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Improving Business IT learning outcomes using Cognitive Load Optimization - a case study in Chinese Graduate studies

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Abstract

This study aims to assess the effectiveness of implementing cognitive load optimization in the instruction of STEM subjects within graduate studies, focusing on the perspective of Chinese students. The primary objective is to scrutinize the influence of this approach on both the student's learning performance and engagement levels. Additionally, this research endeavors to evaluate several key factors, including students' expectations regarding their efforts, the inspiration drawn from lecturers, the conducive learning environment, the anticipation of their performance, their personal innovative thinking, and the perceived relative benefits of this teaching method. By integrating cognitive load optimization strategies into the teaching of STEM disciplines to graduate students, the study seeks to augment their learning performance and enhance their engagement in the subject matter. Particularly, in disciplines like business studies, specialized streams such as IT management may necessitate comprehension of intricate STEM concepts like cybersecurity. Often, business students lack a technical background, resulting in their instruction being reliant on rote memorization of technical information. However, this superficial learning approach often leaves students with an inadequate grasp of the technologies, limiting their applicability in real-world scenarios. To address this challenge, Cognitive Load Optimization (CLO) methodology is employed, converting intricate technical knowledge into easily assimilated mental schemas. These schemas offer the most efficient cognitive pathways for learning, minimizing cognitive load. They serve as the foundation for instructional design and teaching, providing students with structured frameworks for understanding complex concepts. Implementing CLO has demonstrated significant enhancements in learning outcomes, even when dealing with demanding remote and online learning modalities. In this study, a cohort of Chinese graduate students engaged in remote learning were instructed in an IT unit using CLO principles. Their learning experiences were evaluated across six parameters, yielding remarkably high results for five parameters and a high result for the remaining parameter. These findings underscore the potential of cognitive load optimization in enhancing the learning experiences of students, particularly in challenging learning environments.

Keywords: Cognitive Load Optimization (CLO), Learning Theories, Business IT, Student's Learning Performance, Student's Engagement

JEL Classification Code: I21, I23, I25, I29, O30, O35, O39

1. Introduction

Constructivism, Behaviorism, and Cognitive Psychology are only a few major schools of thought on education today. Theories of learning are attempts to explain the learning process. Nonetheless, these approaches from the last century are all founded on qualitative, subjective principles that can be interpreted in various ways, which may result in variations in the quality of learning outcomes. These learning theories are categorized as "soft" science. Because humans are complicated systems that resist the

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reductionist assumptions this is not a derogatory term. To address this problem what is needed is a learning theory based on hard scientific principles. To better comprehend the process of learning, the National Science Foundation (NSF) launched the Science of Learning (SoL) initiative (Science of Learning | NSF - National Science Foundation, n.d.). The NSF has highlighted several overarching research issues, such as "How does the structure of the learning environment impact the rate and effectiveness of learning?" Consider the following: how do variables such as time, content, context, development, and mode of engagement influence the processes and results of learning? The SoL goal was defined as optimized learning for everybody, according to the NSF 2013 SoL seminars. The Deans for Impact proposed six central questions, along with the underlying cognitive concepts and instructional consequences, to facilitate the transfer of SoL research into practice (Donovan, 2012). To give only one illustration: How do kids pick up new concepts? (Research Question 1) According to three theories of cognition, "children learn new ideas by reference to ideas they already know," this is the case. The following have direct educational implications: Students will be better prepared to learn new concepts if they are introduced to them at the appropriate points in the curriculum. Twelve PEN principles (Psychology, Education and Neuroscience) were outlined by the Australian Science of Learning Research Centre (SLRC). However, they represent qualitative guidelines and as such cannot optimize learning. Basic psychological research on the biological foundation of behavior has inspired the development of six cognitive learning strategies: spaced practice, interleaving practice, retrieval practice, elaboration, specific examples, and dual coding (Weinstein et al., 2018). But they are just their strategies and hence qualitative guidelines. A quantitative, practical, scientific method that is easy to use, relevant to all STEM fields, and applicable to all educational levels (school, college, university) that significantly improves teaching and learning outcomes is needed to accomplish the SoL aim of optimum learning for everyone.

This study investigates the adoption of cognitive lo ad optimization to teach technical STEM subjects to C hinese graduate business studies students. The main qu estion formulated:

Does the adoption of cognitive load optimization impro ve learning outcomes for business STEM subjects in gradu ate studies among Chinese students' perspective?

The study objectives were:

1) To evaluate the adoption of cognitive load optimization to teach STEM in graduate studies among Chinese students' perspective in better student's learning performance and engagement.

2) To evaluate students' effort expectancy, lecturer's inspiration, facilitating environment, performance anticipation, personal innovativeness, and relative benefit, adopt cognitive load optimization to teach STEM in graduate studies among Chinese students' perspective in better student's learning performance and engagement.

2. Literature Review and Research Hypotheses

2.1 Cognitive Load Theory

Cognitive Load Theory (CLT) is a theory of learning based in the domain of cognitive science. It is based on the presentation of information in order to maximize intellectual function (Sweller et al., 1998). Schemas, short-term memory (STM), long-term memory (LTM), and automation are the foundational concepts upon which CLT is built. Knowledge is said to be stored in the form of mental constructions known as schemas (Hoz et al., 2001; McVee et al., 2005). The structure of the relationships in a schema provides an implicit basis for meaning and comprehension. The learning process consists of creating new schemas that are stored in LTM (De Jong, 2010). As a result, there is a possibility that learning outcomes will be improved if the content that is to be taught is highly structured. STM (aka working memory) has a finite capacity, and a finite duration, and is sensitive to the load that is placed on it (Baddeley, 2010; Miller, 1956). LTM, on the other hand, does not have these limits and serves as a long-term repository for schemas. It is important to note that the processing of a schema in STM occurs as a single entity. Learning new information is an iterative process that involves providing new information to STM. During this process, existing knowledge (in the form of a schema) is retrieved from LTM and assimilated with new information, so producing new existing knowledge that is stored in LTM. However, all new learning is mediated by STM which, if the knowledge is complex, will be overwhelmed thereby handicapping learning. Schemas are automatically processed in STM as a result of automation, which is possible thanks to automation (Kotovsky et al., 1985). In practice, the stress on STM is decreased as a result of automating schemas (Paas et al., 2003).

