A field experimental research on the influence of needs-satisfying teaching approaches to students' motivation of using e-learning tool in Hong Kong from the perspective of Self-Determination Theory

by

Tam, Lap Kei Frank

A Thesis Submitted to

The Education University of Hong Kong

in Partial Fulfilment of the Requirement for

the Degree of Doctor of Education

September 2024

Statement of Originality

I, TAM, Lap Kei Frank, hereby declare that I am the sole author of the thesis and the material presented in this thesis is my original work except those indicated in the acknowledgement. I further declare that I have followed the University's policies and regulations on Academic Honesty, Copyright and Plagiarism in writing the thesis and no material in this thesis has been submitted for a degree in this or other universities.

I acknowledge the use of Insta Text [https://instatext.io/] to edit my writing at the final stage of preparing my thesis. I used the output to rephrase my previous sentences and help revise my writing in better grammar.

Abstract

COVID-19 virus outbreak started in Hong Kong in January 2020. All schools in Hong Kong were suspended from January 2020 to December 2022. Many secondary schools in Hong Kong would like to catch up with the learning schedule during the pandemic and e-learning became the possible solution. There were different forms of e-learning method. Some common examples were online lecture, e-learning platform and e-learning education technology tools. The use of e-learning tools became popular and common during the pandemic. Because of the sudden shift to e-learning lecture, teachers might not have enough time to realize students' e-learning needs. As a result, teachers may not be able to provide sufficient needs-satisfying support to students when they are using e-learning tools in the lesson. This study would like to apply an experimental approach to investigate the influence of needs-satisfying teaching approaches on the motivation of using e-learning tool based on Self-determination Theory (Deci & Ryan, 1986). Hong Kong secondary school students would be intrinsically motivated to e-learning tool in the Science subject through satisfying the needs for competence, autonomy and relatedness. In this study, the context was e-learning in Science class for secondary school students in Hong Kong. The learning tasks were junior secondary school level Physics and Chemistry. Questionnaire was utilized for quantitative data collection and a subgroup of students were invited to have individual interviews for qualitative data collection. A modified model based on SDT was proposed in this applied field research to study the influence of the intervention of needs-satisfying approaches to the motivation of using science e-learning tool in Science subjects on Hong Kong secondary school students.

Keywords: SDT, needs-satisfying teaching approaches, e-learning, Science, Secondary

Acknowledgments

The author would like to express his heartfelt gratitude to Dr. Wilbert Law for his invaluable guidance and support throughout the progress of this research. His expertise, encouragement, and constructive feedback were instrumental in shaping the direction of this study. The author would also like to express his gratitude to Dr. Lai Yiu Chi for his insightful discussions and guidance in the early stages of this research. His expertise and critical inputs have been invaluable in shaping the research design and methodology. The author would also like to thank the participants who generously devoted their time and shared their experiences, without them this research would not have been a success. Additionally, the author would like to acknowledge the Education University of Hong Kong for providing the necessary resources and facilities. Finally, the author extends his appreciation to his colleagues and friends for their continuous encouragement and assistance.

Table of Contents

List of Abbreviations

SDT	Self-determination Theory
MSE	Students' motivation to use Science e-learning tool
ME	Students' motivation to learn with e-learning
MS	Students' motivation to learn Science
M_pre	The mean score before the intervention
M_post	The mean score after the intervention

List of Figures

List of Tables

1. Chapter 1: Introduction

1.1 Background

Many secondary schools in Hong Kong during COVID-19 pandemic period aimed to continue to provide education during the pandemic period and probably the only available method was e-learning. The Hong Kong Students' Digital Citizenship Development project (Reichert et al, 2020) mentioned that e-learning had acted as the only channel to conduct teaching and learning during COVID time. There are two forms of e-learning, asynchronous and synchronous. For example, some Hong Kong secondary schools would choose to upload the e-learning materials to an e-learning management platform and students would learn at their own pace (asynchronous e-learning), while some others would provide live online lessons to the students according to the normal teaching timetable, e.g., through software such as Zoom and google meet (synchronous e-learning). Students were gradually losing their motivation in about 3 months into (online) learning. Chiu (2020) revealed that most of the local secondary students were not keen on e-learning during the suspension of face-to-face classes. They were also under a lot of stress during e-learning. The survey study collected responses from 1,168 students from April to May 2020. 72% of the participants said they preferred learning in person while only 23% said e-learning was adequate. This finding could be attribute to the sudden shift to e-learning lecture. Teachers were struggling to prepare e-learning lecture materials, not to say addressing students' e-learning needs. As a result, students might not find their psychological needs satisfied in e-learning. The Hong Kong Students' Digital Citizenship Development project (Reichert et al, 2020) partially supported this view such that school leaders and teachers are strongly required to first understand the students' level of digital competence and their technology access, such that knowing the extent students are comfortable with using different learning apps and whether

they have access to laptops and wifi. Otherwise, the existing academic performance division would be further widened due to the differences in digital e-learning readiness.

In the aftermath of the pandemic, since e-learning continues to be crucial, it is essential to prioritize students' motivation and psychological well-being in order to achieve positive educational outcomes. To clarify, “E-learning” tool is a software application for learning purposes which is utilized by the learner. However, “online learning” means a learning action takes place at an online platform. The science simulation software, PhET, utilized in this research is an e-learning software application for simulating the lab environment. This study focused more on the motivation of using the science e-learning tool.

While the COVID-19 pandemic had come to an end, the use of e-learning is going to be continued. It is essential to understand students’ motivation through addressing their needs, which I would extend to students’ basic psychological needs. As mentioned above, Chiu (2020) discovered that most of the local secondary students were not excited about e-learning and preferred face to face learning. Partly, the reason was their experience of stress during e-learning or lack of competence in using digital learning. Pekrun et al. (2017) studied the relationship between achievement emotions and academic performance. It highlighted that negative emotions may have negative influence on learning. This supports Chiu’s (2020) finding that the additional stress and anxiety caused by the COVID-19 pandemic period may demotivate and disengage student learning. Some researchers also mentioned that there was not enough concern put on applying the existing motivational theories for optimizing the e-learning or student engagement within technology infused learning contexts (Hsu, Wang, & Levesque-Bristol, 2019). Based on the concerns from many researchers, the goal of the current research is to examine how educators can apply motivational theories to design e-learning lecture approaches that could enhance students’ learning engagement and motivation.

This study would like to investigate the influence of need-satisfying teaching approaches on the motivation of e-learning based on Self-determination Theory (Deci & Ryan, 1986). Particularly, it is interesting to see if the Hong Kong secondary school students would feel more motivated for e-learning in the Science subject, through satisfying the needs for competence, autonomy and relatedness during e-learning. Self-Determination Theory (SDT; Deci & Ryan, 1986, 2000) is the overarching framework of the project. According to the self-determination theory, people have three basic and fundamental needs, they are relatedness (the perception of association with or connection to others), competence (the perception of capability in skills and actions), and autonomy (the perception of agency and freedom). People's psychological well-being and sense of self-worth are enhanced when the three basic requirements are satisfied. Conversely, if the three basic needs are not satisfied, a person's well-being and psychological development would be negatively impacted. When a student lacks the three basic psychological needs, it can have a negative impact on their motivation, well-being, and academic performance, such as decreased motivation, decreased well-being, and poor academic performance. First of all, a lack of autonomy can lead students to feel externally controlled, resulting in lower intrinsic motivation and greater dependence on rewards or punishments. Similarly, a lack of perceived competence can affect a student's self-confidence and intrinsic motivation. Finally, a lack of perceived relatedness can lead to feelings of isolation, withdrawal and less motivation to participate in learning activities. Second, unmet psychological needs can have a negative impact on a student's well-being. Feelings of frustration, anxiety or helplessness can arise when autonomy is limited, competence is undermined or connectedness is lacking. This can lead to increased stress, decreased satisfaction and a diminished sense of overall well-being. Third, pupils' academic performance may suffer if their basic psychological needs are not addressed. Their capacity to use self-directed learning techniques and assume accountability for their education may be

hampered by a lack of autonomy. Academic accomplishment, perseverance, and self-efficacy can all suffer from a lack of competence. Furthermore, a lack of relatedness might result in a weakened sense of cooperation and belonging, which has an effect on group learning and academic success. Thus, in order to foster students' motivation, well-being, and academic performance, educators and institutions must encourage students' autonomy, competence, and connectivity. Students' engagement, satisfaction, and general learning results can all be improved by establishing a welcoming and inclusive learning environment that supports these requirements.

The Basic Types of Motivation

SDT categorizes human motivation into three divisions: intrinsic motivation (the action due to enjoyment, challenge, or aesthetic pleasure from the activity), extrinsic motivation (the action due to specific outcome related to activity but not about the nature of the activity), and amotivation (lack of intention to perform an action). Extrinsic motivation can be even classified into four domains: integrated regulation, identified regulation, introjected regulation, and external regulation.

Chen and Jang (2010) stated that the aforementioned forms of motivation are positioned along a spectrum of self-determination. Amotivation is the least self-determined form of motivation, whereas intrinsic motivation is the most self-determined form of motivation. Based on SDT, motivation that is closer to the self-determined end of the spectrum, such as intrinsic motivation and identified regulation, can lead to more favourable results. Motivation that is less or not self-determined, such as amotivation, external regulation, and introjected regulation, may lead to more unfavourable outcomes (Deci & Ryan, 1991). Connell and Ryan (1985) devised a method to compute the "relative autonomy index, RAI," which is a single score that takes into account the many forms of motivation to

measure an individual's level of self-determination, based on the weighted sum of the scores on the self-determination continuum.

Chen and Jang (2010) further mentioned that contextual support is a fundamental idea in self-determination theory. People assimilate "nutrients" from social interactions that offer assistance in achieving autonomy, competence, and relatedness, which are the fundamental requirements. Once individuals have their basic needs met, they have a greater sense of confidence and self-control, leading to improved psychological well-being. Several indicators indicate that SDT is a suitable framework for handling motivation in the e-learning environment. SDT can function as a theoretical framework that consolidates several aspects of e-learning. The self-determination hypothesis examines autonomy, relatedness, and competency as factors that influence motivation. These three factors include fundamental features of e-learning, including adaptable learning (Moore, 1993) and the challenges of obtaining technical skills (Howland and Moore, 2002). Contextual support is especially useful for online learners, who require multiple types of assistance from educators, fellow students, administrative personnel, and technological assistance staff (Mills, 2003; Tait, 2000; Tait, 2003). Previous empirical studies have demonstrated that self-determination theory accurately forecasts a range of learning results, including as academic success, perseverance, and overall satisfaction with a course (Deci & Ryan, 1985, as reviewed). The use of self-determination theory has the capacity to address educational challenges, such as student dropout rates, within the context of e-learning.

Chen and Jang (2010) stated that another benefit of SDT is its ability to offer prescriptions for enhancing motivation, in addition to describing the process of people' motivation. Research based on the self-determination theory has revealed ways that promote personal motivation and self-determination. A study was done by Reeve and Jang (2006) that they confirmed the effectiveness of eight specific behaviours exhibited by teachers that

support autonomy. These behaviours include allowing students to make choices, providing reasons for decisions, and giving informative feedback. According to the study, these actions raised students' opinions of their own agency, engagement, and accomplishment. E-learning environments are just one of the many educational contexts in which SDT-based solutions can be applied.

Motivation is no longer seen as an independent characteristic that may account for an individual's willingness to act or learn, according to Järvelä (2001). Rather, Järvelä (2001) views it as a "reflection of the social and cultural context." The self-determination theory seeks to clarify how human wants, motivation, and well-being interact within the confines of one's immediate social environment. Researchers can examine how contextual factors, including social interactions or teacher behaviour, affect online learners' motivation by examining how the SDT paradigm works. The SDT framework makes it easier for educators and curriculum designers to find better ways to serve students who are learning online.

1.2 Aim of the study

The aim of this applied experimental research is to investigate the influence of needs-satisfying teaching approaches based on SDT on Hong Kong secondary school students' motivation of using Science e-learning tool, specifically focusing on competence, autonomy, and relatedness needs. The purpose of the study is to raise the science teachers' awareness on students' needs satisfaction on using science e-learning tool. I hope that the needs-satisfying teaching approaches could be promoted to the Hong Kong Science teachers if students' motivation of using Science e-learning tool could really be enhanced by the e-learning needs-satisfying teaching approaches.

1.3 Objectives

I. By applying an experimental teaching interventions, with taking Physics and Chemistry topics at the junior secondary level as a context, this study aims to

investigate whether the needs-satisfying teaching approaches in e-learning would influence the satisfaction of students' basic psychological needs, i.e. their perceived competence, their perceived autonomy and their perceived relatedness (C, A, R).

II. With implementing the needs-satisfying teaching approaches in e-learning, this study would like to further investigate whether the satisfaction of students' basic psychological needs would influence the students' motivation on using the Science e-learning tool (MSE).

III. With implementing the needs-satisfying teaching approaches in e-learning, this study would like to further investigate whether the satisfaction of students' basic psychological needs would further influence students' motivation on using the e-learning tool (ME) and the motivation on learning Science (MS).

1.4 Significance and potential impact of the research

The proposed research on needs-satisfying teaching approaches to e-learning in Hong Kong, specifically based on Self-Determination Theory (SDT), has significant and profound implications, both in theory and practice. The COVID-19 pandemic has radically changed the education system, requiring an in-depth understanding of how to optimize e-learning to improve students' motivation and engagement in the online environment.

The research has theoretical value as it contributes to the field of educational psychology and motivation theory, specifically by examining it from the perspective of Self-Determination Theory (SDT). The study aims to deepen the understanding of the role of psychological needs for competence, autonomy, and relatedness in the context of e-learning by examining how needs-satisfying teaching approaches affect the intrinsic motivation of secondary school students in Hong Kong. This study enriches current motivational theories, such as Self-Determination Theory (SDT), and applies them to the specific challenges presented by technology-integrated educational settings. The study intends to theoretically

examine the aspects that either enhance or impede students' motivation in the context of e-learning. This project would also differentiate the effect of need-satisfying teaching methods on motivation on e-learning and the subject content. One ambiguity in existing research was whether need satisfaction would impact either e-learning only or the interest in the subject matter as well. The current project aimed to disentangle this ambiguity.

The research effectively addresses a critical gap in present educational methods, especially in the aftermath of the pandemic, where e-learning persists as a substantial instruction method. The study would have multiple practical impacts. After the study, we can further evaluate the influence of the sudden shift to online education within the COVID-19 pandemic on the motivation levels of secondary school students in Hong Kong. Gaining insight into the difficulties encountered by students during this period of transformation is essential for developing successful solutions.

Additionally, the study may be able to discover the obstacles encountered in the acceptance of e-learning, specifically examining the challenges that educators encounter in addressing students' psychological needs, including competence, autonomy, and relatedness. This research can provide educational institutions and policymakers with valuable insights on the specific areas that necessitate attention and enhancement in order to guarantee a more efficient and captivating e-learning experience.

Moreover, the study seeks to offer practical insights for educators and instructional designers by examining the effects of teaching methods based on SDT. The results could inform the development of instructional techniques that amplify students' intrinsic motivation and engagement in online education. This is especially crucial considering the documented dissatisfaction and anxiety encountered by students after the sudden shift to online education.

Another noteworthy practical contribution is the development and implementation of experimental interventions in the field of e-learning at the junior secondary level. By

applying the principles of SDT, educators can systematically investigate how to meet students' psychological requirements and promote motivation in e-learning through focused interventions. The use of experimental method would also increase the causal inference between those specific e-learning lecture strategies and students' motivational outcomes.

The evaluation of the developed model, which proposes a connection between teaching approaches that meet students' needs and the motivation of secondary school students in Hong Kong to participate in e-learning. This research, utilizing both quantitative data from surveys and in-depth qualitative data from personal interviews, has the capacity to provide empirically-supported recommendations for educators and policymakers and overcome the reliance of quantitative data from existing research

In summary, the research holds significant relevance both in terms of theory and practical application. Theoretical findings from this study have the potential to enhance the field of educational psychology by deepening the understanding of motivational elements in the realm of e-learning. Practically, the research findings can directly influence educational practices by offering direction to educators, institutions, and legislators on how to improve e-learning environments to address students' psychological needs and boost their motivation in the post-pandemic period.

1.5 Further Recent Findings of the Application of SDT on Online Courses

Filak & Nicolini (2018) examines the impact of course modality (online vs. face-to-face) on motivation and need satisfaction in college students using self-determination theory. Surveys of 240 college students revealed that online courses led to lower levels of quality motivation, autonomy support, competence, and relatedness compared to face-to-face courses. The study emphasizes the importance of addressing students' psychological needs for autonomy, competence, and relatedness to enhance course and instructor evaluations in both modalities. Online courses result in lower levels of quality motivation, autonomy,

competence, and relatedness compared to face-to-face courses. Higher quality motivation positively predicts need satisfaction in both course modalities. Autonomy, competence, and relatedness impact course and instructor evaluations differently in online and face-to-face courses. Addressing students' psychological needs for autonomy, competence, and relatedness is crucial for improving course and instructor evaluations in both modalities. Meanwhile, Understanding motivation and need satisfaction is essential for enhancing student experiences and success in online courses.

Activities aligning with learners' personal goals, aspirations, and interests

The research by Hartnett, George & Dron (2011) explores motivation in online distance learning environments using self-determination theory. It reveals that online learners have complex motivations influenced by external needs, perceived relevance, and interest in the task. The study emphasizes the need to consider diverse motivations in technology-mediated environments. They mentioned that online learners exhibit multifaceted motivations sensitive to situational conditions. Motivation in online learning environments is not solely intrinsic but influenced by external factors. The study used case-study methodology to explore motivation in two online courses, revealing a diverse range of motivations among participants. Participants in online courses reported varying levels of amotivation, external regulation, identified regulation, and intrinsic motivation. In case study TWO, participants showed higher levels of identified regulation and intrinsic motivation compared to case study ONE. Educators are encouraged to enhance motivation by designing activities that align with learners' personal goals, aspirations, and interests. Meanwhile, the relevance and value of the lesson activities need to be clearly stated and related to learning objectives. The perceived worth of the activity is further increased when learners are given meaningful choices, but not just option choices. Educators may better monitor and give feedback to the situational factors

otherwise the learners' motivation maybe undermined. Having regular, continuous conversation with learners and allow them to have open discussion in an honest way.

Effective self-regulated learning strategies in online learning activity

Papamitsiou and Economides (2019) investigates the relationship between self-regulated learning strategies and autonomous learning capacity using learning analytics. Results show that goal-setting and time-management positively impact autonomous control, while help-seeking has a negative effect. The study suggests implications for designing online learning environments by emphasizing the importance of self-regulated learning strategies in developing autonomous learning capacity. Educators should design the online learning activities with autonomous choices to guide the learners for finding effective self-regulated learning strategies.

Children's need satisfaction in daily real life influences the internet use

Shen, Liu & Wang (2013) explores the relationship between children's need satisfaction perceived online and in daily life with their Internet use and affect. It found that need satisfaction online predicted higher internet use and positive affect, while need satisfaction in daily life predicted less time online and more positive affect. Children's social backgrounds and Internet experiences also play a role in their Internet use outcomes. Enhancing daily psychological need satisfaction can help promote healthy Internet use among children. Self-determination theory applies in explaining children's Internet use motivations. SDT helps in understanding children's Internet use motivations by highlighting the importance of need satisfaction in online and daily life. Promoting appropriate Internet use is important for children's well-being and healthy development. Kids who experience less satisfaction in their everyday lives may be more likely to spend more time online because their requirements for relatedness, competence, and autonomy are more urgent. Reduced satisfaction with daily basic needs suggests that these kids have less possibilities to

get what they need on a daily basis. These kids use the internet more because it becomes more essential to them. Children's need for autonomy can be supported by taking into account what they think, recognizing their emotions, providing opportunities for choice, and promoting self-initiation (Baard et al., 2004). Children's need for competence can be met by giving them tasks that are optimally challenging to their ability and encouraging comments on their performance. Children's sense of belonging in families and schools can be improved by spending more time with them and supporting their connections with peers, which satisfies their need for relatedness.

Students' need satisfaction online and in daily life predicted their well-being

Wang and his colleagues (Wang at al., 2015) examines the impact of psychological need satisfaction perceived online on well-being, with a focus on the moderating role of psychological need satisfaction in daily life. The findings indicate that both online and daily life need satisfaction are positively linked to psychological well-being. Moreover, daily life need satisfaction moderates the relationship between online need satisfaction and well-being, suggesting that higher daily life satisfaction enhances the effect of online satisfaction on well-being. This study underscores the importance of evaluating need satisfaction in various contexts to comprehend its influence on well-being. Students who believe they are not meeting their basic needs in their daily lives are more inclined to take the online environment as a new social universe and utilize the internet as a tool for socio-affective expression.

Creating valuable, interesting and learner-centred online courses to motivate students

Yang and his colleagues (Yang et al., 2011) discovered that gender, team learning orientation, and sense of classroom community all impact student effort in online versus face-to-face courses. Male students exert more effort in online courses, while female students put in more effort in face-to-face courses. The value and interest component of sense of classroom community strongly predicts effort in both course formats. Team learning

orientation positively influences student effort in both online and face-to-face courses. Instructional differentiation is crucial in distance education programs to address gender differences and promote student effort. Instructors can focus on creating valuable and interesting online courses to motivate students, especially females, to put in more effort in distance education programs. Instructional differentiation is crucial to address gender differences and promote student effort in online and face-to-face courses, highlighting the need for tailored approaches to enhance student engagement.

Zhou (2016) examines Chinese university students' acceptance of Massive Open Online Courses (MOOCs) using the Theory of Planned Behaviour and Self-Determination Theory. It finds that attitude towards MOOCs and perceived behavioural control significantly influence intention to use them. Autonomous motivation positively impacts intention, attitudes, and perceived behavioural control, while controlled motivation has mixed effects. Autonomy is crucial in student decision-making regarding MOOCs. Autonomy and relatedness are important in enhancing student motivation and engagement with MOOCs, suggesting positive social relationships can enhance autonomous motivation. The findings suggest that institutions should adopt learner-centred approaches, clarify course requirements, and provide support to enhance student engagement in online education programs like MOOCs.

Chapter 2: Literature Review

2.1 Previous Studies

Although there is no appreciable difference in academic achievement between traditional and online classroom settings, preliminary research indicates that students taking online courses reported significantly lower levels of satisfaction in various areas when compared to students in traditional classrooms. Many obstacles may stand in the way of pupils' successful learning. The primary concern is how effective e-learning is. This prompted research into the particulars of various elements of e-learning and the motivations behind them (Summers, Waigandt, & Whittaker, 2005). Broadbent and Poon (2015) reviewed ten years' worth of studies on self-regulatory learning strategies in the online setting and found a number of parameters linked to academic achievement in online higher education.

These factors included active engagement and participation, technological proficiency, motivation and self-efficacy, support and interaction with instructors, self-regulation and access to resources, etc. These factors are highly related to the scope of satisfaction, competence, intrinsic motivation, relatedness and autonomy. The common and critical issue of a large number of students dropping out is the main worry when it comes to online courses (Chen & Jang, 2010). According to Sun et al. (2019), learning obstacles are a major problem that contributes to the generally low completion rate of MOOCs (Kennedy, 2014). Hew and Cheung (2014) carried out a thorough review of the literature on the main drivers and difficulties of MOOC use. Their research showed that a sizable percentage of participants, up to 90%, quit the course due to a lack of incentives, a misinterpretation of the material, and inadequate support.

Significant concerns are associated with the implementation and utilization of the educational information system. A comparison between the connectivism and traditional pedagogical approaches in MOOCs revealed that they employ distinct methodologies and

instructional techniques, resulting in the attraction of dissimilar audiences (Kennedy, 2014). Consequently, the issues associated with the captioned models vary. Salikhova and colleagues (Salikhova, Lynch & Salikhova, 2020) further defined the term "c-MOOC" refers to a social, distributed, and networked approach to education, which emphasizes student autonomy. The statement by Kop (2011) prompts inquiries on the extent of learner autonomy, presence, and critical literacies necessary for active connectivist learning. By examining the increasing tensions among the components of connectivity that are seen essential for successful learning, as suggested by Tschofen and Mackness (2012), the authors posit that students may exhibit significant variations in their inclination towards and understanding of connectivity, autonomy, openness, and variety.

A number of new theories are emerging in response to the evolving dynamics of e-learning. A portion of these ideas were, at the very least, in line with SDT viewpoints. According to Tschofen and Mackness (2012), connectivism places a strong emphasis on important teaching ideas like relatedness and autonomy, which are also central to SDT (Ryan & Deci, 2017). Due to the critical role that self-regulation plays and the importance of both motivational quality and level in e-learning settings, researchers frequently concentrate on these concerns (de Barba, Kennedy & Ainley, 2016; Buhr, Daniels & Goegan, 2019). Furthermore, it has been noted that intrinsic motivation is very important when it comes to finishing a course (Barak, Watted & Haick, 2016). These advancements have led to the use of SDT in the research of e-learning (Ryan & Deci, 2017).

2.2 The Self-Determination Theory & The Three Basic Psychological Needs

According to SDT, student engagement in e-learning is crucial for its success if the e-learning is driven by intrinsic motivation (Chiu, 2021). Deci and Ryan (1985) contended that there are three basic psychological needs: autonomy, competence, and relatedness, which serve as the underlying and proactive motivation for pupils. The three needs proposed by

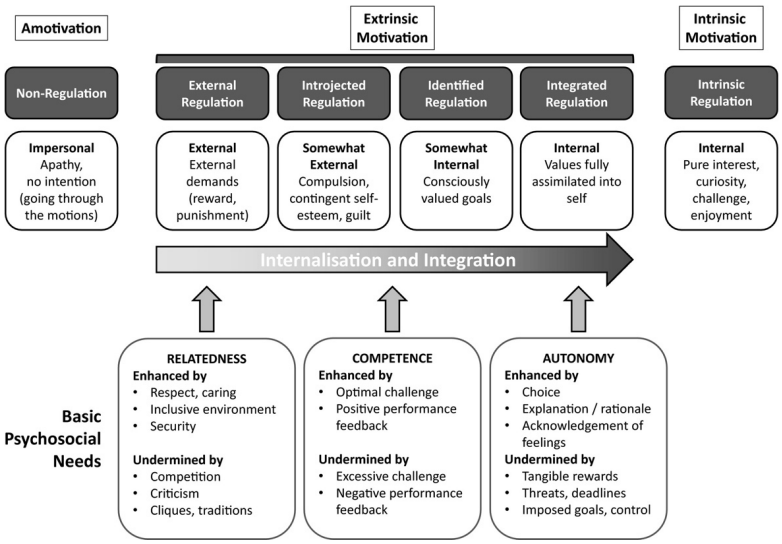
SDT have the potential to enhance students' interests and motivate them to participate in learning willingly rather than due to external pressure (Hornstra et al., 2018).

