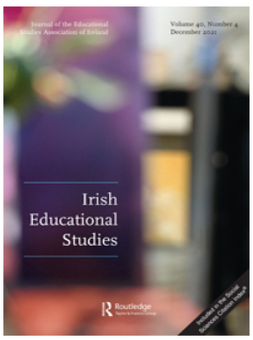

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# Bridging the gaps in information systems: a threshold concepts and troublesome knowledge perspective

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# Bridging the gaps in information systems: a threshold concepts and troublesome knowledge perspective

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**ABSTRACT**

Students entering third-level higher education undergo a transformational learning journey. Learning in this context is defined as the need to understand key concepts (threshold) to engage with the academic content of the course. This learning journey is moulded by their experiences not only within the context of the third-level institution but is also moulded by their experiences in work placement. Threshold concepts and the inherent troublesome knowledge associated with them represent significant barriers to transformational learning. This research uses a case study approach in the Galway-Mayo Institute of Technology to explore final year business information systems (BIS) undergraduate students' understanding of information systems (IS). This research objective was developed following a comprehensive review of the literature which determined that there was a research gap in understanding how BIS students encountered and overcame threshold concepts and troublesome knowledge when learning about IS. The research objective was investigated using several research questions which were explored using a mixed-method approach combining lecturer interviews, a student questionnaire and a student focus group. The study adopts a social constructivist research approach encompassing four theories of learning which act as theoretical lenses: threshold concepts, troublesome knowledge, socio-cultural development and communities of practice. The findings reveal that the students find the theory, and terminology associated with technical aspects, used within the discipline relating to learning about IS challenging. Specific threshold concepts and troublesome knowledge associated with these concepts are identified under several headings. Additionally, it emerged that the students use specific coping mechanisms to assist them in their transformational journey to understand IS which include peer learning, independent learning, practical application, lecturer support, experience and language, work placement mentor support and work-place-based learning. Finally, the results suggest that IS, as social systems, constitute a threshold concept whereby the students struggle with the following troublesome knowledge considerations in their communities of practice: communication, ethics and social system versus technical system differentiation. The study concludes by offering recommendations on how third-level education institutes can enhance awareness of threshold concepts and troublesome to limit their impact on students' transformational learning experiences.

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## 1. Introduction

This study addresses an established educational framework that is emerging in the information systems (IS) research field that asserts threshold concepts as mediators of learning outcomes. Essentially, a threshold concept is information regarding a subject matter in higher education that once understood by the students transforms the way they experience or understand the subject matter. They are concepts which define the discipline and help students define themselves within that discipline. Troublesome knowledge represents a characteristic of a threshold concept in that its mastery requires the acquisition of knowledge which is troublesome. That is, knowledge that when first encountered is alien or counterintuitive.

Over the past decade, there had been increased attention in the literature pertaining to the role of threshold concepts and troublesome knowledge in teaching and learning and for curriculum (re)design. The seminal research framework proposed by Meyer and Land (2003, 2006) has illuminated the value of threshold concepts and troublesome knowledge and their roles in 'improving the quality of instruction but also in shaping the strategies necessary to help students through the liminal stages of learning' (Bajada and Trayler 2016). The threshold concept has been proposed as a method for evaluating how learners gain expertise in conceptually challenging disciplines/fields (Meyer and Land 2006). Moreover, 'threshold concepts enable academics to explore what is fundamental to grasp the subject they teach' (Cousin 2009, 201).

The study of IS has traditionally proved challenging for students (Cope and Staehr 2008). From a business information systems (BIS) discipline perspective, the threshold concept framework enables researchers to understand the manner with which students understand knowledge. Most significantly, threshold concepts can identify aspects of discipline curricula that pose serious barriers to the student learning process. Ultimately, threshold concepts have been described as disciplinary focused and can be used as a research analytical framework which taps into student understanding, curriculum (re)design and professional identity (Land, Neve, and Martindale 2018).

Compared to other disciplines, there has been relatively little published in the education literature on information system threshold concepts and troublesome knowledge, despite calls from authors for more research into this area (see Cope and Staehr 2008). To advance further exploration and debate in the threshold concepts field and provide potential results to inform teaching practice, this study will seek to provide insights into how BIS students' encounter and cope with troublesome knowledge when learning about threshold concepts embedded within the IS curriculum.

Consequently, the primary objective of this study is to identify and explore final year BIS undergraduate students' understanding of IS using four main parameters: threshold concepts, troublesome knowledge, socio-cultural development and communities of practice. The findings from this research will provide insights into how to inform better curriculum and assessment (re)design practices, from the micro (module) to meso (programme) to macro levels (the wider discipline in the workplace).

This study investigates the following several research questions:

RQ1: What threshold concepts and troublesome knowledge do BIS undergraduate students encounter when learning about information systems?

RQ2: What coping mechanisms do BIS undergraduate students use to manage their transition through the liminal space when they encounter threshold concepts and troublesome knowledge?

RQ3: How can BIS students be effective participants in their information systems communities of practice?

This paper is structured as follows. The next section provides an overview of the extant literature. Next, the research methodology is presented. Then study's findings are delineated. A discussion is then presented relating to the main findings. Finally, the study concludes with recommendations for future research.

## 2. Literature review

This section will provide an anchor for this study by presenting an overview of the main concepts which are core to elucidating the research questions. To assist with the identification of major threshold concept themes a network analysis (Figure 1) of all related threshold concept research published in the Web of Science was created. The prominent keywords emerging tend to be 'curriculum', 'knowledge', 'student learning', 'troublesome knowledge', 'higher education' and 'transformative learning'. These themes are discussed in greater detail in the next sections.

### 2.1. Transformational learning and theories of learning

Learning is 'the process of acquiring new understanding, knowledge, behaviours, skills, values, attitudes, and preferences' (Gross 2012). The concept of transformational learning in educational settings has been developed over the past decades by Jack Mezirow and Robert Kegan. First introduced by Jack Mezirow to adult education in 1981, transformative learning can be defined as a

> constructivist theory of adult learning and a process by which learners are challenged to call into question taken-for-granted ideas, beliefs, habits of mind and feelings, and to experience fundamental shifts in perspective so that they can join colleagues in committed actions for change. (Mezirow 2000)

Table 1 provides an overview of the main learning theories which guided this study. It can be argued that these theories are interconnected whereby they are all focused on learning, practice and understanding. This was significant for the purposes of this study as it assisted with insights into the considerations that influenced the research interviewees' knowledge and understanding of IS, specifically with the difficulties encountered. This section will provide an overview of each of the theories and a justification will also be provided explaining their inclusion in the theoretical framework for this study. For example, the theory of threshold concepts is presented first in conjunction with a discussion on liminal spaces. Then, the theory of troublesome knowledge is introduced. These concepts underpin research questions 1 and 2. Finally, the theories of socio-cultural development and communities of practice are delineated. These two concepts underpin research question 3.