There are different categories of cognitive load (aka stress) (Valcke, 2002). Intrinsic cognitive load (ICL) is characterized by the structure of the information that must be learned by the learner, i.e., new knowledge. Extraneous cognitive burden (ECL) is a function of the quality of the instructional material. The task environment represents both of these types of cognitive load. According to van Merrinboer and Sweller (2005), germane cognitive load (GCL) is a distinct category of load that refers to the working memory resources that are immediately relevant (germane) to the process of learning. The concept of understanding in CLT is a function of the elements and their relationships (Marcus et al., 1996). Understanding only applies to high-element engagement in this environment, which is the inherent source of cognitive burden (Sweller et al., 2011).

Simple knowledge consists of a few inter-related elements, but this represents low order learning evaluated by metrics such as list, identify etc. By contrast complex knowledge – the goal of learning - consists of numerous inter-related and interdependent elements which confers understanding evaluated by metrics such as explain. However, due to their logical interconnectedness all of these interacting elements in complex knowledge represent a high ICL likely to overload STM. In effect complex knowledge is hard to teach and learn. By contrast simple knowledge has a low ICL that is easy to teaching and learn because it may be taught in a linear fashion but it fails to demonstrate the connections between concepts that are essential to the achievement of higher-order learning outcomes (Sweller, 2010). It has been suggested that instructional treatments cannot alter intrinsic load (De Jong, 2010). It has also been argued that reducing ICL will compromise students' ability to learn the material, despite the fact that rules for doing so exist, such as the use of scaffolding and whole-task techniques (Wouters et al., 2008). Some argue that instructional methodologies like example-based learning can significantly reduce ICL whereas others disagree (Paas & van Gog, 2006). Ultimately, the purpose of CLT is to improve how material with a high ICL can best be created. However, Pollock claims that interactive learning strategies based on a large number of student participation tasks are ineffective (Pollock et al., 2002). It is widely acknowledged that more sophisticated methods are required to quantify cognitive load (van Merrinboer & Sweller, 2005), but traditional CLT has focused on instructional ways to lower cognitive burden. As a theoretical framework, CLT has been widely utilized to improve and guide the following areas of education: instructional design (Chong, 2005), self-regulated learning (De Bruin & van Merrienboer, 2017), and problem-based learning (Leppink, 2017; Reedy, 2015; Wahyudi & Aqidawati, 2019). Nonetheless, all of these applications are subjective, which means they can be interpreted in a variety of ways.

Computational models, performance during acquisition, error patterns between issues, subjective mental effort and difficulty, efficiency metrics, and physiological measures can quantify cognitive load indirectly, subjectively, and objectively (Sweller et al., 1998, 2011). Subjective cognitive load measuring is flawed (Sweller et al., 2011). According to de Jong, there is no direct measurement of cognitive load but simply an induced outcome. Cognitive load assessments are usually relative. Second, an overall evaluation of cognitive burden, as is typically used, does not help understand results in terms of cognitive load theory since different types of cognitive load contribute differently to learning. Third, the most common metrics aren't responsive to time (De Jong, 2010).

A mediating framework for prior knowledge, spatial ability, and motivation has been recommended (Wouters et al., 2008). Kirschner et al. note that the field of cognition and learning lacks evidenced-based theory-driven research, that optimizing cognitive load is difficult, that performance test results don't correlate with subjective measures, and that "since the early development of CLT there has been a need for cognitive load measures" (Kirschner et al., 2011). A quantitative approach to measuring ICL is needed.

2.2 Solving the problem – Cognitive Load Optimization

IT subjects are complex and hence hard to teach and learn. This problem is compounded because business students are unlikely to have a technical background. An analysis of business IT units found that they were predominantly taught as simple knowledge that could be evaluated by metrics such as list, describe etc. Maj 2021 ASCILITE conference. Furthermore, this low order, rote learning tends to be resident in STM and hence is easy to forget. An analysis of 64 students who successfully completed three business IT units found none of them could answer even simple questions. The objective is not to turn business students into technical experts, which is neither desirable nor attainable, but to provide them with enough technical knowledge to feel competent in the workplace and promote continued study in this sector academically and as employees.

Cognitive Load Optimization (CLO) has a reliable quantitative metric for measuring ICL. Using CLO, complex knowledge with a high ICL can be converted to the lowest ICL that will not overload STM. CLO creates the easiest, most efficient and fastest learning sequence (Maj, 2018). Published work has shown that using CLO in the college and university sectors improves learning outcomes for a wide range of STEM (Science, Technology, Engineering & Mathematics) disciplines (engineering mathematics, object-oriented programming, project management, cybersecurity, network technology, computer systems, biomedical engineering, engineering drawing, science (chemical, biological, environmental), etc.) without compromising academic rigor. Also, business students that need to study IT infrastructure, Cyber security, etc. favoured the CLO technique evidenced by 99% of students said CLO-based training best prepared them for working in industry (Maj, 2018, 2020; Maj & Nuangjamnong, 2020).

2.3 Effort expectancy

The degree of ease connected with the system's adoption is what we mean when we talk about effort expectation (Nuangjamnong & Maj, 2022). The term “effort expectancy” refers to the belief held by graduate students that implementing cognitive load optimization strategies for the instruction of STEM subjects through remote learning systems will be effortless and uncomplicated. They can comprehend the challenging material presented in their STEM course, such as the unit on project management. Because many students in underdeveloped nations do not have access to a wide variety of information systems, most of their education focuses on simply memorizing the material rather than developing an understanding of it. This is effectively superficial learning in which students have little or no understanding of the technologies and is of limited use in the workplace. This concept is a key determining factor when it comes to adopting cognitive load optimization for teaching Business STEM disciplines via remote learning systems. It is anticipated that the acceptance to adopt and use cognitive load optimization for teaching STEM disciplines via remote learning systems will depend on whether or not students believe that applying cognitive load optimization for teaching STEM disciplines via remote learning systems will be easy to use. This is because acceptance will depend on whether or not students believe that applying cognitive load optimization for teaching STEM disciplines via remote learning systems will be easy to digest of understanding the contents of STEM courses.