SDT suggests that humans possess an innate inclination towards curiosity and a desire to acquire knowledge and broaden their understanding (Chiu, 2021). Nevertheless, the educational setting frequently imposes external regulations that might weaken the teacher-student rapport and impede the innate voluntary processes essential for successful learning (Chiu, 2021). Extensive empirical research grounded on SDT indicates that intrinsic and autonomous types of extrinsic motivation play a significant role in fostering optimal engagement and achieving positive learning outcomes in educational environments. Consequently, SDT has substantial ramifications for classroom methodologies and policies about educational reform. This implies that the educational setting should cultivate intrinsic and more autonomous form of external motivation while also addressing students' basic psychological needs. By doing this, educators can establish captivating learning settings that foster ideal learning results, student welfare, and significant educational transformation (Fousiani et al., 2014).

Instead of focusing on the quantity of motivation, SDT concerns about the types and the quality of motivation. It emphasized that there are three basic psychological needs, competence, autonomy, and relatedness (C, A, R) and when these needs are fulfilled, students' learning motivation would be more internalized, shifting from the spectrum of extrinsic motivation to intrinsic motivation, a healthier form of motivation. SDT defined three zones of motivation: amotivation (complete lack of motivation), extrinsic motivation and intrinsic motivation. The shifting process from extrinsic to intrinsic motivation is labelled as internalization. Under these three zones, SDT further differentiated 6 forms of regulation (those dark colored grids in Figure 1).

Figure 1

Taxonomy of Motivation in SDT (Ryan & Deci, 2000)



Note. The internalization and integration are introduced.

Intrinsic motivation could be defined as an activity that is done for its own purpose, or for interest, enjoyment and internal satisfaction (Ryan, 2000). Intrinsic motivation, or intrinsic regulation, is a complete internalized motivation, which is produced from pure personal interest, personal curiosity, excitement on overcoming challenges and the enjoyment of the task nature. Playing, exploration and curiosity are the typical examples of intrinsically motivated behaviours, as these kinds of action are not relied on external incentives or pressure. Actions that are intrinsically motivated could provide the performer with satisfying and joyful feelings. At the other end, amotivation or non-regulation, is defined as inaction or action without any intention. Amotivation refers to a lack of motivation or the absence of intention and drive to engage in a particular behavior. It represents a state of disinterest, apathy, or a complete lack of motivation towards a specific activity or goal. The lack of both internal and external motivation could also be attributed by amotivation. People may become demotivated if they believe they have no control over their behavior if they feel incompetent or overburdened, or if they don't recognize the rationale or importance of an activity. It is frequently linked to emotions of disinterest, boredom, and disengagement from

the work at hand. Amotivation is the lowest level of motivation on the motivation continuum in the context of SDT. It is regarded as non-self-determined, indicating that people do not believe they have an intrinsic intention in the conduct or a choice in it. Since amotivation is linked to decreased levels of engagement, persistence, and general well-being, it is often regarded as a less desirable motivational state.

Extrinsic motivation is in between the zone of amotivation and intrinsic motivation. This zone consists of four regulation domains varying from external regulation to integrated regulation. External regulation could be defined as actions motivated purely by external rewards and external punishments. Introjected regulation is a type of extrinsic motivation that has been partially internalized, which could be defined as actions motivated by internal rewards (e.g., pride) and internal punishments (e.g., guilt or shame). Identified regulation could be defined as actions at a certain level of internal nature and based on conscious values and that which is personally important to the individual; however, the action is still not yet fully internalized to the self. Integrated regulation could be defined as actions with external values fully assimilated into self-values, this form of regulation looks very similar to intrinsic motivation.

The transition from external to integrated regulation requires internalization and integration. Internalization and integration could be enhanced by the satisfaction of the three basic psychological needs: relatedness, competence and autonomy. At the same time, Internalization and integration could be undermined by frustration or deprivation of these needs. The consequence of higher degree of internalization and integration would be higher enjoyment and achievement for a learner. In contrast, extrinsic incentives and punishments would lead to a lower-quality motivation and performance.

Autonomy, competence, and relatedness are the three basic psychological needs essential for optimal functioning and development in human beings. When these needs are

satisfied in a learning environment, for both online and face-to-face instruction, students will feel more intrinsically motivated toward learning. Below, I further elaborated on the definition of the three basic needs.

The need for autonomy is defined as the desire to take the initiative and regulate one's own behaviour. It is seen as a sense of initiative and possession for one's own actions (Ryan & Deci, 2020). Experiences of interest, meaning, and value of the action could increase the perceived feeling of autonomy. On the contrary, receiving external rewards and punishment could reduce the perceived feeling of autonomy. Autonomy support is defined as a personalized catering in which choices or options are offered. It takes the participants' perspectives into concern (Williams, Gagne´, Ryan, & Deci, 2002). Thus, when influential people like teachers, trainers or parents, provide autonomy-supportive, the recipients (i.e. the students) are more likely to become intrinsically motivated toward the activity. Inversely, if the influential people provided the learning activity with many restrictions, especially without clear rationale and choice, the participants are more likely to become extrinsically motivated or amotivated.

The need for relatedness refers to a sense of longing for belongingness and connection (Ryan & Deci, 2020). It is the perception of being connected to and supported by important people (Roca & Gagné, 2008). Respect, caring and harmonious social relationships could increase the perceived feeling of relatedness.

The need for competence can be regarded as a desire to control an outcome or to experience mastery. This concept is similar to Bandura's (1971, 1986, 1997, 2001) definition of self-efficacy which is the belief in one's capabilities to organize and execute the courses of action that are required to produce some given attainments. Deci & Ryan (2000) stated that the sense of self-efficacy is having the role similar to perceived competence. The perception of competence or self-efficacy could make a person feels that he or she can succeed and

grow. Positive constructive feedback, optimal challenges and opportunities for growth could satisfy the need for competence (Ryan & Deci, 2020).

2.2.1 Intrinsic and extrinsic motivations through SDT

The fundamental hypotheses of SDT in education stated that the increased levels of autonomous motivation will result in improved student engagement, learning, and well-being. Autonomous motivation reflects an individual's willingness and desire to engage in an activity based on personal enjoyment, inherent satisfaction, or a sense of personal importance. It is driven by internal factors such as personal goals, values, and interests, rather than external rewards or pressures. Autonomous motivation is associated with a range of positive outcomes, including enhanced performance, greater persistence, increased well-being, and more sustainable engagement in activities over time. When individuals feel autonomous and self-determined in their pursuits, they are more likely to experience a sense of fulfilment, satisfaction, and personal growth. Autonomous motivation is enhanced when parents and instructors provide psychological need support, but it is undermined when these needs are restricted. These ideas, which include all developmental phases (kindergarten through higher education education), a wide range of academic disciplines, and cultural contexts, have garnered a great deal of empirical evidence. Further discussion on this subject could come from a variety of disciplines, including science, math, and physical education. In a study done in physical education courses, Standage et al. (2006) discovered that students' autonomous motivation, enjoyment, and engagement in physical exercise were favourably predicted by teachers who supported their students' autonomy, competence, and relatedness requirements. In their investigation on the function of need support in scientific classes, Ratelle et al. (2007) discovered that students reported higher levels of autonomous motivation, interest, and greater academic achievement in science courses when teachers offered autonomy support. In a study conducted in math classes, Mouratidis et al. (2018)

discovered that autonomous motivation, engagement, and accomplishment in mathematics were positively predicted by teachers who fulfilled students' needs for autonomy, competence, and relatedness. In terms of cultural contexts, Chirkov et al. (2007) demonstrated that parental support for autonomy positively predicted adolescents' autonomous motivation and well-being in a variety of cultural conditions, including nine distinct cultural groups. Soenens et al. (2012) looked at how a sample of international students studying abroad was impacted by the need support in terms of autonomous motivation and adjustment. According to the study, international students' autonomous motivation and well-being while learning in a foreign cultural setting were positively impacted when they felt that their psychological needs were being satisfied.

There are numerous research findings that demonstrate a positive correlation between autonomous forms of motivation in the classroom and learning performance. This has been demonstrated in various studies, including Howard et al. (2017), Grolnick, Ryan, & Deci (1991), Guay, Ratelle, Roy & Litalien (2010), and others. This can be concluded as the greater engagement of students when they are autonomous (León, Núñez, & Liew, 2015). Furthermore, as motivation becomes more internalized, it becomes more integrated into the learner's identity. For example, Skinner, Saxton, Currie, and Shusterman (2017) have shown that fulfilment of basic needs leads to greater engagement and academic achievement in STEAM classes could lead to an enhanced sense of self-recognition to be a future scientist.

Furthermore, research has consistently demonstrated that providing assistance for individuals' basic psychological needs has a strong and positive impact on academic achievements. Research showed that pupils who were supervised by instructors who deliver more autonomy support tend to have stronger intrinsic motivation, self-confidence and perceived competence. The pupils are more likely to achieve higher scores, demonstrate greater internalization of learning activities, and have lower dropout rates compared to

students who are not exposed to such supportive teaching practices. During their study, Black and Deci (2000) found that college students majoring in STEM subjects who rated their lab instructors as more supportive of their autonomy had an increase in their motive to learn independently and their perception of their own competence. Additionally, these students obtained higher grades, even after taking into account their previous GPA and SAT scores. In another study, Manganelli et al. (2019) discovered that the autonomous motivation of college students was a strong predictor of higher academic performance, even after accounting for any prior learning advancement. In a pioneering study of the Spanish collegians, Núñez and León (2019) showed that the perceived autonomy support leads to an increase of learning engagement, which was influenced by autonomous motivation.

The evidence for the link between autonomy-support and more autonomous form of motivation was also found in higher educational settings. Williams, Saizow, Ross, and Deci (1997) discovered that the level of autonomy support provided by mentors to medical students had a significant impact on the choice of residencies made by the students. Sheldon and Krieger (2007) examined the progress of law students throughout their three-year academic program. Law students experienced a decrease in their overall fulfilment of basic psychological needs and well-being throughout this period. However, when students had professors who provided them with more autonomy and support, they saw a smaller decrease in their need fulfilment and overall well-being. Furthermore, individuals who were provided with greater autonomy assistance during their time in law school achieved higher grades, demonstrated superior performance on the bar exam, and reported a greater sense of autonomy in their work after graduation.

Reeve and Tseng (2011) investigated the probable biological factors involved in the impact of teaching that supports autonomy versus teaching that is controlling. The students were subjected to one of three circumstances in which teachers exhibited autonomy-

supportive, neutral, or controlling behaviours. Subsequently, they evaluated salivary cortisol levels, which serve as a reliable indicator of stress. Students who were subjected to a teacher who exerted control over them had higher levels of cortisol compared to those in a neutral environment. Conversely, students who experienced teaching that encouraged autonomy showed lower levels of cortisol compared to those in a neutral environment. On the other hand, Strebet et al. (2015) found that when kids were in learning contexts that valued social relatedness and autonomy support, they showed higher heart rates and emotional arousal, indicating enhanced involvement and energy mobilization. This was observed in settings such as kindergarten compared to schools, as well as voluntary workshops compared to regular lessons. The presence of a supportive environment can enhance the level of engagement associated with autonomous motivation, leading to more significant outcomes.

Ryan and Deci (2020) discovered that numerous research across diverse settings reveal advantages of need-supportive classroom climates in triggering more autonomous student motivation. In the context of SDT, considerable attention has been given to the precise components of enabling settings, a majority of which were originally discovered through experimental investigations (Ryan & Deci, 2017). The ingredients mostly pertain to the teacher's facilitation of autonomy support and structure. The provision of autonomy support is believed to enhance both autonomy and relatedness satisfactions, and when combined with structure, it also promotes competence.

Teachers that advocate for students' autonomy initially strive to comprehend, acknowledge, and, when feasible, be receptive to students' viewpoints. Additionally, they endeavour to offer students the chance to assume responsibility and proactively engage in their academic pursuits by presenting them with purposeful options and assignments that can captivate their interests. When they need something to be done, they offer a meaningful justification. They also provide alternatives to their students which can further enhance

autonomy. On the other hand, authoritarian teachers are primarily focused on exerting influence over pupils, compelling them to adopt specific thoughts, emotions, or behaviours, without taking into account the perspectives of the students.

SDT proposes that when students have the opportunity to make choices, they have a stronger feeling of ownership and independence, which leads to increased level of intrinsic motivation. Research by Bao & Lam (2008) and Reeve, Nix, & Hamm (2003) has corroborated this. According to Bao and Lam (2008), internalization may have been aided by socioemotional relatedness. The study's findings indicated that kids might still feel autonomous even in situations when they had no choices. Furthermore, as shown by Murayama et al. (2015), the process of making decisions might improve performance. Murayama et al. (2015) investigated how decision-making affected motivation and performance. The purpose of the trials was to investigate the effects of decision-making on different types of cognitive activities. The results of this study imply that decision-making can improve motivation and performance in cognitive activities. Giving people the freedom of making choices can boost their sense of control and ownership and eventually provide better results.

Furthermore, autonomy and choice might stimulate curiosity, especially in those with lower levels of autonomy (Schutte and Malouff, 2019). However, not every option is linked to a feeling of autonomy. Meaningless decisions can arise when individuals are presented with options they do not desire or when choices are influenced by subtle influences (Assor, Kaplan, & Roth, 2002; Moller, Deci, & Ryan, 2006). The subtle influences may refer to various factors that affect individuals' decision-making processes and reduce their sense of autonomy. These influences can impact the perceived meaningfulness and authenticity of the choices individuals make. Examples are limited options, pressure from others, social comparison. These factor could undermine individuals' sense of autonomy. On the contrary,

it is possible to experience a sense of autonomy even when there are no choices accessible, if one willingly acknowledges the significance or has a desire to engage in the existing course of action.

Ryan and Deci (2020) further discussed that a meta-analytic study done by Patall, Cooper, and Robinson (2008) supported the general SDT theory of a positive effect of choice on intrinsic motivation. Patall, Dent, Oyer, and Wynn (2013) demonstrated that teachers can enhance students' autonomy by considering their interests in addition to providing choices. When they do so, students are also likely to see themselves as more competent (Jang, Reeve, & Halusic, 2016). In a recent study conducted by Patall et al. (2019), a diary method was employed to investigate the impact of autonomy-supportive behaviours on students in science courses. The results revealed that when teachers exhibited behaviours such as giving choices to students, giving the background reason for a learning task or learning a knowledge, and concentrating on students' interests or inquires would make students reflected a higher rating of learning intention in the learning material. Tsai, Kunter, Lüdtke, Trautwein, and Ryan (2008) demonstrated that changes in student interest and motivation from one class to another were influenced by daily fluctuations in teachers' support for autonomy. Analysis using multi-level modelling across three subject areas indicated that when the instructor exhibited higher levels of autonomy support compared to their regular behaviours, pupils demonstrated increased levels of interest in the respective subject area.

Reeve and his colleagues have employed diverse empirical methods to discover specific features of the behaviours exhibited by teachers who support autonomy. Reeve, Bolt, and Cai (1999) initiated this study by evaluating instructors' self-reports of autonomy support as opposed to controlling. The teachers were then recorded while instructing, and their lessons were evaluated. Teachers who identified themselves as more autonomy supportive demonstrated behaviours such as active listening, responsiveness to student questions,

prioritizing student interests, refraining from providing direct answers, minimizing the use of directives, offering support for student initiatives, and displaying a greater understanding of students' perspectives. Reeve and Jang (2006) identified certain instructor behaviours that either supported or undermined autonomy. They then examined how these observed behaviours were related to the motivation reported by students. The results demonstrated positive correlations between eight teacher behaviours classified as autonomy supportive and students' autonomous motivation. These behaviours included actively collection of reflection from students, giving them enough time for independent learning task, giving them sufficient chance to express themselves, recognizing their improvement and the understanding of knowledge, encouraging them, giving them helpful hints when they encounter difficulties, responding to inquiries and questions, and acknowledging their points of view.

Teacher activities that might be classified as controlling, such as dominating the learning process and resources, prescribing answers for students, issuing commands, and using terms that impose control, such as "should" and "must"," were found to have a negative correlation with students' autonomous motivation. In addition, Assor, Kaplan, Kanat-Maymon, and Roth (2005) demonstrated that the use of strict disciplinary and high level of controlling behaviours adopted by Israeli teachers was associated with a reduced feeling of student autonomy. Ryan and Deci (2020) found that, in a previous study, Liu, Bartholomew, and Chung (2017) employed multilevel growth modelling to demonstrate a correlation between heightened perceptions of controlling teaching and an increase in need frustration throughout the academic year. This, in turn, was found to be associated with decreased autonomous motivation and heightened fear of failure, contingent self-worth, and avoidance of challenges. Need frustration acted as a mediator between these complexities, and the mediation was supported by indirect effects. The complexities lie in the correlations between increased perceptions of controlling instructions and the consequences of reduced

autonomous motivation, increased anxiety about failing, reduced self-esteem, and avoiding of facing challenges.

SDT distinguishes between the ideas of structure and control quite clearly. Most effective parenting and teaching approaches, according to SDT, provision of structure as well as autonomy support. Numerous searches, including those by Grolnick et al. (2014), Grolnick and Ryan (1989), and Jang, Reeve, and Deci (2010), support this point of view. In contrast to controlling behaviours that put pressure on students to squeeze in or perform well, structure involves creating clear expectations and goals, maintaining consistent rules and regulations, providing useful resources for student engagement, and providing positive feedback on performance. An effective structure provides a framework for learning, minimizing the occurrence of suboptimal difficulties and promoting positive feedback and support for effectiveness. Empirical research has shown that when teachers provide a high level of autonomy support and structure, it leads to increased autonomous motivation (both intrinsic and identified), more utilization of self-regulated learning mechanisms, and less anxiety (Hardré & Reeve, 2003; Vansteenkiste et al., 2012). Ryan and Deci (2020) agreed that the impact of structure on competence satisfaction can be significantly enhanced, but its effectiveness is contingent upon the manner in which it is administered (Soenens & Vansteenkiste, 2010). Structure can be implemented through either controlling or autonomy-supportive methods. SDT implies that high levels of both autonomy-support and provision of structure allow higher internalization and competence in both school and home settings.

Janget et al. (2010) conducted a study on teacher autonomy support and structure in U.S. high schools. They discovered that the level of autonomy support and structure provided by instructors, as evaluated by observers, had a significant impact on students' engagement. Additionally, students' own assessment of autonomy support also had a role in predicting their level of engagement. Farkas and Grolnick (2010) shown that the way parents organize

and provide support influenced both the perceived competence and autonomy of children in 7th and 8th grades.

Ryan and Deci (2020) discovered that it is possible to accurately evaluate and apply various combinations of autonomy-support and structure, as well as their opposites of control and chaos, to predict classroom learning outcomes. In 2019, Aelterman et al. (2019) collected self-reports from over a thousand secondary school teachers and pupils in Belgium. They used the Situations-in-School Questionnaire, which is based on vignettes, and performed multidimensional scaling analysis to the data. The results showed that instructional strategies might be grouped into a two-dimensional structure that creates a circumplex with eight subdivisions. These subdivisions are abandoning and waiting, demanding and domineering, guiding and clarifying, and participatory and attuning. These subdivisions' associations with many outcome factors followed the predicted sinusoidal pattern. These findings emphasize that promoting autonomy does not involve being permissive, but rather assisting in stimulating students' motivation to participate in learning through well-structured learning environments and activities. Research on identifying the precise behaviours that promote autonomy, competence, and relatedness in classrooms is actively ongoing in the field of Self-Determination Theory (SDT). Numerous studies have been conducted using direct classroom observations to investigate this topic, such as the works of Haerens et al. (2013), Rogat, Witham, and Chinn (2014), and Wallace, Sung, and Williams (2014). It is worth mentioning that when teachers provide autonomy support, they usually also support students' other basic psychological needs, such as competence and relatedness. Indeed, it is logical that when teachers are supportive of students' autonomy, they become more aware of their viewpoints. This will also enable the students to be more sensitive to their relatedness and competency needs. The needs for relatedness and competency could become normal habits which is likely to be exhibited in the class.

2.2.2 Antecedents of teaching styles and online-based interventions for motivation

Conesa et al. (2023) defined that the 'autonomy-supportive' and 'structured' methods are regarded as motivational, whereas the 'controlling' and 'chaotic' styles are seen as demotivating, since students perceive the teacher's intrusion or neglect, leading to feelings of inadequacy, incompetence, and insignificance. Recent studies have found that when teachers adopt teaching styles that promote autonomy and structure, it has positive effects on their students' satisfaction of basic psychological needs, autonomous motivation, engagement, and achievement. On the other hand, controlling and chaotic teaching styles can have negative consequences. Conesa et al. (2023) further agreed the above finding are well supported by the researches done by Cheon & Reeve (2015), Collie, Granziera, & Martin (2019), Jang et al. (2016), Reeve & Cheon (2021), and Reeve, Ryan, Cheon, Matos, & Kaplan (2022). When teachers effectively attend to the psychological needs of their students, the students cultivate autonomous motivation, which arises from within and is driven by enjoyment and personal value. This is in contrast to controlled motivation, which is characterized by feelings of guilt or a desire for rewards. Furthermore, students engage in their learning activities more actively (Cheon et al., 2012; Vansteenkiste et al., 2005). According to Christenson, Wylie, and Reschly (2012), student engagement is a complex concept that includes the degree to which students actively participate in a learning task, independent of their interest in the learning opportunities that the teacher provides. Scholars have observed that this kind of engagement might be characterized as agentic, implying that people actively improve their own learning environments by expressing their interests and offering suggestions (Patall et al., 2019; Reeve, 2013; Reeve et al., 2021). Student agency engagement can yield various educational advantages, including: (a) fostering a supportive learning environment where students feel secure to voice their thoughts and express their preferences, thereby influencing the teacher's interactions with them (Matos, Reeve, Herrera, & Claux, 2018; Patall et al., 2018, 2019); (b)

enhancing perceived motivational satisfaction by catering to their curiosity, nurturing their interests, and attaining personal goals (Patall et al., 2019, 2022; Reeve, Cheon, & Yu, 2020); (c) promoting effective functioning by assuming control over their learning, consequently leading to higher academic achievement (Patall et al., 2019; Reeve, 2013; Reeve, Cheon, & Jang, 2020).

When examining instructors' preferences for adopting a motivating or demotivating style, researchers have explicitly looked at socio-contextual factors (Pelletier et al., 2002; Pelletier & Sharp, 2009). Nevertheless, there isn't much data to investigate the particular personal characteristics of educators that matter in determining their motivational approaches. These characteristics included the occurrence of burnout (Moè & Katz, 2020; Soenens et al., 2012) and the satisfaction of teachers' own basic psychological needs (Aelterman et al., 2019; Roth, Assor, Kanat-Maymon, & Kaplan, 2007). Numerous research in the field of SDT has shown that demotivating teaching approach in the classroom may be the result of burnout found on teachers (Aelterman et al., 2019; Jennings, 2015; Moè & Katz, 2020; Soenens et al., 2012). The burnout idea that Maslach (2003) put forward is still highly recognized by the research field. The idea states that burnout is defined as a persistently negative emotional state that includes intense fatigue, psychological distress, isolation from other people, and a sense of lacking individual accomplishment. Burnout's main component, emotional exhaustion, is a state of being too tired to go on and is marked by intense fatigue. A state of indifference or insensitivity towards one's professional responsibilities is known as depersonalization. Lack of individual accomplishment is linked to the professional's perception of their own capability to overcome challenges at work, which can result in feelings of dissatisfaction incompetency, and low esteem.

2.3 Technology Pedagogical Content Knowledge (TPACK) model

Shulman (1986) stated that teacher training was mainly focusing on the content (C) and knowledge (K) of a subject. After certain years, the focus of teacher training started to shift to pedagogy (P), the method of delivering content and knowledge. Shulman (1986) further proposed that pedagogy (P), content (C) and knowledge (K) should be further integrated to provide high quality education instead of treating them as isolated elements. Researchers such as Hewson and Hewson (1988), Anderson and Mitchner (1994), Cochran, King and DeRuiter (1993) and two professional association (NSTA, 1999; NCATE, 1997) have all agreed the contribution of Shulman's PCK framework for teacher training and teacher professional development. In the early 2000s, when technology was more often added to teaching, Mishra & Koehler (2006) proposed that it is necessary to implement the Technology (T) element into the PCK framework, resulting in the construct TPACK (Technology, Pedagogy, and Content Knowledge). Mishra & Koehler (2006) stated that Technology had its unique influence. Technology would limit the representation of content and the decision of pedagogy. It is not suggested to consider technology as an isolated element out of the integration of pedagogy and content which many researchers agreed with that (Hughes, 2005; Keating & Evans, 2001; Lundeberg, Bergland, Klyczek, & Hoffman, 2003; Margerum-Leys & Marx, 2002; Neiss, 2005; Zhao, 2003). E-learning is not the conduction of teaching in an online context but also a synergy between technology, pedagogy and content knowledge (TPACK).

Despite being one of the key theories of e-learning, TPACK has its limitations. Firstly the definition of "technology" stated in the TPACK model was too board, as mentioned in Koehler & Mishra's study (2008, 2009). Even the blackboard and chalk were assumed as the technology which is not limited to education-oriented tools (Mishra & Koehler, 2006). Yet, many e-learning systems recently are implemented with certain amount of educational elements and pedagogical elements, such as Khan Academy. There are also many online

simulation in Science invented for educational purpose, like PHET simulation. Since many recent e-learning tools already implemented the content knowledge with the technology, the teachers could shift their focus to the teaching and motivational approaches, the learners' needs and their experience of need fulfilment, instead of only focusing on the content knowledge.

