel valued and connected. The theoretical basis for these design choices is grounded in the second study of the research, which emphasized the importance of autonomy, competence, and relatedness—key components of the Self-Determination Theory (SDT). By aligning the gamification elements with these components, the system aimed to foster intrinsic motivation and a deeper sense of belonging. For instance, the use of avatars and personalized feedback messages were intended to enhance the students' connection to the learning community and the subject matter.

While the simulation study showed that the system has potential, it also highlighted several limitations and areas for improvement. The evaluation, conducted in a simulated environment, indicated that the system could generate appropriate and engaging responses. However, this environment may not fully capture the complexities of real-world student interactions and the diverse contexts in which learning occurs. The sentiment analysis of the chatbot's responses showed that the system could produce contextually appropriate and emotionally resonant responses, particularly at higher cognitive levels. This ability to adapt to the varying emotional and cognitive needs of students is crucial for maintaining engagement and fostering a sense of belonging. However, the sustainability of such engagement

over extended periods and in diverse learning scenarios remains uncertain without real-world implementation and testing.

Overall, this study's findings underscore the potential of AI-enhanced gamified learning systems in supporting the unique needs of Chinese international students in programming courses. The system's design, which combines intelligent tutoring with narrative-driven gamification, offers a promising approach to addressing both academic and social challenges faced by these students. However, the conclusions drawn from the simulation study must be interpreted with caution. The evaluation, while promising, does not provide definitive evidence of the system's effectiveness in real-world conditions. The keyword here is "potential"—the system shows promise, but its true impact can only be validated through empirical studies involving actual student participants.

Future research should focus on several key areas. Firstly, conducting longitudinal studies involving actual student cohorts is essential to measure the system's impact on learning gains, engagement, and sense of belonging. Such studies should encompass diverse learning contexts to capture a comprehensive picture of the system's effectiveness. Additionally, based on feedback from real-world implementations, refining the AI algorithms and gamification elements to better meet the needs of students is crucial. This could involve improving the personalization features, enhancing the narrative elements, and ensuring that the gamification mechanics align closely with educational objectives.

Moreover, investigating the system's effect on long-term retention of programming concepts and overall academic success will help determine whether the initial engagement and sense of belonging translate into sustained academic performance and deeper learning. Exploring additional mechanisms that could enhance social integration and community building among international students, such as peer mentoring, collaborative learning activities, and virtual communities, would also complement the gamified learning system.

In summary, while the exploratory prototyping of the gamified ITS has shown promise, its full potential can only be realized through rigorous, real-world testing and continuous refinement. The insights gained from this study lay a foundation for future research aimed at enhancing the learning experience and fostering a sense of belonging among international students in higher education.

Chapter 7

DISCUSSION AND CONCLUSION

7.1 Summary of research

This project explored the application of gamification to increase Chinese international students' sense of belonging in introductory programming modules. To better understand the needs and expectations of this group, and to provide effective support to address their challenges and improve their learning experience, the study adopted a design-based research approach to develop a gamified learning system. The research process was iterative and divided into three distinct phases.

7.1.1 Study 1: Formative Study

The first phase was an exploratory formative study conducted during the first semester of the 2021/2022 academic year. The aim was to understand the specific challenges faced by Chinese international students in introductory programming modules. Data were collected through questionnaires completed by 57 students and in-depth interviews with nine participants.

The study identified several key challenges: difficulty adapting to teaching methods that emphasize independent and critical thinking, limited interaction with teachers and peers, a perceived disconnect between academic content and real-life applications, and insufficient academic support and timely feedback. These factors contributed to low engagement, poor retention, and negative academic emotions, primarily driven by a lack of intrinsic motivation and a diminished sense of belonging.

7.1.2 Study 2: Field Study of Gamification Design

The second phase involved designing, deploying, and evaluating a prototype of a story-based gamification system integrated into the Blackboard learning management system. This study was conducted over two weeks with 32 Chinese students enrolled in the introductory programming module INF6032 Big Data Analytics, part of the MSc in Data Science program at the University of Sheffield.

The prototype incorporated gamification features such as animated trailers, storytelling, role-playing, teamwork, points, leaderboards, and feedback mechanisms. Practical sessions

included real-life scenarios like airline companies' survival during the pandemic and solving a criminal case, aimed at making students feel more connected to the course content.

Findings from questionnaires (n=32), focus groups (n=32), and participatory observations revealed that the story-based gamification design positively influenced students' sense of belonging. Students reported increased motivation, engagement, and a stronger sense of connection with their classmates. The study also highlighted the importance of considering cultural needs in gamification design to effectively enhance the sense of belonging.

7.1.3 Study 3: Exploratory Prototyping of AI-Enhanced Gamified ITS

The third phase explored the potential of an AI-enhanced gamification design. Based on the feedback from the second phase, a prototype empowered by GPT-3 was developed to better meet individual learners' needs and further increase their sense of belonging to the class, institution, and career-related subjects.

The gamification system comprised four main components: instructional content, gamification mechanism design, user interface, and the generative language model. The system included programming knowledge, demo explanations, exercises, and gamification elements like alternative reality, points, badges, personalized feedback, levels, challenges, avatars, progress bars, and an exploratory word cloud. GPT-3 powered the AI agents to provide Q&A capabilities and code explanations, offering guidance and support throughout the learning process.

A computer simulation study assessed the prototype's potential. Using prompt programming, a dataset with 360 rounds of simulated questions and answers was created based on learning objectives and lecturer reflections. Semantic similarity analysis, topic modeling, and sentiment analysis indicated that GPT-3 agents performed well in providing feedback and insightful conversations, though the quality varied depending on question form and level.

7.2 Revisiting the research questions

The research project aimed to answer three research questions:

- **RQ1** What are the primary challenges that Chinese international students face in developing a sense of belonging in fundamental programming modules, and how do these challenges affect their learning outcomes?

- **RQ2** How effective is gamification in enhancing the learning experiences and sense of belonging for Chinese international students in fundamental programming modules, and what specific gamification features are most impactful?

- **RQ3(exploratory)** How can AI-enhanced gamification design be optimally designed to support the unique learning needs of Chinese international students in programming courses, particularly in fostering a sense of belonging and improving academic outcomes?

7.2.1 Revisiting RQ1

To address **RQ1**, the first study's detailed examination of the experiences of Chinese international students in fundamental programming modules revealed a multi-faceted set of

challenges that impede their academic and social integration. The findings from Study 1 illustrate that Chinese international students face significant challenges in developing a sense of belonging in fundamental programming modules. These challenges are multifaceted and interrelated, impacting their learning outcomes in several ways.

Motivation for Studying in the UK: While the motivations for studying in the UK are strong and diverse, the challenges encountered often overshadow these initial aspirations. The high expectations for career advancement and quality education can be undermined by the difficulties faced in the transition period.

Transition Challenges: The unfamiliar course structure and cultural and language barriers create an environment where students struggle to adapt, leading to decreased academic confidence. This transition phase is crucial and needs more support from educational institutions to help students acclimate effectively.

Coding Difficulties: The lack of foundational knowledge, difficulties in understanding complex coding concepts, and unclear feedback from lecturers significantly hinder students' academic progress. Additionally, the unfamiliar resources exacerbate these challenges, making it imperative to provide more accessible and clear learning materials.

Sense of Belonging: The lack of a sense of belonging, driven by feelings of isolation, difficulties in forming relationships, and perceived disconnection from the programme and job market, has profound implications for students' engagement and academic performance. This highlights the need for targeted interventions to foster a more inclusive and supportive learning environment.

In conclusion, the study identifies critical areas where Chinese international students face challenges in developing a sense of belonging in fundamental programming modules. Addressing these challenges requires a multifaceted approach, including enhanced support during the transition period, culturally sensitive teaching practices, clearer and more accessible learning resources, and initiatives to foster a sense of community and connection within the academic environment. By addressing these issues, educational institutions can significantly improve the learning experiences and outcomes for international students, ensuring they can achieve their full potential. The findings align with existing research highlighting the difficulties international students face when transitioning to new educational environments (Yu and Moskal, 2019).

7.2.2 Revisiting RQ2

To address **RQ2**, the second study revealed that the implementation of gamification in fundamental programming modules significantly enhanced the learning experiences and sense of belonging for Chinese international students. This section will discuss the effectiveness of gamification and the specific features that were most impactful.

The introduction of gamification into the learning environment led to notable improvements in student engagement, motivation, and sense of belonging. The findings indicate that gamification can effectively address some of the key challenges faced by Chinese international students, such as language barriers, cultural differences, and unfamiliarity with independent learning styles. The gamification elements were designed to be culturally relevant and context-specific, which enhanced their effectiveness.

The effectiveness of gamification is supported by prior research, which suggests that gamification can increase student motivation and engagement by making learning more interactive

and enjoyable (Kapp, 2012; Bellotti et al., 2013). The study's findings are consistent with these assertions, demonstrating that gamified learning environments can create a more inclusive and supportive atmosphere for international students.

Several gamification features were identified as particularly impactful in enhancing the learning experiences and sense of belonging for Chinese international students:

Narrative-based Gamification: Embedding the learning content within a compelling story that students could relate to improve their engagement and motivation. Narrative-based elements helped students connect with the material personally, making it more meaningful and easier to understand. This approach aligns with existing literature highlighting the power of storytelling in education to enhance engagement and retention (Mader et al., 2019; Goshevski et al., 2017).

Level-up Mechanisms: These elements fostered a sense of achievement and healthy competition, encouraging students to participate actively in their learning. By providing clear goals and rewards for progress, level-up mechanisms motivated students to invest more effort and time in their studies. This is in line with research that suggests gamification elements like leveling up can boost intrinsic motivation by satisfying the need for competence and achievement (Subhash and Cudney, 2018).

Group-based Activities: Group-based activities and challenges promoted social interaction and collaboration, helping to mitigate feelings of isolation and foster a sense of community among students. Collaborative tasks allowed students to support each other, share knowledge, and build meaningful connections, which are crucial for developing a sense of belonging. This finding is supported by studies that emphasize the importance of social interaction and teamwork in enhancing student engagement and creating a supportive learning environment (Tom, 2015; Lanza et al., 2008; Karl and Zender, 2022).

The success of the gamification elements in this study underscores the importance of culturally relevant and context-specific educational interventions. By tailoring the gamification design to address Chinese international students' unique needs and challenges, the study demonstrated that such interventions can significantly enhance learning outcomes and the overall educational experience. This finding highlights the need for educators and institutions to consider cultural and contextual factors when designing and implementing educational innovations.

7.2.3 Revisiting RQ3

The third study aimed to address **RQ3** focused on developing an AI-enhanced gamification learning system specifically tailored to the needs of Chinese international students in introductory programming courses. The system used artificial intelligence (AI) to enhance the learning experience, foster a sense of belonging, and improve academic outcomes.

Personalized Learning Experiences The question-answering and code explanation empowered by LLM provided immediate, contextually relevant support tailored to each student's individual needs and progress. This personalization could be particularly effective in accommodating the diverse learning paces and styles among students, ensuring that each learner received the appropriate level of challenge and support. The study also explored AI-driven feedback mechanisms enhanced by LLM. The prototype was designed analyze student inputs in real-time and offer targeted suggestions for improvement, thus enhancing the learning process and reducing cognitive load. The immediate feedback loop could be used to help

students correct mistakes promptly but also reinforced their understanding, contributing to better retention of programming concepts.

Gamification Elements The gamification elements incorporated into the system were designed to enhance motivation and engagement while fostering a sense of community among students. Key gamification strategies included:

(1) Narrative-driven Contexts: Embedding learning content within engaging storylines, such as those inspired by the "Sherlock universe," made the learning process more compelling and relatable. This narrative approach helped maintain student interest and motivation over time.

(2) Progress Tracking and Level-up Mechanisms: These elements provided a sense of achievement and progression, encouraging students to stay engaged and continue their learning journey. The visible tracking of progress and the ability to "level up" based on performance created a game-like environment that was both motivating and rewarding.

(3) Group-based Activities and Social Interaction: AI-enhanced gamification facilitated social interaction through virtual study groups, peer-to-peer challenges, and collaborative projects. These activities promoted social bonding and a sense of community, helping to mitigate feelings of isolation commonly experienced by Chinese international students.