2.4 Lecturers’ inspiration

The degree to which an individual believes that important individuals believe he or she should use the new system is an example of lecturer inspiration (Nuangjamnong & Maj, 2022). This parameter illustrates the extent to which students believe other students or important people believe they should adopt and use cognitive load optimization for teaching STEM disciplines via remote learning systems. Lecturer inspiration in this study correlates to lecturers who teach business STEM courses in graduate studies. Previous research has shown that one's classmates or other people, like teachers or lecturers, can have a significant impact on a person's choice, such as a student. This includes the student's parents (Hossain & Nuangjamnong, 2021; Rodprayoon et al., 2017). As a result of this, it is essential to incorporate the inspiration of lecturers as a component of the social inspiration of the adoption of cognitive load optimization to teach STEM in graduate studies among Chinese students' perspective.

2.5 Facilitating environment

The degree to which an individual feels that an organizational and technical infrastructure is in place to enable the use of the system is referred to as the "facilitating environment." The term "facilitating environments" refers to the availability of resources at a certain institution to facilitate the adoption and implementation of cognitive load optimization for teaching business STEM subjects via remote learning systems. The availability of computer-based information systems, mobile devices, a dependable internet connection, and other relevant resources are considered essential resources in the context of cognitive load optimization for teaching STEM disciplines using remote learning systems. Therefore, the decision of graduate students to adopt and use cognitive load optimization for teaching business STEM disciplines via remote learning systems will be reflected by their perception of the availability of support services and resources to deliver remote learning (Nuangjamnong & Maj, 2022; Wang et al., 2022).

2.6 Performance anticipation

The degree to which an individual believes that making use of the system will assist them in achieving gains in terms of student performance is referred to as performance anticipation. The anticipation of future performance is the single most important factor in determining a person's behavioral intention to utilize a variety of technologies in both voluntary and involuntary contexts (Nuangjamnong & Maj, 2022). In the context of this study, it signifies the extent to which students believe that adopting cognitive load optimization for teaching business STEM disciplines via remote learning systems can help boost the learning performance of graduate students and help them get better marks (Wang et al., 2022). If this perception is bolstered, students will have a greater behavioral intention to embrace and employ cognitive load optimization in the classroom instruction of STEM subjects delivered through remote learning systems. The apparent performance anticipation indicated in learning performance has been the driving force behind the construction of this architecture. A comparable study was conducted using the qualitative research approach to identify and investigate Cognitive Load Optimization, a statistical evaluation for three STEM fields by Maj (2018).

2.7 Personal innovativeness

The notion of personal innovativeness can be found in the Theories of Reasoned Action and the Theory of Planned Behavior, the Technology Acceptance Model, the Combined TAM-TPB, and the Motivation Model. The willingness of an individual to experiment with any new information technology is one definition of what is referred to as personal innovativeness (Agarwal & Prasad, 1998). Additionally, the study by Agarwal and Karahanna (2000) established a multidimensional construct labeled cognitive absorption. They suggested that this construct was a predecessor of the two commonly recognized behavioral beliefs regarding technology use: perceived usefulness and perceived ease of use. In addition, according to Nuangjamnong and Maj (2022) the individual characteristics of each student, such as liveliness and personal inventiveness, are major drivers of cognitive absorption. Most graduate students do not have any or a significant amount of knowledge or experience that can assist them in forming a clear perception and understanding of the adoption and usage of cognitive load optimization for teaching STEM disciplines via remote learning systems such as computer network security and wireless mobile technology. Personal inventiveness is support to present sheer boldness and curiosity in students' characters. It may not only strongly amplify their perception of potential benefits but also heighten their confidence in their capabilities to handle learning and understand the technology being adopted. This can be a win-win situation. In the meantime, given that people with higher levels of personal innovativeness tend to be more risk-taking, it is reasonable to anticipate that such people will develop more positive intentions regarding adopting and utilizing cognitive load optimization for teaching STEM subjects via remote learning systems. As a result, the character's innovative nature may very well be the primary and direct determining element for the adoption choice.

2.8 Relative benefit

According to Maj (2022), “relative benefit” measures the level to which an activity delivers more benefit than its instructors. This benefit is compared to the initial benefit that the action provided. The individual's perception of the potential benefits associated with learning outcomes is one of the key components that could drive more positive adoption and practice of cognitive load optimization for teaching STEM disciplines via remote learning systems behaviors. In the context of this research, the term “relative benefit” refers to the positive adoption and utilization of cognitive load optimization for teaching business STEM disciplines via remote learning systems has more advantages than in-class instruction on campus. This is due to the fact that teaching and learning methods are not limited by location. In addition, the implementation and utilization of cognitive load optimization in the classroom setting of remote learning systems are superior in terms of convenience, efficiency, and effectiveness to that of the traditional classroom setting on the university campus.

2.9 Adopt Cognitive Load Optimization

Venkatesh et al. (2003) found that behavioral intention to embrace and use a certain technology considerably influences actual usage behavior. At the moment, there is no correlation between an institution's acceptance and utilization of CLO for teaching business STEM subjects using remote learning systems. This research focuses on graduate Chinese students at a private university in Bangkok and investigates the adoption of LO to teach STEM in graduate studies among Chinese students' perspectives. Remote online teaching and learning are particularly challenging – a national survey of online students in Australia found that some 50% were disaffected, did not like the experience, and did not wish to experience it again (Tertiary Education Quality and Standards Agency, (TEQSA), 2022).