Secondly, the participants in the aforementioned TPACK studies were mainly teacher-learners (e.g., Koehler et al, 2014). Since teacher learners are relatively more independent and proactive in their learning task, the teacher learners could explore the knowledge independently. Teachers are more likely to share their finding to their group members actively. Yet, secondary school students may not be as independent as their teacher-learner counterparts. Therefore, it is unclear whether TPACK is a suitable model for understanding school-age students' motivation and their user experience of e-learning.

Lastly, TPACK is mainly designed for teacher training and teacher professional development (Koehler & Mishra, 2009). TPACK focuses on the integration of technology and the subject knowledge rather than on addressing learning needs and the relevant needs-satisfying teaching approaches.

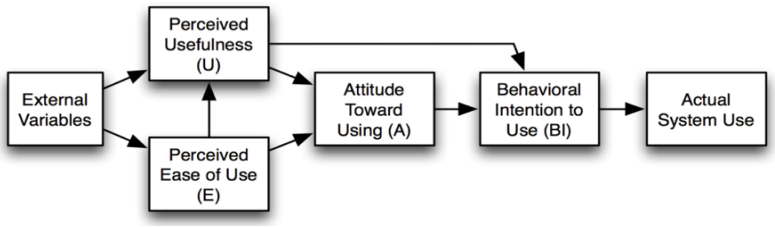
2.4 Technology Acceptance Model

While e-learning is getting popular, models have been proposed to understand factors that influence student's intention of using e-learning technology. One of them is "E-learning TAM", which is the upgraded version of the Technology Acceptance Model (TAM) in the E-learning domain, which is also known as TAM2 proposed by Venkatesh & Davis (2000). TAM has stated two core variables to describe user's intention to use a particular technology. These two variables are the perceived usefulness (PU) and the perceived ease of use (PEOU) of a technology. Davis (1989) defined the perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance". He

also defined perceived ease of use as "the degree to which a person believes that using a particular system would be free from effort". TAM stated that the higher degree of PU and PEOU would lead to higher user's attitude and behavioural intention to use the technology system (Davis, 1989). To give an example, a student would use a library search engine once they know that the search engine is useful to save their time to look for a book. The PU of the search engine is higher than searching by the index number of the book. Moreover, a student would tend to use a library search engine with simple interface rather than complex interface because they found that the former is easier to use. The PEOU of the simple interface is higher than the complex one. This theory is similar to the value-expectancy model developed by Eccles et al. (1983) which states that the value of a behaviour and the likelihood of achieving the behaviour are good predictors of the happening of the actual behaviour.

Figure 2

Technology Acceptance Model (Davis, 1989)



Note. The PU and PEOU are introduced.

There are several limitations found on the original version TAM. Firstly, TAM has followed a direct flow from the PU and PEOU to the intention to use. The flow did not focus on learner's feeling on the knowledge but only the focus on the feeling of technology usage. For studying the learning motivation on e-learning in Science, which required focusing on both Science subject knowledge and the technology usage intention, TAM is not sufficient to measure the factors related to the subject learning condition. Secondly, the e-learning TAM did not focus on the pedagogies and the teaching practice for the subject content, but only the focus on the configuration techniques of the technology. There is little discussion about

pedagogical method and how knowledge content can influence the whole e-learning process. TAM could only measure whether a student would use a technology system but not measure whether a high quality of learning and teaching of subject knowledge is implemented.

Since there are many common e-learning approaches, like Flipped Classroom, Gamification, SLAM, etc. Figure 3 shows the connection between TPACK and TAM that they have some critical elements that the other e-learning models do not have. For TPACK, some essential elements, like technology, subject content and pedagogy, are mentioned in the model, while some crucial elements, like intention and motivation are ignored. For TAM, some crucial elements like technology, intention and motivation, are included in the model, while elements, such as subject content and pedagogy are left out. It is still worthy to mention TAM since those essential elements could not be found in other common e-learning models.

Figure 3

Common elements found among the three theoretical models (TPACK, TAM and SDT)

TPACK	TAM	e-learning SDT & needs for C, A, R*
Technology involved	Technology involved	Technology involved
Subject content involved	Subject content ignored	Subject content is related to C*
Pedagogy involved	Pedagogy ignored	Teaching approaches involved
Intention ignored	Intention involved	Intention involved
Motivation ignored	Motivation involved	Motivation involved
For teacher training	For participant	Especially for learner & participant

*Note. *C = competence, A = autonomy, R = relatedness*

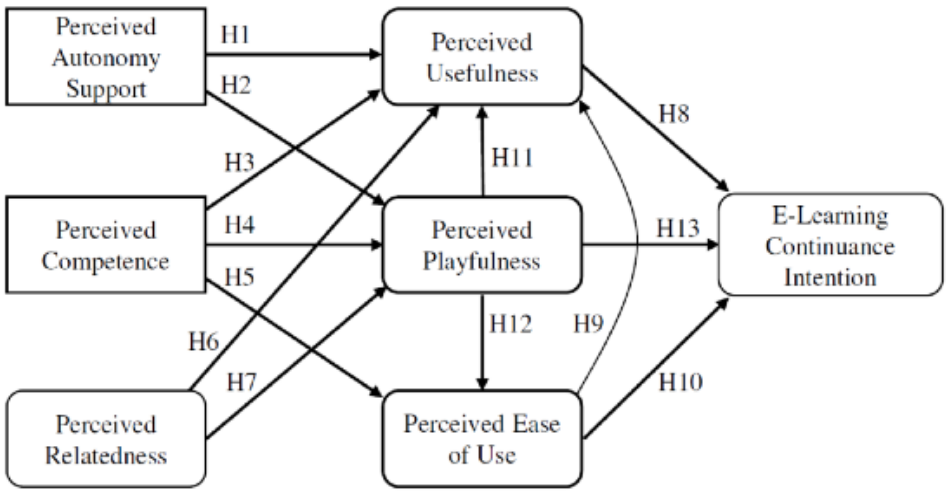
All 6 essential elements (technology, subject content, pedagogy, intention, motivation, and teacher training) are covered in previous SDT research. As a meta-theory, SDT provided a relatively complete explanation on learning motivation with concerns on technology, content and pedagogy.

2.5 Summary of theories and models about learning and e-learning motivation

In the following, I reviewed studies that have utilized SDT to understand the motivation in e-learning. SDT suggested that perceived competence alone is often not sufficient to predict intrinsic motivation without considering perceived autonomy. Roca and Gagné (2008) found all three basic needs in SDT as antecedents of PU, PEOU, and perceived playfulness, an additional factor that captures the level of enjoyment while using a particular technology. They utilized this new conceptual model to predict E-learning continuance intention as the outcome (see Figure 4). This showed that the combination of SDT and TAM are necessary to get a fuller picture of e-learning.

Figure 4

Conceptual model combining SDT with TAM (Roca and Gagné, 2008)



Similar to Roca and Gagné (2008), Sørebø et al. (2009) and Ho (2010) also applied SDT to understand online technology usage. Their main difference was that Roca and Gagné (2008) focused on adult workers, Sørebø and colleagues (2009) focused on teachers, and Ho (2010) focused on public online forum users. They were not focused on students' e-learning in particular. The design of Sørebø's conceptual model is approximately similar to Ho's one. Both models have made the "confirmation" and the "satisfaction" as the critical factors to influence the e-learning motivation. The main difference is that Ho has inserted an extra

factor “attitude” in his model which is visible from Sørebø’s one. Ho further developed the studies from Roca and Sørebø. He integrated the elements from 4 models, SDM, TAM, ECM & COGM. He made a model with higher complexity to predict all the essential factors relating to the e-learning motivation in a more detailed description.

Even though there are similarities found on the development of the conceptual models among different scholars, their finding could be quite different according to their models. In Sørebø et al.’s (2009) study, he found that the perceived e-learning competence was the most influential factors to affect the teachers’ intention of e-learning. He also found that perceived autonomy could produce a sense of unpressured willingness on the teachers to engage more in e-learning application in teaching. Surprisingly, Sørebø et al. (2009) pointed out that perceived competence is the most influential predictor for perceived usefulness (PU) while Roca pointed that perceived autonomy is the most influential predictor to PU. From Ho’s study (Ho, 2010), he agreed with Roca’s finding since his data also supported that the perceived autonomy is the most influential factor of PU. Therefore, I would propose that perhaps for different groups of participants, the need that would be the strongest predictors on different e-learning intention elements could be different.

There were other new attempts to understand some extra elements of motivation in e-learning through SDT model. For example, Chen and Jang (2010) attempted to find the connection between perceive competence, autonomy & relatedness and the different types of motivation, namely, External Regulation, Introjected Regulation, Identified Regulation & Integrated Regulation. Chen, Jang and Branch (2010) further found that perceived autonomy is the most influential factor for online students’ intrinsic motivation. Chen and colleagues further pointed out that perceived ability (competence) is the most significant predictor on amotivation and perceived affiliation (relatedness) is also critical factor affecting the

identified regulation, intrinsic motivation & amotivation. Nonetheless, all three needs are essential for the most optimal form of motivation.

In the field of SDT, Zhao et al. (2011) have done a meta-analysis with 17 high schools, including ten senior high schools and seven junior high schools in Xiangfan, with students mainly from low educated parental families. They have collected 3475 valid responses with the variation of the three basic needs as predictor variables. They have slightly shifted the e-learning intention to students' enjoyment and curiosity to use the internet and their related outcomes. Surprisingly, they found that perceived relatedness is the most significant predictor on high school students' intrinsic motivations to use the internet over the other two needs. High school students would feel more fun and more curious if their peers asked them to use the Internet together. Impact from peers showed a larger influence on intrinsic motivations than that from teachers and parents.

Finally, Chen (2014) has done an important experiment to test the level of understanding and sustained e-learning intention by implementing an adaptive scaffolding e-learning system with pre-test/post-test. Chen (2014) found that the group of students who received the adaptive scaffolding system were able to show better understanding and sustained motivation for learning. Inclusion, the adaptive scaffolding e-learning system is useful to gain conceptual knowledge and promoting inner motivation.

SDT has emerged as a highly significant motivational framework within the field of education. Teachers' interpersonal styles can vary in their level of support for students' basic psychological needs for autonomy, competence, and relatedness, as outlined by SDT principles. Autonomy is the state of being willing and free to carry out activities or acts, such as when pupils have the ability to choose their tasks (Ryan & Deci, 2006). The necessity for competence encompasses a sense of effectiveness in one's engagements with the surroundings (e.g., when students perceive themselves capable of proficiently completing the

tasks assigned by the teacher). Relatedness refers to the inclination to engage with others, showing concern for them and desiring to be understood by them. For example, students may develop a sense of attachment to their teacher or classmates when these important others care and listen to them.

Conversely, when the teaching approach is more authoritarian, educators adopt a mentality that places their own interests and viewpoints as the top priority, resulting in them exerting pressure on pupils to conform to specific behaviours, thoughts, or emotions. Teachers can exert pressure on students through various means, employing strategies such as external control methods like punishment, yelling, intimidation, and offering rewards based on certain conditions (Ryan, 1982; Deci, Koestner, & Ryan, 1999; De Meyer, Soenens, Aelterman, De Bourdeaudhuij, & Haerens, 2016). Conesa et al. (2023) further shared that those teachers may employ internal control strategies that elicit feelings of shame, anxiety, or guilt in students (De Meyer et al., 2016; Soenens, Sierens, Vansteenkiste, Dochy, & Goossens, 2012; Soenens & Vansteenkiste, 2010). Research has found that a teaching style that is more controlling is linked to increased frustration of students' basic psychological needs and a range of negative outcomes in the classroom, including boredom, anxiety, dependent self-esteem, avoidance of challenges, and fear of participation (Assor & Tal, 2012; Bartholomew et al., 2018; Jang et al., 2016). Furthermore, teachers that possess a controlling motivational style may encounter heightened levels of pressure, which can result in emotional and psychological tolls, as evidenced by an elevated prevalence of burnout syndrome (Fernet, Guay, Senécal, & Austin, 2012; Pelletier, Séguin-Lévesque, & Legault, 2002).

The structure-based teaching style refers to the manner in which teachers provide guidance and assistance to students in the classroom, emphasizing the importance of competence. This teaching style is characterized by an interpersonal tone and is recognized and actively endorsed by teachers (Aelterman et al., 2019). Teachers demonstrate support for

competence by engaging in various actions, such as clearly communicating expectations regarding students' tasks and functioning (Cheon, Reeve & Song, 2019). Conesa et al. (2023) agreed that they provide step-by-step guidance and offer feedback that prompts learners to reorganize their strategies, behaviors, and actions in order to meet these expectations (Sierens, Vansteenkiste, Goossens, Soenens, & Dochy, 2009; Jang, Reeve, & Deci, 2010; Aelterman, Vansteenkiste, Van den Berghe, De Meyer, & Haerens, 2014, 2019). Conesa et al. (2023) analysed these multiple empirical studies and discovered that teachers have the ability to adapt their behaviour and foster competence in the classroom, resulting in various advantages for their students (Aelterman et al., 2019; Carpentier & Mageau, 2013; Cheon, Reeve, & Vansteenkiste, 2020; Mouratidis, Michou, Aelterman, Haerens, & Vansteenkiste, 2018). Nevertheless, other studies have also reported a lack of impact (Eckes, Großmann, & Wilde, 2018; Guay, Valois, Falardeau, & Lessard, 2016; Jang et al., 2010). This outcome is probable because the structure must be designed to facilitate autonomy, which in turn assumes that teachers possess prior knowledge on how to support autonomy, thereby avoiding adopting a more controlling teaching style (Curran, Hill, & Niemiec, 2013; Reeve & Cheon, 2021).

To address this problem, several scholars have elaborated on the standards for teaching practices to provide a framework that encourages autonomy in a constructive way. Aelterman et al. (2019), Cheon, Reeve, and Song (2019), and Cheon et al. (2020), for instance, studied a method that seeks to encourage autonomy while also satisfying competence. The methods implemented to promote structure in an autonomy-supportive style include adopting features that support structure, as described by the seven instructional behaviours that support autonomy (Cheon et al., 2020; Cheon, Reeve, & Song, 2019). When introducing classroom rules, the teacher should consider the students' viewpoint. This can be done by asking the group about the rules they believe are important for enhancing our

coexistence in the classroom. Additionally, the teacher should provide a clear explanation for each rule, such as emphasizing the significance of using respectful language to create a welcoming and secure classroom environment. It is also important for the teacher to acknowledge any negative emotions expressed by the students, validating their concerns by saying "You are right." I acknowledge the inherent challenge in this situation, while also employing engaging language to encourage the generation of ideas for improvement. On the other hand, a disoriented teaching style is defined by a persistent condition of inaction, leniency, or disinterest in directing the teaching-learning process (Aelterman et al., 2019; Baumrind, 2012). In such instances, disorderly educators exhibit a laissez-faire demeanour and possess ambiguous standards.

2.6 E-learning growth and acceptance amid Covid-19

The utilization of e-learning has experienced a significant surge due to the COVID-19 pandemic. The implementation of lockdown and social distancing protocols in response to the COVID-19 epidemic has resulted in the shutdown of campuses and compelled colleges to adopt and embrace e-learning as a means of delivering education. He et al. (2023) analysed the multiple researches done by a list of scholars (Bao, 2020; Dhawan, 2020; Grey et al., 2020; Mailizar et al., 2021; Szopiński & Bachnik, 2022). These studies found that even though the frequent emphasis on its accessibility and adaptability in various sources, the overall effectiveness of e-learning remains uncertain. The success of e-learning is contingent not only upon the technological readiness (supply side) but also upon the students' real acceptance (demand side). Undoubtedly, the utilization of E-learning by college students is essential for it to have any purpose. Hence, it is imperative to reassess the efficacy of e-learning in terms of student receptiveness.

The acceptance of e-learning by students can be elucidated through the utilization of the technology acceptance model (TAM), in which perceived usefulness (PU) and perceived ease of use (PEOU) serve as two pivotal indicators of individual attitude and behavioural intention (Mailizar et al., 2021; Szopiński & Bachnik, 2022). Nevertheless, He et al. (2023) summarized the result of recent research on e-learning and it indicated that the TAM components might be additionally impacted by several external variables, such as subjective normal/social influence, fun, and computer anxiety (Abdullah & Ward, 2016; Baby & Kannammal, 2020). These studies primarily focus on the correlation between the educational aspect of e-learning and students' acceptance of e-learning. The research connected to COVID-19 emphasizes the need for e-learning to address negative emotions (Hu et al., 2022b, c).

The COVID-19 pandemic-related literature emphasizes the importance of including emotional factors in order to understand the mechanism of e-learning acceptance. He et al. (2023) further review the studies done by a list of researchers (Hu et al., 2022c; Pedrosa et al., 2020) and concluded that the acceptance of e-learning is influenced not only by educational elements but also by unpleasant emotions. These negative feelings, such as depression, anxiety, or distress, have a tendency to divert students' focus and hinder their attitudes towards e-learning. Conversely, e-learning can function as a channel for college students to seek emotional support, express emotions, and articulate fear. The provision of care, companionship, and solace will subsequently enhance students' attitudes towards e-learning (Hu et al., 2022b, c). Given this information, it is imperative to acknowledge the impact of emotional factors on students' acceptance of e-learning. While the epidemic will eventually come to an end, the bad emotions caused by external factors such as social alienation are expected to persist even after the pandemic is over (Apker, 2022; Szopiński & Bachnik, 2022). There is a requirement to investigate the influence of emotional elements in

order to have a more comprehensive understanding of the acceptance of e-learning (Hsu et al., 2018).

The influence of factors connected to education and emotions on the acceptance of e-learning can be examined individually by applying the theoretical framework of Social Support Theory (Cohen & Wills, 1985). E-learning, similar to social media platforms, can serve as a significant channel for the exchange of social support. In this context, university students have the opportunity to share not only academic knowledge and materials but also emotions such as empathy, love, and care. In considering this, it is important and exciting to look into how the provision of social support affects students' acceptance of e-learning. Perceived emotional support and perceived educational support are two dimensions that are established in this study using the social support theory. These theories show how college students' interest in engaging in online education can be impacted by technological and psychological factors, respectively. Perceived education support is defined as the provision of knowledge, guidance, and direct support for resolving problems within the structure of learning-related elements. It is developed from the social support theory's perceived information support and perceived instrumental support (Semmer et al., 2008). The influence of emotion-related factors is measured by perceived emotional support, which includes compassion, friendliness, encouragement, empathy, love, and esteem (Federici & Skaalvik, 2014).

Because of the COVID-19 pandemic's remarkable extent, significant influence, and sustained persistence, e-learning has had to be widely adopted. Universities all around the world, especially in China, were forced to quickly switch from traditional classroom instruction to distance learning via the internet (Bao, 2020). Many Information and Communications Technologies (ICTs) have been developed or enhanced to satisfy this need, like Tencent Meeting and Zoom. The three problems Dhawan (2020) identified for e-learning

are distance, scalability, and personalization. These factors have been successfully addressed by these ICTs. However, the COVID-19 pandemic's wide adoption of e-learning has brought significant challenges for this kind of teaching. Concerns regarding the readiness for e-learning have been expressed by numerous scholars (Rapanta et al., 2020; Scherer et al., 2021).

The concepts "distant learning," "e-learning," "web-based learning," "blended learning," and others can be linked to the phrase "e-learning." He et al. (2023) summarized the studies conducted by a list of scholars (Sun et al., 2008; Al-Fraihat et al., 2020) and considered together, represent the application of ICT to support education. As a whole, alternative educational paradigms typically provide two significant benefits. According to most authors, e-learning can facilitate remote access, hence enhancing educational chances (Moore & MacKenzie, 2020). He et al. (2023) also analysed another group of scientists and found that they argued e-learning revolutionizes the teaching-learning process by enhancing student-cantered and flexible learning (Dhawan, 2020). Hsu et al. (2012) suggested that e-learning has become the dominant standard in education due to its compelling advantages. However, the drawback of e-learning is significant. Many researchers express apprehension regarding the ability of e-learning to produce high-quality and impactful educational results (Szopiński & Bachnik, 2022). They contend that the lack of in-person social interactions in e-learning could hinder its educational efficacy (Luo et al., 2017).

In this study, the main focus is on the widespread and rapid adoption of ICTs to ensure that learning remains accessible and available during the COVID-19 pandemic. The e-learning notion employed in this study has subtle distinctions compared to that found in non-pandemic literature. In terms of preparedness for e-learning, the implementation of e-learning methods, such as MOOC, necessitates systematic preparation and advancement of ICT to ensure the provision of high-quality education (Szopiński & Bachnik, 2022). Amidst the

COVID-19 epidemic, courses were not originally prepared or structured for the sudden shift to e-learning (Carey, 2020). Furthermore, the implementation of e-learning necessitates the allocation of sufficient time and effort for the training and preparation of both students and teachers to effectively engage in online interactions (Cong, 2020). The rapid implementation of e-learning during the COVID-19 epidemic has placed significant stress on both educators and students. In terms of ICT appropriateness, e-learning has faced criticism for its inability to cultivate a sense of community (Luo et al., 2017) and stimulate social contact among students (Mpungose, 2020). Moreover, the detrimental effects of the lack of social interaction in e-learning are expected to be intensified by the COVID-19 pandemic. The absence of social interactions, combined with the mental health challenges resulting from being isolated at home (Hu et al., 2022a), can undermine the efficiency and calibre of e-learning.

Indeed, e-learning serves as a remedy for education during the COVID-19 crisis (Dhawan, 2020), primarily because it is one of the limited solutions available to ensure education remains accessible amidst rigorous quarantine measures, such as campus lockout and home isolation. After the epidemic, it is a good time to reassess the effectiveness of e-learning based on acceptance. A mixing version of Technology Acceptance Model (TAM) and SDT is introduced to examine students' usage of e-learning tool.

In addition, the literature has consistently emphasized the importance of addressing negative emotions that arise from the external environment, especially during the COVID-19 pandemic (Dhawan, 2020; Grey et al., 2020; Shensa et al., 2020; Szopiński & Bachnik, 2022; Yao et al., 2021). However, there is limited research (Hsu et al., 2018; Weng et al., 2015) that explores the connection between social support and e-learning, specifically in relation to how e-learning can help address negative emotions. However, both research emphasized the necessity of integrating social support theory into the TAM model in order to more accurately

uncover the acceptance of e-learning. However, neither study investigates the direct impact of emotional support or social support on e-learning.

Social support, as described in the literature, refers to the aid and safeguarding provided to individuals, protecting them from challenging circumstances and negative consequences (Wortman & Dunkel-Schetter, 1987). It can be broadly defined as the resources or assistance that are traded (Cohen & Hoberman, 1983). Support is widely recognized as an essential safety net for well-being and a major booster for mental health, even in the absence of an association with problem solving (Cobb, 1976; Hu et al., 2022a; Lin et al., 2015). In the past, social support studies focused on how individuals behaved with each other in their personal relationships (Cohen & Hoberman, 1983). The online environment has been considered in this research more recently (Liu & Ma, 2020; Yao et al., 2021). Through the development of a collaborative support network, the online community provides an alternate atmosphere for social interaction and communication. By reducing negative emotions, this can help people in the community become more resilient to mental stress (Cobb, 1976; Marzouki et al., 2021).

The importance of social support in the online community has been emphasized in literature (Yan & Tan, 2014; Yao et al., 2021). In the specific context of e-learning, there is limited and irregular discussion on this topic (Hsu et al., 2018; Weng et al., 2015). Weng et al. (2015) explored the impact of different kinds of social support, including peers, supervisors, and family, in order to highlight the importance of social support in the acceptance of e-learning. In a different study, Hsu et al. (2018) proposed that social support increases people's psychological resilience to pressure, challenges, and failures. This enhances learners' learning experiences and results in better cognitive processes. Nevertheless, both studies considered social support as a general phrase without particularly

analysing the effects of each unique kind of social support, even though their findings revealed that perceived social support can affect the acceptance of e-learning.

The concept of social support can be diverse and complicated, as explained by Lin et al. (2015). Numerous scholars have proposed different categories for social support, including Cohen (1985) and House (1983). Informational, emotional, instrumental, and appraisal support are the four main categories into which House (1983) classified social support. An alternative viewpoint on social support was offered by Cohen and Syme (1985), who proposed a four-dimensional framework that includes esteem support, instrumental support, social companionship, and informational support.

Educational support refers to the concrete aid given to students to help them achieve specific tasks and handle learning difficulties in a course. This assistance might come from teachers or fellow students who share course materials. Efficient educational assistance enhances students' ability to resolve academic challenges, thereby enhancing their perception of the ease of utilization. In addition, when students perceive a feeling of educational assistance (such as teachers providing explanations for problems), they are more inclined to actively participate in their studies and appreciate them, thereby becoming self-regulated (Federici & Skaalvik, 2014). Hence, it is well acknowledged that providing educational help can have a good impact on academic achievement.

Emotional support involves offering empathy, friendliness, encouragement, esteem, love, and compassion (Federici & Skaalvik, 2014). It is not specifically aimed at addressing the course concerns, but rather at alleviating stress and other unpleasant experiences during e-learning. Efficient emotional support can reduce the cognitive work required to deal with unpleasant emotions, leading to less challenges in adjusting to e-learning. The reason for this is because addressing negative emotions requires less mental work, allowing more mental resources to be dedicated towards adjusting to e-learning (Porumbescu et al., 2017).

2.7 Needs-based criticism of performance goals, grading, and high-stakes testing

The motivation and performance of both teachers and learners can be influenced by several structural elements in classrooms and educational institutions, such as class size and mandated curricula. These factors can have both intentional and unforeseen effects. Detrimental elements on instructors and children include an undue focus on grades, performance objectives, and the stress induced by high-stakes assessments. One of the most prevalent characteristics found in classrooms worldwide is the implementation of grading. Equally prevalent are the social comparisons, personal investment, and, for certain individuals, the humiliations that are inexorably linked to the process of grading (Bulter, 1988; Crooks, 1988, Harlen, 2007; Kohn, 2011; Stiggins, 2005).

Contrary to the typical learning process that involves experimentation, failures, and risks, schools often prioritize evaluating students' performance through the use of grades as feedback. The emphasis on grades, which is shared by instructors and parents, frequently stimulates the pursuit of performance goals, or the aspiration to surpass others, as grades are usually evaluated in relation to others rather than based on specific criteria (e.g., Pulfrey, Buchs, & Butera, 2011). Grading systems are such a defining feature of schools worldwide that it is difficult for some to conceive of a school without them. However, despite their widespread use, there is surprisingly limited data supporting the notion that grading systems improve motivation or learning. However, there is evidence indicating negative consequences.