### 2.2. Threshold concepts, liminal spaces, and troublesome knowledge

According to Land and Meyer (2010) threshold concepts represent *conceptual gateways* and are an approach which 'builds on the notion that there are certain concepts, or

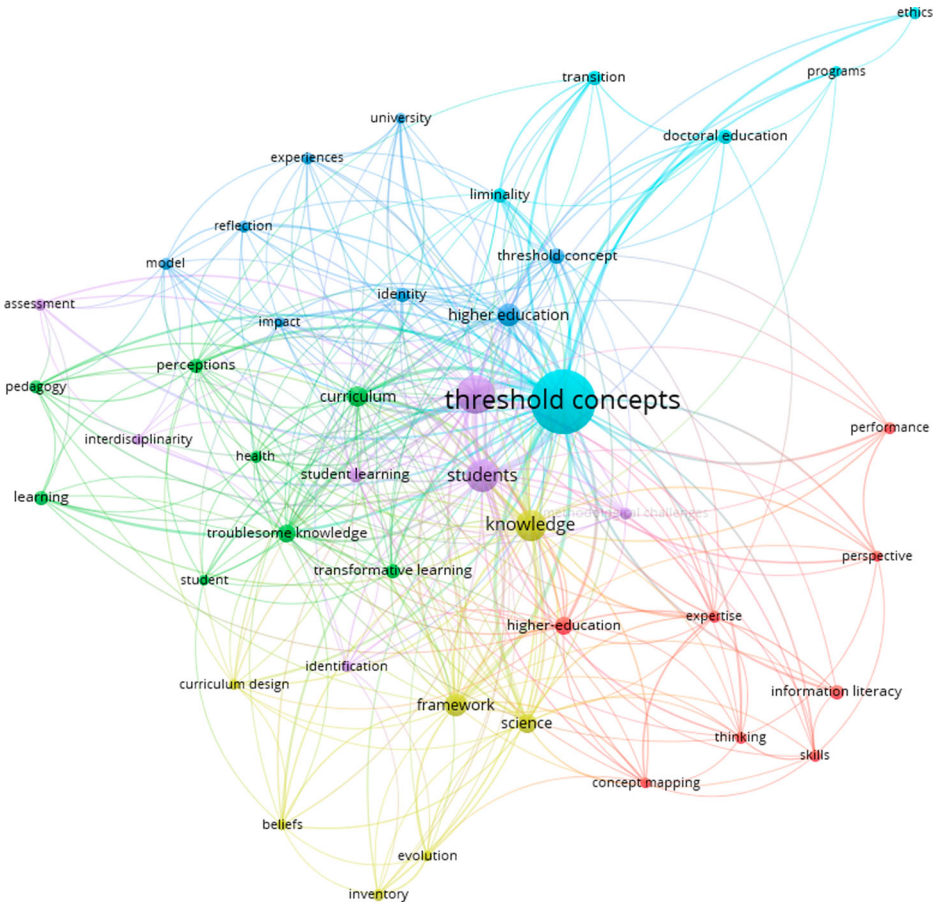


**Figure 1.** Literature review research themes.

certain learning experiences, which resemble passing through a portal, from which a new perspective opens up, allowing things formerly not perceived to come into view.' This enables students to think about a new topic in a manner that was previously inaccessible. In other words, a transformation occurs within the student's frame of learning (Timmermans and Meyer 2019). If a transformation in a student's understanding fails to occur, a student's inability to understand and assimilate these aspects will impede their overall progress in that area of study. Essentially, these threshold concepts serve to block a student's learning.

Figure 2 highlights the relational dynamics of threshold concepts through preliminal, liminal and postliminal states (Land and Meyer 2010). This perspective of transformational learning builds on the work of Kegan's (1982) concept of 'shifts of

**Table 1.** Theoretical framework for this study.

| Theory | Author | Research question(s) |
|---|---|---|
| Threshold concepts | Land and Meyer (2010) | 1 & 2 |
| Troublesome knowledge | Perkins (2006) | 1 & 2 |
| Socio-cultural development | Vygotsky (2012) | 3 |
| Communities of practice | Wenger (1998) | 3 |

consciousness', Boyd and Myers (1988) framework which emphasises affective processes, and Mezirow's (1978, 1990) work on 'perspective transformation'. The latter involves a person triggering a learning transformation when first encountering a disorientating dilemma or a challenging concept (Mezirow 1990). Mezirow's concept of perspective transformation contains a number of transformative phases which are like the 'type of features' depicted in Figure 2. In the Land and Meyer (2010) model, a student's journey towards the acquisition of a threshold concept begins with an encounter with a form of troublesome knowledge in the preliminal state. This troublesome knowledge serves as an instigative or provocative feature which provokes a state of liminality. Within the liminal state mode, 'an integration of new knowledge occurs which requires a reconfiguring of the student's prior conceptual schema and a letting go or discarding of any earlier conceptual stance' (Land and Meyer 2010, 11). This integration/reconfiguration results in an ontological and epistemological shift which is categorised as a reconstitutive feature of the threshold concept. The instigative and reconstitutive features enable the student to cross a conceptual boundary into a postliminal mode and bring about the required new understanding. This postliminal phase manifests a process where the learning and student are both transformed. This change which is marked by a change of discourse is irreversible. These features of the postliminal phase are categorised as consequential features of a threshold concept.

This study will focus on both the *preliminal instigative mode* and *liminal reconstitutive mode features* in the context of the teaching and learning of IS. Ultimately, studying these two modes will identify how BIS students arrive at the *postliminal consequential mode*. This is significant as from a curriculum development perspective, the threshold concepts discussed in the previous section are integrated throughout BIS curriculum and an understanding of them is pivotal to students' successful transition from novice to learner. BIS curricula that are content dense can often result in philosophies that are integral to IS being hidden or overlooked. Teaching threshold concepts that are transformative can, therefore, be challenging and requires educators to engage in creative approaches that inspire and resonate with students. This is compounded by the fact that educators can sometimes encounter difficulties in bringing threshold concepts such as socio-technical systems to life (Cope and Staehr 2008).

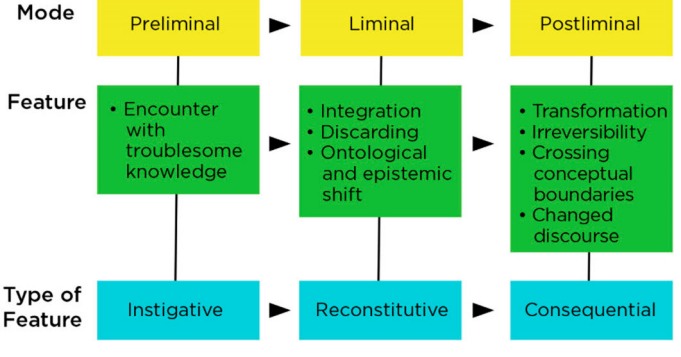


**Figure 2.** A relational view of the features of threshold concepts (Land and Meyer 2010).

### 2.3. Socio-cultural development and communities of practice

Vygotsky (1978) developed a theory of socio-cultural development, in which learning in a social context (for example, an educational setting) forms the basis for the acquisition of higher mental functions such as voluntary attention, categories of perception and particular types of 'schooled' knowledge (Vygotsky 1981). Vygotsky's analysis of higher mental functions provides a basis for a socio-cultural approach to mediated action (Wertsch 1991). Mediated action uses both technical and psychological tools. Vygotsky (1981, 137) describes the difference between technical and psychological tools, with the former 'determining the form of labour operations', and the latter 'changing the structure and flow of mental functions'. Computers, for example, shape and are shaping an individual's working life. Mediation by such a tool changes the nature of human physical performance. Psychological tools, which are internally oriented, transform the inner, natural psychological processes. In this study, both forms of tools are analysed: the use of computer systems (e.g. IS) and language, which is used to shape the learner's experience. For example, the IS discipline possesses distinct terminology which is used in the industry which students are first introduced to in lectures and then again when they are on work placement. When analysing speech as a tool, Vygotsky focused on the linguistic unit of word, and the importance of the word lies in the fact that it refers to a generalisation or to a concept (Vygotsky 1978). In IS, students often find the technical aspects of the curriculum challenging. This can be problematic, as most students are employed as business analysts whose primary role is to 'translate' the technical requirements of a project to non-technical employees. Consequently, the use of language as a tool becomes an important weapon in their business analyst arsenal.