In the traditional face-to-face mode, engagement is synchronous, i.e., communication in real-time with no delays. This highly interactive mode allows immediate, two-way feedback important for deep learning. The lecturer can engage with and monitor student progress using visual cues and questions. Also, students can proactively and iteratively engage with the lecturer to clarify any misconceptions in the knowledge being taught and correct misunderstandings immediately and in real time. In remote learning mode, synchronous engagement is using video. In this mode, the lecturer can view students; however, for large classes, this is problematic due to screen size limitations. While the video mode is synchronous, there are interaction overheads, e.g., mute/unmuting the microphone, switching between the screen of the lecturer to selected students and back again, technical delays and issues, etc., that all take time from the defined lecture period and hence may reduce overall student engagement time. Furthermore, nonverbal communication is not possible in video mode. Nonverbal engagement (aka immediacy characteristics), such as eye contact, physical gestures, moving around the room, etc., not only have immediacy but also be effective for student motivation and cognitive learning (Frymier & Houser, 2000). Superficial learning (rote learning) is based on remembering facts and details. By contrast, more challenging deep learning is acquiring complex knowledge schemas (mental patterns of knowledge) resident in LTM. Deep learning confers the ability to explain, calculate, etc., and is therefore concerned with comprehension and understanding, likely requiring greater lecturer/student engagement. By definition, this type of knowledge consists of many interdependent elements and hence is more difficult to teach and learn. Missing elements and missing element relationships etc., represent cognitive gaps that can result in student misconceptions where the student has come to their incorrect understandings. This is important because, once integrated into a student's cognitive structure, these misconceptions interfere with subsequent learning. The student is then left to connect new information to a cognitive structure that already holds inappropriate knowledge. Thus, the new information cannot be related appropriately to their cognitive structure, and there will be weak understandings or misunderstandings of the concept (Nakhleh, 1992).

Student misconceptions not addressed during the synchronously delivered video-based remote lectures can be addressed asynchronously, i.e., in delay time (e.g., email). This is likely to be less problematic for superficial learning but much more likely to be important when teaching deep understanding. Correcting misconceptions based on deep understanding in an email can be challenging. It may result in the need for multiple time-consuming emails, each with indeterminate delays – a problem exacerbated when students are in different geographical time zones and when English is not their first language. In effect, a student misconception that can be corrected in seconds synchronously may take considerably longer to correct or not be corrected. In summary, teaching relational knowledge with cognitive gaps can result in cumulative student misconceptions, tend to be persistent, hard to correct, and handicap further learning. Early and immediate corrective feedback using student engagement is therefore of paramount importance but is problematic in online learning. Moreover, Rogers (1995) described diffusion as how a community adopts and accepts an idea. Four aspects influence innovation diffusion. The diffusion process is influenced by the innovation itself, how knowledge is disseminated, time, and the social context into which it is introduced (Rogers, 1995). Rogers (1995) contrasted the adoption process with the diffusion process, which is a collective process. Potential adopters appraise an innovation based on its perceived features.

3. Methodology

3.1 Instrument

Figure 1 is an illustration of the study diagram derived from previously cited literature. This diagram is the basis of evaluation CLO to remotely teach business STEM subjects in graduate studies for students in China. The analysis is based on six constraints: personal innovativeness; performance anticipation; lecturers' inspiration; facilitating environments; effort expectancy; and relative benefit to evaluate learning engagement and performance

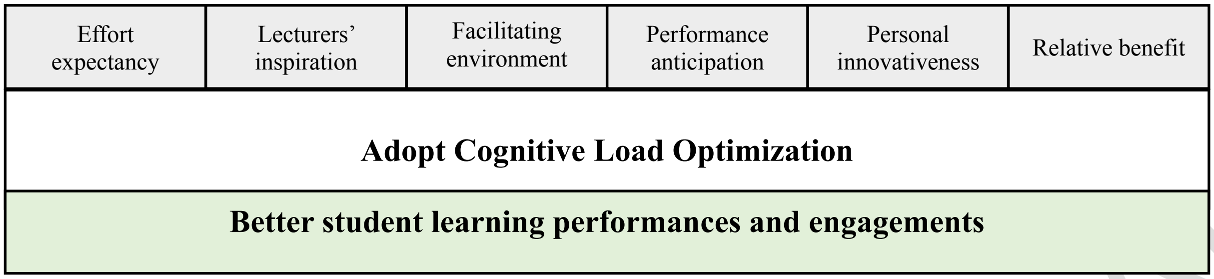

Figure 1: The research diagram

3.2 Study context and sample

Thirty target respondents consisted of graduate Chinese students who were pursuing a project management course through remote studies at a prominent private university located in Bangkok, during the academic year 2021. The selection of participants for this research was purposeful in nature, with a deliberate focus on students specifically enrolled in the project management subject. It is noteworthy that the project management course constitutes a foundational component within the curriculum of the Graduate School of Business and Advanced Technology Management (GSBATM).

In order to enhance the content validity of the questionnaire, three distinguished experts proficient in the academic domain of STEM teaching were engaged. Their invaluable input ensured the refinement of the survey instrument. The assessment encompassed three essential aspects: (i) the alignment of the survey instrument with the study's overarching objectives, (ii) the congruence of individual items with their respective sub-sections, and (iii) the linguistic precision and accuracy of the language employed.

The subsequent data analysis process employed descriptive statistical techniques, in conjunction with key insights gleaned from the target respondents - in this instance, the Chinese students under investigation. It is imperative to highlight that a total of thirty students diligently completed the questionnaire, and an additional seven students were subjected to remote interviews, thereby providing a comprehensive and well-rounded perspective for the study's empirical examination.

4. Findings

This part of the study includes descriptive findings, and results of interviews.

4.1 Descriptive Analysis of Demographic Profile

The results of the demographic sections illustrated some interesting points; the general questions represented the initial idea of the participants' characteristics and Chinese students, which include gender, age groups, and graduate student level (Table 1). The results indicated that participants are graduate Chinese students and they have the adoption and practice of CLO to teach STEM. When asking about gender, the rate of the male group was 40% while the female was 60 %. Next, age group, the number of participants is greater and equal 18 years old to 25 years old was representing 10% and they are Chinese students at the graduate studies in the universities, 30% from the age group between 26 years old to 35 years old, 40% from the age group between 36 years old to 45 years old, 13.3% from the age group between 46 years old to 55 years old, then lastly the age group greater and equal 56 years old was 6.7%.