Enhancing Sense of Belonging One of the core objectives was to explore how gamification, beyond traditional mechanics, could cultivate a sense of belonging among Chinese international students. The design choices were grounded in the principles of Deterding et al. (2011b)'s Self-Determination Theory (SDT), emphasizing autonomy, competence, and relatedness. By aligning the gamification elements with these components, the system aimed to foster intrinsic motivation and a deeper sense of belonging.

A. Autonomy: The system offered students choices in how they engaged with the material, whether through different narrative paths, types of challenges, or modes of interaction. This autonomy supported students' sense of control over their learning process, enhancing their intrinsic motivation.

B. Competence: The personalized feedback and adaptive challenges ensured that students could experience success and mastery at their own pace. This reinforcement of competence helped build confidence and reduced anxiety, contributing to a more positive learning experience.

C. Relatedness: Incorporating social and collaborative elements, such as avatar customization and personalized feedback, helped students feel more connected to their peers and the learning community. This sense of relatedness was crucial for fostering a supportive and inclusive learning environment.

7.3   Limitations

7.3.1   Sampling and methodological constraints

One common theme among the three studies is the methodological limitations that might affect the generalizability and validity of the findings. For instance, small sample sizes or convenience sampling methods might limit the representativeness of the study populations, making it challenging to generalize the results to a broader audience. Prior research, such as by Plonsky (2023), emphasizes the importance of large, diverse samples in educational

research to ensure findings are applicable across different demographics and settings. Additionally, the reliance on self-reported data can introduce biases such as social desirability or recall bias, which can affect the accuracy of the results. This is a common issue in educational and psychological studies, as noted by Gonyea (2005), who highlighted the potential distortions caused by self-reporting in behavioral research.

7.3.2 Cultural variability in gamification

Integrating gamification into educational contexts, particularly for Chinese international students, presents specific challenges. One limitation is the potential cultural differences in the reception and effectiveness of gamified learning elements. While gamification can enhance engagement and motivation, as demonstrated by Hamari et al. (2014), its effectiveness can vary across different cultural contexts. For example, Chinese students might have different preferences and responses to game mechanics than their Western counterparts, influenced by cultural norms and educational expectations. This variation can affect the generalizability of the findings, as the gamification strategies effective for one group may not be as effective for another.

Another issue is the sustainability of gamification effects. Research by suggests that the motivational impact of gamification can diminish over time as students become accustomed to the game elements (Deterding et al., 2011b). This challenges long-term educational outcomes and highlights the need for ongoing innovation in gamification strategies to maintain student engagement.

7.3.3 Measuring sense of belonging

The studies addressing the sense of belonging among Chinese international students also face several limitations. One significant issue is the complexity of measuring a sense of belonging, which can be influenced by various factors such as language proficiency, cultural differences, and social integration. Research emphasizes the multifaceted nature of a sense of belonging and the difficulty in capturing its nuances through standard survey instruments (Strayhorn, 2019).

Moreover, the studies might not have fully accounted for the diverse experiences of Chinese international students. The heterogeneity within this group means that factors such as prior international exposure, individual personality traits, and support systems can significantly impact their sense of belonging. International students' adjustment experiences can vary widely, suggesting that more nuanced, qualitative approaches might be necessary to capture the full range of their experiences (Wu et al., 2015).

7.3.4 Influence of contextual and environmental factors

Another significant limitation across the studies is the potential influence of contextual and environmental factors that were not controlled for or considered in the research design. Educational outcomes and experiences can be significantly affected by variables such as socioeconomic status, prior knowledge, and learning environment, which these studies might not have adequately accounted for. The studies might have benefited from a more comprehensive consideration of these factors, which could provide a deeper understanding of the underlying mechanisms affecting the outcomes.

While the studies contribute valuable insights into the application of gamification and the sense of belonging among Chinese international students, these limitations highlight the need for careful consideration of methodological rigor, cultural context, and individual differences. Addressing these limitations in future research could enhance the reliability and applicability of studies in this domain, aligning with the broader goals of advancing educational research and practice.

7.3.5 Ethical concerns

The discussion on ethical concerns has been revised to align with the revised focus of the thesis, addressing broader ethical considerations relevant to the overall research.

One primary ethical concern is the issue of informed consent and ensuring that participants fully understand the nature of the study and how their data will be used. This is particularly crucial in studies involving international students with varying levels of familiarity with research practices and ethical standards. Ensuring clear communication and obtaining explicit consent are fundamental to maintaining ethical integrity, as emphasized by Pittenger (2003) in their work on ethical issues in social and behavioral research.

Privacy and data security are also significant ethical considerations. Protecting participants' personal information is paramount, especially in educational research where sensitive data about students' backgrounds, academic performance, and personal experiences might be collected. This aligns with broader discussions in the field, such as those by Florea and Florea (2020), who highlighted the ethical implications of data privacy in research.

Another ethical issue is the potential for unintended consequences of the research interventions. For example, while gamification can enhance engagement, it might also increase pressure or competition among students, negatively impacting their well-being. Researchers must carefully consider and monitor the potential negative impacts of their interventions, ensuring that the benefits outweigh any risks involved. This ethical vigilance is crucial for maintaining the well-being of participants and upholding the ethical standards of research.

Finally, the ethical responsibility of cultural sensitivity is critical, particularly in studies involving international students. Researchers must be aware of and respect cultural differences, ensuring that the study design and implementation are culturally appropriate and sensitive to the participants' backgrounds. This ethical consideration is supported by research in cross-cultural psychology, such as the work by Liamputtong (2008), which underscores the importance of cultural competence in research.

7.4 Contributions

7.4.1 Theoretical contributions

The GAME Framework

One of this study's significant theoretical contributions is the development of the GAME framework. This framework integrates gamification principles with motivational theories to create a comprehensive approach to enhancing student engagement and learning outcomes. The GAME framework provides a structured method for designing and implementing gamified learning environments, emphasizing the importance of context-specific and culturally

relevant elements. This framework can serve as a foundation for future research and development in educational technology.

Contextual Adaptation of Gamification

The study highlights the importance of adapting gamification elements to learners' specific cultural and educational contexts, demonstrating significant improvements in student engagement and sense of belonging. Integrating AI into gamification designs offers a promising direction for creating more personalized and effective learning environments, particularly for diverse student populations.

The research provides a unique perspective to the conversations on gamification applications in the classroom for international student groups in introductory programming modules. Furthermore, the current study's application of knowledge in HCI, gamification, and educational technologies will benefit by providing an interdisciplinary view of the development of intelligent tutoring systems.

7.4.2   Practical contributions

Gamified Intelligent Tutoring System

This study's practical contributions include designing and implementing a gamification system tailored to the needs of Chinese international students in programming courses. This system has significantly improved student engagement, motivation, and sense of belonging, offering a valuable tool for educators and institutions seeking to support international students. The detailed design process and evaluation methods provide a blueprint for similar interventions in other educational contexts.

Guidelines for Educators

The study also offers practical guidelines for educators on effectively incorporating gamification and AI-enhanced learning into their teaching practices. These guidelines emphasize the importance of understanding the unique needs of diverse student populations and tailoring interventions to address these needs. By following these guidelines, educators can create more inclusive and supportive learning environments that foster a sense of belonging and improve academic outcomes for all students.

7.5   Future research

7.5.1   Expanding the scope

Future research should investigate the applicability of the gamified intelligent tutoring system (ITS) across various academic disciplines and diverse student populations. Such studies would help determine the broader utility of the approach and identify any discipline-specific adjustments required. By exploring different contexts, researchers can uncover unique challenges and opportunities, thereby enhancing the generalizability and robustness of the gamified ITS.

7.5.2 Longitudinal studies

Longitudinal studies are essential to understand the long-term effects of gamification and AI-enhanced learning on students' academic performance and sense of belonging. These studies could track students' progress over multiple semesters or academic years, providing comprehensive insights into the sustained impact of these interventions. Longitudinal research would also help identify potential long-term benefits and drawbacks, offering a clearer picture of the overall effectiveness of gamified learning systems.

7.5.3 Integration with broader educational strategies

Exploring the integration of gamification and AI-enhanced learning with other educational strategies, such as peer mentoring and collaborative learning, could yield more comprehensive solutions for supporting international students. This holistic approach would address various aspects of students' academic and social experiences, fostering a more inclusive and supportive learning environment. As ITS become more sophisticated, they have the potential to revolutionize education by upskilling and assisting teachers, enabling intelligent learning analytics and adaptive instructional design.

7.5.4 Enhanced intelligent tutoring systems

As the world moves towards automation, the demand for high-level thinking, employability, creativity, and teamwork skills increases. ITS can play a crucial role in developing these skills while fostering a sense of belonging. Future research should focus on the harmonious collaboration between humans and AI to provide a personalized and effective learning experience for all students. ITS should not aim to replace teachers but rather to support and enhance their capabilities.

7.5.5 Incorporating advanced technologies

At the time this research was conducted, GPT-3 had just been released and was considered state-of-the-art in the field of Natural Language Processing (NLP) (Brown et al., 2020). Consequently, GPT-3 was extensively referenced throughout this thesis as a benchmark model due to its groundbreaking capabilities at that time. However, by the time this thesis was completed, the NLP landscape had further evolved with the introduction of several newer and more advanced large language models (LLMs), such as ChatGPT (Ouyang et al., 2022), LLaMA (Touvron et al., 2023), and Gemini. These models represent a significant paradigmatic shift, offering enhanced capabilities in language understanding, generation, and human-like interaction. ChatGPT, for instance, has set new standards in conversational AI, enabling more sophisticated and contextually aware dialogues (Ouyang et al., 2022). Similarly, LLaMA and Gemini have introduced more efficient and scalable architectures, pushing the boundaries of what is possible with LLMs (Touvron et al., 2023). These advancements have opened new avenues for research, particularly in areas such as human-AI collaboration, ethical AI deployment, and the integration of LLMs into more specialized tasks. While this thesis primarily focuses on the state of NLP as it was during the initial research phase, future work could explore the potential impact and applications of these newer models, evaluating how they

might further enhance the research outcomes or introduce new possibilities that were not achievable with GPT-3.

System Framework Development

A new system landscape has been proposed to achieve these goals, involving the development of several APIs to enhance the backend (see Figure 7.1). These APIs include:

Journey Designer: Tracks students' progress and mistakes, providing an adaptive learning journey for different levels. Chatbot Manager: Handles the creation and selection of chatbots based on the student's preferences and learning needs. Adaptive Storyteller: Generates an unfolding storyline tailored to the student's preferences, cultural backgrounds, and learning progress. Context Learner: Actively learns from student interactions, updating responses accordingly and providing context-aware replies using natural language processing models. Human-in-the-Loop Module: Allows human experts to intervene and provide feedback when necessary.

7.5.6 Enhancing front-end features

The front-end of the ITS can be improved by involving human tutors, human peers, and AI chatbots in the chatroom to create a more engaging and personalized learning experience. Adaptive responses to students' quiz submissions based on learning analytics can further personalize the learning experience. Additionally, embedding more personalized gamification elements, such as adaptive storytelling and AI-generated avatars, can enhance students' motivation and engagement.

7.5.7 Ensuring seamless integration

To ensure a seamless and personalized learning experience, the front-end and back-end should communicate effectively through APIs, with components like the Session Manager, Chatbot Manager, Adaptive Storyteller, Context Learner, and database working in unison. The Human-in-the-Loop Module will be integrated to maintain safe boundaries and provide high-quality responses, ensuring the system's overall reliability and effectiveness.