For Vygotsky, processes, or problems which a learner needs to deal with and solve independently in the social context/environment, such as an educational setting, originate, initially, in social dialogue. Vygotsky (1981) argues that in such an interaction, there is a progression from the intermental to the intramental, and language (the word) is an important tool that is used in this process. In this study, the social settings are that of (a) lecture(s), (a) work placement(s) and the more knowledgeable people are the lecturer and the student's assigned work placement project manager. All skills and knowledge are said to become internalised and decontextualised because the learner (student) gradually takes over responsibility from the more experienced person (lecturer). The zone of proximal development (ZPD), which is a theoretical attempt to describe how psychological development occurs in learners working as individuals and learners working in partnership with others, is an example of moving from being a learner to being a more experienced person in the learning environment. It is reasonable to argue that an important part of the ZPD is that students must be able to use words and other tools that go beyond their own current understanding of them. The benefits of performing in the ZPD would not be available to them if the student could not participate in actions that extend beyond their individual's current level of understanding (Chaiklin 2003). One example in IS is that students sometimes are employed as product owners. These products owners must have a level of coding experience. However, coding languages vary from company to company. By performing a product role in the ZPD it would be important that BIS students have a baseline knowledge of the fundamental characteristics of all coding languages. This would allow them to operate in the ZPD

and use the language of the role until they became more knowledgeable in the specific coding language that the company utilise.

One approach which is broadly in line with a socio-cultural interpretation of the ZPD is distributed cognition model (Daniels 2001), which examines cognition in context. In this study, such cognitions are concepts and information specific to IS, which is acquired through lectures and placement/internship. In such contexts, the focus is on co-operating individuals and tools (e.g. specific IS activities), and not on individual cognition. Cognitions are 'stretched over' and are between individuals (for example, students and IS experts when on placement) and culturally provided tools (e.g. IS activities) (Soloman 1993). Taking such a perspective means that knowledge is socially constructed through collaborative efforts to achieve shared objectives in a specific cultural environment. One aim of a BIS student's placement/internship is to refine the practices, techniques and language that they learn in lectures prior to entering the workplace once they graduate. All work placement employers are cognisant of the fact that the students are in training, and they are not yet the finished product.

The socio-cultural emphasis on the use of cultural tools (for example particular types of discourse) in mediated action is observed in settings in which individuals use speech during their day-to-day actions, such as lectures in IS. Socio-cultural theorists (e.g. Lave and Wenger 1991) view learning as integration into a community of practice, in which social actions are identified (for example, specific actions in IS) and suitable activities are designed. One study, carried out by Cope and Staehr (2008), acknowledges that IS are social systems, but they do not afford sufficient attention to the importance of language (e.g. Vygotsky 1978; Wenger 1998). Essentially, their study describes IS as social systems, but does not examine how cultural tools, which shape such systems, are integral in mediating such collective practices. The study reported here examines the importance of how specific forms of language create and maintain such social systems, specifically IS.

In a socio-cultural approach to mind/cognitive development, it is argued that action is mediated, and it cannot be set apart from the social milieu in which it is carried out (Wertsch 1991). Essentially, knowledge is socially constructed through collaborative efforts to achieve shared objectives (Soloman 1993). The lecture room is part of the wider community of higher education (and beyond) and incorporates social norms and cultural practices. Lave and Wenger (1991) refer to a 'community of practice' to encompass the social and cultural practices of a particular community. A community of practice is defined as 'groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly' (Wenger 1998, 1). Wenger (1998, 4) outlines how communities of practice view higher education as a broader learning system which is based on the following salient questions which must be posed along three dimensions:

- 'Internally: How to create educational experiences that cement school learning in practice through participation in communities around subject matters?
- Externally: How to connect the experience of students to actual practice through peripheral forms of participation in broader communities beyond the walls of the school?
- Over the Lifetime of Students: How to serve the lifelong learning needs of students by organising communities of practice focused on topics of continuing interest to students beyond the initial schooling period?'

These several questions which encompass elements of social participation, interaction and development when learning echoes Vygotsky's (1978) theory of socio-cultural development and identity. Specifically, they embody Vygotsky's concept of ZPD and the use of language which were described earlier. Unlike threshold concept theory, which focuses on the individual learner's liminal space experience, the socio-cultural development theory and the communities of practice theory both place an emphasis on the social nature of teaching, learning and practice. This aspect is core to this study in terms of understanding research question 3 where the communities of practice are the higher education and work placement environments and the participants are the BIS students.

## 3. Method

A research methodology is 'the logical sequence that connects the empirical data, a study's initial research questions and, ultimately its conclusions … every empirical study as an implicit, if not explicit, research design' (Yin 2014, 19). Table 2 states the main research methodology pillars operationalised for this study in terms of the philosophical assumption, research stance, research strategy and research choice. These research strategy and the research methods will now be discussed in greater detail in the next sections.

### 3.1. Research strategy

For the purposes of this study, an interpretive case study approach was selected to 'gain a rich understanding of the context of the research and the process being enacted' (Saunders, Lewis, and Thornill 2016, 146). The case study setting for this research is the Department of Enterprise and Technology contained within the Business Department of the Galway-Mayo Institute of Technology, Galway, Ireland. The study focused on the 4-year Bachelor of Science in BIS. For the purposes of this study, final year BIS students and lecturers were selected as a purposive sample so that the several research questions posed in this study could be answered. Final year students were selected as a study cohort because they have completed a work placement in the 3rd year of the degree and were able to provide nuanced industry insights pertaining to threshold concepts and troublesome knowledge. Also, having covered the main IS-specific modules, they more than likely will have mastered the relevant concepts will have developed some perspective. Lecturers were selected to provide some rich and contextual data relating to the several research questions. Additionally, the data obtained from lecturers assisted with the triangulation and validation of the data obtained from the student cohort.

**Table 2.** Research methodology.

| Philosophical assumptions | Philosophical stance | Research strategy | Research methods |
|---|---|---|---|
| Epistemology and Ontology | Social Constructivism | Case Study<br>• Galway Mayo Institute of Technology<br>• BIS<br>• 4th-Year Students | Mixed-Method<br>• Interview<br>• Questionnaire<br>• Focus Group |

### 3.2. Research methods

The primary research method selected for this study was mixed-method research. A mixed-method study can be defined as one which combines both quantitative and qualitative data collection techniques to report findings based on a single study (Creswell and Clark 2017). The quantitative phase (e.g. questionnaire) in this study was used to establish patterns and frequencies, whereas the qualitative phases (e.g. interviews and focus groups) were used to give a voice to the research participants' perspectives. The qualitative phase of the research also enabled the in-depth investigation of the contradictions which emerged from the questionnaire data analysis.

Table 3 provides an overview of the number of participants who completed each of the research instruments and the timeline of when they completed them. Timmermans and Meyer (2019) advocate that research studies that investigate threshold concepts in educational settings should 'draw on multiple sources of input from various stakeholders and participants in the teaching and learning'. As can be seen, there were several research phases which drew on the experiences of both lecturers and students. During each research phase, the study's several research questions were investigated. Each research phase followed a logical sequence with the results from the previous phase informing the development of the research instrument for the next.