Table 1: Demographic distribution of participants

		n	%
Gender:	Male	12	40.0
	Female	18	60.0
	Total	**30**	**100.0**
Age Group:	18 yrs - 25 yrs	3	10.0
	26 yrs - 35 yrs	9	30.0
	36 yrs - 45 yrs	12	40.0
	46 yrs - 55 yrs	4	13.3
	≥ 56 yrs	2	6.7
	Total	**30**	**100.0**
Graduate level:	Master Degree	11	36.7
	Doctoral Degree	19	63.3
	Total	**30**	**100.0**

4.2 Descriptive Analysis with Mean Score

A descriptive statistic was used to present the mean and standard deviation. The researchers used the Moidunny (2009) questionnaire score range of the mean score to explain the results. Score range 1.00 < x < 1.80 refers to "Very low," 1.81 < x < 2.60 refers to "Low," 2.61 < x < 3.40

refers to "Medium," 3.41 < x < 4.20 refers to "High," and 4.21 < x < 5.00 refers to "Very high."

The survey was conducted to understand Chinese students' perspectives on adopting CLO to teach business STEM subjects based on the six parameters of lecturer's inspiration, supportive environment, performance anticipation, effort expectancy, personal innovativeness, and relative benefit. The results are tabulated in figure 2.

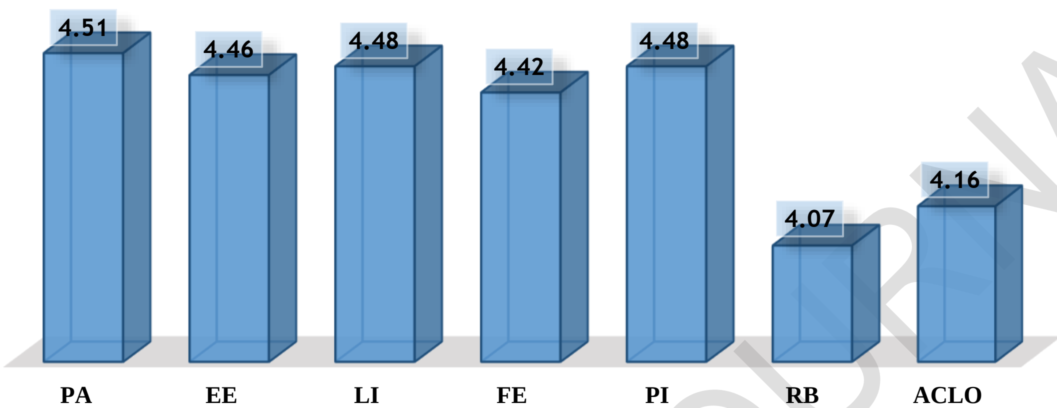

Figure 2: Mean score graph in the adoption of CLO to teach STEM in graduate studies among Chinese students' perspective
Note: PA - Performance anticipation | EE - Effort expectancy | LI - Lecturers' inspiration | FE - Facilitating environment | PI - Personal innovativeness | RB - Relative benefit | ACLO - Adopt cognitive load optimization

Regarding figure 2; personal innovativeness and lecturers' inspiration have very high mean score ($\bar{x}$ = 4.48), followed by performance anticipation ($\bar{x}$ = 4.51), effort expectancy ($\bar{x}$ = 4.46), facilitating environment ($\bar{x}$ = 4.42), adopt cognitive load optimization ($\bar{x}$ = 4.16), and lastly relative benefit ($\bar{x}$ = 4.07).

When look at the performance anticipation aspect in table 2, the results show that the mean scores are "very high" in all items. The highest item is - adopting CLO in STEM with teaching in the project management course by the lecturer, this technique would enable me to achieve learning tasks more quickly and shortly ($\bar{x}$ = 4.57, SD = .724), and the lowest item is - adopting CLO in STEM with teaching in the project management course by the lecturer, this technique would improve my learning performance in my studies ($\bar{x}$ = 4.44, SD = .725).

For the effort expectancy in table 2, all of the items are also "very high". The highest item is - my interaction with adopting CLO in STEM with teaching in the project management course by the lecturer, this technique would be clear context and understandable ($\bar{x}$ = 4.58, SD = .633), and the lowest item is - it would be easy for me to become skillful, knowledgeable, and great learner at adopting CLO in STEM with teaching in the project management course by the lecturer ($\bar{x}$ = 4.39, SD = .716).

Lecturers' inspiration in table 3, all of the items are also "very high". The highest item is - I would inspire to adopt CLO in STEM with teaching in the project management course by the lecturer, if my lecturers supported the use of this technique ($\bar{x}$ = 4.57, SD = .630), and the lowest item is - lecturers who inspire my learning behavior think that I should adopt CLO in STEM with teaching in the project management course ($\bar{x}$ = 4.36, SD = .600).

Facilitating environment in table 2, all of the items are also "very high". The highest item is - I have all the necessary resources and support to adopt CLO in STEM with teaching in the project management course by the lecturer ($\bar{x}$ = 4.50, SD = .615), and the lowest item is - if I have any doubts about how to adopt CLO in STEM with teaching in the project management course, I do have a support channel to help me by the lecturer ($\bar{x}$ = 4.35, SD = .692).

Personal innovativeness in table 2, all of the items are also "very high". The highest item is - among my classmates, I am usually the first to try out to adopt CLO in STEM with teaching in the project management course by the lecturer ($\bar{x}$ = 4.54, SD = .614), and the lowest item is - I like to experiment with adopting CLO in STEM with teaching in the project management course by the lecturer ($\bar{x}$ = 4.44, SD = .631).

Relative benefit in table 2, all of the items are also "high". The highest item is - adopting CLO in STEM with teaching in the project management course by the lecturer, this technique has more advantages than other teaching techniques because the contents in the course will focus only necessary knowledge in-depth ($\bar{x}$ = 4.09, SD = .739), and the lowest item is – adopting CLO in STEM with teaching in the project management course by the lecturer, this technique is more convenient and useful than other teaching techniques ($\bar{x}$ = 4.05, SD = .740).