The future of ITS is promising, with significant potential to transform education by providing personalized, engaging, and effective learning experiences. Continued research and development in these areas will be crucial to realizing this potential.
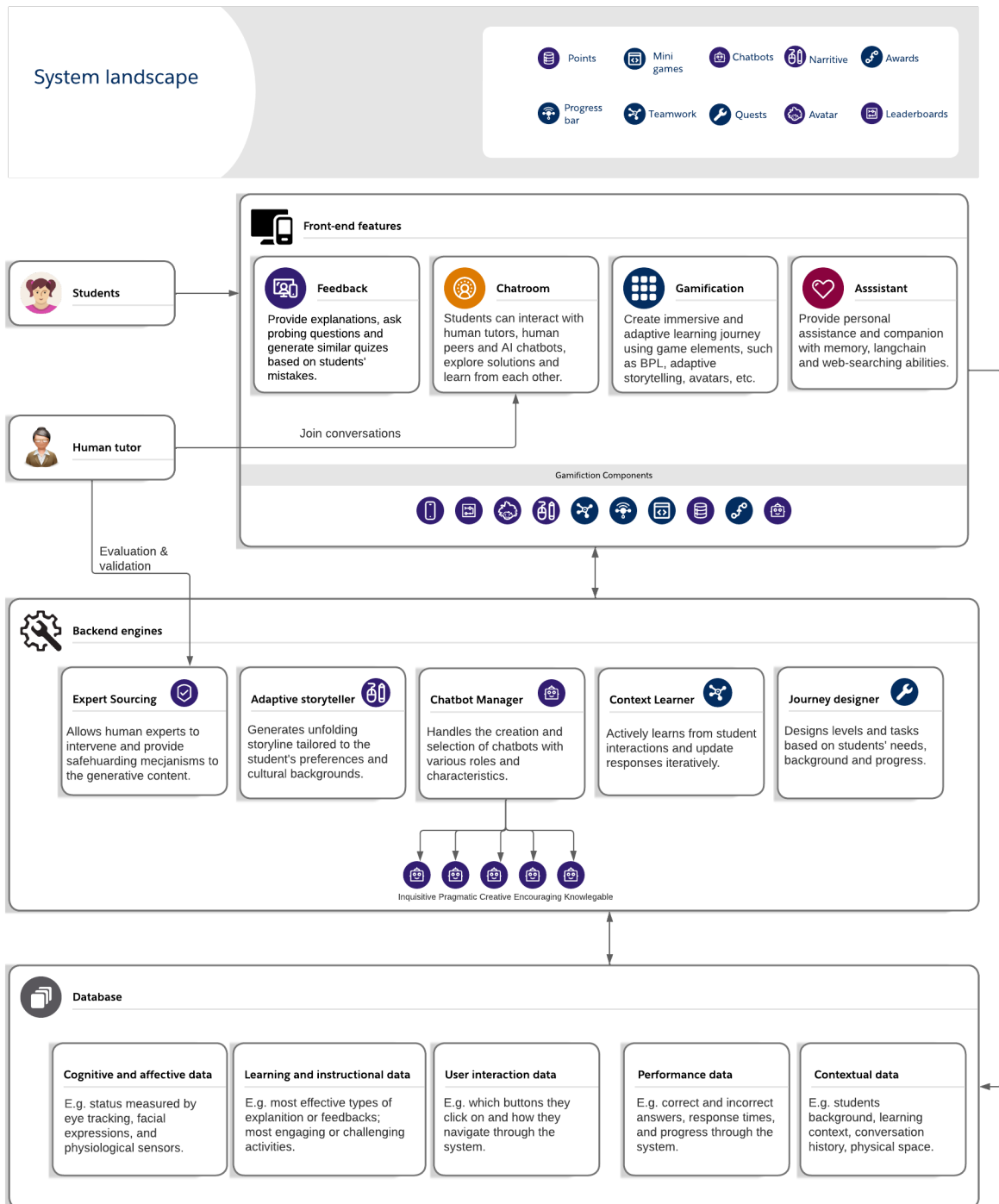
Figure 7.1: *Proposed system landscape for future work.*

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Appendices

Appendix A

Questionnaire Used in the 1st Phase of Study 1

Survey of Chinese Students' Sense of Belonging
Section 1 Personal information (Short answer)

1. What is your current level of study?

2. What's your gender?

3. What's your age?

Section 2 Learning backgrounds and skills (Short answer, 5 Likert scale and multiple-choice)

1. Have you studied abroad before your current program?

2. If the answer to the last question (Sec 2 Q1) is 'yes', please specify which foreign country (es) you have travelled to for study.

3. Self-rating of academic skills.

4. Self-rating of language skills.

5. Self-rating of communication skills.

6. What motivates you to study in the UK? a) Family connection and/or contact with students or graduates. b) Academic reputation. c) Campus lifestyle and/or Halls of Residence. d) Course available only at the UK universities. e) To enjoy new places, and people and increase independence. f) Other.

7. Are you planning to work or study in the UK after completing your program?

Section 3 Perceived Peer Support (5 Likert scale)

1. I discuss events which happened outside of class with my classmates.

2. I have discussed personal matters with students whom I met in class.

3. I could contact another student from class if I had a question.

4. Other students are helpful in reminding me when assignments are due or when tests are approaching.

5. I have developed personal relationships with other students in class.

6. I invite people I know from class to do things socially.

Section 4 Perceived Classroom Comfort (5 Likert scale)

1. I feel comfortable contributing to discussions in the lecture theatre.

2. I feel comfortable contributing to online class discussions.

3. I feel comfortable asking a question in class.

4. I feel comfortable volunteering ideas or opinions in class.

5. Speaking in class is easy because I feel comfortable.

Section 5 Perceived Isolation (5 Likert scale)

1. It is difficult to meet other students in class.

2. No one in my classes knows anything personal about me.

3. I rarely talk to other students in my class.

4. I know very few people in my class.

Section 6 Perceived Teaching Team Support (5 Likert scale)

1. I feel comfortable talking about a problem with an academic member of the teaching team.

2. I feel comfortable asking a lecturer for help if I do not understand course-related material.

3. I feel that a teaching team member would be sensitive to my difficulties if I shared them.

4. I feel comfortable socializing with a member of the teaching team outside of class.

5. I feel that a teaching team member would be sympathetic if I was upset.

6. I feel that an academic member of the teaching team would take the time to talk to me if I needed help.

7. If I had a reason, I would feel comfortable seeking help from an academic member of the teaching team outside of class time (office hours etc.).

8. I feel comfortable seeking help from a lecturer before or after class.

9. I feel that an academic member of the teaching team really tried to understand my problem when I talked about it.

10. I feel comfortable asking a lecturer for help with a personal problem.

Section 7 Engagement and motivation (5 Likert scale)

1. I'm motivated to study.

2. I try to do a bit more on the program than it asks me to.

3. I try to link the content that I learn in different modules (e.g., by reflecting on case studies).

4. I reach out to academic members of staff in order to discuss topics relevant to my program.

5. I use feedback on my work to help me improve what I do.

6. I actively seek feedback from an academic member of the teaching team.

7. I put a lot of effort into the work I do.

Section 8 Self-confidence (5 Likert scale)

1. I expect to achieve high grades in my studies.

2. I doubt my ability to study abroad at the university level.

3. I am worried about the difficulty of my program.

4. I'm confident to complete my program successfully.

Section 9 Transition to British Universities (5 Likert scale)

1. I maintain frequent contact with my friends and family in my home country..

2. I find it easy to make friends with students of another nationality.

3. I find it easy to make friends with students of my nationality.

4. I feel that my college/university honours diversity and internationalism.

5. I have felt insulted or threatened based on my cultural/ethnic background at my college/university.

6. I enjoy it when my friends from other cultures teach me about our cultural differences.

7. I am able to take on various roles as appropriate in different cultural and ethnic settings.

Appendix B

Questionnaire Used in the 2nd Phase of Study 2

Students' sense of belonging and learning experience for the gamification prototype
Personal information (Short answer)

1. What is your current level of study?

2. What's your gender?

3. What's your age?

Section 2 Learning backgrounds and skills (Short answer, 5 Likert scale and multiple-choice)

1. Have you studied abroad before your current program?

2. If the answer to the last question (Sec 2 Q1) is 'yes', please specify which foreign country (es) you have travelled to for study.

3. Self-rating of academic skills.

4. Self-rating of language skills.

5. Self-rating of communication skills.

6. What motivates you to study in the UK? a) Family connection and/or contact with students or graduates. b) Academic reputation. c) Campus lifestyle and/or Halls of Residence. d) Course available only at the UK universities. e) To enjoy new places, and people and increase independence. f) Other.

7. Are you planning to work or study in the UK after completing your program?

B.1   Sense of belonging

1.1 Peer level (5 Likert scales)

1. I feel comfortable discussing class materials (e.g. worksheets) with classmates

2. I feel engaged in the learning process with other students in the class.

3. I feel

4. I am part of the learning community with my classmates.

5. I think the gamification system improved my sense of belonging at the peer level.

1.2 Departmental level (5 Likert scales)

1. I am recognized and noticed when I'm good at something or making progress. It is easy for me to approach an instructor or other teaching support member (e.g. TAs and the chatbot) if I have a problem.

2. I feel that a teacher or the teaching support member understand my problem when I talked about it.

3. I feel integrated into the educational culture of the school. The school and staff valued my opinions and perceptions.

4. I feel proud of belonging to the information school.

5. I think the gamification system improved my sense of belonging to the department.

1.3 Subject-related Career level (5 Likert scales)

1. I enjoy learning data science.

2. I understand how I could apply the knowledge I learned in the data science projects

3. I am interested in learning more about data science.

4. I am interested in being a data scientist for my future career.

5. I am confident that I'm able to tackle data science projects in the future.

6. I think the gamification system improved my sense of belonging to the data science-related career.

B.2 Academic emotion

2.1 Please describe your emotions during the session (5 Likert scales)

1. I am more motivated to do the learning activities

2. I am more focused on the learning activities

3. I am more relaxed about the learning activities

4. I am more satisfied with the learning and teaching process

5. I find the session more enjoyable

6. I find the session bored

7. I feel hopeless when learning the materials

8. I feel anxious when learning the materials

9. I feel angry when learning the materials

B.3   Gamification experience

3.1 Interface design (5 Likert scales)

1. Smooth experience using the system

2. Easy to access each page and function

3. Clear instructions to follow

3.2 Rate your experience with each game element (5 Likert scales)

1. Alternative reality (Storyline of Mind Palace)

2. Narrative (Trailer and instructions)

3. AI chatbot (Sherlock Holmes as your personal tutor)

4. Points and leaderboards

5. Personalized encouragement

6. Personalized real-time feedback

7. Level up (Episodes, challenges and puzzles)

8. Avatar (The profile photos)

9. Progress bar

10. Reward (Extra access to the mind palace and the chatbot)

3.3 Do you have any suggestions or comments you'd like to tell us? (fill in the blank/optional)

Appendix C

Training Needs Analysis Forms

FACULTY OF SOCIAL SCIENCES: TRAINING NEEDS ANALYSIS (TNA)
The skills and experience you should gain by the end of your higher degree studies.

Name of student: *Chen Cao*
Department or School: *Information School*
Names of all supervisors: *Dr Frank Hopfgartner (1ˢᵗ) ; Dr Xin Zhao (2ⁿᵈ)*
Year of study: *1ˢᵗ*

Completing your TNA
Before completing your TNA in consultation with your supervisor(s), you should read the guidance notes that accompany this form.

The Faculty's TNA form has been compiled with reference to the Vitae Researcher Development Framework (RDF), which divides into four 'Domains' the skills, and attitudes and behaviours required to be an effective researcher. The framework is also recognised widely outside academia, and can provide you with an effective way of articulating your skills to employers.

To familiarise yourself with the terms used in the Researcher Development Framework and this form, visit the University's online RDF tool.

Prioritising your training and development
Academic, professional and personal development are all key aspects of your doctoral research experience, and the Faculty will support you to develop your skills throughout the course of your PhD. However, time is a precious resource, so it is important to ensure that you undertake the *right training at the right stage* of your PhD. When considering the twelve areas (three within each 'Domain') in the following table, please decide – in consultation with your supervisor(s) – to what extent it is a priority for the coming year (*low*, *medium* or *high*).

Formal training (such as that within the Faculty of Social Science Core Programme) may be part of your development, but many of the skills required of an effective researcher will also be developed through the process of working on your PhD itself (e.g. developing your critical thinking through writing thesis chapters). Through discussion with your supervisor(s), you should use this form to set realistic goals and identify the action to achieve them – you can then use this to reflect on your development throughout the year.

In addition, remember to keep an up-to-date record of the training you have undertaken within your PhD, as you will need to submit a Doctoral Development Programme Summary Form at the end of your doctoral studies.