SDT possesses a distinct and well-defined viewpoint regarding the process of assigning grades. The theory posits that feedback on performance might possess diverse functional value or meaning for the receiver. Feedback can be of informational importance when it is relevant to effectiveness, meaning that it provides insights that assist the individual in enhancing their skills or highlighting areas of expertise. Informational inputs have a

tendency to increase intrinsic motivation and internalization. On the other hand, feedback can exert a dominant influence when perceived as a form of coercion towards particular actions or results (Deci & Ryan, 1985).

According to Nolen (2020), the interpretation and importance of grades for kids might differ, particularly due to the way they are implemented and responded to by instructors, parents, and the overall institutional environment. However, grades, in their widespread usage, are sometimes perceived as exerting excessive control. Grolnick and Ryan (1987) conducted an empirical study to examine the impact of grading on motivation in a real-life school activity. They discovered that grading was linked to a decline in intrinsic motivation and reduced conceptual learning. This finding aligns with the research conducted by Benware and Deci (1984). Klapp (2015) documented a natural experiment involving more than eight thousand Swedish pupils who were enrolled in elementary schools that used either graded or non-graded performance evaluations. Klapp (2015) examined the impact of primary school grading on academic performance in grades 7, 8, and 9, as well as the subsequent consequences in grade 12. The findings indicated a negative correlation between primary school grading and academic performance in grades 7-9, as well as a decreased likelihood of completing secondary education. These impacts were particularly noticeable among students with lesser abilities.

Considering that conventional grading systems have the capacity to detrimentally impact students' motivation and learning, particularly for those who are vulnerable, it is worth questioning the reasons behind their widespread prevalence. Part of the reason for this is the false belief among educators and policymakers that grades are an effective means of motivating. They hold the belief that in grading students, they are motivating effort and provide feedback. However, both Butler's research in 1987 and our findings indicate that grades alone do not offer much useful feedback on competence. Instead, they primarily

inform students about their relative standing compared to others, which might negatively impact their autonomous motivation, particularly for those who are not considered "winners."

SDT posits that when grades are used as incentives, they are often perceived as controlling and reduce the intrinsic motivation to study. For instance, Krijgsman et al. (2017) shown that after participating in courses that included performance grading, children in physical education reported reduced levels of intrinsic motivation and inner regulation, as well as increased levels of external regulation, amotivation, and fear. The satisfaction and frustration of basic psychological needs played a mediating role in the relationship between grading and motivational outcomes. While grading may serve the purpose of "gatekeeping" by identifying weak performers and preventing them from advancing, it should not be seen as an effective approach for motivating learning. Conversely, knowledge about effectiveness and genuine feedback regarding mastery have a positive impact on motivation, suggesting that they are more intrinsic rather than extrinsic motivators.

The assessment and grading methods used to evaluate pupils are closely connected to the extensive body of literature on mastery vs performance goals (Urdan & Kaplan, 2020). Mastery goals involve improving the learner's current skill or knowledge, while performance goals prioritize the student surpassing others. Both mastery and performance goals can be categorized into approach and avoidance categories. Extensive data indicates that performance-avoidance goals have the most negative impact on both academic achievement and overall well-being in educational environments (Elliot, 2005).

The impacts resulting from mastery and performance goals can be primarily comprehended via the lens of SDT's notion of functional importance. Performance goals, especially if they are focused on achieving a specific outcome, are often perceived as exerting control, while mastery objectives are typically seen as providing knowledge and guidance. Consequently, Pulfrey et al. (2011) discovered, in accordance with SDT, that when students

anticipated being evaluated, their level of autonomous motivation decreased and they were more inclined to adopt goals focused on avoiding poor performance. Vansteenkiste et al. (2010) evaluated the achievement-oriented aspirations of students, specifically focusing on their autonomous and controlled motives for pursuing these goals. When the analyses included autonomous and controlled motives, these SDT motives explained the majority of the variance in outcomes such as self-regulated learning, achievement, and cheating.

Gillet, Lafrenière, Huyghebaert, and Fouquereau (2015) conducted a study to assess six different categories of achievement goals in two educational environments. Additionally, they examined the autonomous and controlled motivations for achieving these goals. The learning goals encompassed many sorts of task, self, and other-focused learning objectives, including both approach and avoidance orientations. The study found that the motivations behind the goals were more accurate predictors of well-being than the goals themselves (Vansteenkiste, Lens, Elliot, Soenens, & Mouratidis, 2014). Performance goals are frequently perceived as pressure to achieve specific outcomes and can lead to constrained incentives, which can explain their detrimental impacts.

Over the past few years, there has been a rising global competition to improve educational results. As a result, politicians are now demanding increased responsibility from instructors and students, and exerting pressure on both to demonstrate improved test scores. In the United States and several other countries, legislation has included rewards and penalties based on performance on standardized tests, transforming them into "high-stakes tests" (HST). This strategy is founded on the belief that providing incentives to teachers and administrators based on the results of test scores will serve as a "motivation" for them to deliver higher quality education to pupils. Essentially, they believe that low performance is a result of insufficient teacher motivation, and they propose that offering rewards and punishments will solve this issue.

The high-stakes reform method, which has been anticipated by SDT (e.g., Ryan & La Guardia, 1999), has proven to be significantly ineffective. Hout and Elliott (2011) found that HST motivates teachers to concentrate narrowly on the content that is anticipated to be assessed in the examinations. With regards to scores, instructors have employed strategies such as prohibiting underperforming children from participating in assessments, or providing inaccurate data on results. Considering these circumstances, it is not surprising that enhanced HST results generally do not apply to other standardized tests that are more reliable and accurate (Nichols & Berliner, 2007). In addition, due to the emphasis on test scores in particular subject areas for the purpose of imposing penalties or providing incentives, it is common to limit or disregard activities and subjects that are stimulating and beneficial for overall growth (such as hands-on projects, music, arts, civics, and physical education), but are not included in the High-Stakes Testing (HST) evaluation. Education policies that prioritize test outcomes over addressing the psychological needs of teachers and students are undermining the quality of learning and instruction, particularly for disadvantaged and ESL students. This approach neglects the importance of supporting teachers and students on a psychological level, as highlighted by Early et al. (2016) and Korentz (2017).

In accordance with SDT principles, the author has consistently expressed the opposition to high-stakes testing methods. They have also presented detailed explanations of the motivational factors that have led to the widespread failure of such programs (see to Patall & Zambrano, 2019; Ryan & Brown, 2005). SDT contends that outcome-based incentives and penalties strengthen any path towards achieving a goal, regardless of whether it involves unethical or ineffective methods. Conversely, our evaluation standards for assessing policies and practices prioritize their ability to foster self-motivation and the fulfilment of basic psychological needs among both instructors and students. Specifically, we advocate for policies that prioritize enhancing the most effective methods within classrooms,

rather than attempting to incentivize and penalize educators and learners based on results. The HST serves as a prime example of the challenges posed by outcome-oriented demands, as they have a tendency to undermine optimal methods and, ironically, are less successful in attaining the intended results.

The topic of HST has had global implications, extending beyond the borders of the Hong Kong. The Chinese education system is predominantly centred around the gaokao, also known as the National Higher Education Entrance Examination. This examination, which is focused on evaluating the student's abilities rather than the teacher or school, holds significant influence in the Chinese education system. The significant focus on this particular examination results, as we have previously indicated with other policies of the HST, in a teaching approach that prioritizes exam preparation, excessive pressure, and the displacement of intrinsic motivation and independence in the educational process (Sun, Dunne, Hou, & Xu, 2013; Yu, Chen, Levesque-Bristol, & Vansteenkiste, 2018). While the specific implementation of HST varies across countries, if designed to exert external pressure on teachers and students to focus solely on a limited range of outcomes, it hinders the adoption of more comprehensive and supportive approaches that better promote students' overall development, interests, abilities, and well-being.

2.8 Limitations of existing research

As discussed, some e-learning models have already integrated SDT elements in them. Yet, these “e-learning SDT frameworks” are not without their limitations. There are four common limitations or research gaps coming from the reviewed studies. First, the sample groups were mostly non-student population and generalizability to student population was under-examined. Second, these studies applied cross-sectional data to build a conceptual model but there were not much experimental data supporting them. Third, these studies were concerning general e-learning instead of subject-specific e-learning and the current study

would focus on e-learning in secondary school science subjects. Fourth, there was a lack of investigation of specific teaching strategies that would enhance the three basic psychological needs in an e-learning setting as most studies only measured perceived need-satisfaction in the classroom or e-learning platform.

Regarding the sample demographic, Roca and Gagné (2008) focused on adult workers, while Sørebø et al. (2009) only focused on teachers and Ho(2010) only focused on the public online forum users. Roca and Gagné's (2008) study was based on the workers' user experience on the information technology application, which is not related to students' e-learning. The study concerned the workplace setting for the workers but not the learning environment for the students. In Sørebø's study, the participants were university teachers which were originally having strong learning ability. It is unclear whether their findings could be generalized to the e-learning motivation on secondary school students, for example, Sørebø's study is not applicable since university teachers are generally higher achievers in learning while the secondary school students are not. Moreover, the participants in the research had an average age of 47 years old. Age is an important factor affecting the users' intention to use technology. Furthermore, the response rate is relatively low which increased the chance of self-selection bias in the recruitment phase. For Ho's (2010) study, 68% of the participants had college/ university degree which means that the study can only reflect the e-learning intention of highly educated adults but not for secondary school students. There were a handful of studies that had college students as participants. For example, in Chen and Jang's study (2010), the participants were adult students in a certificate programs at a large research university in southeastern United States. For Koh et al.'s (2010) study, the study only concerned the engineering field with university students in the school of engineering. For Edmund et al.'s (2012) study, the student participants in open university were mature

with a mean age 37.62. These student samples have relatively strong learning abilities comparing to secondary school students.

Secondary students often reported that their lecturers would apply non-science content to make them interested in the lesson. The students were seldom asked to learn how science impacts people, society and technology and to learn about how science related to contemporary issues. However, based on SDT, these practices did not seem to support students' autonomy and intrinsic motivation for the study of science. The study also reported that students reflected the lack of challenging experiences to develop understanding. This is related to the need for competence. The study emphasized that student's experience in science is important to their learning engagement. The voice from secondary students is required to be listened in order to enhance their learning engagement.

In conclusion, the current study would employ 1) an experimental research, 2) design and implement a needs-satisfying e-learning approach based on Self-determination theory, 3) for secondary school students, 4) in the field of Science subject in order to address the existing research gap. The next section is focused on classroom practices that are need-supportive and how these practices could transfer to the e-learning setting.

2.9 The classroom practice of need-supportive teaching approaches

Student engagement encompasses students' active participation in educationally impactful activities and their dedication to educational objectives and acquiring knowledge. It serves as a crucial means to attain highly desirable educational outcomes, including academic success (Christenson et al., 2012). The construct is multi-layered and consists of four dimensions: Behaviour, cognition, emotion and action. Behavioural engagement pertains to the level of student engagement in learning activities, encompassing factors such as attention, participation, effort, intensity, and persistence. Cognitive engagement pertains to the extent of

mental exertion that students invest in accomplishing learning tasks, specifically by employing advanced rather than superficial learning tactics. Emotional engagement encompasses the emotions that students experience towards their teachers, friends, learning activities, and overall school experience, as well as their sense of belonging (Sinatra et al., 2015). Agentic engagement refers to the proactive engagement in activities that positively contribute to the process of learning and teaching (Reeve, 2013; Reeve & Tseng, 2011). The components mentioned correspond to the cognitive, affective, and communicative aspects of the learning processes (Reeve, 2013; Wang & Eccles, 2013).

Student engagement is commonly regarded as a result of motivational processes. Teacher practices are crucial in promoting student motivation in online/distance learning in order to increase student engagement. This can be achieved by fostering student autonomy, ensuring a sense of effectiveness, and maintaining interpersonal engagement (Hartnett, 2015; Vonderwell et al., 2007; Xie et al., 2006; Xie & Ke, 2011). According to SDT, teaching practices are categorised into three aspects: autonomy support, structure, and engagement. These dimensions are also referred to or supporting the three needs, autonomy, competence, and relatedness, respectively (Lietaert et al., 2015; Sierens et al., 2009; Vansteenkiste et al., 2009; Vollet et al., 2017). Promoting students' autonomy includes helping them actively explore their own goals and enhancing the acceptance of learning behaviours (Assor et al., 2002). Like in a traditional classroom, teachers who support autonomy in the context of e-learning consider students' points of view, offer them the chance to make choices regarding their learning, explain the reason why choices are limited, avoid using controlling language, and reduce unnecessary stress and demanding expectations on students (Alamri et al., 2020; Lee et al., 2015; Trenshaw et al., 2016; Xie et al., 2006).

In order to enable students to choose from different learning materials with different degrees of difficulty or format, teachers should give students a choice of a wide range of

learning resources in different languages and offer navigational instruction direction (Bedenlier et al., 2020; Hartnett, 2015). Teachers should also allow students to choose their own learning activities and appreciate their particular interests in order to provide personalized learning experiences (Alamri et al., 2020; Lee et al., 2015). With this approach, students are able to make independent decisions based on their own interests and personal goals. Additionally, students should have the courage to ask for help and voice opinions because accomplishing also improves their learning experience (Alamri et al., 2020; Lee et al., 2015; Trenshaw et al., 2016). Additionally, using autonomy-supportive teaching strategies encourages students to actively participate in and engage in learning.

Vansteenkiste et al. (2005) found that students who have teachers who support autonomy exhibited stronger attention spans and time management skills. Furthermore, Reeve (2013) noted that these students are more likely to participate in conversations with their teachers regarding their learning. Skinner et al. (2008) discovered that these students also enjoy their classes more. Although the impact of autonomy support on students' cognitive engagement has not been well investigated, it is thought that giving students greater freedom in choosing their goals for learning could increase their cognitive engagement. Bedenlier et al. have proposed this theory (2020). Effectively communicating clear expectations to students is necessary for students' learning behaviour (Sierens et al., 2009).

Teachers with good organizing skills will build well-structured discussion forums in the context of e-learning (Vonderwell et al., 2007). These kind of teachers would include elements that are easy for students to navigate (Xie et al., 2006). Moreover, Ryan and Deci (2000) further summarized the results from a list of scholars (Chiu et al., 2020; Chiu & Lim, 2020; Chiu & Mok, 2017; Ng & Chiu, 2017) and their studies supported that these kind of teachers will distribute effective learning resources to achieve desired outcomes; They would also facilitate peer moderation to encourage students to share information with their peers

(Xie & Ke, 2011); they will also provide clear guidance during online lessons, define the boundaries of learning activities, provide feedback that is relevant to students' competence, express trust regarding students' abilities. There is a strong connection between student engagement and the presence of structure. An appropriate educational framework enables students to have a sense of competence, effectiveness, and stimulation in their learning. Consequently, it is regarded as a crucial aspect in encouraging students' cognitive engagement (Skinner et al., 2008). When this requirement is fulfilled, students will acquire a sense of expertise in the subject being studied and be motivated to actively engage in course activities, while also experiencing a favourable attitude towards the course. This will result in improved behavioural and emotional engagement (Reeve, 2013). Several studies have examined the correlation between structure and agentic engagement (Reeve, 2013), although the research in this area is limited.

While research have shown that factors such as perceived autonomy, competence, and relatedness are crucial to student's e-learning motivation, experimental tests of actual online classroom practices that are need-satisfying are rare. In order to give specific guidelines to teachers on the need-supportive classroom practice, I would review various kinds of classroom practices suggested by the literature in traditional classroom. Lyness et al. (2013) gave us some initial ideas of the positive effect of teaching practices that enhance the three basic psychological needs (see Figure 5).

Figure 5

Teaching practices to enhance the three basic psychological needs (Lyness et al, 2013)

Need for Autonomy	Need for Competence	Need for Relatedness
Take others' perspectives	Set an optimal level of challenge.	Acknowledge feelings and convey Empathy
Provide choices	Support the skills development necessary to meet the posed challenge.	Create structures to foster individual connections
Provide a meaningful rationale when choices cannot be offered	Give meaningful feedback framed positively toward the achievement of competence	Create structures to foster group and community connections
Minimize controlling words		

To increase students' perceived competence, the teacher could provide evaluative feedback related to the improvement of students' performance instead of norm-based feedback (Muller & Dweck, 1998; Niemiec & Ryan, 2009), provide optimally challenging task according to students' ability (Csikszentmihalyi, Abuhamdeh & Nakamura, 2005). If teachers could take students' interest into account of their learning activities, students are more likely to have a higher level of perceived competence. (Jang, Reeve & Halusic, 2016). In addition, by providing demonstration of performance and vicarious experiences, students are more likely to have a higher self-efficacy. The increase of self-efficacy would lead to an increase of perceived competence as well (Hughes et al., 2011). The suggestion mentioned here could highly predict the students' perceived competence. In terms of online classroom, subject teachers could also provide more immediate positive and reflective feedback to individual students through email, e-learning platform or even social media, provide optimally challenging online task according to students' ability level or prior performance, provide e-learning tasks with respect to students' interest and their common language, and provide online demonstration video to support and scaffold student learning.

To increase students' perceived autonomy, subject teachers could provide choice for learning activities and the pace of learning (Niemiec & Ryan, 2009), provide explanation on the meaning of the learning activity, acquire students' perspective on the knowledge,

minimize pressure and control, and reduce over-supervision (Plant & Ryan, 1985; Ginsburg & Bronstein, 2008), provide scaffolding support (Jang et al., 2010), and reduce external rewards for self-directed learning activities (Deci, 1985). In terms of online classroom, subject teachers could easily provide choice on the reading material or the learning tasks by uploading learning materials online and let student learn at their own pace, provide rationale before the delivery of learning task in the online meeting, allow student to share their thoughts during the online meeting or e-learning platform, give them a large room of freedom to select when to submit the online assignment .

To increase students' perceived relatedness, the teacher could provide a warm and respectful caring atmosphere (Niemiec & Ryan, 2009) to students, provide unconditional caring (Assor & Tal, 2012; Roth et al., 2009; Roth & Assor, 2010) and maintain a good teacher-student relationship (Zhou, Lam & Chan, 2012). In terms of online classroom, subject teachers could provide frequent greeting and reflection session during the online meeting, Teachers could also be easier to inquire about students' feeling on the subject content or learning process, and keep a regular and frequent online gathering to maintain a good teacher-student relationship.

Moreover, teachers could take advantage on the characteristics of e-learning to enhance their teaching environment as well. Firstly, e-learning tools can generate instant statistic result on students' response. It could also provide instant assessment marking. Teachers could utilize this advantage to offer some instant checking on students' knowledge. Secondly, e-learning does not have limitation on the location. During the period of COVID19 epidemic, class teachers can reach their students easily using video meeting and other social media platform such as WhatsApp to express care and support. Thirdly, a subject teacher could collect students' works through e-learning platforms and give instant reflective feedback or instant individual comment. Students could even receive synchronized instant

written entry from the teacher inside a shared electronic document, like google-doc or google spreadsheet. This helps senior students to modify the essay type homework and work collaboratively with the teachers enhancing their sense of competence and relatedness.

Lastly, some e-learning tasks are not limited by time and duration. A teacher could design an e-learning task in recorded video. It allows the student to complete the learning task with according to their own schedule and revise the video when they encounter any difficulties.

Figure 6

Summary of need-supportive e-learning teaching approaches

Needs	e-learning teaching approaches	Function
Competence	Scaffolding supportive system by instant knowledge-checking online questions	Sense of mastery & optimal challenges
	Positive and reflective feedback	Encouragement and confidence
	Provide e-learning tasks with respect to students' interest	Interest of knowledge
	Provide an online demonstration on the usage of the e-learning tool	Sense of efficacy
Relatedness	Provide frequent greeting and reflection session	Experience of acceptance
	Care about students' feeling on the subject content by providing online reminder	Interest in one's thoughts and feelings by others
	Maintain a good teacher-student relationship	sense of connectedness
Autonomy	Provide choice on the learning tasks	Sense of choice
	Provide rationale before the delivery of learning task	Sense of feeling volitional
	Allow student to share their thoughts on the instant online reflection boxes.	Taking one's perspective into account.
	Give them a large room of freedom to submit the online assignment before the deadline	Learn at your own pace

2.10 The increasing demands on the quality of learning in online environment

Recently, the education industry fully utilized edtech and e-learning tool. This comprises a range of technological tools that can increase education's reach, accessibility, and standard of teaching as well as the quality of learning. Proposed tools include Massive Open Online Courses (MOOCs), mobile technologies, online distant learning, hybrid virtual classes, hybrid online and offline training, synchronous and asynchronous online courses to connect close and local students or distant and remote students, and some other online tool, etc (Bubnova et al., 2018; Razumovskaya et al., 2018). Salikhova, Lynch & Salikhova (2020) mentioned that the study of how individuals interact and progress in complex and diverse environments is increasingly gaining attention, as evidenced by one of the earliest comprehensive analyses of MOOC research conducted between 2008 and 2012 (Liyanagunawardena, Adams, & Williams, 2013). However, more questions persist, with a primary concern on the efficacy of e-learning.

According to Chen and Jang (2010), motivation has been recognized as a pivotal element that impacts the process of learning, which is also agreed by Lim (2004). Past research has demonstrated that learner motivation is linked to several significant learning outcomes, including persistence (Vallerand & Bissonnette, 1992), achievement (Eccles et al., 1993), retention (Lepper & Cordova, 1992), and course satisfaction (Fujita-Starck & Thompson, 1994). Empirical research indicates that motivation should be given serious consideration in the context of e-learning. An e-learning environment is a setting that utilizes the internet to provide learning experiences to learners who are physically separated by time, distance, or both (Dempsey & Van Eck, 2002, p. 283). Despite its differences to face to face traditional learning environment, motivation should remain the centre of student learning.

Students' learning performance in the online context

Numerous issues have been noted as potential roadblocks to knowledge acquisition. Prior studies have demonstrated that although academic performance is not significantly different in traditional and online classrooms, students in online courses report being significantly less satisfied with a number of aspects of their learning experience than their counterparts in traditional classrooms, including attentiveness and student engagement (Chiu, 2022). This prompted us to examine the complexity of various kinds of components of e-learning tool and the influential forces at play (Summers, Waigandt, & Whittaker, 2005). Broadbent and Poon (2015) conducted a comprehensive analysis of publications on self-regulatory learning strategies in the online environment spanning a period of 10 years. They discovered a number of variables linked to academic achievement in distance learning. Though they were relatively less influential, they were generally in line with the factors impacting academic success in the traditional system. The scientists hypothesized that additional, as-yet-unstudied elements would have a greater bearing on online environments. The high rate of student withdrawal or dropout in the context of online courses is one issue that is often mentioned and deemed urgent (Chen & Jang, 2010). The rate of completion of MOOCs is usually fairly low, according to Sun et al. (2019), suggesting that there are significant barriers to learning (Kennedy, 2014). All of these suggest that low motivation in the e-learning environment may be a problem, concluded by Chen and Jang (2010).

The motivational challenges of e-learning

Hew and Cheung (2014) have done a quite all-rounded and comprehensive analysis of research on the key motivations and challenges of using MOOCs from a student perspective. With Hew and Cheung's finding (Hew & Cheung, 2014), Salikhova and colleagues (Salikhova, Lynch & Salikhova, 2020) agreed that a significant proportion up to nearly 90% of the student participants withdraw from the course because of poor assistance,

misinformation about the course materials, and a lack of incentives. There are serious issues surrounding the implementation and adoption of the educational information system. Two different MOOC models—connectivism and the traditional pedagogical approach—were compared and found to use different approaches and teaching strategies, which appeal to different populations (Kennedy, 2014). This connectivist approach relates to situated and social learning theories such as social constructivism (Kop, 2011). Hence, the issues associated with these models also vary. The term "c-MOOC" refers to a collaborative, distributed, and networked approach to education, which emphasizes a high level of student autonomy. Kop's (2011) statement raises the question of the extent to which learner autonomy is significantly required in active learning in order to overcome the motivational challenges of e-learning. In the context of Rita Kop's paper, the term "presence" refers to the extent to which learners feel engaged, connected, and involved in an active connectivist learning environment. It includes both the learners' subjective experience of being present and their active participation in the learning process. Presence can be understood in several dimensions. One dimension is social presence, which refers to the sense of community and social interaction among learners in an e-learning environment. Social presence can be fostered through various means, such as collaborative activities, discussions and group projects that help learners build relationships and engage with their peers. Another dimension is cognitive presence, which is about learners' ability to construct and explore knowledge and their critical thinking skills. Cognitive presence is fostered through activities that encourage reflection, analysis and problem solving, allowing learners to actively construct meaning and deepen their understanding of the subject matter.

In addition, emotional presence is another aspect of presence that is emphasized in this paper. Emotional presence refers to learners' emotional engagement in the learning process, including their motivation, interest and sense of personal relevance. Emotional

presence can be fostered by creating a supportive and inclusive learning environment that recognizes and takes into account learners' emotions and experiences. Overall, presence in the context of this article refers to the combination of social, cognitive and emotional factors that contribute to learner engagement, participation and meaningful learning experiences in an active, connectivist learning environment.

By examining the increasing conflicts between the components of connectivity that are considered essential for successful learning, as suggested by Tschofen and Mackness (2012), the authors argue that students may differ significantly in their propensity for and understanding of connectedness, autonomy, openness, and diversity. Given the changing dynamics of e-learning, several new theories are emerging. Some aspects of these concepts resonate to some extent with SDT perspectives.

Investigate motivational concerns in relation to e-learning

Tschofen and Mackness (2012) state that connectivism emphasizes basic teaching concepts like autonomy and connectedness. Ryan and Deci (2017) explore how these elements are also essential to Self-Determination Theory (SDT). Scholars frequently investigate motivational concerns in relation to e-learning because it is well-known that this type of learning environment necessitates a higher level of self-regulation, making motivational factors of the highest level significant (de Barba, Kennedy & Ainley, 2016; Buhr, Daniels & Goegan, 2019). In addition, the importance of intrinsic motivation has been emphasized specifically in relation to course completion (Barak, Watted & Haick, 2016). The utilization of self-determination theory (SDT) has become prevalent in the examination of e-learning (Ryan & Deci, 2017).