Table 2: The result of Mean and Standard Deviation of Scale items for each variable

	Mean	Std. Deviation	Interpretation
Performance anticipation (PA)	**4.51**	**.729**	**Very high**
PA1: I find to adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer, it is useful for my studies.	4.52	.737	Very high
PA2: Adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, this technique would enable me to achieve learning tasks more quickly and shortly.	4.57	.724	Very high
PA3: Adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, this technique would improve my learning performance in my studies.	4.44	.725	Very high
Effort expectancy (EE)	**4.46**	**.684**	**Very high**
EE1: Adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, this technique does not require much effort for my learning ability.	4.41	.703	Very high
EE2: My interaction with adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, this technique would be clear context and understandable.	4.58	.633	Very high
EE3: It would be easy for me to become skillful, knowledgeable, and great learner at adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer.	4.39	.716	Very high
Lecturers' inspiration (LI)	**4.48**	**.636**	**Very high**
LI1: I would inspire to adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer, if this technique was recommended to me by my lecturers and the school.	4.50	.677	Very high
LI2: I would inspire to adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer, if my lecturers supported the use of this technique.	4.57	.630	Very high
LI3: Lecturers who inspire my learning behavior think that I should adopt cognitive load optimization in STEM with teaching in the project management course.	4.36	.600	Very high
Facilitating environment (FE)	**4.42**	**.652**	**Very high**
FE1: I have all the necessary resources and support to adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer.	4.50	.615	Very high
FE2: I have the knowledge and appropriated tools to adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer.	4.40	.648	Very high
FE3: If I have any doubts about how to adopt cognitive load optimization in STEM with teaching in the project management course, I do have a support channel to help me by the lecturer.	4.35	.692	Very high
Personal innovativeness (PI)	**4.48**	**.619**	**Very high**
PI1: I like to experiment with adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer.	4.44	.631	Very high
PI2: When I hear about adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, I look forward to examining this technique.	4.45	.613	Very high
PI3: Among my classmates, I am usually the first to try out to adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer.	4.54	.614	Very high
Relative benefit (RB)	**4.07**	**.743**	**High**
RB1: Adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, this technique has more advantages than other teaching techniques because the contents in the course will focus only necessary knowledge in-depth.	4.09	.739	High
RB2: Adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, this technique is more effective than other teaching techniques.	4.06	.749	High
RB3: Adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer, this technique is more convenient and useful than other teaching techniques.	4.05	.740	High
Adopt cognitive load optimization (ACLO)	**4.16**	**.753**	**High**
ACLO1: I intend to increase my learning outcomes of adopting cognitive load optimization in STEM with teaching in the project management course by the lecturer in the future.	4.10	.753	High
ACLO 2: I will adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer.	4.26	.711	Very high
ACLO 3: I would recommend others to adopt cognitive load optimization in STEM with teaching in the project management course by the lecturer.	4.12	.795	High

4.3 Graduate students' Interviews from China

Seven students were interviewed virtually using Zoom meetings by means of five semi-structured open-ended questions as detailed shown in table 3.

Question 1 (Q1): What experiences, information, or resources do you have in project management?

Question 2 (Q2): What is your role in the project that you conduct interests? Give examples of initiatives and actions taken.

Question 3 (Q3): What actions led you to adopt cognitive load optimization in promoting your learning performances and engagement?

Question 4 (Q4): What are the main challenges in improving learning performances and engagement?

Question 5 (Q5): Is there any feedback or recommendation you would like to add?

Table 3: Interview respond detail

	Q1	Q2	Q3	Q4	Q5
Participant 1	"The quarantine transforms how we think about the future. As students, we take time to cope with our challenges in learning performance, and we want to engage with all the practical exercises rather than theories."	-	"Some projects example from previous class"	"Lecturer's inspiration"	-
Participant 2	"Technology became essential to our lives, especially after the pandemic. Many thoughts are shared with our classmates about how CLO will be a more efficient technique in the future for increasing our learning performance and learner engagement."	-	"Video clip as an example of presentation and support by the lecturer"	"Lecturer's inspiration"	"It is essential to shift the focus toward students' learning performance and engagement with a proper technique like the CLO in STEM concept. Emphasis on practical class"
Participant 3	-	"We have to collaborate with the lecturer on planning activities in project management from the beginning of the class"	"Small seminar in the class"	-	-
Participant 4	-	"I work in specific areas of petroleum, then my job needs a lot of activities in a project, then in project management, the lecturer gave me a hand after class to support and guide me"	"Lecturer encouragement and support"	"Lecturer's inspiration"	-
Participant 5	"I started to look at the activities in my project as a priority in my practical choices due to the challenges in a period of the timeslot in this class; I do not want to waste my time with many technical key terms. We want to learn some things that we can use to apply with our work, not learning something that we cannot use and apply without jobs."	-	"Support by the lecturer"	"Personal innovativeness, relative benefit and lecturer's inspiration"	-
Participant 6	-	"Many particular projects become more meaningful when one lecturer handles them	"A good care of lecturer"	-	"There should be a proper review of the curriculum, especially between

	Q1	Q2	Q3	Q4	Q5
		with a good approach e.g. However, I and my classmates share information in our classes with the project of our interest as part of real-life examples."			theories and practical class, to avoid any gap in learning performance and engagement from learners."
Participant 7	"We want lecturers to teach us how to do, not talk in front of the camera, with the CLO approach we understand the big picture of the project management class, then we go step by step with practical exercises. It is a very useful technique and improves my learning ability."	-	"Challenge myself and encourage by the lecturer"	"Relative benefit, lecturer's inspiration and performance anticipation"	-

5. Discussion

The discussion in this section seeks to answer the research question of the study: Does the adoption of cognitive load optimization improve learning outcomes for business STEM subjects in graduate studies among Chinese students' perspective*?*

5.1 The adoption of cognitive load optimization to teach business STEM subjects in graduate studies among Chinese students' perspective

The results of the adoption of CLO to teach business STEM disciplines (the project management course) in graduate studies based on Chinese students' perspective shows improved learning performance and engagement. This is particularly significant because, according to the TEQSA (2022) study of Australian students studying in remote, online mode, some 50% were disaffected, did not like the experience, and did not wish to experience it again. The Chinese students in this survey were taught in remote, online mode, and English was not their first language.