For instance, research phase 1 (e.g. the lecturer interviews) served the basis for identifying specific threshold concepts (e.g. database design), the troublesome knowledge associated with these threshold concepts (e.g. normalisation, entity relationship theory) and the methods used by students to traverse the liminal space, which were then used to develop the questionnaire instrument for phase 2. The following question is an example of one asked during the lecturer interviews: What concepts do students become stuck in/find challenging to grasp? In your opinion, why do the students find them difficult? To ensure that the students were not biased towards specific answers, it was important that the questionnaire instrument for research phase 2 did not directly refer to the threshold concepts and troublesome knowledge identified in phase 1. Therefore, the questions used were more high level. Once the student had identified challenging topics (e.g. Figure 3), there was a follow-up question which asked 'Provide an explanation for your answer highlighting how it was challenging? For example, highlight a time when you became "stuck" when learning.' A focus group discussion guide was created following an analysis of the questionnaire and lecture interview results. The primary objective of the third phase (e.g. focus group) was to provide in-depth insights and explanations to the findings.

Each phase of the analysis was exited once a point of theoretical saturation was identified and encompasses a point where no new insights were being discovered in the data (Strauss and Corbin 1998). Tables 4–6 provide examples of supplementary evidence in the form of exemplar quotes harnessed from each of the several research phases to

**Table 3.** Research instrument overview.

| | Phase 1 | Phase 2 | Phase 3 |
|---|---|---|---|
| Research instrument | Interview | Questionnaire | Focus group |
| Cohort | Lecturers | Students | Students |
| Number of participants | 8 | 20 | 8 |
| Time frame | November 2020 | December 2020 | January 2021 |

support the findings presented in the tables in relation to the several research questions which were investigated in research phases 1, 2 and 3.

### 3.3. Data analysis

The focus group and lecturer interviews were both audio recorded and transcribed. All transcribed data was then stored in a qualitative data analysis database called Quirkos which can be used to find organise and insights from unstructured qualitative data (Harvey and Powell 2020). Once all the data were imported, a two-stage coding process was carried out incorporating initial coding and axial coding as per the guidelines outlined in Saldaña (2021). The first stage of the coding process involved initial or open coding which involves breaking the data down into individual fragments and juxtaposing each fragment for similarities and differences. The primary objective of the initial coding stage is to 'remain open to all possible theoretical directions indicated by your readings of the data' (Charmaz 2006, 46). Each interview and focus transcript were coded line by line. Unique keywords were identified which provided an initial summary of the data (Charmaz 2014). Next axial coding was used to strategically rebuild the data (e.g. unique keywords) that was fragmented during the initial coding process (Strauss and Corbin 1998). This coding process continued until saturation had been achieved and no new themes were being identified. That is no new information was emerging from the coding process (Strauss and Corbin 1998). For the online questionnaire, Microsoft forms were used to collect and analyse the data. Microsoft forms enable the identification of actionable insights from the data collected through cross distribution analysis, association rule analysis, correlation analysis and sentiment analysis. The data were also exported to excel to run tests that were not available in Microsoft forms (e.g. pivot

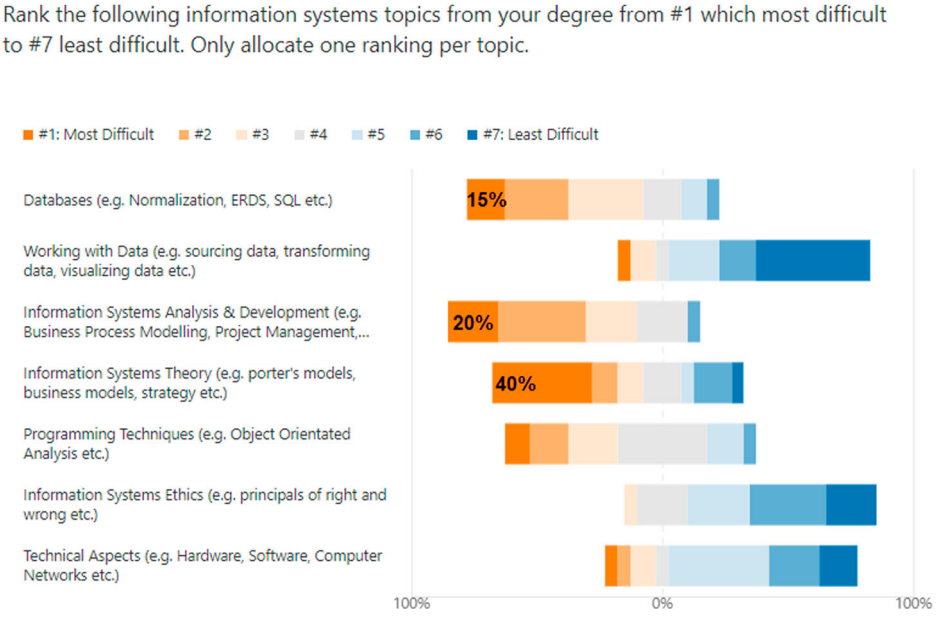


**Figure 3.** Most challenging subjects.

**Table 4.** Student learning challenge themes: lecturer and student perspectives.

| Student learning challenge themes | Lecturer example quote(s) [*sic*] | Student example quote(s) [*sic*] |
|---|---|---|
| **Troublesome concept:** Databases design **Troublesome knowledge:** Normalization Entity relationship theory | 'Database design is very frustrating to teach. That has been my experience over the past 5 years. Particularly with the iterative nature of database design. They know that databases are used to store data and are needed in everyday life, but often struggle with identifying what is required to design an effective database.' (L1)<br>'Normalization, which is the organization of data into logical groupings, is really troublesome for students … the problem is that if they do not get it following my module, they will struggle with database design in the workplace.' (L10) | 'I found normalisation challenging. Especially when we first started it as we had to go step by step through 1NF, 2NF and 3NF. I found at this stage I kept skipping to 3NF without doing the steps for 2NF.' (S13)<br>'We have been taught that to design a database correctly you have to be good at normalization. The lecturer also says that to learn it we must practice it repeatedly but I just find it boring and the there is so much theory associated with it.' (F3) |
| **Troublesome concept:** Business process modelling **Troublesome knowledge:** Data flow diagramming | 'The students struggle with the theoretical and practical elements of business process modelling. You are challenging them to sit between the business and technical side of the organization and to produce an accurate depiction and visualization of what the information system does. I have found that even the most technically proficient students struggle with the simplest business aspects and vice versa with the business proficient students.' (L6). | 'I struggled to break down information systems from the higher levels the lower levels using the data flow diagramming. I could never get the lower levels right.' (S10).<br>'While the topic itself is very interesting and practical, the diagrams that are needed for BPM have a lot of information being presented to you which can be a little overwhelming. This has really caught up to me in the final year especially when not being able to see how it is done in a traditional class.' (F8) |

tables). The data were then visualised as either bar charts or tables. A sample of the data was re-analysed by another experienced qualitative researcher using the same analysis techniques as the primary researcher to ensure trustworthiness and rigour. No conflicts emerged during this peer-debriefing analysis.

## 4. Results

For the first phase of the study, interviews were conducted with eight lecturers who had an average experience of 10 years lecturing IS modules. The research participants have been assigned specific codes to ensure anonymity (e.g. L1, L2, L3, etc.). For the second of the study, an online questionnaire was used to elicit responses from the students. A total of 20 students completed the online questionnaire. This quantified a high response rate given that there are 25 students in the class. The questionnaire was anonymous, and each student has been given a code of S1, S2, S3, etc. The questionnaire contained a number of open-ended questions which allowed the students to corroborate and provide further insights into their quantitative responses in the questionnaire. For instance, Question 17 in the questionnaire asked the students to provide an open-ended answer to the following question: For the topic or topics that you identified as challenging in Question 15 how you overcame those challenges (e.g. self-learning, student support, lecturer support, etc.). Another example of an open-ended question was Question 18 which asked: What has been the impact of you being unable to get your head around a specific challenging topic or topics? Tables 4–6 provide examples of the students' answers to the various open-ended questions posed in the questionnaire.