Using Self-determination Theory (SDT) to predict motivation and intentions to progress e-learning, Roca and Gagné (2008) proposed that the application of Self-Determination Theory (SDT) to e-learning could be beneficial in anticipating individuals'

intends to continue learning in the workplace, as the issue of high dropout rates became evident over 10 years ago. Due to potential disparities in the influence of fulfilling basic needs on the motivation for online and offline learning, it is not feasible to directly apply existing context to the unique circumstances of e-learning. According to recent research, fulfilling the three basic psychological needs of autonomy, competence, and relatedness has a notable and beneficial impact on intrinsic motivation. This, in turn, enhances students' learning participation and engagement in Massive Open Online Classes (MOOCs) (Sun et al., 2019).

Further application of SDT model

Additionally, as stated by Fang et al. (2019), need fulfilment serves as a complete mediator for the influence of social interaction on academic engagement in a MOOC. Nevertheless, contrasting outcomes have also been achieved. When examining the factors that influence the ongoing use of C-MOOC, Fang et al.'s (2019) focused on self-determination factors. Surprisingly, these factors did not have a significant impact on satisfaction with the course itself. However, they did have a significant influence on students' intention to continue using the course. The factors that positively influenced satisfaction were the convenience of use and usefulness of the e-learning tool (Joo, So, & Kim, 2018). SDT has been applied not only in studies on MOOC, but also in studies on the utilisation of mobile training applications (Jeno et al., 2019; Yang, Zhou, & Cheng, 2019). The primary findings demonstrated that the impact of self-determination elements, such as the satisfaction of the three basic needs, intrinsic and extrinsic motivation, on engagement and the desire to continue learning in the mobile mode.

Furthermore, it is observed that the structure of mobile learning itself has a role in fulfilling the requirement for independence, which subsequently influences academic accomplishments and the effective absorption of educational content (Jeno et al., 2019).

Several research have addressed the question of how SDT factors affect learning results. Inconsistent data have been obtained regarding this matter. Chen and Jang (2010) found that the SDT-based model is not effective in predicting learning outcomes in online programmes. After conducting a thorough analysis of the techniques employed by Chen and Jang (2010), Hsu, Wang, and Levesque-Bristol (2019) made modifications to the measurement methods and proceeded to carry out a study based on the SDT model. Their findings demonstrated that the fulfilment of basic psychological needs enhanced self-regulatory motivation, which in turn correlated with greater proficiency in acquiring knowledge and attaining learning objectives in online courses. The satisfying of many basic psychology needs has distinct impacts on various aspects of e-learning. According to Fang et al. (2019), although meeting the need for competence had the highest correlation with engagement in MOOC learning, meeting the need for autonomy had the lowest correlation. A separate study conducted by Durksen et al. (2016) established probabilistic connections between the basic psychological needs of learners within the framework of a MOOC. The findings revealed that participants with a high level of autonomy had an 80.01% likelihood of experiencing an average level of competence. Additionally, the need for relatedness was found to be distinct from both autonomy and competence.

Chen and Jang (2010) found that, although motivation plays a crucial role in determining learning outcomes, it has not been accorded substantial emphasis in the context of e-learning, which was also well recognized by some other researchers (Jones and Issroff, 2005, Miltiadou and Savenye, 2003). An underlying factor could be that instructors formerly prioritized student cognition while neglecting affective and socio-emotional processes (Kreijns, Kirschner, & Jochems, 2003). Given the increasing concern among online educators about high attrition rates, which are a negative sign of motivation, it is crucial to examine the motivation of online learners, including its causes and effects, through the lens of needs-

satisfying teaching. In their literature review, Miltiadou and Savenye analysed six motivation components and explored their implications for e-learning. The researchers determined that additional empirical research is necessary to examine motivation theories and constructs in the e-learning setting, with the goal of decreasing attrition rates and promoting student achievement. Consistent with the assertion made by Miltiadou and Savenye (2003), Gabrielle (2003) employed Keller's (1983) ARCS model, which consists of attention, relevance, confidence, and satisfaction, to develop instructional strategies for online students that are based on technology. The findings indicated that the utilization of ARCS-based learning assistance yielded positive outcomes in enhancing students' motivation, academic performance, and ability to engage in self-directed learning.

In a study conducted by Lee (2002), the researcher examined the concepts of self-efficacy (proposed by Bandura in 1982) and task value (proposed by Eccles in 1983). The study revealed that both concepts were important factors in predicting the satisfaction and performance of online students. The theory-based investigations conducted by Gabrielle and Lee (2003) have yielded useful insights for the field of instructional design and facilitation. Hence, compelling data has surfaced that justifies the need to investigate how a student personally assesses the impact of motivation on their performance in the e-learning setting.

Chen and Jang (2010) supported that an important motivation theory should be thoroughly examined in e-learning contexts. The self-determination theory (SDT) is eligible to examine in both the traditional lessons and the online context, which was proposed by Deci and Ryan in 1985 and 2002. Pintrich and Schunk (2002) have described SDT as "one of the most comprehensive and empirically supported theories of motivation available today" (p. 257). The theory of self-determination has been effectively utilized in various contexts, such as physical education (Standage, Duda, & Ntoumanis, 2005), politics (Losier, Perreault, Koestner, & Vallerand, 2001), healthcare (Williams et al., 2006), religion (Neyrinck, Lens, &

Vansteenkiste, 2005), and general education (Niemiec et al., 2006). Nevertheless, the validity of self-determination theory in the context of e-learning has not been adequately tested (Chen, 2007). Except for a few instances, such as the study conducted by Xie, Debacker, and Ferguson (2006) which utilized SDT to analyse online debate, and the research conducted by Roca and Gagné (2008) which analysed the desire to continue e-learning in the workplace, there is a scarcity of studies that apply SDT in the context of e-learning environment. In their study of student perceptions, Mullen and Tallent-Runnels (2006) found that students from online classes and traditional face-to-face lectures perceived the classroom environment, the support and expectations from instructors significantly. The variations in perception were associated with the students' level of motivation, contentment with the course, and acquisition of knowledge. Mullen and Tallent-Runnels stated that teachers should exercise caution in assuming that teaching in both environments will provide comparable outcomes. Similarly, it is not valid for researchers to claim that motivation theories developed for traditional face-to-face classrooms and other contexts can be applied directly to e-learning without evidence, as the e-learning environment has distinct characteristics (such as flexibility, accessibility, and computer-mediated communications) that affect student motivation dynamics differently. Hence, it is imperative to conduct a comprehensive examination of the motivation of online learners, which entails evaluating the applicability of self-determination theory within the e-learning setting. The subsequent segment delineates the fundamental principles of SDT, succeeded by an examination of why SDT may be a suitable framework for addressing learner motivation in e-learning. Self-determination theory, proposed by Deci and Ryan around forty years ago, is a comprehensive theory of motivation that aims to comprehensively explain the interplay between human needs, motivation, and well-being in the immediate social environment. Self-determination, as conceptualized by Deci and Ryan (1985), refers to a fundamental aspect of human functioning that encompasses the subjective

experience of having choices. The ability to make choices and have those choices influence one's actions is referred to as agency.

Chen and Jang (2010) discovered there is only a handful of studies sought to examine the applicability of SDT in e-learning environments. For example, Xie et al. (2006) utilized SDT to investigate student motivation within an online discussion board. Xie et al. (2006) conducted a study using a mixed-methods approach to examine students' perception of their interest (intrinsic motivation), value (extrinsic motivation), choice (perceived autonomy), course engagement (measured by login frequency and participation in discussion boards), and attitudes towards the class. The correlation analyses demonstrated a positive relationship between the three indicators derived from SDT (perceived interest, value, and choice) and the course attitude and engagement of online students. Furthermore, findings from interviews and open-ended questions revealed that the active engagement, direction, and constructive input of instructors played a crucial role in fostering motivation among online students. Furthermore, it was discovered that having a distinct justification aided online students in recognizing the significance of engaging in discussion activities, hence reinforcing the principles of SDT.

The validity of SDT in the context of e-learning

Chen and Jang (2010) also discovered that, contrary to SDT, Xie and his colleagues' research (2006) found no significant connections between perceived competency, engagement and course attitude. The research demonstrated initial support in the application of SDT to the context of e-learning. Nevertheless, Chen and Jang (2010) found that Xie's research (Xie et al., 2006) study has not yet investigated the connections between contextual support, need satisfaction, motivation, and learning outcomes. In addition, although SDT acknowledges that perceived autonomy, relatedness, and competency are three factors influencing motivation and well-being, the Xie et al. (2006) study did not evaluate the impact

of perceived relatedness. Finally, the authors' conclusion was that online learners' perception of their own competency did not accurately reflect their actual learning outcomes. However, the definition of "competency" used in their study seemed to be lacking in completeness. The authors solely employed computer/internet abilities as the criterion for measuring proficiency. However, for online discussion, competency may encompass additional facets such as communication and metacognitive skills. Omitting these dimensions is likely to produce biased findings. Considering these constraints, the findings of the Xie et al. (2006) appear inadequate for making definitive statements on the viability of SDT. Therefore, further research is necessary to confirm the validity of SDT in the context of e-learning.

Utilizing SDT, David (1989) have put out a conceptual framework for understanding the motivation of online learners. Within our suggested model, contextual support is a latent variable that is measured by autonomy support and competency support. Within the literature, the majority of research based on SDT have focused on assessing individuals' perception of relatedness, including the actual support they receive in terms of relatedness (Ryan & Deci, 2000).

Chen and Jang (2010) shared that the satisfaction of online students' psychological needs was measured using an endogenous latent variable called "need satisfaction," which was assessed through markers such as perceived autonomy, perceived competency, and perceived relatedness. SDT suggests that an individual's motivation and sense of self-determination are influenced by their fulfilment of these basic psychological needs. Empirical research have provided support for the mediating effect of basic need satisfaction (Vansteenkiste et al., 2010). For instance, Standage et al. (2005) discovered that students who reported an environment that supported their needs would have a higher level of perceived satisfactory. The fulfilment of basic psychological needs was then a strong predictor of intrinsic motivation, which is a form of motivation that comes from within oneself. Thus, it

can be suggested that contextual support has a positive correlation with need satisfaction, and need satisfaction, in turn, has a positive correlation with self-determination form of motivation. SDT posits that motivation characterized by autonomy and self-determination leads to more favourable outcomes, whereas motivation that are less self-determinated yields more unfavourable outcomes. Research conducted by Grolnick and Ryan in 1987, 1989, and 1991 have demonstrated that increased self-determination and relative autonomy support (RAI) are positively associated with conceptual learning, affect, students' engagement, and effective coping methods.

Paths from contextual support to learning outcome

Furthermore, Chen and Jang (2010) discovered that the research done by Roca and Gagne´ (2008) successfully showed a positive linear relationship between self-determination and job satisfaction, whereas Vallerand and Bissonnette (1992) observed that persistent students exhibited higher levels of self-determination compared to those who dropped out. Therefore, it can be proposed that the level of self-determination in online learners has a positive correlation with their learning outcomes. The model examined two hypotheses to gain a deeper understanding of the dynamics and interplay between motivational factors and learning outcomes. The model includes additional paths from contextual support to learning outcome and from need satisfaction to learning outcome, in addition to the main causal chain "contextual support → need satisfaction → self-determination → learning outcome." These paths are included to directly evaluate the impact of contextual support and need satisfaction on learning outcomes. Black and Deci (2000) discovered that instructors' provision of autonomy support had a direct and positive correlation with the academic achievement of students who initially had poor self-determination. In their study, Deci et al. (2001) discovered that a direct and positive relationship between need satisfaction and engagement,

overall self-esteem, as well as a decrease in anxiety. Therefore, it can be assumed that both contextual support and need satisfaction had a positive correlation with learning outcomes.

Mobile Application and Intrinsic Motivation

Research has discovered that a mobile application has a beneficial effect on intrinsic motivation, perceived competence, and student accomplishment (Jeno, Grytnes, & Vandvik, 2017). Students who utilised ArtsApp, a biology-focused application, had greater levels of intrinsic motivation, perceived competence, and academic accomplishment in comparison to the control group that relied on a conventional textbook. Conversely, intrinsic motivation was found to be a strong predictor of improved academic performance, increased interest in the subject matter, and a greater recognition of the value of acquired knowledge. The optimal outcomes were linked to the fulfilment of students' psychological needs for autonomy, competence, and relatedness. The mobile application incorporated built-in functions such as interest, choice, and feedback, which were identified as contributing elements (Jeno et al., 2017). Individuals have the freedom to decide when to utilise mobile education technologies (Hamidi & Chavoshi, 2018), which enhances their autonomy.

Further Influence of Relatedness in Online Environment

An entirely distinct scenario may occur in relation to the fulfilment of another fundamental psychological need, namely the need for relatedness. The need for relatedness is a potent, fundamental, and very pervasive motive. It exerts significant and diverse effects on emotional and cognitive processes (Baumeister & Leary, 1995). Within the framework of SDT, it holds a significant position. MOOCs establish a novel educational setting where the significance of relatedness can have a particularly crucial impact. MOOCs offer exceptional prospects for both connection and solitude. Durksen et al. (2016) provided evidence that relatedness is certainly a crucial factor in this particular situation. Students have observed that in the realm of online courses, arranging group work poses a greater challenge.

Consequently, fulfilling this requirement becomes more arduous, particularly for individuals who typically prefer face to face collaborative work (Vanslambrouck et al., 2018; Zaitseva et al., 2020). Some academics have contended that the development of interpersonal relationships—which is essential for success in any educational environment—is frequently restricted by online courses (Butakova et al., 2020; Butz & Stupnisky, 2017; Raes et al., 2020). This presents a challenge as well as an additional angle for the study of digital technology in education. According to Deci and Ryan (2014), not every relationship meets the criteria for relatedness and is of a high calibre. In order to ascertain whether e-learning technologies can foster high-quality relationships, researchers are searching for answers. For instance, a 2017 study by Butz and Stupnisky demonstrated the significance of development and engagement in forums to uphold the requirement for relatedness.

Here, the forum is regarded as a mechanism for cultivating interpersonal connections among those participating in online courses. Consequently, the organisation of the online course alone could be sufficient to fulfil the basic need for relatedness. Additional alternatives exist, such as the inclusion of mentors in the online platform. Baranik, Wright, and Reburn (2017) proposed that supervision and mentoring by teacher could fulfil students' need for relatedness in e-learning, hence enhancing their success in online activities by satisfying basic psychological needs. The core principles of SDT are applied not just in research, but also in the creation of digital instructional tools. Martin, Kelly, and Terry (2018) put out a paradigm for the development of MOOCs that is rooted in the ideas of SDT. This framework establishes the correlation between intrinsic motivation and the basic psychological needs of autonomy, competence, and relatedness. The authors have obtained first evidence that a design structure based on SDT is effective in creating Massive Open Online Courses (MOOCs) and may effectively engage students, enhance completion rates, and foster intrinsic motivation.

Further utilization of SDT in other area

The utilisation of SDT facilitated the creation of a digital design project tailored for novice students, with the aim of enhancing their intrinsic motivation to pursue further education in the fields of engineering and digital design (Danowitz, 2016). Analysis of the digital libraries program in Australia through the lens of SDT has enabled a more comprehensive and critical evaluation and has led to improvements in the program (Robertson, 2018). The concepts behind SDT served as the basis for the creation of a template along with a web extension that facilitates course design and learning strategies in several academic disciplines (Bachman & Stewart, 2011). The integration of SDT and cognitive load theory (Sweller, 2011) serves as the theoretical basis for the creation of an online course in medical emergencies using the learning management portal Moodle (De Araujo Guerra Grangeia, et al., 2016). Self-determination theory has been used in the implementation of gamification strategies (Proulx et al., 2017; Shi & Cristea, 2016; Tan, 2018) and in the development of a reward mechanism for children in play practice (Ahn et al., 2019). To improve video game quality, it is imperative to understand how different types of input contribute to the overall enjoyment of the game.

According to Rogers (2017), it is possible to predict the degree of enjoyment one will feel while playing a game when the feedback, rules, and social components of the game coincide with the traits of SDT - autonomy, competence, and relatedness. SDT concepts have been successfully applied to various theories, frequently with the mediation of specific components, producing fascinating and productive outcomes. The significance of basic psychological needs in connection with learning motivation was examined by Faye and Sharpe (2008). They found that connectedness and identity are predictors of learning motivation through path analysis. They also discovered that basic psychological requirements had an impact on these interactions. Self-determination theory (SDT) and other

models have been combined in a number of studies to predict various aspects of using Massive Open Online Courses (MOOCs) in terms of student accomplishment. Results from Buhr, Daniels, and Goegan's (2019) study provide insights into the relationships among basic psychological needs, cognitive assessments, and the emotions of pleasure and boredom in a MOOC.

Recently research models are updated with more variables for learning process

According to a study by Fang et al. (2019), social interaction had a greater impact on satisfying basic psychological needs when a mutual learning group was present. Concurrently, the relationship between social interaction and engagement in the learning process was mediated by the satisfaction of psychological expectations. In order to investigate the factors influencing students' acceptance of MOOCs, the authors performed a study. The authors' approach included social motivation as well as task and technological alignment in accordance with SDT. According to Khan et al. (2018), students' behavioural intentions toward embracing MOOCs were favourably and significantly influenced by perceived relatedness and perceived competence. Pedrotti and Nistor (2016) investigated the relationship between user motivation and technology acceptance using the Unified Theory of Acceptance and Use of Technology. Based on the Theory of Planned Behaviour (TPB), Cincinnato, Zhu, and De Wever (2016) investigated the variables that influence instructional strategies in online and blended learning (OBL). These included perceived ICT (information and communication technology) competency and institutional innovation orientation.

The Theory of Planned Behaviour (TPB), found by Icek Ajzen (1991), is a well-known social psychological theory that explains human behaviour and decision-making. According to this theory, human behaviour is determined by three main factors. Attitude: the positive or negative evaluation of a person's performance of a particular behaviour. It reflects their beliefs about the results and consequences of the behaviour. Subjective norms:

Perceived pressure from social interaction or influence from each other such as colleagues, superiors or the institution on the performance of the behaviour. Perceived behavioural control: The person's perception that they are able to perform the behaviour successfully, taking into account factors such as their abilities and environmental limitation .

Cincinnato, Zhu, and De Wever's study looked at how teaching strategies in OBL were impacted by institutional innovation orientation and perceived ICT competence. Because it indicates a person's confidence and perceived ability to use ICT for teaching, perceived ICT competency is linked to the TPB's perceived behavioural control component. Subjective norms are related to institutional innovation orientation because it expresses the institution's expectations, support, and encouragement for innovative methods of teaching.

Zhou (2016) investigated the factors influencing students' acceptance of MOOC by utilizing the theory of planned behaviour (TPB) and self-determination theory (SDT). It was discovered that all three of the main components of the Theory of Planned Behaviour (TPB) originated from autonomous motivation. Structural Equation Modelling (SEM) was utilized in the study to investigate the effects of various motivational styles on the completion of tasks associated with Open Source Software (OSS). Ke and Zhang (2010) examined the effect of meeting relatedness, competence, and autonomy needs on the relationship between extrinsic motivation and job tasks (or learning tasks) by combining an Affective Event Theory with Self-Determination Theory (SDT). examining SDT's function in e-learning from the viewpoint of the teacher.

The psychological theory known as Affective Event Theory (AET) focuses on how emotional events or experiences affect people's attitudes, behaviours, and results connected to their jobs in the workplace (Weiss & Cropanzano, 1996). In order to investigate how the satisfaction of relatedness, competence, and autonomy requirements can mitigate the effect of extrinsic motivation on task-related outcomes, Ke and Zhang (2010) combined AET with

Self-Determination Theory (SDT). It implies that the fulfilment of fundamental psychological needs may have an impact on the emotional experiences brought on by extrinsic motivation, with varying results in terms of engagement, performance, or job (or learning) satisfaction.

For teachers and students alike, the world of e-learning presents a great challenge. Sørebø et al. (2009) found that predicting teachers' intentions to continue using e-learning in their interactions with students requires taking into account basic psychological needs and intrinsic motivation. An investigation was carried out to look at the connections between basic psychological needs, engagement levels, feelings, and emotional exhaustion associated with the learning process. Klassen, Perry, and Frenzel (2012) found that teachers who focus on satisfying their students' need for relatedness exhibit higher levels of positive emotions and engagement while displaying lower levels of negative emotions than teachers who prioritize relating to their peers. Chang, Fu, and Huang (2017) found that school teachers' intrinsic motivation and willingness to accept and reuse e-learning were favourably influenced by their perceptions of autonomy and competence. The intrinsic motivation of educators in the context of cloud computing technologies and cloud virtual learning environments (VLEs) was investigated. The cloud makes it easy to access, store, retrieve, and distribute training materials without being constrained by time or place. SDT factors had a significant impact on the intention to adopt VLE, as Hew and Kadir (2016) showed. Kreijns et al. (2014) integrated SDT with the Theory of Planned Behaviour of the Integrated Model of Behaviour Prediction (IMBP) to assess instructors' propensity to use digital learning materials (DLM). The unified model potentially offered a more comprehensive elucidation of teachers' volitional behaviour concerning the use of DLMs.

2.11 Summary of the rationale for this study

Previously there was some similar research in investigating the learning motivation by using the SDT framework. Some researchers are only targeted on the e-learning acceptance

of adult workers, the university students in the U.S. and the university students in the UK (Roca, 2008; Chen, 2010). Even though there was previous research focused on secondary school students in central China (Zhao et al, 2011), it was only studying the perception on the e-learning material management platform, but not on the usage performance on the e-learning application tool. My study aims to find out students' motivation on using Science e-learning tools. The study on the perceived feeling of the online learning management platform is different from a study of analysing the usage motivation of a knowledge-oriented e-learning tool. As the e-learning management platform, like Moodle or Google classroom is technique-oriented, while the subject based e-learning application is knowledge-oriented. The motivation on using the technology is different from the motivation on learning the subject knowledge.

Moreover, with the help of STEM Education, Science is becoming more essential and popular than before (White, 2014). In my study, I would like to emphasize student's e-learning motivation on using the Science-oriented e-learning tools. Through studying this kind of motivation, I could understand if there are effective teaching strategies that could raise the students' interest in using Science e-learning tools for their own self-directed learning by using the e-learning material and online tasks prepared by the teachers.

This study would be conducted with experimental design in a mixed method. A lot of existing studies were correlational and survey-based. Previous studies mostly concerned how the participants sense of the three needs without understanding what teaching practices would fulfil those needs in a virtual learning environment. In this study, the focus would be put on the influence of teaching practices in the context of e-learning and Science among Hong Kong secondary students. I have made use of basic variables from the SDT model to become my research model. These measuring variables are perceived competence, perceived autonomy, perceived relatedness and the motivation of using e-learning tool to learn Science.

The research aims to study the influence of the intervention of needs-satisfying approaches on the e-learning motivation. The current study could find out the causation between the specific e-learning teaching approaches that would motivate the secondary school students in Hong Kong.

This study of e-learning tool will not be out-dated as it holds the value to continue in the future. No matter during the pandemic and post-pandemic period, online lecture is well utilized by education organizations. An example is that the use of online program and online meeting did not disappear after the resumption of school. E-learning become an option for students who want to pursue distance learning while they do not want to travel overseas. Many high schools and tertiary institutes offer online diploma or certificate program in this post-pandemic period and it is popular among many online applicants, e.g. Ontario Secondary School Diploma offered by Ontario e-school and online Postgraduate Certificate of Education program offered by University of Sunderland, etc. E-learning lessons and edtech e-learning tools still have a huge demand in the world after the pandemic.

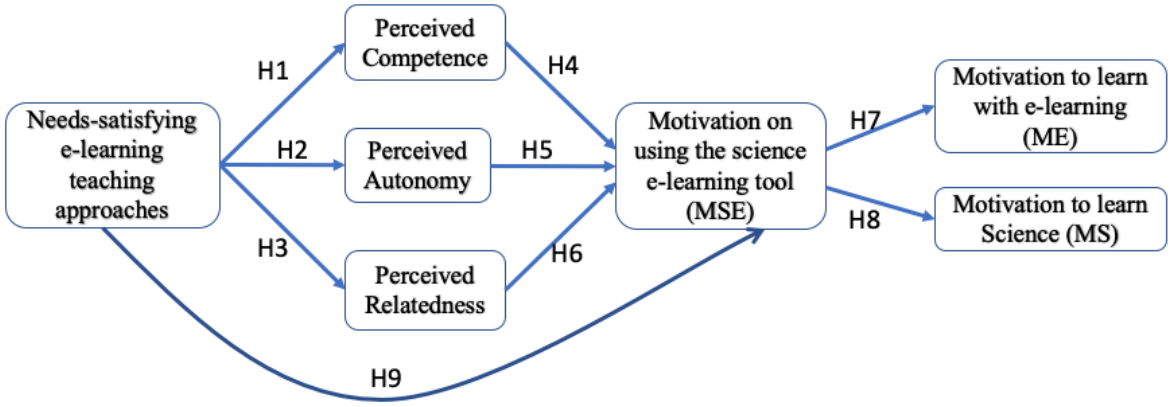
Chapter 3 Methodology

3.1 The goal of this study and the Hypotheses

The goal of the study was to provide experimental evidence of how the proposed e-learning practices could satisfy the three basic needs and impact the motivation of e-learning and learning Science. Figure 7 shows the theoretical model of the current study.

Figure 7

The theoretic model of the experiment research of this study



Based on the literature review, the following hypotheses were set:

Hypothesis H1: Need-satisfying e-learning teaching approaches positively affects students' perceived competence on using the e-learning tool.

Hypothesis H2: Need-satisfying e-learning teaching approaches positively affects students' perceived autonomy on using the e-learning tool.

Hypothesis H3: Need-satisfying e-learning teaching approaches positively affects students' perceived relatedness on using the e-learning tool.

Hypothesis H4: The increase in perceived competence positively affects students' motivation in using the Science e-learning tool.

Hypothesis H5: The increase in perceived autonomy positively affects students' motivation in using the Science e-learning tool.

Hypothesis H6: The increase in perceived relatedness positively affects students' motivation on using the Science e-learning tool.

Hypothesis H7: The increase in motivation on using the Science e-learning tool could positively affects students' motivation to learn with e-learning.