RDF Domain A: Knowledge and Intellectual Abilities		
the knowledge, intellectual abilities and techniques to do research		
	Reflection on your current ability/experience in this area and main priorities for the coming year	**Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).**
Knowledge base (RDF subdomain A1) *Including:* - Subject knowledge - Research methods – theoretical knowledge and practical application - Information seeking and information management skills - Academic literacy and numeracy	I did qualitative research for my master dissertation about the gamification application in programming learning in China, through which I had a general understanding of the subject. However, my current study requires much deeper and broader interdisciplinary knowledge, including theories and methodologies of game design, information study, pedagogy, sociology, etc, and this is my main concern at the start of my PhD. What's more, I would like to enhance my knowledge and practices with quantitative methods, so that I could adopt more efficient methodologies in my research. I'm also interested in the wider development opportunities included in this doctoral programme and want to be an active researcher.	*Medium* –I aim to gain a thorough understanding of the subject through core readings and writing tasks in discussion with my supervisors. I would also attend lectures and seminars provided by the White Rose DTP training regarding quantitative and qualitative research methods, such as cluster analysis, SPSS, surveys and interviews, etc. Besides, I intend to make the most of the resources offered by the university, such as the DDP portal, Think Ahead researcher development training, White Rose Social Sciences Doctoral Training, etc, to enhance my academic skills.
Cognitive abilities (A2) *Including:* - Analysing - Synthesising knowledge - Critical thinking	In my master study, I've enrolled in the courses of quantitative and qualitative methods, from which I have a basic understanding on how to collect and analyze data. I've also applied these methods in my MA dissertation, but in a relatively limited way. My synthesising knowledge and critical thinking skill was developed and reflected by my MA study and dissertation as well, but I'm not sure if it is at an appropriate level for the PhD. Therefore, my main properties would be updating my analysing skills, enriching my knowledge of more advanced methodologies, and developing academic skills at a higher level.	*High priority* –I will read the online materials on the Social Sciences Training Portal to enrich my knowledge in researching skills. I will also attend tutorials and workshops in DDP training, 301 skills and ELTC, to further develop my cognitive abilities. It is important to write and reflect on my thinking regularly as well, and discuss my written work with my supervisors, in order to put forward ideas more clearly and concisely..
Creativity (A3) *Including:*	At the start of my PhD study, I feel like having so many ideas about the subject after reading literature and	*Medium* –I will attend the workshops offered by Think Ahead , which might be useful for developing

- Intellectual insight - Innovation - Argument Construction	meeting with supervisors, but find it quite difficult to . It could be both exciting and overwhelming for me, because it's quite challenging to explore the ambiguous problems and find appropriate methods to solve them. Thus, my main concern would be cultivating creativity and enhancing creative research proficiency in order to efficiently produce more innovative research.	creative and innovative approaches and intellectual insight. And I will look at additional resources about creativity online, such as the book *Creativity in Research: Cultivate Clarity, Be Innovative, and Make Progress in Your Research Journey.* Above all, the feedback and advice from my supervisors about my writing could be very helpful for me to improve my argument construction skills.

RDF Domain B: Personal Effectiveness
the personal qualities and approach to be an effective researcher

	Reflection on your current ability/experience in this area and main priorities for the coming year	Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).
Personal qualities (B1) *Including:* - Resilience - Self-confidence - Integrity - Self-reflection	Doing a PhD is hard work and solitary journey, and I sometimes feel very challenged and overwhelmed when dealing with unfamiliar aspects in the field. The good thing is that I have great motivation and passion to do it. However, I'm not very confident when attending meetings and doing presentations at the beginning. Therefore, my main priority for the first year would be building self-confidence. When it comes to Integrity and self-reflection, I think I need to update the abilities to a higher level which is appropriate to PhD research as well.	*Medium* –I will read the online materials on the Social Sciences Training Portal and attend workshops offered by WRSSDTC, Think Ahead, DDP, etc, to improve my personal qualities. Besides, I'll work harder on my research and try to do presentations more on meetings and seminars when I have the opportunities, in order to develop confidence. I will also look at additional resources related to these qualities, such as the UKIO site, to better understand the importance of these qualities during the research process.
Self-management (B2) *Including:* - Time management - Responsiveness to change - Work-life balance	I think I'm good at time management, because I love to make plans for both short-terms and long-terms and try my best to stick on them. I also have a quite solid daily routine, which helps me keep good balance between work and life. It's also not very difficult for me to deal with changes, which may be thanks to my work experience in magazines and publishing house.	*Low* –I will attend the workshops offered by Kickstart your PhD and 301 skills centre to improve my self-management skills. I will also adjust my timeline and plans for PhD research by discussing with supervisors.
Professional and career development (B3) *Including:* - Career management	I would like to develop a career as an academic, and I'm aware that I have to start thinking about it early within the PhD process. I also have awareness of the need for	*Low*- I will plan on producing and publishing effective papers during my doctorate. I will also

	Reflection on your current ability/experience in this area and main priorities for the coming year	Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).
- Networking - Reputation and esteem	networking, though it might be quite difficult in the special time, when we all have to work from home.	seek networking chances through White Rose DTC Pathway, PhD students conference, AFHEA, etc.

RDF Domain C: Research Governance and Organisation
the knowledge of the standards, requirements and professionalism to do research

	Reflection on your current ability/experience in this area and main priorities for the coming year	Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).
Professional conduct (C1) *Including:* - Ethics - Respect and confidentiality - Attribution and co-authorship	During my master study, I gained a general understanding and experience regarding research ethics. I also have awareness of issues surrounding respect, confidentiality, attribution and co-authorship, but I still think it's very important to learn more about this area, especially for the preparation of the upcoming confirmation review.	*Medium*–I will read the online materials on the Social Sciences Training Portal, and learn about the University research ethics and integrity policy carefully. I will also look at additional useful resources online, such as guides on MindTools.
Research management (C2) *Including:* - Research strategy; - Project planning and delivery; - Risk management.	Most of the experience I gained in research management is from my master study and dissertation, so I might need a general improvement in these skills.	*Medium*– I will look at related resources provided in the DDP portal, and attend seminars in the department for social science research. Above all, I will discuss with my supervisors regarding my PhD project timeline and "milestones".
Finance, funding and resources (C3) *Including* - Income and funding; - Financial management.	Existing skills are moderate/good. As a self-funded student, most of the expenses including study and life are covered. I have some experience in financial management from my previous work as well.	*Low* – This won't be a priority for me at the moment, thanks to the support from my family, but I would love to gain teaching experience by doing a GTA job in the school, or be involved in funded research or projects.

RDF Domain D: Engagement, Influence and Impact
the knowledge and skills to work with others and ensure the wider impact of research

	Reflection on your current ability/experience in this area and main priorities for the coming year	Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).
Working with others (D1) *Including:* - Team working; - People Management; - Influence and leadership.	I have some experience in the area from my internships and engagement in social activities. Working with others might be important capacites for my future research and career, but I don't think developing leadership should be the main priority for my first year of PhD study.	*Medium/ low*– Working with supervisors and research groups will provide some experiential learning.
Communication and dissemination (D2) *Including:*	My existing communication skills are moderate, and I have limited experience in publication.	*Medium*– I will attend Pathway workshops on writing for academic audiences, and improve my

- Communication Methods; - Publication.		communication skills by actively attending seminars and research groups.
Engagement and impact (D3) *Including:* - Teaching; - Public Engagement; - Global Citizenship.	I have some teaching experience as a personal tutor and teaching assistant during my undergraduate study. I'm also aware and interested in public engagement and global citizenship.	*Low*- As mentioned above, I would love to gain teaching experience in the department. If it's possible, I'm also keen to share my research experience and findings outside the university.

Feedback (to be completed after the supervision in which the TNA is discussed)

Comments from supervisor(s)	*Any further action agreed by the supervisor and the student [please specify]:*

Signature of researcher: Chen Cao	**Date: 29/05/2020**
Signatures of supervisor(s): Frank Hopfgartner,Xin Zhao	**Date: 29/05/2020**
Signature of departmental PGR Director:	**Date:**

FACULTY OF SOCIAL SCIENCES: TRAINING NEEDS ANALYSIS (TNA)
The skills and experience you should gain by the end of your higher degree studies.

Name of student: *Chen Cao*
Department or School: *Information School*
Names of all supervisors: *Dr Frank Hopfgartner (1st) ; Dr Xin Zhao (2nd)*
Year of study: *2nd*

Completing your TNA
Before completing your TNA in consultation with your supervisor(s), you should read the guidance notes that accompany this form.

The Faculty's TNA form has been compiled with reference to the Vitae Researcher Development Framework (RDF), which divides into four 'Domains' the skills, and attitudes and behaviours required to be an effective researcher. The framework is also recognised widely outside academia, and can provide you with an effective way of articulating your skills to employers.

To familiarise yourself with the terms used in the Researcher Development Framework and this form, visit the University's online RDF tool.

Prioritising your training and development
Academic, professional and personal development are all key aspects of your doctoral research experience, and the Faculty will support you to develop your skills throughout the course of your PhD. However, time is a precious resource, so it is important to ensure that you undertake the *right training at the right stage* of your PhD. When considering the twelve areas (three within each 'Domain') in the following table, please decide – in consultation with your supervisor(s) – to what extent it is a priority for the coming year (*low*, *medium* or *high*).

Formal training (such as that within the Faculty of Social Science Core Programme) may be part of your development, but many of the skills required of an effective researcher will also be developed through the process of working on your PhD itself (e.g. developing your critical thinking through writing thesis chapters). Through discussion with your supervisor(s), you should use this form to set realistic goals and identify the action to achieve them – you can then use this to reflect on your development throughout the year.

In addition, remember to keep an up-to-date record of the training you have undertaken within your PhD, as you will need to submit a Doctoral Development Programme Summary Form at the end of your doctoral studies.

RDF Domain A: Knowledge and Intellectual Abilities *the knowledge, intellectual abilities and techniques to do research*		
	Reflection on your current ability/experience in this area and main priorities for the coming year	**Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).**

Knowledge base (RDF subdomain A1) *Including:* - Subject knowledge - Research methods – theoretical knowledge and practical application - Information seeking and information management skills - Academic literacy and numeracy	In the past ten months, I have read literature related to my project and accumulated plenty of relevant knowledge. Besides, I've learned R programming and mixed research methods which would be very useful in conducting my own research. What's more, In order to improve my academic skills, I attend to White Rose Social Sciences Doctoral Training and Think Ahead researcher development training.	*Low*–I have gained a basic understanding of the subject through core readings and relevant courses. Next year, I'll try to apply the knowledge in practice and develop an efficient gamification application.
Cognitive abilities (A2) *Including:* - Analysing - Synthesising knowledge - Critical thinking	I have attended numerous tutorials and workshops in DDP training, 301 skills and ELTC which give me a fundamental cognitive ability. During the period of confirmation review writing, I learned how to analyse data and do critical thinking.	*Low*– I will continue to attend those tutorials and workshop
Creativity (A3) *Including:* - Intellectual insight - Innovation - Argument Construction	I attend my group meeting every week and listen to my colleagues share their research and experiments. Those works give me enormously inspiration. I also developed my creativity skills in my teaching experience, where I added some interesting learning activities to motivate my students, such as teamwork debating. Next, I will enter the actual experimental stage. So I need to expand my insight which can help me finish a novel research work.	*Low*–I will attend the workshops offered by Think Ahead , which might be useful for developing creative and innovative approaches and intellectual insight.
RDF Domain B: Personal Effectiveness *the personal qualities and approach to be an effective researcher*		
	Reflection on your current ability/experience in this area and main priorities for the coming year	**Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).**
Personal qualities (B1) *Including:* - Resilience - Self-confidence - Integrity - Self-reflection	Doing a PhD during the pandemic is quite difficult and challenging, but I think I've found the balance between research and life. I set myself a fixed time for working every day and keep doing reflection at the end of it, which I find quite useful to stay focused. The research activities I was involved in the past year increased my self-confidence.	*Low*– Randomly chosen some Think Ahead workshops to attend.
Self-management (B2) *Including:* - Time management	I think I'm good at time management, because I love to make plans for both short-terms and long-term and try my	*Low* –I will attend the workshops offered by Kickstart your PhD and 301 skills centre to improve my

- Responsiveness to change - Work-life balance	best to stick to them. I also have a quite solid daily routine, which helps me keep a good balance between work and life. It's also not very difficult for me to deal with changes, which may be thanks to my work experience in magazines and publishing houses.	self-management skills. I will also adjust my timeline and plans for PhD research by discussing with supervisors.
Professional and career development (B3) *Including:* - Career management - Networking - Reputation and esteem	I would like to develop a career as an academic, and I'm aware that I have to start thinking about it early within the PhD process. I also have awareness of the need for networking, though it might be quite difficult in the special time, when we all have to work from home.	*Low-* I will plan on producing and publishing effective papers during my doctorate. I will also seek networking chances through White Rose DTC Pathway, PhD students conference, AFHEA, etc.