**Table 5.** Coping mechanisms enabling students to manage their transition through the liminal space.

| Managing the liminal space themes | Lecturer perspective example quote(s) [*sic*] | Student perspective quote(s) [*sic*] |
|---|---|---|
| **Peer learning** | 'Whenever I have struggled with topics, I have always asked colleagues for help to improve my understanding. The same works with students who work in project groups. The students will be working in project groups when they leave so it is of paramount importance that we embrace them also for continuous assessments so that all students within the group can derive the benefits of peer learning.' (L8) | 'Lecturer support was fantastic in information system topics that I struggled with throughout GMIT. I also took online courses to help me. However, if it wasn't for the knowledge that I got from my teammates working in project groups there is no way I would have the level of understanding that I have now.' (S10)<br>'The importance that GMIT put on group projects helped me to overcome challenging topics that I came across. Whenever I or anyone else was struggling we brought all our strengths together to work more efficiently.' (S8) |
| **Practical application** | 'I think the students learn more by implementing, you know, so I'd be a big believer of driving the key learnings in a more applied way. I am not a big believer in presenting, you know, 60 or 80 slides, and just talking about the theory, I am very much about going into the lab and getting students to do exercises, getting them to follow along with the lab practical to reinforce learning. And it works. I have seen students with very little technical knowledge at the start of the semester propel to having satisfactory competency which prepares them for the next module.' (L5) | 'The teaching was very good, and the lecturers did their very best to help us understand the topics. In terms of learning I would like to see less theoretical aspects and more focus on the technical aspects from first year onwards.' (S2)<br>'It has already impacted me from a professional perspective. During my internship, I was asked by the company to design a database. The stress of the internship was unbelievable as I did not know how to design one correctly. I always struggled with normalisation and entity relationship diagrams so not knowing this led to the creation of a database by me which wasn't great.' (S19) |
| **Independent learning** | 'Using the engagement analytics on Moodle I can see that the students that engage with external learning resources that I recommend always fare better with challenging topics such as data flow diagramming. Students who do not engage or students who just memorise my slide deck for an exam always tend to demonstrate superficial learning.' (L3) | 'I normally look for online resources to help. Whether that be an article or YouTube video. But at the end of the day if you want to improve at something, you just need to practice more questions. The old cliche of practice makes perfect.' (F3)<br>'I spent additional time learning by myself and took a different approach to database development by doing the suggested practical extra exercises provided by the lecturer and doing exercises on websites such as Wise Owl. Over time I improved and was able to keep up with the class lecturer.' (S4) |
| **Lecturer support and experience** | 'When I first inherited this module, I struggled with the practical implementation of abstract concepts such as normalization and entity relationship diagramming. I do not have a technical background, so it took a few years of teaching the module to become comfortable with the topics. With experience comes understanding … because is struggled with these concepts I ensured that I teach them in depth.' (L6) | 'I found for practical subjects having weekly lab classes with smaller class sizes beneficial because I could ask lecturers questions in person or show them issue, I was having.' (F7)<br>'Group members or a lecturer who understood the concept and could clearly explain the problem I found challenging was so beneficial in seminars and labs. 1 to 1 teaching like that helped me to understand tricky aspects.' (F5) |

For the final part of the study, a virtual focus group was conducted with a total of eight BIS students. The students who participated in the focus group have been assigned specific codes to ensure anonymity (e.g. F1, F2, F3, etc.).

**Table 6.** Social system considerations for enabling effective participation in a community of practice.

| Social system community of practice themes | Lecturer perspective example quote(s) [*sic*] | Student perspective quote(s) [*sic*] |
|---|---|---|
| **Communication considerations** | 'They also have difficulty in understanding why a business analyst must mingle back and forth between the project team members. Surely, we are doing technical development only they might exclaim. So, I try to show them many examples of the human side of information systems and technical systems and the negative consequences that can occur if they are not considered.' (L6). | 'I found communicating with others a bit tricky, as they have been in the company for x number of years and they rather keep an eye for themselves. Not everyone of course, but I noticed that they tend to look out for themselves more.' (F1) |
| **Technical system vs social system differentiation** | 'It can be quite challenging for students to differentiate the technical and social aspects of information systems. When I first started lecturing on this topic, I neglected the social aspects and placed core focus on the technical side. But students only then get one half of the picture.' (L7) | 'A bank would have an IS within it but it is not an IS. The ATM could probably be described as an aspect of an IS, but my understanding is that an IS is a large group of systems used to process data for the good of an organisation.' (S5) |
| **Ethical considerations** | 'I think the ethical side of information systems as social systems should be given more prominence in the curriculum. We seem to just skim over it and the students struggle with that aspect. Even though they are going to be involved in the design of information systems and technology we need to drive home the message that ethical aspects are critical to their future employment.' (L8) | 'GDPR is a big concern for companies. But its such a big document that I have not researched it in full detail. I don't think it will impact me in the workplace as I plan to work with cloud technologies.' (F8)<br>'I am only concerned with software coding. I am assuming that it will be the responsibility of my manager to deal with the ethical side of the product that I am developing.' (F4) |

### *4.1. Research question 1*

Table 4 provides a summary of the main themes that will now be discussed in this section in relation to answering research question 1 which investigates what threshold concepts and troublesome knowledge do BIS undergraduate students encounter when learning about IS?

#### *4.1.1. Lecturer and student insights*

The results revealed that database design and business process modelling were considered to be threshold concepts. These concepts contained the eight fundamental characteristics of threshold concepts as outlined by the work of Meyer and Land (2006). Encompassed within each of these threshold concepts were issues relating to specific troublesome knowledge. This section will provide an overview of these two threshold concepts and the troublesome knowledge associated with them. The first threshold concept identified is related to database design. Broadly defined, a database stores data, usually electronically, which can be retrieved to create information. Databases represent a crucial learning aspect of IS in that every information system requires a database. Companies can store customer, product and employee data in their databases. This data can be converted to valuable information usually in the form of business intelligence insights (e.g. best performing customer bases, etc.). BIS students are usually involved in the design, creation and day-to-day running and maintenance of databases. The analysis revealed that while students cope well with basic theoretical and practical design elements, they often struggle with two complex and abstract database design

elements that could be categorised as troublesome knowledge for students: entity relationship theory and normalisation. The former is an illustrative approach to designing databases where students must create a diagram that maps out the specific relationships contained within the database. This can serve as a blueprint for designing the actual database. Normalisation principles ensure that the database redundancy is avoided so that it makes it easier to modify the table. The data revealed that both aspects were fundamental to the understanding of database design with an understanding of entity relationship theory being a crucial pre-requisite for a student's ability to fully understand referential integrity. The data also identified that there was troublesome language related to databases. Terminology like referential integrity (e.g. determines how data are linked in a database) and data consistency (e.g. predefined rules which determine how data is entered into a database) are used when alluding to the design of optimal performing databases. Referential integrity is concerned with deciphering how tables within a database which contain data are linked together throw primary and foreign keys. Data consistency is concerned with ensuring that the data contained within the database is accurate and measures exactly what it should. Many lecturers observed that students interpret these concepts differently which often leads to the development of databases which are subpar.