5.2 Students' effort expectancy, lecturer's inspiration, facilitating environment, performance anticipation, personal innovativeness, and relative benefit, adopt cognitive load optimization to teach STEM in graduate studies among Chinese students' perspective in better student's learning performance and engagement

For all the six parameters the results were either "very high" or "high." In the "very high," category the parameters were: performance anticipation (PA), effort expectancy (EE), lecturers' inspiration (LI), facilitating environment (FE), and personal innovativeness (PI). The parameter of relative benefit (RB) scored a result of high.

All these parameters are essential in developing and increasing student learning performance and engagement classes. According to Tan et al. (2013), lecturers' advice, the ways lessons are taught, social factors etc., all affect student learning. This finding is consistent with Hossain and Nuangjamnong (2021), which emphasized the strong effect of students' performance and engagement from their lecturer's inspiration. In the interviews, four students responded to question 1 with comments that included: "we want to engage with all the practical exercises rather than theories" and "I started to look at the activities in my project as a priority in my practical choices due to the challenges in a period of the timeslot in this class; I do not want to waste my time with many technical key terms. We want to learn some things that we can use to apply with our work, not learning something that we cannot use and apply without jobs."

Of the seven students interviewed, five students responded to question 4 (What are the main challenges in improving learning performance and engagement?) that lecturer's inspiration was the main factor

6. Conclusion and Recommendation

The objective is not to turn business students into technical experts, which is neither desirable nor attainable, but to provide them with enough technical knowledge to feel competent in the workplace and promote continued study in this sector academically and as employees. STEM areas, like project management, are technically complex and likely to overwhelm a learner without a technical background. The typical approach to teaching these types of topics to business students is to teach simple knowledge consisting of a few inter-related elements, but this represents low order learning evaluated by metrics such as list, identify etc. Furthermore, this type of learning is likely to be resident in STM and also of little use in the workplace. By contrast complex knowledge-the goal of learning - consists of numerous inter-related and interdependent elements which confers understanding evaluated by metrics such as explain. However, due to their logical interconnectedness all of these interacting elements in complex knowledge represent a high ICL likely to overload STM. In effect complex knowledge is hard to teach and learn. By contrast simple knowledge has a low ICL that is easy to teaching and learn because it may be taught in a linear fashion but it fails to demonstrate the connections between concepts that are essential to the achievement of higher-order learning

CLO is a new, practical, quantitative Science of Learning theory. CLO has a reliable metric for measuring cognitive load hence it is possible to produce schemas (mental patterns of knowledge) with the minimum ICL. These CLO schemas are the easiest, most efficient, and fastest learning paths. Because these schemas have the minimum ICL, few cognitive gaps result in few, if any, student misconceptions. Furthermore, the CLO schemas are not only the basis of instructional design but are also given to student teaching (i.e., student engagement) and the basis of highly interactive teaching. In effect, students are given what they will learn and how this can be achieved. According to one student, “We want lecturers to teach us how to do, not talk in front of the camera; with the CLO approach, we understand the big picture of the project management class, then we go step by step with practical exercises. It is a very useful technique and improves my learning ability.”

References

Agarwal, R., & Prasad, J. (1998). A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology. *Information Systems Research, 9*, 204-224. http://dx.doi.org/10.1287/isre.9.2.204

Baddeley, A. (2010). Working memory. *Current Biology: CB, 20*(4), 36-40. https://doi.org/10.1016/j.cub.2009.12.014

Chong, T. S. (2005). Recent Advances in Cognitive Load Theory Research: Implications for Instructional Designers. *Malaysian Online Journal of Instructional Technology (MOJIT), 2*(3), 106-117.

De Bruin, A. B. H., & van Merrienboer, J. J. G. (2017). ridging Cognitive Load and Self-Regulated Learning Research: A complementary approach to contemporary issues in educational research. *Learning and Instruction, 51*, 1-9. https://doi.org/https://doi.org/10.1016/j.learninstruc.2017.06.001

De Jong, T. (2010). Cognitive load theory, educational research, and instructional design: some food for thought. *Instructional Science, 38*(2), 105-134. https://doi.org/10.1007/s11251-009-9110-0

Donovan, S. (2012, September 21). *FY 2012 Agency.* https://www.doi.gov/sites/doi.gov/files/uploads/PFM_AFR_FY2012.pdf

Frymier, A. B., & Houser, M. L. (2000). The teacher-student relationship as an interpersonal relationship. *Communication Education, 49*(3), 207-219.

Hossain, M. S., & Nuangjamnong, C. (2021). Development of E-Readiness Scale in Blended Learning in Filmmaking Program for a Private University in Bangladesh-Initial Stage. *ABAC ODI JOURNAL Vision. Action. Outcome, 9*(1), 162-180. http://www.assumptionjournal.au.edu/index.php/odijournal/article/view/5601

Hoz, R., Bowman, D., & Kozminsky, E. (2001). The differential effects of prior knowledge on learning: A study of two consecutive courses in earth sciences. *Instructional Science, 29*(3), 187-211. https://doi.org/10.1023/A:1017528513130

Kirschner, P. A., Ayres, P., & Chandler, P. (2011). Contemporary cognitive load theory research: The good, the bad and the ugly. *Computers in Human Behavior, 27*(1), 99-105. https://doi.org/https://doi.org/10.1016/j.chb.2010.06.025

Kotovsky, K., Hayes, J. R., & Simon, H. A. (1985). Why are some problems hard? Evidence from Tower of Hanoi. *Cognitive Psychology, 17*(2), 248-294. https://doi.org/https://doi.org/10.1016/0010-0285(85)90009-X

Leppink, J. (2017). Cognitive load theory: Practical implications and an important challenge. *Journal of Taibah University Medical Sciences, 12*(5), 385-391. https://doi.org/https://doi.org/10.1016/j.jtumed.2017.05.003

Maj, S. P., & Nuangjamnong, C. (2020). Using Cognitive Load Optimization to teach STEM Disciplines to Business Students. *2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE),* 428-435. doi: 10.1109/TALE48869.2020.9368351.