	Reflection on your current ability/experience in this area and main priorities for the coming year	Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).
Professional conduct (C1) *Including:* - Ethics - Respect and confidentiality - Attribution and co-authorship	I've got the ethics approval for my first stage of research and have learned issues regarding ethics in social sciences during my GTA work. I've also attended the ethics module provided by the school.	*Low*–Update relevant information in time.
Research management (C2) *Including:* - Research strategy; - Project planning and delivery; - Risk management.	Confirmation review writing makes me understand how to design the project plan, manage the data and develop a practical research strategy. In the coming years, I should focus on the implementation of the plan.	*Medium*– Discuss with my supervisor and revise the plan if research is obstructed.
Finance, funding and resources (C3) *Including* - Income and funding; - Financial management.	Existing skills are moderate/good. As a self-funded student, most of the expenses including study and life are covered. I have some experience in financial management from my previous work as well.	*Low* – This won't be a priority for me at the moment, thanks to the support from my family, but I would love to gain teaching experience by doing a GTA job in the school, or be involved in funded research or projects.

	Reflection on your current ability/experience in this area and main priorities for the coming year	Action to be taken to develop this area (if appropriate), agreed with your supervisor(s).
Working with others (D1) *Including:* - Team working; - People Management; - Influence and leadership.	I attend the group meeting every week and listen to my colleagues share their research and experiments. I also engage in administrative work for four months as a student assistant.	*Low*– Working with supervisors and research groups will provide some experiential learning.

Communication and dissemination (D2) *Including:* - Communication Methods; - Publication.	My existing communication skills are moderate, and I have limited experience in publication.	*Medium*– I will attend Pathway workshops on writing for academic audiences, and improve my communication skills by actively attending seminars and research groups.
Engagement and impact (D3) *Including:* - Teaching; - Public Engagement; - Global Citizenship.	In this semester, I teach two courses (INF6027 and INF6033) as a GTA to lead students in practicals and seminars. I'm also aware and interested in public engagement and global citizenship.	*Low*- As mentioned above, I would love to gain teaching experience in the department. If it's possible, I'm also keen to share my research experience and findings outside the university.

Feedback (to be completed after the supervision in which the TNA is discussed)

Comments from supervisor(s)	**Any further action agreed by the supervisor and the student [please specify]:**

Signature of researcher: Chen Cao	**Date: 16/12/2021**
Signatures of supervisor(s): Frank Hopfgartner,Xin Zhao	**Date: 16/12/2021**
Signature of departmental PGR Director:	**Date:**

Appendix D

Data Management Plan

Using Gamification to support international students' transition in higher education

A Data Management Plan created using dmproadmap

Creator: Chen Cao

Affiliation: The University of Sheffield

Template: The University of Sheffield Postgraduate Research DMP

Project abstract:

Previous studies have shown that the appropriate onboarding process plays an important role for international students in many aspects, especially in increasing their retention rate and improving learning performance. As the largest portion of international students in global higher education, Chinese students' learning experience and their academic transitional problems calls for more attention. The aim of this study is to identify the transitional learning difficulties faced by Chinese students studying in British Universities, and design a gamified online course on existing learning management system (LMS) to soften the impact of the academic transition, improve their motivation as well as engagement in learning activities, and thus enhance their learning experience. The study intends to contribute in improving theoretical and practical knowledge of supporting international students' transition by implementing gamified e-learning.

Last modified: 17-03-2021

Using Gamification to support international students' transition in higher education

Defining your data

- What data will you collect or create during the project?
- How will the data be collected or created, and over what time period?
- What formats will your digital data be in?
- Approximately how much digital data will be generated during the project?
- Are you using pre-existing datasets? Give details if possible, including conditions of use

Data description:
This research will generate video and text data primarily from participatory. Video data is from interview and text data created by surveys.

Data format:
.mp4 .csv .docx

Data collection:
Data collection will include survey, interview, observation and experiments. Online surveys and semi-structured interviews will be conducted with the current, previous postgraduate international students and relevant staffs. This process is finished through Google forms and store the data in the Google sheets. In the data analysis stage, I will feed those data to SPSS for quantitative analysis.

The survey and interview will be composed of five sections, which are personal information, educational background and learning styles, teaching and learning expectations, academic challenges and difficulties, and other perceptions or suggestions. Paricopatories need to download a template file (.docx), fill the question and submit their response.

Looking after your data

- How will you make data easier to understand and use? *(e.g. creating a README file)*
- Where will you store digital and physical data during the project?
- How will you name and organise your data files?
- How will you ensure data is backed up? *(e.g. using University research data storage)*
- How often will you check your backup files? *(e.g. on backup, at set intervals)*
- Will you use extra security precautions for any of your digital or physical data? *(e.g. for sensitive and/or personal data)*

Each participator will have an individual data fold to store data. This fold names by surname and university user name. The data in the fold will be organised through naming conventions covering the archival source, folio and date obtained. Besides, no spaces in naming and using "_" conjunction(eg. 2021_01_10_interview.docx).

All the paper record will have a digital scan and all the data will upload to Google drive for backup. Besides, the data stored in the local computer will be encrypted.

Archiving your data

- What data will be archived (stored on a long-term basis) at the end of the project?
- How long will the data be stored for? *(e.g. standard TUoS retention period of 10 years)*
- Where will the archive be stored? *(e.g. subject-specific repository, or ORDA)*
- Who will archive the data? *(e.g. you, or your supervisor)*
- If you plan to use storage other than a repository, who will be responsible for the data?

When I finish the project, I will erase all raw data and only keep the public data (eg. student mark form university) and analysis result. I will archive the data by myself and upload it to Github. Those data will retent for 10 years.

Sharing your data

- How will you make your data available outside the research group after the project? *(e.g. through data repository, or access on request via data availability statement)*
- Will you make all of your data available, or are there reasons you can't do this? *(e.g. personal data, commercial or legal restrictions, very large datasets)*
- How might you make more of your data available? *(e.g. anonymisation, participant consent, analysed data only)*
- What licence might you attach to your data to say how it can be reused and shared?

I'm willing to share all the result and my observation note. But for the data, directly from the participator (interview video, questionnaire), will not share with the public because of privacy protection.

Implementing your plan

- Who is responsible for making sure the plan is followed? *(e.g. you, your supervisor)*
- How often will the plan be reviewed and updated? *(e.g. if the project changes, yearly)*
- What actions have you identified from the rest of this plan? *(e.g. selecting a repository, requesting University research data storage)*

My supervisor and I will guarantee this plan is followed and I will review and update this plan twice a year.

Appendix E

Ethics Application and Approval

Application 050164

Section A: Applicant details

Date application started:
Sun 23 October 2022 at 14:36

First name:
Chen

Last name:
Cao

Email:
ccao5@sheffield.ac.uk

Programme name:
PhD in Information studies

Module name:
Information studies
Last updated:
15/12/2022

Department:
Information School [a.k.a iSchool]

Applying as:
Postgraduate research

Research project title:
Developing an AI and AR Enhanced Gamification Learning System for Introductory Programming Courses

Has your research project undergone academic review, in accordance with the appropriate process?
Yes

Similar applications:
Application 044908

Section B: Basic information

Supervisor

Name	Email
Laura Sbaffi	l.sbaffi@sheffield.ac.uk

Proposed project duration

Start date (of data collection):
Wed 9 November 2022

Anticipated end date (of project)
Wed 1 February 2023

3: Project code (where applicable)

Project externally funded?
No

Project code
- not entered -

Suitability

Takes place outside UK?
No

Involves NHS?
No

Health and/or social care human-interventional study?
No

ESRC funded?
No

Likely to lead to publication in a peer-reviewed journal?
Yes

Led by another UK institution?
No

Involves human tissue?
No

Clinical trial or a medical device study?
No

Involves social care services provided by a local authority?
No

Is social care research requiring review via the University Research Ethics Procedure
No

Involves adults who lack the capacity to consent?
No

Involves research on groups that are on the Home Office list of 'Proscribed terrorist groups or organisations?
No

Indicators of risk

Involves potentially vulnerable participants?
No
Involves potentially highly sensitive topics?
No

Section C: Summary of research

1. Aims & Objectives

The current study aims to develop an artificial intelligence (AI) and alternative reality (AR) enhanced gamification learning system for introductory programming courses. The specific objectives of the study are as follows:

1. To design an AI and AR enhanced gamification learning system for introductory programming courses.
2. To evaluate the effectiveness of the AI and ARenhanced gamification learning system in terms of students' sense of belonging, learning outcomes and engagement.
3. To explore students' perceptions of the AI and AR enhanced gamification learning system.

2. Methodology

The current study will use a combination of system log data, questionnaires, and interviews to examine the effectiveness of the AI-enhanced gamification learning system for introductory programming courses.

Students enrolled in the INF6027 module will be given the consent form about collecting system log data and questionnaires at the

beginning of the practical sessions. System log data and questionnaire responses will be collected from those who agreed to participate in the study during the class. The system log data will be analysed to track students' learning behaviours and interactions with the gamification learning system and the AI chatbots, in order to evaluate the effectiveness of the system in terms of students' engagement, retention and learning performance. The questionnaire will be distributed at the end of the class to collect students' demographic information, and investigate their sense of belonging, their learning experience and their perceptions of the gamification learning system.

After the practical session, interviews will be conducted to explore students' in-depth experiences of using the gamification learning system. Students who attended the gamified class and completed the questionnaires will be invited to participate in the focus group via email with another consent form and information sheet. Students who replied to the invitation email with signed consent forms will be arranged for online or offline interviews.

Overall, there will be two samples of participants within the same population. The population is the students who enrolled in the INF6027 module in the 22/23 academic year. The log data collection and questionnaire will be conducted during the practical sessions of the INF6027. The first sample for system data collection and questionnaire will be students who signed the first consent form distributed at the beginning of the practical sessions. The focus group will be conducted after the practical sessions, and the sample of the focus group interview will be students who respond to the invitation email and sign the second consent form.

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3. Personal Safety

Have you completed your departmental risk assessment procedures, if appropriate?

Not applicable

Raises personal safety issues?

Yes

When participants attend face-to-face interviews, there might be risks of catching coronavirus (COVID-19). To manage this issue, participants and the interviewer will be asked to provide negative test results for COVID-19 and wear masks during the interview. All applicable university COVID-19-related procedures current at the time of the study will be put in place and complied with. Cleaning, hygiene and handwashing products will also be provided.

There is the issue of personal safety in general. Even though the campus is generally a safe place, there is always the potential for personal safety incidents (e.g., theft, assault, etc.) to occur. To help mitigate this risk, the face-to-face interview will be conducted in the meeting room at the information school, which is safer, more comfortable and quiet.

Section D: About the participants

1. Potential Participants

The potential participants are postgraduate-taught students who are enrolled in the INF6027 Introduction to Data Science module at the University of Sheffield.

2. Recruiting Potential Participants

Students will be approached through email sent by the instructors and in the practical sessions of the INF6027 module. Every student of the module will be invited to participate in the gamified activities to give everyone the same opportunities, but only students who are willing to be involved in the research will be collected data in this study.

There will be two samples of participants within the same population. The population is the students who enrolled in the INF6027 module in the 22/23 academic year. The log data collection and questionnaire will be conducted during the practical sessions of the INF6027. The first sample of the above two methods will be students who signed the first consent form distributed at the beginning of the practical sessions. The interviews will be conducted after the practical sessions, and the sample of the interview will be students who respond to the invitation email and sign the second consent form.