Hypothesis H8: The increase in motivation on using the Science e-learning tool could positively affects students' motivation to learn Science.

Hypothesis H9: There is a mediation effect (indirect effect) of the needs-satisfying teaching approaches (intervention) to motivation to use Science e-learning tool (MSE) through the satisfaction of competence, autonomy and relatedness.

3.2 The Participants

108 students in four classes of year 8 students who studied in ELCHK Lutheran Academy in Secondary School Division were recruited. Each class had about 26-29 students. Two classes were assigned as the control groups while the other two classes were assigned as the experimental groups, while one class was set as the experimental group for Study 1 and the other class was set as the experimental for Study 2. The writer conducted a pilot test using two Year-8 students in a class to represent the control group and two other Year-8 students in the fifth class (Class E) to represent the experimental group. Evaluation was collected from the pilot students to ensure the fluency of the intervention procedure. Some students were absent from the classes. Finally, 95 responded data were collected. The control group and the experimental group for the two studies were assigned according to the mechanism in Figure 8a. For an effect size with a benchmark from medium to large, the ANOVA-f value could be accepted in a range from 0.25 to 0.40 while η^2 in a range from 0.06 to 0.14 (Cohen, 1988). If we set the f value as 0.28, we have a the power for sample size as 0.9523 and the sample size is 44 students. The size of two classes is at least 47 student participants, which is enough.

Figure 8

The arrangement of the control group and the experimental group (i.e. intervention group)

Class*	Study 1 – Physics content	Study 2 – Chemistry content
Year 8 Class A	Control	Experimental
Year 8 Class B	Experimental	Control
Year 8 Class C	Experimental	Control
Year 8 Class D	Control	Experimental

Note. Year 8 Class E was chosen for selecting students for the pilot test.

3.3 Procedures

An initial survey (Pre-test) was completed before the start of the experiment. Participants reported on their perception of the satisfaction of the three basic psychological needs, the motivation on using the e-learning tool and the motivation in learning Science before the experiment. Then, participants received different instructions according to the group that they were assigned to.

In the experimental group, students completed an online instruction with the implementation of need-satisfying e-learning teaching supports based on SDT. Meanwhile, in the control group, students received instruction as normal, without the emphasis of any need-satisfying teaching approaches.

There were two studies in the project. Study 1 was conducted within a Physics class and Study 2 was conducted within a Chemistry class. In Study 1, both groups of students would be given an online virtual lab simulation. The students were asked to connect the targeted circuits by using the online virtual lab simulation with the aid of a simple circuit diagram. They were required to find out the values of the current and the voltage of the

connected circuit. In Study 2, the students were required to find out the pH values and some other chemical quantities of a certain amount of chemical solution. In the experimental group, the teacher would provide a series of needs-satisfying support. The detailed comparison of the teaching methods of the two conditions were displayed in Figure 9 and the step-by-step procedures were listed in the Chapter 3.5.

I adopt the mixed method in my study. This is called the explanatory sequential design of mixed mode (Creswell & Clark, 2017). This is because I am going to interpret the quantitative results with the assistance of qualitative data. The quantitative data is collected by the questionnaire. The qualitative data would be collected by in-depth individual interview with a subgroup of 16 students. The individual interviews were recorded in sound format. The sound record was then transcribed to word text. The word scripts were then imported to a qualitative analysis software called Dedoose. I adopt thematic analysis. The word scripts were separately coded by relevant features, and then organized the codes into broader themes. The quantitative analysis is followed by the qualitative analysis. The quantitative data may show a tendency of correlation between the measuring variables while the qualitative data is treated as the interpretation and explanation for such a trend. Finally, the rationale behind the tendency could be interpreted by certain factors mentioned by the students.

I would like to provide supplementary information about the normal teaching practices for the control group. I was the Head of Science in ELCHK Lutheran Academy. For appraisal purpose, I have to observe all the science teachers' lessons. Based on the experience of the lesson observation, I was familiar with the daily teaching practices of the science teachers. Since ELCHK Lutheran Academy did not especially emphasize the importance of psychological needs-satisfaction, the school did not intentionally promote needs-satisfying teaching practices to teachers. The general teachers from Lutheran Academy are not required to exhibit the needs-satisfying teaching approaches in their lesson, so that they would not

especially demonstrate needs-satisfying teaching approaches in the simulation lab lesson. According to the lesson observation, I recorded the normal teaching practices the science teachers. The teachers did not alert much students' needs satisfaction on using e-learning, so that they were not much intentionally perform needs-satisfying teaching approaches in their class, especially in a simulation lab lesson. In Figure 9, the "normal practice of simulation lab to be applied in the control group" is the daily practices performed by the science teachers. The normal teaching practices without emphasizing the needs-satisfying teaching approaches would become the control group.

My research context was originally designed for online learning. When I was developing this research topic during the pandemic period, the schools in Hong Kong were having suspension from 2020 February to early 2021. I noticed that the teachers cannot be aware of students' facial expressions and their performance in online environment, the teacher would easily ignore student's needs and miss to provide the support. However, when I collect the data in Jun 2021, the school resumed to normal lessons without no more suspension. So I shifted my research focus on how teachers satisfy students' psychological needs in a lesson with using science e-learning tool, rather than focusing on the teaching practices in the online learning environment. For the literature review, I would still acquire common elements from the online learning researches. However, for the experiment, I emphasize on the how the needs-satisfying teaching practices cater students' e-learning usage. Even though the teacher researchers were physically presented in the class, they were asked to provide a lesson with science e-learning tool as usual as their daily practices. As mentioned in p.83, their daily practices in a lesson with e-learning tool was free of awareness on students' satisfaction on using e-learning too. Meanwhile, the students were also facing their laptop screen and focusing on their e-learning task. If the teachers did not intentionally pay attention to students' e-learning needs satisfaction, it would not be shown by the student

apparently. The first science class without alerting students' needs satisfaction on using e-learning and not much needs-satisfying teaching practices provided by teachers was treated as the control group (i.e. 1st class as control group). The second class with some needs-satisfying teaching approaches for e-learning would be treated as the intervention group.

For the intervention group, the needs-satisfying teaching practices for e-learning simulation are emphasized in terms of competence, autonomy and relatedness. This is the differentiation from the teaching practices without emphasizing needs satisfaction in e-learning lesson on the right column. (see Figure 9).

To satisfy the need of competence, the subject teacher provided an online demonstration video for an online experiment. According to Bandura (1986), a demonstration of a technique would provide a vicarious experience to the audience. Bandura's social learning theory indicated that people could gain vicarious experiences by observing the actions performed by others. This vicarious experiences could enhance an individual's belief in their own ability to perform a task (Bandura, 1986). In conclusion, vicarious experiences enhance the self-efficacy which is very similar to the sense of perceived competence of the observer. It is well-elaborated by Hughes and his colleagues (Hughes et al., 2011). In my study, the SDT is applied to the online environment which is related to the task performance of the e-learning tool. The overlapped similarity is that the lecturer is encouraged to provide detailed demonstration of configurating the e-learning tool for the student observers in order to satisfy their sense of perceived competence. The vicarious experience, i.e. an observation of a demonstration, would enhance the self-efficacy of the audience. In addition, the teacher would provide optimally challenging online task according to students' information literacy and provide e-learning tasks with respect to students' interest and their common language. In this regard, tutorial guiding questions were implemented at different stages of the demonstration video to ensure the students to have enough information literacy on

configuring the online lab so that the task would not be too difficult for them and the difficulty of the task would fall into their zone of optimal development. Once the student has enough confidence in configuring the online lab, the online experiment would more likely become an optimally challenging task for the students. The guiding questions are also designed with some straightforward spoken language which the students would use in their daily conversation with their teachers inside the integrated science lesson. This ensures the students would have their common language used in the online lab. The subject teacher would provide reflective and personalized feedback to the students. Automatic encouraging feedback would be given to students in the demonstration video after the students answering the guiding questions. The student's work was graded by the chief researcher and encouraging and evaluative feedback would be given to individual students upon the completion of the marking of the online experiment worksheet. Yet the student work of the control group was not marked and no comment was provided.

To satisfy the need of autonomy, the subject teacher provided rationale of learning the materials before the delivery of the learning task. With respect to this, the teacher in the experimental group would explain the rationales of the learning task to the students such that the task would help the students to understand the relationship between the connection method and the brightness of a light bulb. The subject teacher is suggested to provide choice on the reading material or the learning tasks. In the study, there was a demonstration video which allowed the students to choose to watch the entire content or skip the unwanted parts. The teacher allowed the students to share their reflection and to provide online tutorials to lower achievers. In particular, the teacher would provide a series of tutorial guiding questions provided in different stages of the demonstration video to the students in the experimental group. Some of these questions helped the students to have a quick reflection on what they learned at different stages of the demonstration video. The students were also allowed to

choose to reflect at all these kind of scaffolding questions, or simply skip it. The teacher provided the students with room of freedom to submit the online assignment. Comparing to students in the control group who were asked to complete the online task with a close deadline (10 minutes), the students in the intervention group would have no limitation on the completion time. They only had to submit the task before the end of the day of delivering the learning materials.

To satisfy the need of relatedness, the teacher designed the Edpuzzle system to allow student to give reflection during the online task. Some tutorial guiding questions at different stages of the demonstration video were provided for the student to reflect their learning progress. Automatic positive and encouraging feedback was then provided by the video learning platform. Relatively, it could be a form of encouragement and room for reflection while comparing to other e-learning platform which did not provide such a support. In addition, the teacher in the intervention group would give appreciation and recognition to the students upon the submission of the electricity quantities measurement and the online circuit diagram, no matter whether the answers were correct or not in order to enhance the teacher-student relationship. When students receive unconditional recognition and appreciation from the teachers, perceived relatedness was found to be increased from previous studies (Assor & Tal, 2012; Roth et al., 2009; Roth & Assor, 2010). Moreover, the teacher would also care about each individual student's feeling of completing the e-learning task. This also might help to build a good student-teacher relationship.

Figure 9

Difference between the normal practice and the needs-satisfying teaching practice for conducting a Science experiment.

Basic needs	Normal practice of simulation lab to be applied in the control group	Needs-satisfying approaches to be applied in the intervention group
For Competence	1. live demonstration without video record 2. provide standard task for all students 3. provide standard feedback	1. **online demonstration video** 2. **online scaffolding questions** 3. **instant evaluative feedback online**
For Autonomy	1. Directly go to the instruction of the task 2. Only provide 1 standard set of reading material and 1 standard set of learning task 3. Not much reflection time for students 4. Ask the students to submit the task during the lesson period or a fixed duration	1. **explains the rationales of the instruction of the online learning task** 2. **provides choices on the online support material of the learning tasks** **3. allows the students to share their reflection online** 4. provides a **larger room of freedom to submit** the work
For Relatedness	1. No reflection session for students, only allow students to ask, but not to reflect. 2. Only general comments but not specific appreciation and recognition to students. 3. care about the submission status of student's and the correctness of the task.	1. **allows student to reflect** online during the learning progress 2. **gives immediate appreciation and recognition** to the students 3. **cares about** each individual **student's feeling**

Note. The normal practice mentioned above is based on the author's observation and experience in his teaching.

To minimize self-fulfilling research bias of the students, I would ensure neither the participating teachers nor the student participants know the experimental conditions. This helps to prevent unintentional cues or biases from influencing the research process or outcomes. It also prevent their expectations from influencing outcomes. I would like to ensure consistent and standardized instructions and procedures for all participants to reduce variability. I have drafted standardized protocols for data collection. It clearly define the steps, instructions, and criteria for assessments to minimize variability and subjective

interpretation. This helps to ensure consistency across participating teachers and minimize the potential impact of biases.

I asked the teacher-researchers to conduct the experiment during the post-exam period in June. It was firstly mentioned to students that their performance will not influence their formative or summative scores. The students have no incentives to performance better or show self-fulfilling research bias in order to get better score for the subject grade. It could help to minimize students' self-fulfilling bias because of getting advantages from academic result. I have also invited different teacher-researches (Mary, Johnny and Sunny) for the four classes in the experiment. The students have no incentives to please any teachers for better impression since the teacher will not be their teachers in year 9 after 1 month if the summer break came. If the student really tends to do better by their own intention by not influenced by the intervention, it means the students have the inherent motivation to work better in e-learning. We should accept this kind of learning diversity found in some students.

To solve the stage of practice effect, I arranged the data collection for control class earlier than the intervention class. It aims to prevent the need-satisfying teaching approaches appearing too early to the students and creating a long-lasting effect. For example, the control classes have the lessons and data collection within June 3 and 4. The experimental class have the lessons and data collection within June 7 and 8. Between June 4 and June 7, there was a weekend with Saturday and Sunday. The weekend holiday could bring a refreshing effect to the students. The general steps look similar for Physics and Chemistry. However, the subject-specific steps for e-learning tasks and challenges in Physics were quite different from Chemistry. The students were asked to find different answers by using the e-learning tool with unique subject-specific knowledge. So that the students did not do similar steps.

I would like to clarify the methodology gap from the literature review so far. One perspective is the gaps from different motivation models while another perspective is the

gaps from different methodological gap within SDT. Firstly, I used Figure 3 to compare the 6 critical elements among TPACK, TAM and SDT. I found that TAM model focused more on the design of the tool, since it emphasizes on the perceived usefulness and the perceived ease of use. My study focused on how the teaching approaches influence the students' motivation to use science e-learning tool, which did not mention in the TAM model. In consequence, after comparison, pure SDT model is good enough to measure the motivation of using e-learning tools with respect to the science subject and teaching approaches. Secondly, according to my objectives, I would like to investigate the influence of the need-satisfying teaching approaches on students' needs satisfaction and on the motivation of using science e-learning tool in Hong Kong secondary science education context. So far, there are not much researches investigated for Hong Kong secondary science education. The methodological implications from previous studies, e.g. Online learning satisfaction in China Universities or online self-regulated learning in European University, are still too advanced when compared with my research level. So finally, I have adopted a relatively direct methodology to collect and analyse the data for online learning in HK secondary education. Nevertheless, from the previous methodological implications of SDT, I have learnt many good elements to suggest the e-learning teaching practices in Figure 6. These e-learning teaching practices contributed to the methodological gap and it finally led to my experimental interventions and the theoretical model.

3.4 The Collection of Measures

From the questionnaire of this study, the questions are divided into three different parts of scale, Parts A, B and C. Part A and Part C are utilized for comparing the contrast before and after applying the intervention effect, i.e. the pre-test and post-test on the needs-satisfying teaching approaches. It seems like a pre/post comparison. Since there are two experimental groups of students, one is the intervention group and the other one is the control

group. Both experimental groups of students have to fill in a similar set of instrument questions, while some items in part A will not appear in part C because some items are only suitable for asking before the intervention. Part B consists of questions related to the perception of the 3 basic needs satisfaction affected by the intervention were newly designed by the writer of this paper, according to the intervention procedures with respect to the needs-satisfying teaching approaches.

For the “Enjoyment” part of the questionnaire, the participants will complete the shortened version of the general internet self-efficacy (GISE) Scale (Hsu & Chiu, 2004). The scale consists of four items rated with seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree). The scale assesses the extent to which participants feel if the e-learning task is interesting, enjoyable, exciting and fun. There are 4 items in total, which consists of "I think doing the e-learning task is interesting" and "I think doing the e-learning task is enjoyable". An overall Enjoyment score was derived by averaging all the four items. Based on the reliability analysis (Zhao et al, 2011), Cronbach’s $\alpha = .886$, showing good reliability (Nunnally, 1978).

For the “Curiosity” part of the questionnaire, the participants will complete the shortened version of the Curiosity Scale (Huang, 2003). The scale consists of three items rated with seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree). The scale assesses the extent to which participants feel if the e-learning task could connect with curiosity. There are 3 items in total, which consists of "Doing the e-learning task excites my curiosity", "Doing the e-learning task makes me curious", and "Doing the e-learning task arouses my imagination". An overall Curiosity score was derived by averaging all three items. Based on the reliability analysis (Zhao et al, 2011), Cronbach’s $\alpha = .847$, showing good reliability (Nunnally, 1978).

For the “Teacher Support” part of the questionnaire, the participants will complete the shortened version of the scales of superior influence (Taylor & Todd, 1995) and organizational support (Igbaria et al., 1996). The scale consists of three items rated with seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree). The scale assesses the extent to which participants feel if their teacher is supportive. There are 3 items in total, which consists of "My teachers always encourage me to use the Internet", "My teachers are providing most of the necessary help and resources to get us used to the Internet quickly", and "I am always supported and encouraged by my teachers to use the Internet". An overall Teacher Support score was derived by averaging all three items. Based on the reliability analysis (Zhao et al, 2011), Cronbach’s $\alpha = .868$, showing good reliability (Nunnally, 1978).

For the “Basic Need Satisfaction” part of the questionnaire, the participants will complete the shortened version of the Basic Need Satisfaction at Work Scale which is used by Kasser, Davey, and Ryan (1992) and Baard, Deci, and Ryan (2004). The scale consists of 15 items rated with seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree). The scale assesses the extent to which participants feel if their e-learning consists of a general sense of relatedness, autonomy and competence. The relatedness subscale consists of “People at school care about me” and “People at school are pretty friendly towards me”. The autonomy subscale consists of “I feel pressured at using e-learning in my study” and “I feel like I can pretty much use e-learning as I want to”. The competence subscale consists of “I have been able to learn interesting new skills in e-learning” and “When I am using e-learning I often feel very capable”. An overall Basic Need Satisfaction score was derived by averaging all 15 items. Based on the reliability analysis (Sørebø et al., 2009), Cronbach’s α for the three subscales are .76, .89 and .81 respectively, showing good reliability (Nunnally, 1979).

For the “General Feeling on learning Science with e-learning tool” part of the questionnaire, it consists of 5 items which are newly designed by the writer of this paper. The scale consists of 5 items rated with seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree). The scale assesses the extent to which participants feel if they are enjoyable and motivated in learning Science with the e-learning tools. There are 5 items in total, which consists of "I have motivation in learning Science with e-learning" and " I have the motivation to learn Science at all". An overall General Feeling on learning Science with e-learning tool score was derived by averaging all 5 items. Since the 5 items are newly designed by the writer of this paper, the reliability is yet to be calculated.

For the “Perceived Needs Satisfaction affected by the intervention” part of the questionnaire (part B of the questionnaire), it consists of 18 items which could be categorized into the 3 sub-scales of competence-type (5 items), autonomy-type (10 items) and relatedness-type (3-items). The sets of questions related to the perception of the 3 basic needs satisfaction affected by the intervention were newly designed by the writer of this paper, according to the intervention procedures with respect to the needs-satisfying teaching approaches in the intervention. The Competence subscale indicates one’s feelings on his/her abilities while the Autonomy subscale indicates one’s sense of his/ her degree of freedom and volition of himself to decide things. The Relatedness subscale indicates one feels that he/she is supported by the environment. All items were measured using a 7-point Likert-type scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Sample items of Competence subscale, Autonomy subscale, and Relatedness subscale are “After watching the demonstration of using the online lab, I am confident to use the online lab.”, “Choosing to watch the demonstration video or skip it makes me feel free to explore my knowledge.” and “The e-learning support gives me a feeling of caring.” respectively. An overall Perceived Needs Satisfaction affected by the intervention score was derived by averaging all 18 items.

Since the 5 items are newly designed by the writer of this paper, the reliability is yet to be calculated.

A very similar study on investigating students' cognitive and motivation condition has been done by Ching-Huei Chen from National Changhua University of Education, Taiwan (Chen, 2014). The study involved middle school students in learning Physics. It was also an applied experimental research with comparing the result of the experimental group and the control group. That study pointed out that adaptive scaffolding on e-learning system could improve students' cognitive performances and motivational outcomes. The first difference comparative to my study is that Chen was using the Academic Motivation Scale (Vallerand et al, 1992) without applying the perspective of self-determination theory. The second difference is that Chan was studying on the learning management system while I am studying on the knowledge-oriented interactive e-learning tool, the online simulation experiment. Since there are many similarities found on these two studies, I think my study could take a good reference on Chen's research. The effect size for Chen's student motivational profile is $\eta 2=.08$ which is medium to large. From the reference table below, I could set my effect size $f=.28$ and the sample size would be 44.

According to the Free-Choice period (Wiechman & Gurland, 2009), it is stated that the participant would pick a free-choice activity to show their intrinsic motivation for that particular activity. With respect to this theory, I have created a new behavioural indicator at the end of the framework, called the choosing action. Firstly, after the completion of the online experiment worksheet task, students are given an extra simulation lab work to do. They could choose to do or not to do. If they still choose to do extra Science simulation task, it could show that the students have motivation in using the e-learning too. Secondly, after the completion of the extra simulation lab work, students are given a Science article for them to read. They could choose to read or not to read. If they still choose to read the Science

article, it could show that the students have motivation in learning Science too. At this point, we could not provide book from other subjects. Since choosing a History book in independent to the students' motivation in learning Science. So, choice option will not be provided in different subjects.

Before the intervention, the major variables from the control group and experiment group are measured to see the pre-test perception of student's learning motivation on using the Science e-learning tool including Competence, Relatedness, Autonomy and Motivation on learning Science with e-learning tool (MSE). After the intervention, these variables were measured again. These variables are measured in Study 1 about Physics and Study 2 about Chemistry. Hence, the students' motivation to learn with e-learning (ME) and the student's motivation to learn Science (MS) were also measured to check their motivation on the e-learning and Science. We count the duration, in seconds, for how much additional time a student would spend on using the e-learning tool and reading the Science article after the completion of the short quiz in Physics or Chemistry. For example, if a student spent longer additional time using the e-learning tool after the experiment, it means that the student would have a higher motivation to learn with the e-learning tool. If a student spent longer additional time to read the Science article after the experiment, it means that the student would have a higher motivation on learning the subject to learn Science. After the quantitative data is collected, there were 16 individual interviews for qualitative analysis.

For the free choice period, I can measure the time that the student willing to spend on reading an extra science article or doing an extra e-learning task. The time was measured by another online survey with time recording function. When a student pressed the article link and started reading, the online survey recorded the start time. Once the student finished reading the article or just simply skipped reading at any moment, they will go back to submit the survey and end time would be recorded. The duration for which they spent on reading the

science article was the free-choice period to indicate their motivation to learn Science (MS). On the other hand, When a student pressed the link to do another simulation task, the online survey recorded the start time. Once the student completed the extra e-learning task, or just simply skipped the task at any moment, they will go back to submit the survey and end time would be recorded. The duration for which they spent on doing extra e-learning task was the free-choice period to indicate their motivation for e-learning (ME).

The interview questions are set based on the need-satisfying teaching approaches mentioned in the quantitative questionnaire. I would like to investigate whether such an increase or decrease of students' need satisfaction could be attributed to the need-satisfying teaching approaches. I want to understand whether the need-satisfying teaching approaches were really effective to the students. The students have freedom to reflect that their feeling has no relationship with the teaching approaches. If so, I would stop mentioning the teaching approaches but ask if there are any other rationales behind their own thoughts. By the way, not all the interview questions will be asked if a student reflected strong comment and rationale. The interview questions are asked only when the students responded not much comments and reflection. In general, follow-up questions will be asked according to students' different responses. If students have different responses, different follow-up questions will be interacted.

3.5 The Procedure Steps of the Experiment of Study 1

This study would like to investigate the influence of the needs-satisfying teaching approaches to the motivation of e-learning. We are questioning whether the needs-satisfying approaches would enhance the learning motivation among secondary school students in Hong Kong in the perspective of Self-determination Theory (Deci & Ryan, 1986, 2000). Through satisfying the needs of competence, autonomy and relatedness, we are going to find out

whether the Hong Kong secondary school students in Science would really feel motivated in the needs-satisfying e-learning teaching approaches.

3.5.1 Detailed Procedure for Study 1 about Physics

In Study 1, we will try to make an experiment on a Physics-oriented online simulation called the "circuit construction kit - dc virtual lab" organized by the PHET interactive simulation website. Below is the procedure stated with theoretical assumption.

Step 1: Two experimental groups of students are asked to fill in the questionnaire before the experiment.

Step 2: Two experimental groups of students are asked to use the online simulation lab to connect a circuit. Link: https://phet.colorado.edu/sims/html/circuit-construction-kit-dc-virtual-lab/latest/circuit-construction-kit-dc-virtual-lab_en.html

Step 3: The supervisor teacher asks the students to measure the current flowing through the circuit built by them and the voltage across it. The circuit diagrams are showing two batteries as the supply source with two lamps connected in-series and in-parallel. A diagram is shown below. The supervisor teacher in the intervention group would explain the rationales of the learning task to the students that this task would help the students to understand the relationship between the connection method and the brightness of the light bulb. It helps to understand the basic principle of the performance of electronic device, which helps studying electrical engineering in the future.

Step 4: The teacher supervisor would provide a demonstration video to the students in the **intervention group only**. The video link is: https://edpuzzle.com/assignments/65af3472cb5ed1a811012c78/watch. There are some scaffolding guiding questions provided in different stages of the video to help the student to understand the configuration of the simulation laboratory more. The students can choose to

give reflection at all the checkpoint questions, or simply skip it. Evaluative and encouraging feedback would be given to the students according to their responses on the guiding questions. The control group of students are not provided with any demonstration video or guiding questions.

Step 5: The control group of students are asked to complete the task within 10 minutes. The Intervention group of students have no limitation on the completion time. They only have to submit it before the end of the day. Moreover, the students in the control group are asked to complete all the answers in the learning task worksheet. Yet the students in the intervention group are told that they are allowed to choose to complete any part of the worksheet tasks. Supervision is relatively reduced in the intervention group compared to the control group.

Step 6: Upon the submission of measuring the electricity quantities, the teacher supervisor would give appreciation and recognition to the intervention group of students, no matter whether their answers are correct or not. The control group of students will not receive any appreciation. The teacher supervisor would also care about each individual student's feeling of completing the e-learning task. Warm caring and encouraging appreciation would be given to the students upon their submission of the learning task, which is independent of the quality of submitted work and unconditional to each of the students in the intervention group.

Step 7: The teacher would ask the two groups of students to fill in the questionnaire about their perceived feeling on the e-learning application after the submission of the measured values.

Step 8: The student's work of the intervention group will be marked by the teacher supervisor. Positive and evaluative feedback will be provided to the student in the

intervention group. Yet the student works of the control group will not be marked and no comments will be provided.