The next threshold concept identified relates to business process modelling which entails the graphical representation of what an organisation's information system does on a day-to-day basis. Students must use sophisticated techniques (e.g. flow charts, data flow diagramming, Gantt charts, PERT diagrams, etc.) to model specific business processes and data flows that occur within the information system and how this system interacts with its internal and external organisational environment. Business process modelling represents a core aspect of every student's learning as it is required in every aspect of a business information system graduate's day to day work activities. The analysis identified that there was also troublesome knowledge relating to business process modelling. Specifically, they identified the data flow diagramming technique as troublesome. This technique is used to visualise the way data flow within an information system in terms of inputs and outputs. There are several levels of abstraction that data flow diagrams can represent. The first is level 0 which is a higher-level contextual overview of the IS, and their data flow processes. Level 1 and level 2 go into more detail and are inherently more complex requiring the students to break the level 0 diagram into subprocesses. An understanding of this technique is crucial for BIS students as it is the primary technique used for business process modelling.

The overall results of the questionnaire identified that theoretical, practical and terminology aspects of learning about IS were challenging. Figure 3 shows that 40% of the students found IS theory challenging (10% ranked it number 2), while 20% found IS analysis and development difficult (35% ranked it number 2) and 15% found databases challenging (25% ranked it number 2). Interestingly, 45% of students indicated that working with data was the least challenging. The results for research question 2 will now be presented in the next section.

### 4.2. Research question 2

Table 5 provides a summary of the main themes that will now be discussed in this section in relation to answering research question 2 which investigates the coping mechanisms

BIS undergraduate students use to manage the liminal space when they encounter threshold concepts and troublesome knowledge?

#### 4.2.1. Lecturer and student insights

As previously highlighted, a student's understanding of a threshold concept can be thought of as a relational journey through several phases. A student's first encounter with troublesome knowledge can be categorised as a preliminal phase. The troublesome knowledge serves as a trigger whereby the student attempts to combine this new knowledge with their prior knowledge of a concept. This occurs in a phase referred to as the liminal space. Should a student undergo a successful ontological and an epistemological shift in this phase of liminality they will successfully cross a boundary into a post liminal phase (Rattray 2016). Consequently, they will have traversed the liminal space with a new understanding and transformed from 'not knowing' to 'knowing' (Land and Meyer 2010). Students who fail to cross this boundary must reengage with the preliminal and liminal phases.

The analysis revealed how students successfully traversed the liminal space when encountering the troublesome topics of entity relationship theory and normalisation in the case of database design and data flow diagramming in the case of business process modelling. The first aspect which was spotlighted was the importance of peer learning. Next, practical application as identified as being important whereby theoretical concepts are applied in real-life scenarios and examples. Next, the data revealed the significance of independent student learning with the help of external learning resources:

> YouTube, chat forums, other students, just simple google searches because you usually aren't the only one who encountered that specific problem. (F8)

Finally, the analysis also identified how a lecturer's student support and previous experience of encountering a threshold concept was crucial in signposting the possibility that the concept may also be troublesome for students. These support mechanisms however had been hampered by the emergence of Covid-19 and remote learning.

In the case of remote learning, the supportive environments of the lab practicals and seminars were difficult to emulate, and the students felt that they had lost that close connection with the lecturers which enabled them to overcome the challenges posed by conceptually difficult concepts.

> I would have either asked the lecturer or completed research into the topic myself through google. Especially if it were a project, I would have done my research to further understand the topic. Remote learning made it more difficult to ask lecturers. (F1)

The students also identified what additional supports would they have liked to have had access to help them with challenging concepts and troublesome knowledge. The students identified that pre-Covid19 that they would have liked to have more 1–1 interaction with lecturers. They also felt that seminars and lab practical should have smaller groups attending so that each group could have availed of the lecturer for support when learning:

> Weekly drop in sessions would be great. Any additional student queries could be covered in 1 on 1 or small group sessions every week. I feel 1 on 1 or small group learning can be especially beneficial when teaching technical aspects of a course vs theory topics. (F2)

The students also identified additional supports that they would like now that they are engaged in remote learning during Covid-19 in terms of additional live tutorials, increased feedback from lecturers and lighter workloads:

> Lighter workloads, as some theoretical subjects can be very tough to understand leading students not fully understanding what they are doing. (F8).

> We need home licenses for programs instead of having to use eLabs. Live classes for every module would really help interaction and allow us to ask questions when we are having difficulties when tough subjects are being introduced in the lecture. (F4)

In the next section, the results in relation to research question 3 are presented.

### 4.3. Research question 3

Table 6 provides a summary of the main themes that will now be discussed in this section in relation to answering research question 3 which investigates how BIS students can be effective participants in their IS communities of practice.

#### 4.3.1. Lecturer and student insights

The data revealed that IS as social systems do in fact represent a threshold concept for BIS students and this finding supports the work of Cope and Staehr (2008). Table 6 provides a summary of the main troublesome knowledge themes associated with social systems which impaired their ability to operate effectively in their communities of practice.

Both lecturers and students were asked questions relating to the student work placement experience which provided insights into the understanding of the social aspects of IS.

Firstly, the students were asked if anything had caught them by surprise during their work placement when working with IS development teams. It was interesting to note that socialisation and specifically the communication was identified by all participants as being troublesome:

> I enjoyed the experience, although I did find it hard sometimes to communicate and integrate with those working in the company. (F8)

Once again, it was interesting to note the impact of Covid19 which seemed to exacerbate the student's communication issues with other teams' members:

> Communication and teamwork in a virtual office was tricky as we could no longer work in the same room in a casual or informal way that we had gotten used to pre-covid. (F4)

When asked how students get on with other professionals during their work placement, communication skills were once again identified. By being part of a specific social context or community of practice, students are exposed to particular ways of interacting and speaking. Through interaction with more experienced people, words that are used to explain specific IS concepts (such as 'no code low code') become familiar to the student and by understanding and mastering such words, they can then enter into dialogue with their peers. It is reasonable to argue that without knowing what these words or concepts mean, becoming a fully active participant in a community of practice (IS) is not possible.

Delving deeper into this question revealed the various additional supports that the students identified that they would have liked to have received before commencing their work placement such as having a buddy system in the work placement and regular meetings with other students to report on each other's experiences:

> I was appointed a buddy on day 1 of my work placement and he really helped me settle in quickly. I know this was not the case for everyone so I would strongly recommend this should be a mandatory approach for future work placements. (F5)

> A regular meeting with everyone else in the class on work placement in different companies to compare experiences. (F7)

> A learning support point of contact in my team. Someone who could aid in where I should focus my learning attention to get up to speed with the team's processes. (F2)

In terms of the technical system differentiation versus the social system differentiation, it emerged that the social system side (some lecturers referred to this as the human side) of IS was central to enhancing students understanding of the more complex and technical aspects of the IS module:

> You have to drive home the that organizations comprise networks of people where information goes back and forth to make decisions. Information systems complement this decision making process. Humans still must read the output of information systems and act on that data. Sometimes it can take students the entire 4 years to absorb this, and some instances they never do. (L3)

> From my experience, the students have difficulty seeing why they need to care about the social side of information systems. For example, they might want to be a business analyst and then struggle with the specifications of the job (e.g. incorporating end user information system requirements). (L6)

An interesting aspect of social systems which was identified as being troublesome for students was the ethical aspects of IS as social systems:

> When we cover new information systems advancements like artificial intelligence, blockchain, big data the students are excited about covering these aspects. When I bring up the ethical dimensions, they struggle to come to terms with that aspect of new technological developments in terms of why they should care about how the technology could impact people. Even when I break it down into relatable examples only some get it. (L2)

> If I am being paid to develop software for a product it should not be my role to justify the ethics of it. That should be the company's role. I did not encounter anything to do with ethics during my work placement. (F3).