2.1. Advertising methods

Will the study be advertised using the volunteer lists for staff or students maintained by IT Services? No

- not entered -

3. Consent

Will informed consent be obtained from the participants? (i.e. the proposed process) Yes

Informed consent (attached in this application) will inform the research participants about the research aims, procedures, and any potential risks or benefits that may arise from their participation. It will also inform participants about their right to withdraw from the study at any moment and that their responses will be removed from further study (if reasonably possible). Informed consent forms will be displayed in the system for participants to read and sign prior to the start of the sessions. Informed consent forms will also be sent to participants prior

to the interviews. Participants will be asked to read and sign the form and return it to the researcher by email before the interview begins.

4. Payment

Will financial/in kind payments be offered to participants? No

5. Potential Harm to Participants

What is the potential for physical and/or psychological harm/distress to the participants?

Participating in the research is not anticipated to cause any disadvantages or discomfort. This empirical study is not concerned with sensitive matters, which might embarrass or harm the research participants. The risks of participating are the same as those experienced in everyday life. The participants of the interviews will be informed that their identities will not be protected from those who attended the same interview. Participants should not be identifiable when their experiences are discussed in the thesis to avoid any potential harm to them.

There may be an issue with face-to-face meetings with strangers during the COVID-19 situation, therefore, interviews will be conducted in the meeting room of the information school where the student can feel safe and comfortable. If a student cannot make the face-to-face interview, then they will be interviewed via Google Meetings.

How will this be managed to ensure appropriate protection and well-being of the participants?

In this research, participants will be informed that any personal information, such as their names, will be anonymised. If there is a need to present any script from the interview in the text, it will be translated and then presented with codes.

Furthermore, as previously mentioned the interviews will be conducted in the meeting room of the information school. However, if this is not applicable or students do not want to be interviewed in these places, then they will be given the choice to be interviewed online by Google meeting

6. Potential harm to others who may be affected by the research activities

Which other people, if any, may be affected by the research activities, beyond the participants and the research team?

Students who have not participated in the research activities will also have the chance to see and use the system, but their data will not be collected in any form.

What is the potential for harm to these people?

The potential harms for students who are not participating in the study are the same as those experienced in everyday life.

How will this be managed to ensure appropriate safeguarding of these people?

The data of non-participants will not be collected in any form. The data collected will be fully anonymized when writing up findings, and any other information that might lead to participants' or other students' identity (e.g., university name, location) will not be reported to preserve privacy and confidentiality.

7. Reporting of safeguarding concerns or incidents

What arrangements will be in place for participants, and any other people external to the University who are involved in, or affected by, the research, to enable reporting of incidents or concerns?

The University of Sheffield has a range of policies, procedures and support mechanisms in place to deal with social harm. These include our Code of Ethics (https://www.sheffield.ac.uk/govern/ethics-code), which provides a framework for the reporting and investigating of incidents of social harm; our Safeguarding Policy (https://www.sheffield.ac.uk/study/policies/safeguarding), which sets out the University's commitment to safeguarding and protecting children, young people and vulnerable adults; and our Student Support and Wellbeing team (https://students.sheffield.ac.uk/mental-health/confidentiality), who provide support and advice to students who have been affected by social harm.

Besides, the University has a number of policies and processes providing information and routes for reporting concerns or incidents in a range of areas. Student Services Information Desk 'Signposting Our Support' pages provide information and links to further support mechanisms, as well as emergency contacts, for a range of issues including harassment, bullying and hate crimes, and domestic violence and sexual assault.

Report + Support is available to any member of staff, student, or visitor for reporting any form of discrimination such as harassment, abuse, bullying, or sexual violence that may be based on race, gender, sexuality, or other characteristics.

The research Misconduct toolkit is available to staff, students, stakeholders, collaborators and members of the public to raise concerns about research misconduct. Research misconduct encompasses a breach of duty of care, placing anyone in danger, not observing ethical or legal obligations, breach of confidentiality, plagiarism and inappropriate authorship practices.

Who will be the Designated Safeguarding Contact(s)?

Prof Peter Bath, Research Ethics Coordinator, Information School, The University of Sheffield (ischool_ethics@sheffield.ac.uk) will be the Designated Safeguarding Contact.

How will reported incidents or concerns be handled and escalated?

Concerns that are raised via an agreed Designated Safeguarding Contact (DSC) for an individual research project should be dealt with in an impartial, timely and fair manner, which protects the rights of all individuals involved, takes concerns seriously adopting a victim/survivor-centred approach, and ensures that appropriate action is taken. The highest level of confidentiality relating to individual cases should be maintained and information shared only as necessary to safeguard individuals and to ensure compliance with legislation, regulation, funder terms and conditions, and relevant guidance.

Section E: About the data

1. Data Processing

Will you be processing (i.e. collecting, recording, storing, or otherwise using) personal data as part of this project? (Personal data is any information relating to an identified or identifiable living person).
Yes

Which organisation(s) will act as Data Controller?

University of Sheffield only

2. Legal basis for processing of personal data

The University considers that for the vast majority of research, 'a task in the public interest' (6(1)(e)) will be the most appropriate legal basis. If, following discussion with the UREC, you wish to use an alternative legal basis, please provide details of the legal basis, and the reasons for applying it, below:

- not entered -

Will you be processing (i.e. collecting, recording, storing, or otherwise using) 'Special Category' personal data?
No

3. Data Confidentiality

What measures will be put in place to ensure confidentiality of personal data, where appropriate?

I will anonymise the data before analysis, but I cannot guarantee that members of the focus group will not discuss their participation, although I will request that they not do so. When writing up findings, the personal information that appeared in the discussion will be anonymized into Student A, B, C, etc., and any other information that might lead to students' identity (e.g., university name, location) will not be reported.

4. Data Storage and Security

In general terms, who will have access to the data generated at each stage of the research, and in what form

In accordance with the university policies, the data will be stored in a password-protected system. It will be stored in a secure server and in the researcher's University of Sheffield Google Drive account. The participants' user names will be anonymised and data will be also encrypted, and it will be accessed only by the researcher and her supervisors. The use of paper copies will be avoided unless essential and will be kept in locked storage in the Information School. The papers will be destroyed as soon as they are no longer needed. The data will be stored on the Information School's research data drive which can be accessed only by me, my supervisor, the School's Examinations Officer and the ICT staff operating the facility. I will also store an encrypted password-protected backup copy on my personal laptop. This data will be
deleted within 3 months of my degree being awarded.

What steps will be taken to ensure the security of data processed during the project, including any identifiable personal data, other than those already described earlier in this form?

The Data Management Plan is attached in the next section.

Will all identifiable personal data be destroyed once the project has ended?
Yes

Please outline when this will take place (this should take into account regulatory and funder requirements).

This identifiable personal data will be destroyed within 3 months of my degree being awarded. The data will not be handed over to third parties and transcribing and encoding of the data will be done by the researcher.

Section F: Supporting documentation

Information & Consent

Participant information sheets relevant to project?
Yes

Document 1112860 (Version 3)	All versions

Document 1113723 (Version 2)	All versions

Consent forms relevant to project?
Yes

Document 1112859 (Version 3) — All versions
The version 1 of the consent form will be distributed to the students through the gamification system before the practical sessions start. The version 2 will be distributed to the participants before the start of the focus group interview.

Document 1113724 (Version 2)	All versions

Additional Documentation

Document 1112861 (Version 2) — All versions
Data management plan

External Documentation

- not entered -

Section G: Declaration

Signed by:
Chen Cao
Date signed:
Thu 17 November 2022 at 18:58

Offical notes

- not entered -

Chen Cao
Registration number: 190320195
Information School [a.k.a iSchool]
Programme: PhD in Information studies

Dear Chen

PROJECT TITLE: Developing an AI and AR Enhanced Gamification Learning System for Introductory Programming Courses
APPLICATION: Reference Number 050164

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 15/12/2022 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 050164 (form submission date: 17/11/2022); (expected project end date: 01/02/2023).
- Participant information sheet 1112860 version 3 (17/11/2022).
- Participant information sheet 1113723 version 2 (17/11/2022).
- Participant consent form 1112859 version 3 (08/11/2022).
- Participant consent form 1113724 version 2 (17/11/2022).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Peter Bath
Ethics Administrator
Information School [a.k.a iSchool]

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Application 044908

Section A: Applicant details

Date application started:
Mon 24 January 2022 at 11:09

First name:
Chen

Last name:
Cao

Email:
ccao5@sheffield.ac.uk

Programme name:
Information Studies

Module name:
PhD Project
Last updated:
23/02/2022

Department:
Information School [a.k.a iSchool]

Applying as:
Postgraduate research

Research project title:
Implementing Gamification in programming module on LMS to increase Chinese students's sense of belonging in the UK higher education

Has your research project undergone academic review, in accordance with the appropriate process?
No

Similar applications:
- not entered -

Section B: Basic information

Supervisor

Name	Email
Frank Hopfgartner	f.hopfgartner@sheffield.ac.uk

Proposed project duration

Start date (of data collection):
Thu 24 February 2022

Anticipated end date (of project)
Tue 24 May 2022

3: Project code (where applicable)

Project externally funded?
No

Project code
- not entered -

Section C: Summary of research

1. Aims & Objectives

The research aims to explore the affordance of gamification in improving Chinese students' sense of belonging to UK higher education and if the gamification design can mediate their learning and transitional experience. The research takes the form of a case study, which implements gamification in a programming course (INF6032 Big Data Analytics) at the information school of the University of Sheffield. The objectives are:

1. Identify game characteristics that can be employed in programming courses to increase Chinese
students' sense of belonging.
2. Implement selected gamification attributes on the programming course and evaluate the effectiveness of each gamification element on Chinese students' sense of belonging.
3. Investigate the way gamification mediate students' learning outcomes and level of transition.

2. Methodology

Mixed methods are applied in order to achieve adequate research triangulation. The first research objective will be accomplished by a

literature review to identify the gamification components that have the potential to facilitate students' sense of belonging and are suitable to be embedded on Blackboard. After reviewing the literature, identified gamification elements will be added to the practical session in the module INF 6032 Big Data Analysis. The evaluation and reflection are based on the gamified learning theory, in which the changes of students' affection, behaviour and cognition, as well as the learning and transition outcomes will be assessed through both quantitative and qualitative methods.

In this study, a non-probability sampling method is adopted. The researcher will invite potential participants by using the Blackboard to email all Chinese students on INF6032. Participants are volunteering involved in the study and will be clarified that participation in this study won't have any detrimental nor beneficial impact on their module grades. Students who are not participating in the study will also be informed that the gamified activities embedded in the practical sessions are free to use, and won't affect their module grades. To minimize the potential ethical issues regarding anonymization, participants of the focus group are not recommended to mention the name of their classmates or academic-related staff during the interview, nor have discussions regarding the interview questions after their participation. Anonymization is not guaranteed during the interview, but all data in relation to personal information will be coded and anonymized in the data analysis process and won't appear in the researchers' paper. Data of those who are not participating in the study but enrolled on INF6032, their personal information will not appear in the research paper.

Regarding the implementation of gamification, game elements, such as story, teammates, shared goal, that were examined in previous studies having positive effects on improving students' social relatedness, will be matched in line with students' needs related to the sense of belonging identified in the prior phase of the study, and the instructional content. The chosen game elements will be applied by using Wiki features on the blackboard. The outcomes of implementing gamification in the course will be the improvement of both students' learning outcomes of the module and their transitional experience.

Participatory observation will be the main method of data collection in this study. The researcher will participate in the gamified module as an outsider and observe students' behaviour both online and offline as blended learning will be adopted by the school for the 21/22 academic year. The observation will take the forms of note-taking, classroom observation, online behavioural data collection, informal discussions, etc.

The focus group methods are also used to partially address the second and third research objective, which is to evaluate the impact of each gamification element on students' sense of belonging. Participants' changes of attitude, cognition and behaviours during the gamified course will be discussed. Their perception toward each gamification component and their perceived level of transition will also be asked.

Besides the above data collection methods, students' learning outcomes will be assessed through the learning analytics feature provided by Blackboard. Their academic performance will also be assessed by participatory observation and feedback from the instructor.