Step 9: After the completion of the online experiment worksheet task, students are given an extra simulation lab work to do. They could choose to do or not to do. If they still choose to do extra Science simulation task, it could show that the students have higher motivation in using the e-learning too.

Step 10: After the completion of the extra simulation lab work, students are given a Science article for them to read. They could choose to read or not to read. If they still choose to read the Science article, it could show that the students have higher motivation in learning Science too.

3.5.2 Detailed Procedure for Study 2 about Chemistry

This study would like to investigate the influence of the needs-satisfying teaching approaches to the motivation of e-learning. We are questioning whether the needs-satisfying approaches would enhance the learning motivation among secondary school students in Hong Kong in the perspective of Self-determination Theory (Deci & Ryan, 1986, 2000). Through satisfying the needs of competence, autonomy and relatedness, we are going to find out whether the Hong Kong secondary school students in Science would really feel motivated in the needs-satisfying e-learning teaching approaches.

In Study 2, we will try to make an experiment on a Chemistry-oriented online simulation called the "pH scale" organized by the PHET interactive simulation website. Below is the procedure stated **with theoretical assumption.**

Step 1 : Two experimental groups of students are asked to fill in the questionnaire before the experiment.

Step 2 : Two experimental groups of students are asked to use the online simulation lab to mix the acid and alkaline. Link: https://phet.colorado.edu/sims/html/ph-scale/latest/ph-scale_en.html

Step 3 : The supervisor teacher asks the students to measure the pH value and some other chemical quantities of the mixture solution. The supervisor teacher in the intervention group would explain the rationales of the learning task to the students that this task would help the students to understand the relationship between the pH value and the function of the solution. The learning task would also help the students to understand how to change the acidity of a solution, in order to adjust the concentration of the acidity by themselves. It helps to understand more on Food Science and Pharmacy in the future.

Step 4 : The teacher supervisor would provide a demonstration video to the students in the **intervention group only.** The video link is: https://edpuzzle.com/assignments/65af4247bf420d6c4da5d3ab/watch. There are some scaffolding guiding questions provided in different stages of the video to help the student to understand the configuration of the simulation laboratory more. The students can choose to give reflection at all the checkpoint questions, or simply skip it. Evaluative and encouraging feedback would be given to the students according to their responses on the guiding questions. The control group of students are not provided with any demonstration video or guiding questions.

Step 5 : The control group of students are asked to complete the task within 10 minutes. The Intervention group of students has no limitation on the completion time. They only have to submit it before the end of the day. Moreover, the students in the control group are asked to complete all the answers in the learning task worksheet. Yet the students in the intervention group are told that they are allowed to choose to complete any part of the

worksheet tasks. Supervision is relatively reduced in the intervention group compared to the control group.

Step 6 : Upon the submission of the assigned tasks on the worksheet, the teacher supervisor would give appreciation and recognition to the intervention group of students, no matter whether their answers are correct or not. The control group of students will not receive any appreciation. The teacher supervisor would also care about each individual student's feeling of completing the e-learning task. Warm caring and encouraging appreciation would be given to the students upon their submission of the learning task, which is independent of the quality of submitted work and unconditional to each of the students in the intervention group.

Step 7 : The teacher would ask the two groups of students to fill in the questionnaire about their perceived feeling on the e-learning application after the submission of the measured values.

Step 8 : The student works of the intervention group will be marked by the teacher supervisor. Positive and evaluative feedback will be provided to the student in the intervention group. Yet the student works of the control group will not be marked and no comments will be provided.

Step 9 : After the completion of the online experiment worksheet task, students are given an extra simulation lab work to do. They could choose to do or not to do. If they still choose to do extra Science simulation task, it could show that the students have higher motivation in using the e-learning too.

Step 10 : After the completion of the extra simulation lab work, students are given a Science article for them to read. They could choose to read or not to read. If they still choose to read the Science article, it could show that the students have higher motivation in learning Science too.

Chapter 4 Data Analysis and Results

4.1 Result of Quantitative Data

Table 1.

Means and Standard Deviations of Basic Needs Satisfaction at Different Time Points For Physics.

	Control			Intervention		
Variable	Time 1	Time 2	t(46)	Time 1	Time 2	t(47)
Competence	4.04	3.88	-1.01	4.24	5.40	13.59
Autonomy	4.20	3.67	-4.41	4.32	4.57	12.04
Relatedness	4.52	3.97	-4.53	4.45	5.37	13.73

Note. Means and standard deviations of basic needs satisfaction at different time points for Physics.
Note. t=t-value for the T-test with the degrees of freedom (df).

In order to test Hypothesis H1, we are going to find out whether the need-satisfying e-learning teaching approaches, i.e. the intervention, could positively affect the students' perceived competence in using the e-learning tool to learn Science by repeated measure ANOVA. From the data found in Study 1 about Physics, it showed that there is a significant time X condition interaction effect ($F(1, 93)=52.88$, $p<0.01$, partial $\eta^2 = 0.36$. In other words, the pre- and post-perceived competence is significantly different across the two experimental conditions. For the simple main effect analysis on Physics, there is a significant drop between the pre-score and post-score for the control group (M_pre = 4.04; M_post = 3.88, $t(46) = -1.01$, $p = 0.319$). A significant increase is found between the pre-score and post-score was detected for the experimental group (M_pre = 4.24; M_post = 5.40, $t(47) = 13.59$, $p < 0.01$).

Table 2

Test of within-subject subject contrasts for the perceived competence in Physics.

Source	df	mean square	F	Sig.	Partial η^2
time	1	11.793	30.015	.000	.244
time*Group_Condition	1	20.778	52.883	.000	.363
Error(time)	93	.393			

In order to test Hypothesis H2, we are going to find out whether the need-satisfying e-learning teaching approaches, i.e. the intervention, could positively affect the students' perceived autonomy in using the e-learning tool to learn Science. From the data found in Study 1 about Physics, it showed that there is a significant time X condition interaction effect ($F(1, 93)=42.25$, $p<0.01$), partial $\eta^2 = 0.31$). In other words, the pre- and post-perceived autonomy is significantly different across the two experimental conditions. For the simple main effect analysis on Physics, there is a significant drop between the pre-score and post-score for the control group ($M_{pre} = 4.20$; $M_{post} = 3.67$, $t(46) = -4.41$, $p<0.01$). A significant increase between the pre-score and post-score was detected for the experimental group ($M_{pre} = 4.32$; $M_{post} = 4.57$, $t(47) = 12.04$, $p<0.01$).

Table 3

Test of within-subject subject contrasts for the perceived autonomy in Physics.

Source	df	mean square	F	Sig.	Partial η^2
time	1	.874	5.135	.026	.052
time*Group_Condition	1	7.192	42.248	.000	.312
Error(time)	93	.170			

In order to test Hypothesis H3, we are going to find out whether the need-satisfying e-learning teaching approaches, i.e. the intervention, could positively affect the students' perceived relatedness in using the e-learning tool to learn Science. From the data found in

Study 1 about Physics, it showed that there is a significant time X condition interaction effect ($F(1, 93)=112.22$, $p<0.01$), partial $\eta^2 = 0.55$). In other words, the pre- and post-perceived relatedness is significantly different across the two experimental conditions. For the simple main effect analysis on Physics, there is a significant drop between the pre-score and post-score for the control group ($M_{pre} = 4.52$; $M_{post} = 3.97$, $t(46) = -4.533$, $p<0.01$). A significant increase between the pre-score and post-score was detected for the experimental group ($M_{pre} = 4.45$; $M_{post} = 5.37$, $t(47) = 13.73$, $p<0.01$).

Table 4

Test of within-subject subject contrasts for the perceived relatedness in Physics.

Source	df	mean square	F	Sig.	Partial η^2
time	1	1.515	6.658	.011	.067
time*Group_Condition	1	25.533	112.220	.000	.547
Error(time)	93	.228			

In order to test Hypothesis H1, H2 and H3 with respect to the perceived competence , autonomy and relatedness for Chemistry, we are now looking into the table 5 below.

Table 5

Means and Standard Deviations of Basic Needs Satisfaction at Different Time Points For Chemistry.

	Control			Intervention		
Variable	Time 1	Time 2	t(47)	Time 1	Time 2	t(46)
Competence	4.21	3.78	-2.44	4.07	5.27	10.90
Autonomy	4.33	3.74	-4.35	4.27	4.99	8.06
Relatedness	4.48	3.59	-6.93	4.50	5.44	15.40

Note. Means and standard deviations of basic needs satisfaction at different time points for Chemistry.
Note. t=t-value for the T-test with the degrees of freedom (df).

From the data found in Study 2 about Chemistry for Hypothesis 1, it showed that there is a significant time X condition interaction effect ($F(1, 93)=60.83$, $p<0.01$, partial $\eta^2 = 0.40$). In other words, the pre- and post-perceived competence is significantly different across the two experimental conditions. For the simple main effect analysis on Chemistry, there is a significant drop between the pre-score and post-score for the control group ($M_{pre} = 4.21$; $M_{post} = 3.78$, $t(47) = -2.44$, $p = 0.018$). A significant increase between the pre-score and post-score was detected for the experimental group ($M_{pre} = 4.07$; $M_{post} = 5.27$, $t(46) = 10.90$, $p<0.01$).

Table 6

Test of within-subject subject contrasts for the perceived competence in Chemistry.

Source	df	mean square	F	Sig.	Partial η^2
time	1	7.004	13.519	.000	.127
time*Group_Condition	1	31.514	60.830	.000	.395
Error(time)	93	.518			

From the data found in Study 2 about Chemistry for Hypothesis H2 , it showed that there is a significant time X condition interaction effect ($F(1, 93)=64.19$, $p<0.01$), partial $\eta^2 = 0.041$). In other words, the pre- and post-perceived autonomy are significantly different across the two experimental conditions. For the simple main effect analysis on Chemistry, there is a significant drop between the pre-score and post-score for the control group ($M_{pre} = 4.33$; $M_{post} = 3.74$, $t(47) = -4.35$, $p<0.01$). A significant increase between the pre-score and post-score was detected for the experimental group ($M_{pre} = 4.27$; $M_{post} = 4.99$, $t(46) = 8.06$, $p<0.01$).

Table 7

Test of within-subject subject contrasts for the perceived autonomy in Chemistry.

Source	df	mean square	F	Sig.	Partial η^2
time	1	.189	.586	.446	.006
time*Group_Condition	1	20.708	64.189	.000	.408
Error(time)	93	.323			

From the data found in Study 2 about Chemistry for Hypothesis H3, it showed that there is a significant time X condition interaction effect ($F(1, 93)=163.91$, $p<0.01$, partial $\eta^2 = 0.64$). In other words, the pre- and post-perceived relatedness are significantly different across the two experimental conditions. For the simple main effect analysis on Chemistry, there is a significant drop between the pre-score and post-score for the control group ($M_{pre} = 4.48$; $M_{post} = 3.59$, $t(47) = -6.93$, $p<0.01$). A significant increase between the pre-score and post-score was detected for the experimental group ($M_{pre} = 4.50$; $M_{post} = 5.44$, $t(46) = 15.40$, $p<0.01$).

Table 8

Test of within-subject subject contrasts for the perceived relatedness in Chemistry

Source	df	mean square	F	Sig.	Partial η^2
time	1	.035	.144	.705	.002
time*Group_Condition	1	40.102	163.909	.000	.638
Error(time)	93	.245			

In order to test Hypothesis H4, 5, 6, to examine whether perceived competence, autonomy and relatedness would positively affect (MSE) the students' motivation in using the Science e-learning tool, multiple regression analyses were conducted with the three needs entered simultaneously to the model . From the data found in Study 1 about Physics, it

showed that the perceived competence significantly influenced the (MSE) students' motivation in using the Science e-learning tool (t(0.35, 0.10)=3.46, p=0.001). However, the perceived autonomy did not influence the (MSE) students' motivation in using the Science e-learning tool (t(0.05, 0.11)=0.44, p=0.66). Nevertheless, the perceived relatedness significantly influenced the (MSE) students' motivation in using the Science e-learning tool (t(0.60, 0.10)=5.76, p<0.001) as well. It means that perceived competence and perceived relatedness are positively related to the motivation to use Science e-learning (MSE) respectively while perceived autonomy is not.

Table 9

Coefficients of basic needs satisfaction under regression by MSE for Physics.

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	0.024	0.342		0.070	0.944
Post_Perceived_relatedness	0.594	0.103	0.555	5.760	0.000
Post_Perceived_Autonomy	0.049	0.110	0.028	0.443	0.659
Post_Perceived_Competence	0.347	0.100	0.350	3.457	0.001

Note. Note. MSE=students' Motivation to use Science e-learning tool

From the data found in Study 2 about Chemistry, it showed that the perceived competence significantly influenced the (MSE) students' motivation in using the Science e-learning tool (t(0.47, 0.07)=6.52, p<0.01). The perceived autonomy also significantly influenced the (MSE) students' motivation in using the Science e-learning tool (t(0.17, 0.08)=2.05, p<0.05). The perceived relatedness significantly influenced the (MSE) students' motivation in using the Science e-learning tool (t(0.43, 0.07)=6.12, p<0.01) as well. It means that perceived competence, perceived autonomy and perceived relatedness are positively related to the motivation to use Science e-learning (MSE) respectively.

Table 10

Coefficients of basic needs satisfaction under regression by MSE for Chemistry.

Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	-0.350	0.281		-1.243	0.217
Post_Perceived_Competence	0.465	0.071	0.471	6.524	0.000
Post_Perceived_Autonomy	0.168	0.082	0.115	2.049	0.043
Post_Perceived_relatedness	0.430	0.070	0.416	6.116	0.000

Note. Note. MSE=students' Motivation to use Science e-learning tool

In Hypothesis H7, linear regression was used to test if students' motivation on using the Science e-learning tool (MSE) significantly predicted students' motivation to learn with e-learning (ME). From the data found in Study 1 about Physics, the overall regression was not statistically significant (R^2= .035, β = 37.544, SE = 20.407, F(1,93)= 3.39, p = 0.069). It was found that students' motivation on using the Science e-learning tool (MSE) did not significantly predict students' motivation to learn with e-learning (ME).

Table 11a

Coefficients of linear regression with MSE as independent variable and ME as dependent variable for Physics.

R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics R^2 Change	F Change	df1	df2	Sig. F. Change
.187	.035	.025	262.138	.035	3.385	1	93	.069

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning

Table 11b

ANOVA with MSE an independent variable and ME as dependent variable for Physics

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	232598.298	1	232598.298	3.385	.069
Residual	6390615.32	93	68176.294		
Total	6623213.62	94			

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning(MSE)

Note. DV: students' motivation to learning with e-learning tool(ME)

Table 11c

Coefficients of linear regression with MSE an independent variable and ME as dependent variable for Physics

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	123.601	97.978		1.262	.210
Post_feelings_learning_science_e_learning	37.544	20.407	.187	1.840	.069

Note. DV: students' motivation to learning with e-learning tool (ME)

From the data found in Study 2 about Chemistry, the overall regression was statistically significant (R^2=0.135, F(1,93)= 14.517, $p < 0.01$). It was found that students' motivation on using the Science e-learning tool (MSE) significantly predicted students' students' motivation to learn with e-learning (ME) ($\beta = 69.737$, SE = 18.303, $p < 0.01$).

Table 12a

Coefficients of linear regression with MSE as independent variable and ME as dependent variable for Chemistry.

R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
				R^2 Change	F Change	df1	df2	Sig. F. Change
.367	.135	.126	244.141	.135	14.517	1	93	.000

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning

Table 12b

ANOVA with MSE an independent variable and ME as dependent variable for Physics

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	865298.369	1	865298.369	14.517	.000
Residual	5543251.42	93	59604.854		
Total	6408549.79	94			

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning(MSE)

DV: students' motivation to learning with e-learning tool(ME)

Table 12c

Coefficients of linear regression with MSE an independent variable and ME as dependent variable for Chemistry

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-11.954	84.670		-.141	.888
Post_feelings_learning_science_e_learning	69.737	18.303	.367	3.810	.000

Note. DV: students' motivation to learning with e-learning tool (ME)

In Hypothesis H8, linear regression was used to test if students' motivation on using the Science e-learning tool (MSE) significantly predicted students' motivation to learn Science. From the data found in Study 1 about Physics, the overall regression was statistically significant (R^2= 0.094, β = 116.508, SE = 37.479, F(1,93)= 9.664, p < 0.01). It was found that students' motivation on using the Science e-learning tool (MSE) significantly predicted students' motivation to learn Science (MS).

Table 13a

Coefficients of linear regression with MSE as independent variable and MS as dependent variable for Physics.

				Change Statistics				
R	R^2	Adjusted R^2	Std. Error of the Estimate	R^2 Change	F Change	df1	df2	Sig. F. Change
.307	.094	.084	481.440	.094	9.664	1	93	.002

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning

Table 13b

ANOVA with MSE as independent variable and MS as dependent variable for Physics

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2239900.19	1	2239900.19	9.664	.002
Residual	21555936.6	93	231784.264		
Total	23795836.7	94			

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning(MSE),

Note. DV: students' motivation to learn Science(MS)

Table 13c

Coefficients of linear regression with MSE an independent variable and MS as dependent variable for Physics.

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-7.846	179.945		-.044	.965
Post_feelings_learning_science_e_learning	116.508	37.479	.307	3.109	.002

Note. DV: students' motivation to learning Science (MS)

From the data found in Study 2 about Chemistry, the overall regression was not statistically significant (R^2<0.01, β = -53.341, SE = 449.594, F(1,93)= 0.014, p = 0.906). It was found that students' motivation on using the Science e-learning tool (MSE) did not significantly predict students' motivation to learn Science (MS).

Table 14a

Coefficients of linear regression with MSE as independent variable and MS as dependent variable for Chemistry.

R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
				R^2 Change	F Change	df1	df2	Sig. F. Change
.012	.000	-.011	5997.086	.000	.014	1	93	.906

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning

Table 14b

ANOVA with MSE as independent variable and MS as dependent variable for Chemistry

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	506242.705	1	506242.705	.014	.906
Residual	3.345E+9	93	35965044.0		
Total	3.345E+9	94			

Note. Predictors: (Constant), Post_feelings_learning_science_e_learning(MSE)

Note. DV: students' motivation to learn Science(MS)

Table 14c

Coefficients of linear regression with MSE an independent variable and MS as dependent variable for Chemistry.

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1252.552	2079.829		.602	.548
Post_feelings_learning_science_e_learning	-53.341	449.594	-.012	-.119	.906

Note. DV: students' motivation to learning Science (MS)

In Hypothesis H9, it aims to investigate whether the mediation effect (indirect effect) of the needs-satisfying teaching approaches (intervention) through competence, autonomy and relatedness to affect the motivation on Science e-learning tool (MSE) is significant.

From the data found in Study 1 about Physics, it showed that the motivation on using the e-learning tool to learn Science (MSE) is significantly influenced by the intervention ($F(1, 93)=41.22$, $p<0.01$). From the data found in Study 2 about Chemistry, it showed that the motivation on using the e-learning tool to learn Science (MSE) is significantly influenced by the intervention ($F(1, 93)=90.21$, $p<0.01$). It means that the motivation on using the e-

learning tool to learn Science (MSE) is positively influenced by the needs-satisfying teaching approaches for both Physics and Chemistry.

Table 15

Coefficients of regression of MSE under group conditions for Physics

Effect	F	Hypothesis df	Error df	Sig.
MSE	18.120	1	93	0.000
MSE*Group_Condition	41.221	1	93	0.000

Table 16

Coefficients of regression of MSE under group conditions for Chemistry

Effect	F	Hypothesis df	Error df	Sig.
MSE	4.302	1	93	0.041
MSE*Group_Condition	90.205	1	93	0.000

In Study 1 about Physics, the needs-satisfying teaching approaches (the intervention) predicted perceived competence significantly ($\beta = 0.57$, SE = 0.22, $t(47)=13.59$, $p < 0.001$). Furthermore, the perceived competence was significantly associated with higher motivation on using the science e-learning tool (MSE) ($\beta = 0.36$, SE = 0.10, $t=3.46$, $p < 0.001$). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived competence was 0.54, 95% CI [0.21, 0.87]. Since the interval did not include zero, we concluded that the indirect effect was significant. This model accounted for 80.6% of variance of MSE at $p < 0.001$.

Table 17

Coefficients of indirect and total effect of basic needs satisfaction to MSE for Physics.

Type	Effect	Estimate	SE	95% C.I. (a)		β	z	p
				Lower	Upper			
Indirect	Group_Condition ⇒ Post_Perceived_Competence ⇒ Post_feelings_learning_science_e_learning	0.5405	0.1694	0.208	0.873	0.2050	3.190	0.001
	Group_Condition ⇒ Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.0729	0.1025	−0.128	0.274	0.0276	0.711	0.477
	Group_Condition ⇒ Post_Perceived_relatedness ⇒ Post_feelings_learning_science_e_learning	0.8466	0.1897	0.475	1.218	0.3212	4.463	<.001
Component	Group_Condition ⇒ Post_Perceived_Competence	1.5235	0.2235	1.085	1.962	0.5731	6.816	<.001
	Post_Perceived_Competence ⇒ Post_feelings_learning_science_e_learning	0.3548	0.0983	0.162	0.547	0.3578	3.610	<.001
	Group_Condition ⇒ Post_Perceived_Autonomy	0.8992	0.1262	0.652	1.147	0.5901	7.124	<.001
	Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.0810	0.1134	−0.141	0.303	0.0468	0.715	0.475
	Group_Condition ⇒ Post_Perceived_relatedness	1.3965	0.2081	0.989	1.804	0.5671	6.710	<.001
	Post_Perceived_relatedness ⇒ Post_feelings_learning_science_e_learning	0.6063	0.1015	0.407	0.805	0.5664	5.976	<.001
Direct	Group_Condition ⇒ Post_feelings_learning_science_e_learning	−0.1381	0.1548	−0.441	0.165	−0.0524	−0.892	0.372
Total	Group_Condition ⇒ Post_feelings_learning_science_e_learning	1.3219	0.2352	0.861	1.783	0.5015	5.620	<.001

Note. Confidence intervals computed with method: Standard (Delta method)
Note. Betas are completely standardized effect sizes

Moreover, the needs-satisfying teaching approaches predicted perceived autonomy significantly (β = 0.59, SE = 0.13, t(47)=12.04, p < 0.001). However, the perceived autonomy was not significantly associated with the motivation on using the science e-learning tool (MSE) (β = 0.05, SE = 0.11, t=0.44, p < 0.48). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived autonomy was 0.07, 95% CI [-0.13, 0.27]. Since the interval includes zero, we concluded that the indirect effect was not significant. This model accounted for 80.6% of variance of MSE at $p = 0.66$.

On the other hand, the needs-satisfying teaching approaches (the intervention) predicted perceived relatedness significantly (β = 0.57, SE = 0.21, t(47)=13.73, p < 0.001. Furthermore, the perceived relatedness was significantly associated with the motivation on using the science e-learning tool (MSE) (β = 0.57, SE = 0.10, t=5.76, p < 0.001). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived relatedness was 0.85, 95% CI [0.48, 1.22]. Since the interval did not include zero, we concluded that the indirect effect was significant. This model accounted for 80.6% of variance of MSE at $p < 0.001$.

Table 18

Coefficients of linear regression of basic needs satisfaction by MSE for Physics.

Model Fit Measures

Model	R	R^2
1	0.898	0.806

Model Coefficients - Post_feelings_learning_science_e_learning

Predictor	Estimate	SE	t	p
Intercept	0.0240	0.342	0.0704	0.944
Post_Perceived_Competence	0.3474	0.100	3.4571	<.001
Post_Perceived_Autonomy	0.0488	0.110	0.4429	0.659
Post_Perceived_relatedness	0.5942	0.103	5.7596	<.001

In Study 2 about Chemistry, the needs-satisfying teaching approaches (the intervention) predicted perceived competence significantly (β = 0.54, SE = 0.24, t(46)=10.90, p < 0.001). Furthermore, perceived competence was significantly associated with the motivation on using the science e-learning tool (MSE) (β = 0.47, SE = 0.07, t=6.52, p < 0.001). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived competence was 0.70, 95% CI [0.39, 1.00]. Since the interval did not include zero, we concluded that the indirect effect was significant. This model accounted for 83.5% of variance of MSE at $p < 0.001$.

Table 19

Coefficients of indirect and total effect of basic needs satisfaction to MSE for Chemistry.

Type	Effect	Estimate	SE	95% C.I. (a) Lower	95% C.I. (a) Upper	β	z	p
Indirect	Group_Condition ⇒ Post_Perceived_Competence ⇒ Post_feelings_learning_science_e_learning	0.6973	0.1544	0.3947	1.000	0.2548	4.517	<.001
	Group_Condition ⇒ Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.2015	0.1175	−0.0288	0.432	0.0736	1.715	0.086
	Group_Condition ⇒ Post_Perceived_relatedness ⇒ Post_feelings_learning_science_e_learning	0.7850	0.1706	0.4507	1.119	0.2868	4.602	<.001
Component	Group_Condition ⇒ Post_Perceived_Competence	1.4917	0.2394	1.0225	1.961	0.5386	6.230	<.001
	Post_Perceived_Competence ⇒ Post_feelings_learning_science_e_learning	0.4675	0.0713	0.3277	0.607	0.4730	6.557	<.001
	Group_Condition ⇒ Post_Perceived_Autonomy	1.2568	0.1439	0.9748	1.539	0.6674	8.734	<.001
	Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.1603	0.0917	−0.0194	0.340	0.1103	1.749	0.080
	Group_Condition ⇒ Post_Perceived_relatedness	1.8551	0.1937	1.4754	2.235	0.7008	9.576	<.001
	Post_Perceived_relatedness ⇒ Post_feelings_learning_science_e_learning	0.4232	0.0806	0.2651	0.581	0.4092	5.248	<.001
Direct	Group_Condition ⇒ Post_feelings_learning_science_e_learning	0.0305	0.1832	−0.3286	0.390	0.0111	0.166	0.868
Total	Group_Condition ⇒ Post_feelings_learning_science_e_learning	1.7143	0.2201	1.2829	2.146	0.6263	7.789	<.001

Note. Confidence intervals computed with method: Standard (Delta method)
Note. Betas are completely standardized effect sizes

Moreover, the needs-satisfying teaching approaches (the intervention) predicted the perceived autonomy significantly (β = 0.67, SE = 0.14, t(46)=8.06, p < 0.001) Furthermore, perceived autonomy was not significantly associated with the motivation on using the science e-learning tool (MSE) (β = 0.11, SE = 0.09, t=2.05, p < 0.08). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived autonomy was 0.20, 95% CI [-0.03, 0.43]. Since the interval included zero, we concluded that the indirect effect was not significant. This model accounted for 83.5% of variance of MSE at $p < 0.05$.