Most of the students assigned the ethical responsibility to their future manager or their future employer. This finding was somewhat surprising as one of the core features of IS development is human-centred design which has ethics as a core foundational underpinning.

The next section will discuss how the key findings presented in this section align with the extant literature and the study's overall research objective. Avenues for future research will also be recommended.

## 5. Discussion

Figure 4 reintroduces the relational view of the features of threshold concepts model which was introduced the literature review section to summarise the main study findings around which the following discussion will be scaffolded.

In terms of the findings in relation to the preliminal mode, several threshold concepts which are inherent to the teaching and learning of IS were identified which included database design, business process modelling and social systems. The two former threshold concepts can be classified as technical in nature. Within each of these threshold concepts, the study identified six troublesome knowledge aspects of the teaching and learning if these threshold concepts (Figure 4). To recap, the preliminal mode represents a student's first encounter with a threshold concept and the troublesome knowledge associated with it (Land and Meyer 2010). For example, this study has demonstrated that when BIS students first encounter the threshold concept of database design, the troublesome knowledge of normalisation and entity relationship theory embedded within the threshold concept 'serves here as an instigative or provocative feature which unsettles prior understanding rendering it fluid and provoking a state of liminality' (Land and Meyer 2010, 9). This process of provoking a state of liminality also occurs for students when encountering the threshold concepts of business process modelling and social systems. This research study's findings in relation to preliminal mode build on a previous study's findings (e.g. Cope and Staehr 2008) which proposed the following: (1) that IS as a social system represents a possible threshold concept, (2) the theoretical, practical, and terminology aspects of technical concepts used within the IS discipline represents possible threshold concepts. In relation to number (1), this study identified that social systems not only represent threshold concepts within the IS discipline but also went a step further than the previous study by identifying several troublesome knowledge aspects associated with this specific threshold concept (e.g. ethics, social vs technical systems and communication considerations). The socio-cultural development framework (Vygotsky 2012) and communities of practice framework (Wenger 1998) were crucial in elucidating these aspects. The *communication troublesome knowledge consideration* manifested strongly

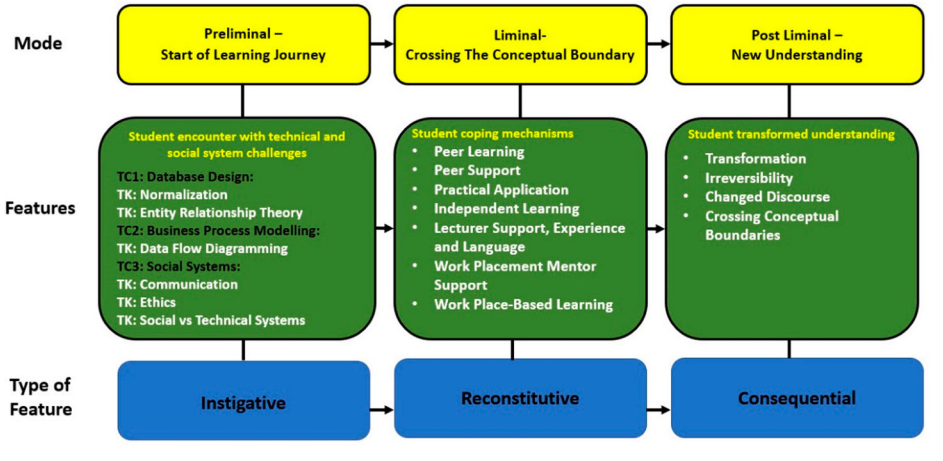


**Figure 4.** Study findings (TC, threshold concept; TK, troublesome knowledge).

for the BIS students during their remote GMIT learning and work placement experiences because of Covid-19. This consideration resonates not just for BIS students, but for all students in general. From a GMIT remote teaching and learning experience, the students had to acquaint themselves with the nuances of online learning (e.g. working from home, working with peers on projects remotely) over the past 12 months. The data revealed that students often struggled with these nuances, and this impacted on their ability to traverse the liminal space when encountering threshold concepts and troublesome knowledge. Consequently, the flexibility of learning and the manner with which language is used in a remote teaching and learning environment becomes important and should be considered by lecturers when teaching IS to BIS students. In relation to number (2), this study confirmed that the technical aspects associated with the teaching and learning of IS do represent threshold concepts. Again, this study provides a nuanced contribution having identified two specific technical threshold concepts and the troublesome knowledge associated with them. This research represents a further step along the pathway towards illuminating the social and technical threshold concepts in the IS discipline which can be leveraged to improve teaching and student learning.

Next, the student enters what is known as a liminal mode where they use a multitude of learning supports to integrate new knowledge with existing knowledge to assist them to traverse the liminal space (Perkins 2006). In this process, the student's previous understanding of a concept(s) may be discarded. In the context of this study, the data analysis revealed how threshold concepts which the students encountered in the preliminal mode fell under the umbrella of *technical and social aspects,* used within the discipline relating to learning about IS. *From a technical perspective, peer learning and support* (e.g. teams-based continuous assessments), *practical application* (e.g. project that mirrors real-life industry projects), *independent self-learning* (e.g. reading supplementary materials) and *lecturer support, experience and language* (e.g. real-time feedback, more experienced other, consistent terminology) play crucial roles in enabling students to overcome the troublesome knowledge associated with technical threshold concepts. These findings are significant as this study represents one of the first to identify how students cope with threshold concepts and troublesome knowledge when learning about IS. Additionally, it was interesting to note how some students resorted to 'rote memory and routine procedures as a way of coping' (Perkins 2006, 37) when they encountered threshold concepts and troublesome knowledge. According to Perkins (2006, 37), this form of surface learning involves students trying 'to learn enough about ideas, explanations, and alternative perspectives to pass the test without developing a real insider feel (Perkins 2006, 37). This 'real insider feel' refers to a student's ability to operate within their community of practice. This segways nicely into the ZPD perspective (Vygotsky 1978), in which students are guided through their learning with the assistance of a more *experienced other*. It is also important for educators to consider the two aspects of learner development associated with ZPD: the natural line (e.g. intelligence quotient) and the schooled line of development (e.g. what is learned in the community or from an expert other). For example, with regards to the former natural line, it would be important for a lecturer to teach the theoretical and practical aspects of IS technical subjects such as database design and business process modelling in a way that would enable the students to traverse the liminal space. This would involve the students transforming from novice to expert with the assistance of the experienced lecturer. However, the teaching must be appropriate to

the student's innate level of intelligence. In other words, a lecturer would not teach 4th-year theoretical and technical concepts to 1st-year students. Thus, there must be a scaffolded approach to the student's learning. An experienced work placement mentor also has an important role to play in assisting a student traversing the liminal space and this will be highlighted later in this discussion.