During the researcher's participatory observation in the practical session, data will be collected by researchers' note-taking and self-refections in the forms of text documents. Data will also be collected by the video and audio recording taking place in the interviews. The recordings will be transferred into transcripts for further analysis. The text and audio data will be stored as .mp4 .csv .docx format. In the data analysis stage, SPSS and Nvivo will be used for data analysis.

3. Personal Safety

Have you completed your departmental risk assessment procedures, if appropriate?

Not applicable

Raises personal safety issues?

Yes

If participants prefer face to face interviews, there might be risks of catching coronavirus (COVID-19). To manage this issue, participants and the interviewer will be asked to provide negative test results of COVID-19 and wear masks during the interview. All applicable university COVID-19 related procedures current at the time of the study will be put in place and complied with. Cleaning, hygiene and handwashing products will also be provided.

Section D: About the participants

1. Potential Participants

The potential participants are Chinese postgraduate taught students who are enrolled in the INF6032 Big Data Analytics module at the University of Sheffield.

2. Recruiting Potential Participants

Students will be approached through email by using the Blackboard email function on INF6032. Every student of the module will be invited to participate in the gamified activities to give everyone the same opportunities, but only Chinese students who are willing to be involved in the research will be observed in this study. The sample for the study will be the Chinese postgraduate taught students who are enrolled in the INF6032 Big Data Analytics module at the University of Sheffield and are willing to participate in the case study.

Will the study be advertised using the volunteer lists for staff or students maintained by IT Services? No

- not entered -

3. Consent

Will informed consent be obtained from the participants? (i.e. the proposed process) Yes

Informed consent (attached in this application) will inform the research participants about the research aims, procedures, and any potential risks or benefits that may arise from their participation. It will also inform participants about their right to withdraw from the study at any moment and that their responses will be removed from further study (if reasonably possible). Informed consent forms will be handed to participants prior to the focus group interviews. Participants will be asked to read and sign the form before the interview begins. For those interviewed by Google meeting, the consent form will be sent by email, and participants will need to sign and return it to the researcher.

4. Payment

Will financial/in kind payments be offered to participants? No

5. Potential Harm to Participants

What is the potential for physical and/or psychological harm/distress to the participants?

Participating in the research is not anticipated to cause you any disadvantages or discomfort. This empirical study is not concerned with sensitive matters, which might embarrass or harm the research participants. The risks of participating are the same as those experienced in everyday life. For the participants of the focus group interviews, they will be informed that their identities will not be protected from those who attended the same focus group interview. Participants should not be identifiable when their experiences are discussed in the thesis to avoid any potential harm to them.
There may be an issue with face-to-face meetings with strangers under the COVID-19 situation, therefore, interviews will be conducted on the university library or students union where the student can feel safe and comfortable. If a student cannot make the face-to-face interview, then they will be interviewed by Google meeting.

How will this be managed to ensure appropriate protection and well-being of the participants?

In this research, participants will be informed that any personal information, such as their names, will be anonymised. If there is a need to present any script from the interview in the text, it will be translated and then presented with codes. Furthermore, as previously mentioned the interviews will be conducted at the university library or students union. However, if this is not applicable or students do not want to be interviewed in these places, then they will be given the choice to be interviewed online by Google meeting.

6. Potential harm to others who may be affected by the research activities

Which other people, if any, may be affected by the research activities, beyond the participants and the research team?

The students enrolled in the same module but are not participants of the research might be affected by the research activities. Their name might be mentioned during the focus group interview.

What is the potential for harm to these people?

The anonymization might be violated during the focus group interview. I will anonymise the data before analysis, but I cannot guarantee that members of the group will not discuss their participation, although I will request that they not do so. They may also mention the name of the students from other countries as I mentioned in the above section during or after the focus group interview, which may cause an issue with social harm.

There might also be privacy issues during the observation in the practical sessions, where both participants and non-participants will attend the sessions.

How will this be managed to ensure appropriate safeguarding of these people?

Before the interview, I will remind participants not to mention the real name of their classmates and explain how they might be affected and why it is a neglectable issue. If they happened to mention personal information about them or their classmates, the data will still be fully anonymized when writing up findings, and any other information that might lead to participants' or other students' identity (e.g., university name, location) will not be reported to preserve the privacy and confidentiality of these people.

For the privacy issues in the session observation, the data of the non-participants will not be collected for data analysis nor appear in the research paper. To minimize the potential privacy problems for non-participants, participants' seats in the classroom will be arranged together to be distinguished from the non-participants and won't be observed.

7. Reporting of safeguarding concerns or incidents

What arrangements will be in place for participants, and any other people external to the University who are involved in, or affected by, the

research, to enable reporting of incidents or concerns?

The University has a number of policies and processes providing information and routes for reporting concerns or incidents in a range of areas.

Student Services Information Desk 'Signposting Our Support' pages provide information and links to further support mechanisms, as well as emergency contacts, for a range of issues including harassment, bullying and hate crimes, and domestic violence and sexual assault.

Report + Support is available to any member of staff, student, or visitor for reporting of any form of discrimination such as harassment, abuse, bullying, or sexual violence that may be based on race, gender, sexuality, or other characteristics.

Research Misconduct toolkit is available to staff, students, stakeholders, collaborators and members of the public to raise concerns about research misconduct. Research misconduct encompasses a breach of duty of care, placing anyone in danger, not observing ethical or legal obligations, breach of confidentiality, plagiarism and inappropriate authorship practices.

Who will be the Designated Safeguarding Contact(s)?

Prof Peter Bath, Research Ethics Coordinator, Information School, The University of Sheffield (ischool_ethics@sheffield.ac.uk) will be the Designated Safeguarding Contact.

How will reported incidents or concerns be handled and escalated?

Concerns that are raised via an agreed Designated Safeguarding Contact (DSC) for an individual research project should be dealt with in an impartial, timely and fair manner, which protects the rights of all individuals involved, takes concerns seriously adopting a victim/survivor-centred approach, and ensures that appropriate action is taken. The highest level of confidentiality relating to individual cases should be maintained and information shared only as necessary to safeguard individuals and to ensure compliance with legislation, regulation, funder terms and conditions, and relevant guidance.

Section E: About the data

1. Data Processing

Will you be processing (i.e. collecting, recording, storing, or otherwise using) personal data as part of this project? (Personal data is any information relating to an identified or identifiable living person).
Yes

Which organisation(s) will act as Data Controller?

University of Sheffield only

2. Legal basis for processing of personal data

The University considers that for the vast majority of research, 'a task in the public interest' (6(1)(e)) will be the most appropriate legal basis. If, following discussion with the UREC, you wish to use an alternative legal basis, please provide details of the legal basis, and the reasons for applying it, below:

- not entered -

Will you be processing (i.e. collecting, recording, storing, or otherwise using) 'Special Category' personal data?
No

3. Data Confidentiality

What measures will be put in place to ensure confidentiality of personal data, where appropriate?

I will anonymise the data before analysis, but I cannot guarantee that members of the focus group will not discuss their participation, although I will request that they not do so. When writing up findings, the personal information that appeared in the discussion will be anonymized into Student A, B, C, etc., and any other information that might lead to your identity (e.g., university name, location) will not be reported.

4. Data Storage and Security

In general terms, who will have access to the data generated at each stage of the research, and in what form

In accordance with the university policies, the data will be stored in a password-protected system. It will be stored in a secure server and in the researcher's University of Sheffield Google Drive account. The participants' user names will be anonymised and data will be also encrypted, and it will be accessed only by the researcher and her supervisors. The use of paper copies will be avoided unless essential and will be kept in locked storage in the Information School. The papers will be destroyed as soon as they are no longer needed. The data will be stored on the Information School's research data drive which can be accessed only by me, my supervisor, the School's

Examinations Officer and ICT staff operating the facility. I will also store an encrypted password-protected backup copy on my personal laptop. This data will be deleted within 1 month of my degree being awarded.

What steps will be taken to ensure the security of data processed during the project, including any identifiable personal data, other than those already described earlier in this form?

The Data Management Plan is attached in the next section.

Will all identifiable personal data be destroyed once the project has ended?
Yes

Please outline when this will take place (this should take into account regulatory and funder requirements).

This identifiable personal data will be destroyed within 1 month of my degree being awarded. The data will not be handed over to third parties and transcribing and encoding of the data will be done by the researcher.

Section F: Supporting documentation

Information & Consent

Participant information sheets relevant to project?
Yes

Document 1101622 (Version 2)	All versions

Consent forms relevant to project?
Yes

Document 1101621 (Version 1)	All versions

Additional Documentation

Document 1101623 (Version 1) Data Management Plan	All versions

External Documentation

- not entered -

Section G: Declaration

Signed by:
Chen Cao
Date signed:
Wed 23 February 2022 at 10:39

Offical notes

- not entered -

Chen Cao
Registration number: 190320195
Information School [a.k.a iSchool]
Programme: Information Studies

Dear Chen

PROJECT TITLE: Implementing Gamification in programming module on LMS to increase Chinese students's sense of belonging in the UK higher education
APPLICATION: Reference Number 044908

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 23/02/2022 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 044908 (form submission date: 23/02/2022); (expected project end date: 24/05/2022).
- Participant information sheet 1101622 version 2 (17/02/2022).
- Participant consent form 1101621 version 1 (03/02/2022).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Peter Bath
Ethics Administrator
Information School [a.k.a iSchool]

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Application 043614

Section A: Applicant details

Date application started:
Thu 7 October 2021 at 16:05

First name:
Chen

Last name:
Cao

Email:
ccao5@sheffield.ac.uk

Programme name:
Information Studies

Module name:
PhD Project
Last updated:
30/11/2021

Department:
Information School [a.k.a iSchool]

Applying as:
Postgraduate research

Research project title:
Implementing Gamification in higher education to support Chinese students' transition by increasing their sense of belonging

Has your research project undergone academic review, in accordance with the appropriate process?
Yes

Similar applications:
- not entered -

Section B: Basic information

Supervisor

Name	Email
Frank Hopfgartner	f.hopfgartner@sheffield.ac.uk

Proposed project duration

Start date (of data collection):
Fri 26 November 2021

Anticipated end date (of project)
Tue 1 February 2022

3: Project code (where applicable)

Project externally funded?
No

Project code
- not entered -

Suitability

Takes place outside UK?
No

Involves NHS?
No

Health and/or social care human-interventional study?
No

ESRC funded?
No

Likely to lead to publication in a peer-reviewed journal?
Yes

Led by another UK institution?
No

Involves human tissue?
No

Clinical trial or a medical device study?
No

Involves social care services provided by a local authority?
No

Is social care research requiring review via the University Research Ethics Procedure
No

Involves adults who lack the capacity to consent?
No

Involves research on groups that are on the Home Office list of 'Proscribed terrorist groups or organisations?
No

Indicators of risk

Involves potentially vulnerable participants?
No
Involves potentially highly sensitive topics?
No

Section C: Summary of research

1. Aims & Objectives

The survey aims to identify the extent of Chinese students' sense of belonging, their specific needs and the challenges they encounter. The objectives of the survey are to

1) Investigate the extent of sense of belonging to which Chinese students enrolled in the Data Science Programme at the University of Sheffield perceive;
2) Explore Chinese students' needs regarding sense of belonging;
3) Identify challenges and barriers they met that impact their sense of belonging

2. Methodology

A mixed-methods is adopted in this project. To measure the extent of Chinese students' sense of belonging and gain an overview of their transitional experience, a quantitative online survey is conducted with the current postgraduate Chinese students enrolled in Data Science Programme. The questionnaire is composed of four sections, which are student background, the extent of sense of belonging, needs and expectations, challenges and barriers. Most of the questions are in the form of 5-Likert scales, which allows further quantitative analysis.

The advantage of using questionnaires is that it provides an efficient and economical way of collecting sufficient data from the population.

After the online survey, a focus group interview will be conducted to investigate in-depth thoughts of participants perceived belongingness. For students, there will be four topics in the interview, which are personal background, perceived belongingness, needs and expectations towards the sense of belonging, barriers or perceived biggest factors affecting their sense of belonging. The advantage of applying focus group interviews is that it is more flexible and insightful, which is more suitable in seeking deeper explanations under specific topics of the research (Galletta. 2013).