Maj, S. P. (2018). Cognitive Load Optimization - A New, Practical, Easy-to-Use Teaching Method for Enhancing STEM Educational Outcomes Based on the Science of Learning. *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE),* 142-147.

Maj, S. P. (2020). A Statistical Evaluation for three STEM disciplines. *The IEEE International Conference on Teaching, Assessment, and Learning for Engineering (IEEE TALE2020),* 8-12.

Maj, S. P. (2022). A Practical New 21st Century Learning Theory for Significantly Improving STEM Learning Outcomes at all Educational Levels. *Eurasia Journal of Mathematics, Science and Technology Education, 18*(2), em2073. https://doi.org/10.29333/ejmste/11510

Marcus, N., Cooper, M., & Sweller, J. (1996). Understanding Instructions. *Journal of Educational Psychology, 88*(1), 49-63. https://doi.org/https://doi.org/10.1037/0022-0663.88.1.49

McVee, M. B., Dunsmore, K., & Gavelek, J. R. (2005). Schema Theory Revisited. *Review of Educational Research, 75*(4), 531-566. http://www.jstor.org/stable/3516106

Miller, G. A. (1956). The magical number seven plus or minus two: some limits on our capacity for processing information. *Psychological Review, 63*(2), 81-97.

Moidunny, K. (2009). *The Effectiveness of the National Professional Qualification for Educational Leaders (NPQEL)* [Unpublished Doctoral Dissertation]. Bangi: The National University of Malaysia.

Nakhleh, M. B. (1992). Why some students don't learn chemistry: Chemical misconceptions. *Journal of chemical education, 69*(3), 191.

Nuangjamnong, C., & Maj, S. P. (2022). Students' Behavioral Intention to Adopt Cognitive Load Optimization to Teach STEM in Graduate Studies. *Journal of Education Naresuan University, 24*(3), 24-43. https://so06.tcithaijo.org/index.php/edujournalnu/article/view/246962

Paas, F., & van Gog, T. (2006). Optimising worked example instruction: Different ways to increase germane cognitive load. *In Learning and Instruction, 16*(2), 87-91. https://doi.org/10.1016/j.learninstruc.2006.02.004

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive Load Theory and Instructional Design: Recent Developments. *Educational Psychologist, 38*(1), 1-4. https://doi.org/10.1207/S15326985EP3801_1

Pollock, E., Chandler, P., & Sweller, J. (2002). Assimilating complex information. *Learning and Instruction, 12*(1), 61-86. https://doi.org/https://doi.org/10.1016/S0959-4752(01)00016-0

Reedy, G. B. (2015). Using Cognitive Load Theory to Inform Simulation Design and Practice. *Clinical Simulation in Nursing, 11*(8), 355-360. https://doi.org/https://doi.org/10.1016/j.ecns.2015.05.004

Rodprayoon, N., Nuangjamnong, C., & MAJ, S. P. (2017). Distance Learning-A Potential Opportunity for Thailand. *Modern Applied Science, 11*(11), 20. https://doi.org/10.5539/mas.v11n11p20

Rogers, E. M. (1995). *Diffusion of Innovation* (4th ed.). Free Press.

Sweller, J. (2010). Element Interactivity and Intrinsic, Extraneous, and Germane Cognitive Load. *Educational Psychology Review, 22*(2), 123-138. https://doi.org/10.1007/s10648-010-9128-5

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Categories of Knowledge: An Evolutionary Approach. In: Cognitive Load Theory. Explorations in the Learning Sciences, Instructional Systems and Performance Technologies*. Springer. https://doi.org/https://doi.org/10.1007/978-1-4419-8126-4_1

Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive Architecture and Instructional Design. *Educational Psychology Review, 10*(3), 251-296. https://doi.org/10.1023/A:1022193728205

Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate between their narrated and embod- ied identities in considering a STEM trajectory. *Journal of Research in Science Teaching, 50*(10), 1143-1179.

Tertiary Education Quality and Standards Agency (TEQSA). (2020, November 30). *New TEQSA report details student experiences of switch to online learning.* News and Events in TEQSA. https://www.teqsa.gov.au/about-us/news-and-events/latest-news/new-teqsa-report-details-student-experiences-switch-online-learning

The U. S. National Science Foundation. (2017, November 13). *NSF makes new awards to advance Science of Learning*. NSF - National Science Foundation. https://www.nsf.gov/news/news_summ.jsp?cntn_id=243658#:~:text=TheNationalScience Foundation (NSF,%2C processes%2C environments and constraints

Valcke, M. (2002). Cognitive load: updating the theory?. *Learning and Instruction, 12*, 147-154.

van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive Load Theory and Complex Learning: Recent Developments and Future Directions. *Educational Psychology Review, 17*(2), 147-177. https://doi.org/10.1007/s10648-005-3951-0

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly, 27*(3), 425-478. https://doi.org/10.2307/30036540

Wahyudi, S., & Aqidawati, E. F. (2019). Learning a Supply Chain Management Course by Problem Based Learning: Case Studies in the Newspaper Industry. *Proceedings of the International Conference on Industrial Engineering and Operations Management Bangkok, Thailand*, 3559-3570. http://ieomsociety.org/ieom2019/papers/820.pdf

Wang, L., Hossain, M. S., & Nuangjamnong, C. (2022). The Differences of Students Traits in Computer Science Program with the Perception of Using Laptops for Studying in Chengdu, Sichuan, China. *AU-GSB e-Journal, 15*(1), 164-173. http://www.assumptionjournal.au.edu/index.php/AU-GSB/article/view/6114

Weinstein, Y., Madan, C. R., & Sumeracki, M. A. (2018). Teaching the science of learning. *Cognitive Research: Principlesand Implications, 3*(2), 1-17. https://doi.org/10.1186/s41235-017-0087-y

Wouters, P., Paas, F., & van Merriënboer, J. J. G. (2008). How to Optimize Learning from Animated Models: A Review of Guidelines Based on Cognitive Load. *Review of Educational Research, 78*(3), 645-675. http://www.jstor.org/stable/40071140