The data also revealed that the language used by lecturers within the IS discipline is also important. This points towards the development of a lexicon of terms which are troublesome for students. This lexicon will also be beneficial for lecturers in that it will educate them and remind them that every subject within the IS discipline has its own language and discourse. This resonates strongly with the work of Vygotsky (1994) who states that 'thought development is determined by language i.e. the linguistic tools of thought and the socio-cultural experience of the [learner].' For instance, words and terms that are introduced by the lecturer in class (e.g. outer speech) are then used and practised by the students and become internalised (e.g. internal speech) which helps them to shape their understanding of a threshold concept and troublesome knowledge thus *making them independent learners*. *Language is key to this transformation* of outer speech to internal speech (Vygotsky 1994). This process also holds true for BIS students when they are on work placements where their manager and work colleagues now become the vehicles for outer speech. However, the data revealed that the ability of a BIS student to internalise new learning may be comprised due to the specific social system threshold concept troublesome knowledge aspects which were discussed earlier.

From a work placement perspective, the student's new remote working environment required the students to communicate, network, and socialise (virtually) with new colleagues. According to Vygotsky (1994), this form of new socialisation is significant for learners whereby, 'The tasks with which society confronts a [learner] as he or [she] enters the cultural profession undoubtedly become a crucial factor in the emergence of conceptual thinking.' The students were also tasked with new challenges and work practices which in most cases would have been alien to them. This can lead to the manifestation of *professional troublesome knowledge* considerations (Perkins 2006) which can inhibit a student's ability to learn the language associated with being a professional. The manner with which students can overcome these troublesome knowledge considerations can be assisted with the introduction of a designated experienced mentor in work placements who can guide BIS students through the liminal space so that they learn the language of the profession and the creation of a work-place-based learning specific module(s) within the curriculum. This new module would involve 'a shift in learning from the traditional content and instead looks at a [helping] students build on content knowledge while also developing empathy and social-emotional learning skills … these opportunities foster student agency' (Dene Roth 2019). The emphasis here would be to incorporate specific socialisation learning outcomes with this module(s) which would prepare students for their work placements which would enable them to *know the language* of the community and assist them to *talk the talk* within the community while on work placement. Furthermore, the addition of ongoing supports (e.g. peer meetups) for students while they are on work placements would be beneficial. This work-place-based learning module(s) would answer the questions posed by Wenger's (1998) several dimensions for preparing, connecting, and sustaining a student's learning within their professional community of practice.

Once a learner successfully crosses the conceptual boundary of the liminal space, they will have undergone an ontological/epistemological shift in their understanding of a threshold concept and they will arrive at a new conceptual space referred to as a post liminal phase (Land and Meyer 2010) which comprises the consequential aspects of threshold concepts: transformation, irreversibility, changed discourse, and crossing of conceptual boundaries. For example, this study has demonstrated that once a student is first introduced to the threshold concept of database design, they will encounter the troublesome knowledge of entity relationship modelling and normalisation. Using the liminal phase features identified in Figure 4, their conceptual understanding of how databases can be designed will be changed irreversibility and they will be able to use a new and changed discourse within their community of practice. Failing to cross the conceptual boundary may result in the student be constrained or inhibited with the community of practice (e.g. poor database design methods).

One caveat that must be noted for the relational view of threshold concepts depicted in Figure 4 is that 'the acquisition of threshold concepts often involves a degree of recursiveness, and of oscillation, which would need to be layered across this simple diagram' (Land and Meyer 2010, 9). That is for students to traverse the liminal space successfully and repeatedly when encountering threshold concepts and troublesome knowledge throughout their professional and academic learning that a *structured approach is taken to curriculum development* that embodies:

- consistent use of discipline and professional language;
- practice and repetition of threshold concepts and troublesome knowledge;
- exposure to environments where the threshold concepts and troublesome knowledge can be teased out and questioned;
- exposure and refinement of skills within a community of practice.

There is also an underlying game inherent to the model which is often required for entering a community of practice. This underlying game

> in which ways of thinking and practising that are often left tacit come to be recognised, grappled with and gradually understood. This underlying game is a common feature of the processes of entry, meaning making and identity formation typically required for entry to a given community of practice. (Land and Meyer 2010)

Returning to our example of students encountering the troublesome knowledge of normalisation and entity relationship theory when they are first introduced to the concept of database design, their journey as a class cohort may not be universally linear in progression as depicted in Figure 4 (Meyer 2016). Some students may go back and forth between the preliminal and liminal spaces. Furthermore, some students may progress faster than others (e.g. learning pacing) through their learning journeys (Wu et al. 2012) and some students may have varying levels of self-efficacy (Bandura 2010). It is important for lecturers to know that a *student's experience of the liminal space can be characterised by states of feeling confused, threatened and uncomfortable* (Land, Rattray, and Vivian 2014). A lecturer's experience in identifying when a student is struggling with the troublesome knowledge associated with a specific threshold concept becomes of significant importance. Failure to do so may constrain a student's

ability to cross the liminal conceptual boundary which may have knock-on consequences in their community of practice.

## 6. Conclusion

This case study explored both lecturers' and students' perspectives of threshold concepts and troublesome knowledge when teaching and learning about BIS. Specifically, this research identified several threshold concepts which are inherent to the teaching and learning of IS. The study also identified specific troublesome knowledge which are associated directly with these identified threshold concepts. Most significantly this research identified seven coping mechanisms which enable students to traverse the liminal space when they encountered these threshold concepts when learning about IS.

Finally, the study highlighted how specific troublesome knowledge considerations were impacting BIS students' ability to operate effectively in their communities of practice.

Looking beyond the horizon, this study has demonstrated that threshold concepts have the potential to assist academic departments to (re)design curriculum, particularly during programmatic review and new programme development, and assist with a shared understanding amongst staff and students of their existence which will enhance staff teaching and student learning. The next phase of this research will investigate how the findings from this study can be fed back to our institution to assist with curriculum development. The researchers intend to use Timmermans and Meyer's (2019) threshold concept framework which provides 'empirically grounded teaching and learning strategies that support threshold concept learning.' For example, two important components of Timmermans and Meyer's (2019) framework is defining threshold concepts and making explicit expert's understanding of threshold concepts. As evidenced by our findings, the use of language, and specially the use of terms, plays a pivotable role in managing a teacher and learner's understanding of IS threshold concepts. As indicated in section 5 the researchers intend to develop a lexicon of terminology which will explicitly define the specific threshold concepts that students will encounter when learning about IS. This lexicon will also make use of metaphors which 'offers order to the chaos of the new language and unfamiliar concepts' (Kanthan and Mills 2006). Prior to creating this lexicon, the researchers intend to conduct further interviews with multidisciplinary experts to further 'decode' the specific threshold concepts (Timmermans and Meyer 2019) identified in this study.

There are also avenues for future research which merit further investigation. First, while this case study reported rich findings, which were explored from the merging perspectives of both lecturers and students, it only focused on GMIT 4$^{th}$-year BIS students. It does not consider other Irish or International third-level higher education BIS programmes, and modules. Consequently, one area ripe for future research could be to replicate this study within another Irish third-level institution. This would enable the comparison of the findings at an Irish third-level education context. It would also be interesting to replicate the study at a third-level education institution outside of Ireland. As stated earlier in the literature review there is a dearth of research which has examined threshold concepts and troublesome knowledge from a BIS perspective. There is also an opportunity to replicate this study using the same case study approach

which would add a longitudinal dimension element to the research. It would also be interesting to analyse the research objective and several research questions in a non-Covid-19 environment and juxtapose the findings of this new study with the findings of this study. Finally, there is an opportunity to conduct research which

> might explain why some learners persist in their efforts to grasp a threshold concept sufficiently to negotiate the liminal space, and why others either do not embark on the journey at all or give up part way through and remain stuck in the liminal tunnel. (Rattray 2016, 71)

This would elucidate underlying learner motivations who persevere in their transformation learning journeys aimed at proficiency in a threshold.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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