In this study, a non-probability sampling method is adopted. The researcher will invite potential participants by the university email with the email list provided by the information school. Participants are volunteering involved in the two stages of the survey and will be clarified that participation in this study won't have any impact on their study performance. To minimize the potential ethical issues regarding anonymization, participants of the focus group are not recommended to mention the name of their classmates or academic-related staff during the interview, nor have discussions regarding the interview questions after their participation. Anonymization is not guaranteed in the interview, but all data in relation to personal information will be coded and anonymized in the data analysis process and won't appear in the researchers' paper.

There are two stages of data collection in the study. For the online survey stage, data will be collected by collecting questionnaire responses. For the focus group stage, data will be collected by the audio recording taking place in the interviews. The recordings will be transferred into transcripts for further analysis. The text and audio data will be stored as .mp4 .csv .docx format. In the data analysis stage, SPSS and Nvivo will be used for data analysis.

3. Personal Safety

Have you completed your departmental risk assessment procedures, if appropriate?

Yes

Raises personal safety issues?

Yes

If participants prefer face to face interviews, there might be risks of catching coronavirus (COVID-19). To manage this issue, participants and the interviewer will be asked to provide negative test results of COVID-19 and wear masks during the interview. Cleaning, hygiene and handwashing products will also be provided.

Section D: About the participants

1. Potential Participants

The potential participants are Chinese postgraduate taught students who are enrolled in the Data Science programme at the University of Sheffield.

2. Recruiting Potential Participants

For the first stage of the study, students will be approached mainly through email by using the email list provided by the University of Sheffield. The sample for the questionnaire will be the Chinese postgraduate taught students who are enrolled in the Data Science programme at the University of Sheffield and are willing to participate in the survey. When it comes to the interview, students who have finished the questionnaire with valid answers will be invited for a focus group interview to further illustrate their perception of belongingness and their transitional experience during their study.

2.1. Advertising methods

Will the study be advertised using the volunteer lists for staff or students maintained by IT Services? No

- not entered -

3. Consent

Will informed consent be obtained from the participants? (i.e. the proposed process) Yes

Informed consent (attached in this application) will inform the research participants about the research aims, procedures, and any potential risks or benefits that may arise from their participation. It will also inform participants about their right to withdraw from the study at any moment and that their responses will be removed from further study (if reasonably possible). In the first stage of the study, informed consent forms will be attached to the online questionnaire. Participants will be asked to read and sign the form before starting answering the questionnaires. For the second stage, informed consent forms will be handed to participants prior to the focus group interviews. Participants will be asked to read and sign the form before the interview begins. For those interviewed by Google meeting, the consent form will be sent by email, and participants will need to sign and return it to the researcher.

4. Payment

Will financial/in kind payments be offered to participants? No

5. Potential Harm to Participants

What is the potential for physical and/or psychological harm/distress to the participants?

Participating in the research is not anticipated to cause you any disadvantages or discomfort. This empirical study is not concerned with sensitive matters, which might embarrass or harm the research participants. The risks of participating are the same as those experienced in everyday life. For the participants of the focus group interviews, they will be informed that their identities will not be protected from those who attended the same focus group interview. Participants should not be identifiable when their experiences are discussed in the thesis to avoid any potential harm to them.

There may be an issue with face-to-face meetings with strangers under the COVID-19 situation, therefore, interviews will be conducted on the university library or students union where the student can feel safe and comfortable. If a student cannot make the face-to-face interview, then they will be interviewed by Google meeting.

How will this be managed to ensure appropriate protection and well-being of the participants?

In this research, participants will be informed that any personal information, such as their names, will be anonymised. If there is a need to present any script from the interview in the text, it will be translated and then presented with codes. Furthermore, as previously mentioned the interviews will be conducted at the university library or students union. However, if this is not applicable or students do not want to be interviewed in these places, then they will be given the choice to be interviewed online by Google meeting.

6. Potential harm to others who may be affected by the research activities

Which other people, if any, may be affected by the research activities, beyond the participants and the research team?

The classmates of the participants who are not from China, but enrolled in the same programme (Data Science Programme at the University of Sheffield in the 21/22 academic year) might be affected by the research activities. Their name might be mentioned during the focus group interview, but there won't be harms to them.

What is the potential for harm to these people?

The anonymization might be violated in the second stage of the study. I will anonymise the data before analysis, but I cannot guarantee that members of the group will not discuss their participation, although I will request that they not do so. They may also mention the name of the students from other countries as I mentioned in the above section during or after the focus group interview, which may cause an issue with social harm.

How will this be managed to ensure appropriate safeguarding of these people?

Before the interview, I will remind participants not to mention the real name of their classmates and explain how they might be affected and why it is a neglectable issue. If they happened to mention and personal information about them or their classmates, the data will still be fully anonymized when writing up findings, and any other information that might lead to participants' or other students' identity (e.g., university name, location) will not be reported to preserve the privacy and confidentiality of these people.

7. Reporting of safeguarding concerns or incidents

What arrangements will be in place for participants, and any other people external to the University who are involved in, or affected by, the research, to enable reporting of incidents or concerns?

The University has a number of policies and processes providing information and routes for reporting concerns or incidents in a range of areas.

Student Services Information Desk 'Signposting Our Support' pages provide information and links to further support mechanisms, as well as emergency contacts, for a range of issues including harassment, bullying and hate crimes, and domestic violence and sexual assault.

Report + Support is available to any member of staff, student, or visitor for reporting of any form of discrimination such as harassment, abuse, bullying, or sexual violence that may be based on race, gender, sexuality, or other characteristics.

Research Misconduct toolkit is available to staff, students, stakeholders, collaborators and members of the public to raise concerns about research misconduct. Research misconduct encompasses a breach of duty of care, placing anyone in danger, not observing ethical or legal obligations, breach of confidentiality, plagiarism and inappropriate authorship practices.

Who will be the Designated Safeguarding Contact(s)?

Prof Peter Bath, Research Ethics Coordinator, Information School, The University of Sheffield (ischool_ethics@sheffield.ac.uk) will be the Designated Safeguarding Contact.

How will reported incidents or concerns be handled and escalated?

Concerns that are raised via an agreed Designated Safeguarding Contact (DSC) for an individual research project should be dealt with in an impartial, timely and fair manner, which protects the rights of all individuals involved, takes concerns seriously adopting a

victim/survivor-centred approach, and ensures that appropriate action is taken. The highest level of confidentiality relating to individual cases should be maintained and information shared only as necessary to safeguard individuals and to ensure compliance with legislation, regulation, funder terms and conditions, and relevant guidance.

Section E: About the data

1. Data Processing

Will you be processing (i.e. collecting, recording, storing, or otherwise using) personal data as part of this project? (Personal data is any information relating to an identified or identifiable living person).
Yes

Which organisation(s) will act as Data Controller?

University of Sheffield only

2. Legal basis for processing of personal data

The University considers that for the vast majority of research, 'a task in the public interest' (6(1)(e)) will be the most appropriate legal basis. If, following discussion with the UREC, you wish to use an alternative legal basis, please provide details of the legal basis, and the reasons for applying it, below:

- not entered -

Will you be processing (i.e. collecting, recording, storing, or otherwise using) 'Special Category' personal data?
No

3. Data Confidentiality

What measures will be put in place to ensure confidentiality of personal data, where appropriate?

For the first stage of the study, participation in the questionnaire is confidential. The raw data collected from the survey responses will be anonymized. For the second stage of the study, participation is in a focus group with six other people. I will anonymise the data before analysis, but I cannot guarantee that members of the group will not discuss their participation, although I will request that they not do so. When writing up findings, the data will be fully anonymized and any other information that might lead to your identity (e.g., university name, location) will not be reported.

4. Data Storage and Security

In general terms, who will have access to the data generated at each stage of the research, and in what form

In accordance to the university policies, the data will be stored in a password-protected system. It will be stored in a secure server and in the researcher's University of Sheffield Google Drive account. The participants' user names will be anonymised and data will be also encrypted, and it will be accessed only by the researcher and her supervisors. The use of paper copies will be avoided unless essential and will be kept in a locked storage in the Information School. The papers will be destroyed as soon as they are no longer needed. The data will be stored on the Information School's research data drive which can be accessed only by me, my supervisor, the School's Examinations Officer and ICT staff operating the facility. I will also store an encrypted password-protected backup copy on my personal laptop. This data will be deleted within 1 month of my degree being awarded.

What steps will be taken to ensure the security of data processed during the project, including any identifiable personal data, other than those already described earlier in this form?

The Data Management Plan is attached in the next section.

Will all identifiable personal data be destroyed once the project has ended?
Yes

Please outline when this will take place (this should take into account regulatory and funder requirements).

This identifiable personal data will be destroyed within 1 month of my degree being awarded. The data will not be handed over to third parties and transcribing and encoding of the data will be done by the researcher.

Section F: Supporting documentation

Information & Consent

Participant information sheets relevant to project?
Yes

| Document 1098357 (Version 2) | All versions |
| Document 1099810 (Version 1) | All versions |

Consent forms relevant to project?
Yes

| Document 1098356 (Version 2) | All versions |
| Document 1099811 (Version 1) | All versions |

Additional Documentation

| Document 1098358 (Version 1) | All versions |
| Data Management Plan | |

External Documentation

Link of the questionnaire:

https://docs.google.com/forms/d/e/1FAIpQLSdYpsIVj5u9Z66Snl4eXeICi5ErhJwz1duUiuolkPlwk2JD6A/viewform?usp=pp_url

Section G: Declaration

Signed by:
Chen Cao
Date signed:
Mon 29 November 2021 at 13:47

Offical notes

- not entered -

Chen Cao
Registration number: 190320195
Information School [a.k.a iSchool]
Programme: Information Studies

Dear Chen

PROJECT TITLE: Implementing Gamification in higher education to support Chinese students' transition by increasing their sense of belonging
APPLICATION: Reference Number 043614

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 30/11/2021 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 043614 (form submission date: 29/11/2021); (expected project end date: 01/02/2022).
- Participant information sheet 1098357 version 2 (29/11/2021).
- Participant information sheet 1099810 version 1 (29/11/2021).
- Participant consent form 1098356 version 2 (29/11/2021).
- Participant consent form 1099811 version 1 (29/11/2021).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Claire Du Puget
Ethics Administrator
Information School [a.k.a iSchool]

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Appendix F

Sense of Belonging Scale – Revised by Hoffman et al. (2002)

Response Scale:

- Completely Untrue

- Mostly Untrue

- Equally True and Untrue

- Mostly True

- Completely True

Perceived Peer Support (8 items)

1. I have met with classmates outside of class to study for an exam.

2. If I miss class, I know students who I could get notes from.

3. I discuss events that happened outside of class with my classmates.

4. I have discussed personal matters with students who I met in class.

5. I could contact another student from class if I had a question.

6. Other students are helpful in reminding me when assignments are due or when tests are approaching.

7. I have developed personal relationships with other students in class.

8. I invite people I know from class to do things socially.

Perceived Classroom Comfort (4 items)

1. I feel comfortable contributing to class discussions.

2. I feel comfortable asking a question in class.

3. I feel comfortable volunteering ideas or opinions in class.

4. Speaking in class is easy because I feel comfortable.

Perceived Isolation (4 items)

1. It is difficult to meet other students in class.

2. No one in my classes knows anything personal about me.

3. I rarely talk to other students in my class.

4. I know very few people in my class.

Perceived Faculty Support (10 items)

1. I feel comfortable talking about a problem with faculty.

2. I feel comfortable asking a teacher for help if I do not understand course-related material.

3. I feel that a faculty member would be sensitive to my difficulties if I shared them.

4. I feel comfortable socializing with a faculty member outside of class.

5. I feel that a faculty member would be sympathetic if I was upset.

6. I feel that a faculty member would take the time to talk to me if I needed help.

7. If I had a reason, I would feel comfortable seeking help from a faculty member outside of class time (office hours, etc.).

8. I feel comfortable seeking help from a teacher before or after class.

9. I feel that a faculty member really tried to understand my problem when I talked about it.

10. I feel comfortable asking a teacher for help with a personal problem.