In addition, the needs-satisfying teaching approaches (the intervention) predicted perceived relatedness significantly (β = 0.70, SE = 0.19, t(46)=15.40, p < 0.001). Furthermore, perceived relatedness was significantly associated with the motivation on using the science e-learning tool (MSE) (β = 0.57, SE = 0.10, t=6.12, p < 0.001). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived relatedness was 0.79, 95% CI [0.45, 1.12]. Since the interval did not include zero, we concluded that the indirect effect was significant. This model accounted for 83.5% of variance of MSE at $p < 0.001$.

Table 20

Coefficients of linear regression of basic needs satisfaction by MSE for Chemistry.

Model Fit Measures

Model	R	R^2
1	0.914	0.835

Model Coefficients - Post_feelings_learning_science_e_learning

Predictor	Estimate	SE	t	p
Intercept	−0.350	0.2814	−1.24	0.217
Post_Perceived_Competence	0.465	0.0713	6.52	<.001
Post_Perceived_Autonomy	0.168	0.0819	2.05	0.043
Post_Perceived_relatedness	0.430	0.0703	6.12	<.001

Table 21

Coefficients of indirect and total effect of perceived autonomy to MSE for Physics.

Type	Effect	Estimate	SE	95% C.I. (a) Lower	95% C.I. (a) Upper	β	z	p
Indirect	Group_Condition ⇒ Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.783	0.187	0.4172	1.15	0.297	4.19	< .001
Component	Group_Condition ⇒ Post_Perceived_Autonomy	0.899	0.126	0.6518	1.15	0.590	7.12	< .001
	Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.871	0.168	0.5419	1.20	0.503	5.19	< .001
Direct	Group_Condition ⇒ Post_feelings_learning_science_e_learning	0.539	0.256	0.0372	1.04	0.204	2.11	0.035
Total	Group_Condition ⇒ Post_feelings_learning_science_e_learning	1.322	0.235	0.8609	1.78	0.501	5.62	< .001

Note. Confidence intervals computed with method: Standard (Delta method)
Note. Betas are completely standardized effect sizes

Although perceived autonomy was not a significant mediator when it was simultaneously evaluated with perceived competence and perceived relatedness, when perceived autonomy was the only mediator in the analysis, it showed that it was a significant mediator between the intervention and MSE. For Study 1 about Physics, the needs-satisfying teaching approaches (the intervention) predicted the perceived autonomy significantly (β = 0.59, SE = 0.13, t(46)=8.06, p < 0.001) Furthermore, perceived autonomy was also significantly associated with the motivation on using the science e-learning tool (MSE) (β = 0.50, SE = 0.17, t=7.70, p < 0.001). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived autonomy was 0.78, 95% CI [0.42, 1.15]. Since the interval did not included zero, we concluded that the indirect effect was significant. This model accounted for 38.9% of variance of MSE at $p < 0.001$.

Table 22

Coefficients of linear regression of perceived autonomy to MSE for Physics.

Model Fit Measures

Model	R	R^2
1	0.624	0.389

Model Coefficients - Post_feelings_learning_science_e_learning

Predictor	Estimate	SE	t	p
Intercept	0.160	0.588	0.272	0.786
Post_Perceived_Autonomy	1.080	0.140	7.703	< .001

For Study 2 about Chemistry, the needs-satisfying teaching approaches (the intervention) predicted the perceived autonomy significantly (β = 0.67, SE = 0.14, t(46)=8.06, p < 0.001) Furthermore, perceived autonomy was significantly associated with the motivation on using the science e-learning tool (MSE) (β = 0.43, SE = 0.14, t=8.40, p < 0.001). The indirect effect of the needs-satisfying teaching approaches (the intervention) to MSE through perceived autonomy was 0.79, 95% CI [0.40, 1.18]. Since the interval did not included zero, we concluded that the indirect effect was significant. This model accounted for 43.2% of variance of MSE at $p < 0.001$.

Table 23

Coefficients of indirect and total effect of perceived autonomy to MSE for Chemistry.

				95% C.I. (a)				
Type	Effect	Estimate	SE	Lower	Upper	β	z	p
Indirect	Group_Condition ⇒ Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.787	0.200	0.395	1.180	0.288	3.93	< .001
Component	Group_Condition ⇒ Post_Perceived_Autonomy	1.257	0.144	0.975	1.539	0.667	8.73	< .001
	Post_Perceived_Autonomy ⇒ Post_feelings_learning_science_e_learning	0.626	0.142	0.348	0.905	0.431	4.40	< .001
Direct	Group_Condition ⇒ Post_feelings_learning_science_e_learning	0.927	0.268	0.402	1.452	0.339	3.46	< .001
Total	Group_Condition ⇒ Post_feelings_learning_science_e_learning	1.714	0.220	1.283	2.146	0.626	7.79	< .001

Note. Confidence intervals computed with method: Standard (Delta method)
Note. Betas are completely standardized effect sizes

Table 24

Coefficients of linear regression of perceived autonomy to MSE for Chemistry.

Model Fit Measures

Model	R	R^2
1	0.657	0.432

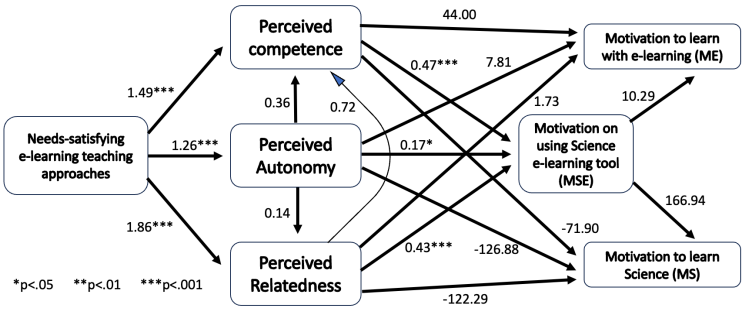
Model Coefficients - Post_feelings_learning_science_e_learning

Predictor	Estimate	SE	t	p
Intercept	0.258	0.507	0.508	0.612
Post_Perceived_Autonomy	0.955	0.114	8.404	< .001

After an independent analysis of the mediation for perceived autonomy, we found that perceived autonomy is a significant mediator between the needs-satisfying teaching approaches and the motivation to use Science e-learning tool (MSE) when evaluating alone.

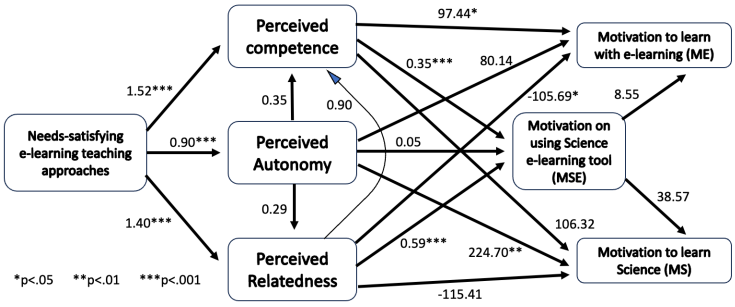
The hypothesized model for Chemistry was put to have a SEM analysis. Indices of fit provided for LISREL are the chi-square test statistic, the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the normed fit index (NFI). The overall model did not fit the data well, $\chi^2 = 14.440$, CFI = 0.97, RMSEA = 0.167, NFI = 0.97.

Figure 10. SEM analysis of the research model for Chemistry.



The hypothesized model for Physics was put to have a SEM analysis as well. The overall model did not fit the data well, $\chi^2 = 68.16$, CFI = 0.87, RMSEA = 0.41, NFI = 0.87.

Figure 11. SEM analysis of the research model for Physics.



The models for Physics and Chemistry have poor fit. The possible reasons may be due to the some factors. Firstly, the hypothesized relationships between variables may not reflect the true underlying structure. Secondly, some important variables may be left out, leading to biased estimates. Thirdly, an overly complex models with too many parameters can lead to overfitting and poor generalization to other samples. It implies that I need to revise the

theoretical framework or consider alternative model. To improve the fitness, I should consider ensuring a larger sample size and addressing measurement with other strategies.

4.2 Results of Qualitative Data

16 students are invited from the four year 8 classes for the individual interview. In the individual interviews, in-depth questions are asked to see if the students' perceived competence, autonomy and relatedness have been raised by the interventions. Hence the causes for such a rise are also record. Afterwards, further in-depth questions would be asked to see whether the change in perceived competence, autonomy and relatedness would further influence the higher motivation of using the science e-learning tool. 8 of them came from the classes with the intervention of needs-satisfying teaching approaches in Physics and having the control experimental setup in Chemistry. The other 8 students came from classes with the intervention in Chemistry and having the control experimental setup in Physics.

4.2.1 Qualitative Responses for Perceived Competence

4.2.1.1 Perceived Competence caused by Guiding Questions

13 students out of 16 students reflected that their competence is increased because the guiding questions in the demonstration video could help them to understand the topic which enhanced their competence. A student (p1) explained that "the guiding questions guided them step by step gradually". The student further expressed that "the guiding questions allow the students to have a certain understanding before proceeding to another part of the demonstration video". Another student (p3) also stated that "the guiding questions helped them to remember the information of the simulation experiment which would allow them not to forgot the information after usage". Another student (p4) reflected that "the guiding questions could help them to realize which parts they have done wrong and right. It could help them to make evaluation on themselves and check the understanding". A student (p5) also mentioned that "the guiding questions look like a teacher who checks their

understanding during the lesson before going to the next session of lesson. It is very useful". A student (p7) described that "the guiding questions provided choices to them which allowed them to have revision and rethinking, which is useful". Another student (p8) also stated that "the guiding questions helped them for revision and checking for understanding". One more student (p9) agreed that "the guiding questions helped to keep oneself on track and it looked like some checkpoints. Those checkpoints would give you explanation which could make the concept easier to understand". A student (p10) stated that the "guiding questions could ensure the task for each session was on track". A student (p11) further expressed that "the guiding questions would allow you to check your understanding by providing correct answers to you". Another student (p12) mentioned that "the guiding questions would allow you to think deeper which enables one to review the knowledge". One more student (p13) also agreed that "the guiding questions could help to check the understanding". A student (p14) reflected that the "guiding questions acted as a reminder for the knowledge". Another student (p15) pointed out that "the guiding questions could provide a direction of thinking framework which act like a mind map". Finally, a student (p16) further expressed that "the guiding questions could act as a reminder for key points. He explained that the "guiding questions could make the task more clear which help him to understand what he is learning".

However, there is one student disagreed with the influence of the guiding questions. He mentioned that "the guiding questions are useless since the task are quite easy to him. It is not necessary to have those guiding questions for easy learning tasks".

4.2.1.2 Perceived Competence caused by the Demonstration Video

All 16 students responded that their competence is raised because of the demonstration video. A student (p1) reported that "the demonstration video would provide some hints as a guidance for the learning task". Another student (p3) agreed that "the video

acts as a guidance to provide with more information which could help to absorb the knowledge easier. A student (p4) agreed that "the video make the task easier to follow and easier to understand". Another student (p5) added that "the demonstration video is the source of motivation for revision". Another student (p8) appreciated that the video could help him to review what he has learnt. Three more students (p9, p10 and p12) mentioned that "the rewind function of the video makes her feel easier to understand the learning task. One students (p11) agreed that "demonstration of the task could bring him more understanding to complete the task". A student (p16) also agreed the demonstration video provided an explanation on the task which could bring him more understanding.

However, one student reflected that the demonstration video make no difference on learning. He mentioned that the task is not really difficult so it is not required for the demo video.

4.2.1.3 Perceived Competence caused by the Feedback in the video

Only one student (p10) out of 16 students responded that his competence is raised because of the feedback provided by the video. He stated that "the feedback in the video acts as hints for the student to do better". However, a student (p9) found that "the feedback is only for students who is confusing about the topic". Another student (15) agreed that the feedback is meaningless to him since it could be find in the internet easily.

4.2.1.4 Perceived Competence caused by the Reflection section

4 students out of 16 students responded that their competence is raised because of reflection section. One student (p5) mentioned that "the reflection acts like a summary which could bring him more understanding". Another student (p8) agreed that "the reflection acts like a tester before your leave the lesson". One more student (p9) agreed that "reflection ensure a student could learn from past mistake, understand the meaning of the task and apply

the skill to other discipline in her life". Finally another students (p16) also expressed that "reflection could make you to know your own mistake and you could know what thing you should focus on".

4.2.1.5 Increase Motivation by Perceived Competence

9 students out of 16 students responded that their learning motivation could be raised by the increase of perceived competence. A student (p1) mentioned that "if there are demonstrations and hints provided, I would have more motivation to learn". Another student (p4) expressed that "the video provided her with a guidance which is appreciated by her. Hence she could develop her own competence to complete the task". A student (p6) mentioned that "I would have more motivation if I have higher competence on learning". Four other students (p5, p10, p11, p12) also agreed that "if I have more understanding, I would have more competence. Hence, I would have higher motivation to learn." However, 5 students (p2, p3, p7, p8, p13) found that an increase in competence would not much help to influence their learning motivation. They mentioned that the rise in competence has no relationship with the motivation. They have more competence does not mean that they would have more interest in use the Science e-learning tool.

4.2.2 Qualitative Responses for Perceived Autonomy

4.2.2.1 Perceived Autonomy caused by having more Freedom and Choice

14 students out of 16 students responded that their perceived autonomy is raised because of more freedom and choice provided. Eleven students (p1, p2, p3, p4, p6, p8, p9, p11, p12, p13, p16) reflected that longer time for them to submit the work provided them a freedom which would raise their perceived autonomy. Some other students (p3, p4, p5, p6, p8, p9, p11, p12, p14, p15, p16) reflected that allowing students to skip the questions, the

video progress and the reflection section in the demonstration video clip provided them a feeling of freedom and choices which would raise their perceived autonomy.

However, a student (p2) insisted that providing freedom to skip the questions or video progress would make no difference if a student loves the area of study with higher motivation. Four students (p7, 10, 14, 15) preferred submitting the work in the class rather than providing them extra time to avoid non-submission of homework. If they have more time to complete the task, they would probably forgot to submit the work. If they submit the work in class, they could grasp the chance to ask the teacher for solving the difficulties during the lesson. Three student (p7, p10, p13) mentioned that skipping of the self-learning section would lead to missing of knowledge. This could not help for learning but a loss of learning. They could imagine that some students would really skip all the guiding questions, all the reflection and the whole demonstration video if they are lacking of self-discipline for learning.

4.2.2.2 Perceived Autonomy caused by knowing the Rationale for Learning

12 students out of 16 students responded that their perceived autonomy is raised because of being told the rationale of learning the topic. Some students (p1, p2, p3, p4, p8, p9, p11, p13, p14, p16) described that knowing the rationale of learning would make them know more the usefulness of the knowledge in the daily life. Some other students (p3, p4, p8, p16) further explained that it will make them to have higher intention to prepare for the future if they know that the knowledge is meaningful to their career. However, a student (p7) insisted that knowing the rationale would help her to prepare for the exam but not preparing for the future career.

However, some students disagree that understanding the rationale behind the knowledge would lead to higher autonomy. Some students (p5, p6, 12, 15) reflected that

telling the rationale did not make a difference on their perceived autonomy. They did not feel any special rights to control any thing for their learning. A student among them (p5) even mentioned that telling the rationale behind the knowledge might not fit all the 24 students in a class. This practice could not ensure all the students in a class found the knowledge meaningful for their future career.

4.2.2.3 Perceived Autonomy caused by having Self-reflection

8 students out of 16 students responded that their the self-reflection section could help them to raise their perceived autonomy. Some of them (p1, p2, p7, p12, p13, p14, p15, p16) found that allowing them to reflect on how much they have learn is a room of autonomy while comparing to not allowing to reflect. A student (p13) further mentioned that allowing student to have freedom to reflect or not somehow provided a choice for some students, who did not learn so much, to reflect less on their learning status. This become no longer compulsory to students to reflect and it will make the students feel more comfortable. Two more students (p15, p16) further explained that the reflection section could help them to evaluate their mistakes and realize the improvement by their own thought, which bring them a feeling of greater autonomy.

However, two students (p6, p9) found that the reflection section would not bring them any difference on the perceived autonomy. They do not require any reflection in their learning.

4.2.2.4 Increased Motivation by Perceived Autonomy

11 students out of 16 students (p3, p4, p5, p6, p8, p9, p10, p11, p12, p13, p16) responded that their learning motivation could be raised by the increase of perceived autonomy. They mentioned that giving them more choices, more freedom and telling the rationale of learning would lead to a higher intention to learn a certain knowledge. Some

students (p5, p6, p9, p16) even mentioned that giving more freedom and time would lead to less control and less pressure on learning. This will make them to have more motivation to learn because they do not like restriction in studies. Four students (p8, p10, p11, p12) mentioned that telling the rationale of learning would provide the students with a sense of preparation for knowledge, especially effective to those students who care about their future. This gave them higher motivation to learn a certain knowledge. A student (p13) further mentioned that giving more time for the students to submit their works could allow the students to put their effort for researching more related knowledge which may be interesting. If a student only have limited time, they may not be able to fully engaged in the searching process and they might be pressured by the time.

However, four students (p1, p2, p7, p15) disagreed that higher autonomy would bring a higher learning motivation. They reflected that the autonomy in learning would not make them feel more interested in learning because they are not much influenced by the autonomy approaches. A student (p15) even mentioned that she does not like Science so much. No matter how much autonomy she perceived, it will not increase her learning motivation in Science.

4.2.3 Qualitative Responses for Perceived Relatedness

4.2.3.1 Perceived Relatedness caused by Caring on students' learning progress

14 students out of 16 students (p1, p2, p3, p4, p5, p6, p8, p9, p10, p11, p12, p13, p15, p16) responded that their perceived autonomy is raised because of the caring on their learning progress. Students reflected that such a caring on learning progress would give them a feeling of caring on the students as well. It would make the students to treat this kind of caring as a support of learning. Some students (p10) further mentioned that the caring on learning

progress would lead to a caring image on the teacher which would further lead to more respect and more motivation to learn.

However, a student (p7) held an opposite thought that caring on learning progress would only make a teacher having a good image but not making the learning become motivated.

4.2.3.2 Perceived Relatedness caused by Recognition from Teacher

15 students out of 16 students responded that recognition from teacher would increase their perceived relatedness. Those students reflected that such a recognition given by teacher would lead to a feeling of encouragement and bring them confidence. The encouragement would raise their motivation to learn and the recognition could prove their understanding on the right track. Two of them (p10, p12) even mentioned that the recognition from teacher could show teacher's caring on student which would also enhance the relationship with the students.

Only 1 student (p15) held an opposite thought. She thought that if the teacher provided recognition to all students then the recognition become no longer special and unique to an individual student. This kind of recognition would become meaningless and it would not increase her perceived relatedness.

4.2.3.3 Perceived Relatedness caused by Reflection Section

7 students out of 16 students (p2, p3, p8, p10, p13, p15, p16) responded that providing reflection section could increase their perceived relatedness. They described that allowing students to give reflection could make the students feel cared for by the teacher. Comparing with those teachers who did not allow students to reflect, the reflection section allowed students to show their understanding or misunderstanding to the teachers. It would raise the feeling of relatedness.

However, two students (p6, p7) suggested that allowing students to give reflection is the fundamental responsibility of a teacher which did not bring them an extra caring to the students.

4.2.3.4 Increased Motivation by Perceived Relatedness

11 students out of 16 students agreed that the increase of perceived relatedness would raise their learning motivation. The increase of perceived relatedness maybe caused by the caring of the learning progress, the recognition from teacher or the reflection section provided by the teacher. A student (p16) even mentioned that a popular teacher could make the students miss him / her and feel enjoyable in the lecture. This kind of teacher could make the students love the subject as well. Another student (p9) mentioned that a teacher who is more caring for students, the students would tend to seek for more recognition from this teacher. They will then show more effort on their learning which will raise their learning motivation as well.

Chapter 5 Discussion & Conclusion

5.1 Discussion on the hypotheses based on the results

Hypothesis 1 was supported such that the need-satisfying e-learning teaching approaches could positively affect students' perceived competence in doing the Science e-learning task. From the data found in Study 1 about Physics, it showed that the pre- and post-perceived competence is significantly different across the two experimental conditions. There is a significant drop between the pre-score and post-score for the control group which was not involved with any need-satisfying teaching approaches. However, a significant increase between the pre-score and post-score was found for the experimental group which was implemented with need-satisfying teaching approaches. It showed that the need-satisfying teaching approaches really helped the students to raise their competence. The drop found in the control group may due to loss of competence for the continuous challenging e-learning tasks. Similar result also takes place in the Study 2 about Chemistry. A significant drop between the pre-score and post-score could be seen for the control group and a significant increase was found between the pre-score and post-score was detected for the experimental group in the Chemistry study. These results well align with the attribution stated in the individual interview by the students in the qualitative analysis. They mentioned that the competence-based needs-satisfying teaching approaches could help them to raise their perceived competence. Competence-satisfying teaching approaches included the guiding questions, demonstration video, reflection section and the feedback in the video. The guiding questions allowed the students to have a certain understanding before proceeding to another part of the demonstration video and helped them to realize which parts they have done wrong and right. It could help them to make evaluation on themselves and check the understanding. The demonstration video acted as a guidance to provide more information which could help the students to absorb knowledge easier and it provided an explanation on the task which

could bring him more with understanding. The feedback in the video acted as hints for evaluation which made the student do better. The reflection section made students to know their own mistake and they could know what thing they should focus on and made the student to know their own mistakes and they could know what thing you should focus on.

Hypothesis 2 was supported such that the need-satisfying e-learning teaching approaches could positively affect students' perceived autonomy in doing the Science e-learning task. From the data found in Study 1 about Physics, it showed that the pre- and post-perceived autonomy is significantly different across the two experimental conditions. There is a significant drop between the pre-score and post-score for the control group which is similar to the result of perceived competence. Again, a significant increase between the pre-score and post-score was found for the experimental group which was implemented with need-satisfying teaching approaches. It showed that the need-satisfying teaching approaches really helped the students to raise their perceived autonomy. The drop of autonomy found in the control group may due to the restriction and the lacking of freedom on the e-learning simulation. Similar result also appeared place in the Study 2 about Chemistry. A significant drop between the pre-score and post-score could be seen for the control group and a significant increase was found between the pre-score and post-score was detected for the experimental group in the Chemistry study. These results well align with the rationale stated in the individual interview by the students in the qualitative analysis. They mentioned that the autonomy-satisfying teaching approaches could help them to raise their perceived autonomy. Autonomy-satisfying teaching approaches included providing more freedom and choices, telling the rationale of learning and providing self-reflection section. Giving more freedom and choices in the teaching approaches could provide the students with a higher flexibility to submit their learning tasks and a higher flexibility to skip unwanted part of the demonstration video. Telling the rationale of learning to students could make them know more about the

usage of the knowledge in daily life and make them to have higher intention to prepare for future if they know that the knowledge is meaningful to their career. Providing self-reflection section could help the student to evaluate their improvement by their own thought, which bring them a feeling of greater autonomy.

Hypothesis 3 was supported such that the need-satisfying e-learning teaching approaches could positively affect students' perceived relatedness in doing the Science e-learning tasks. The results in Study 1 showed that the pre- and post-perceived relatedness is significantly different across the two experimental conditions. There is a significant drop between the pre-score and post-score for the control group which is similar to the results of perceived competence and perceived autonomy. Again, a significant increase between the pre-score and post-score was found for the experimental group. It showed that the need-satisfying teaching approaches raises the perceived relatedness of the students. The drop of relatedness found in the control group may be due to the lack of support and caring in e-learning. Similar results were obtained in Study 2 in the subject of Chemistry. A significant drop between the pre-score and post-score could be seen for the control group and a significant increase was found between the pre-score and post-score was detected for the experimental group in the Chemistry study. These results well align with the causes stated in the individual interview by the students in the qualitative analysis. They mentioned that the relatedness-satisfying teaching approaches could help them to raise their perceived relatedness. The relatedness-satisfying teaching approaches included providing caring on students' learning progress, providing recognition from teacher and providing reflection section. Providing caring on students' learning progress could give the student a feeling of caring on the students as. It would make the students to treat this kind of caring as a support of learning. Caring on learning progress would also create a caring image on the teacher which would further lead a student to respect a teacher more and the student would have

more motivation to learn. Providing recognition from teacher would lead to a feeling of encouragement to student and bring them with more confidence. This kind of encouragement would raise the students' learning motivation since their understanding is recognized by the teacher on the right track. Providing reflection section could allow the students to feel being cared by the teacher since it allowed students to show their understanding or misunderstanding to the teachers.

Hypothesis 4-6 were largely supported such that the increase in the satisfaction of the three basic needs could increase students' motivation in using the Science e-learning tool (MSE). Results showed that perceived competence significantly influenced the students' motivation in using the Science e-learning tool in Studies 1 and 2. From the results of the Physics and Chemistry study, it showed a consistent relationship between perceived competence and the motivation to use Science e-learning (MSE). When I examined the qualitative data from the individual interview, the majority of the interviewed students agreed that the increase in perceived competence could lead to an increase in learning motivation. Some of them explained once they have more understanding, they would have higher perceived competence. They could then develop their own competence to complete the learning task. Hence, there will be higher motivation to learn.

The results were less consistent for perceived autonomy. In Study 1 (Physics) perceived autonomy did not predict the (MSE) students' motivation in using the Science e-learning tool at a significant level. In Study 2 (Chemistry), perceived autonomy significantly influenced the students' motivation in using the Science e-learning tool (MSE). When the qualitative data from the individual interview were examined, most of the interviewees responded that their learning motivation could be improved by the increase of perceived autonomy. Some of them explained that giving more freedom and time would lead to less control and less pressure on learning. Four out of 16 students further explained that telling the

rationale of learning would provide the students with a sense of preparation for knowledge, especially effective to those students who care about their future. This gave them higher motivation to learn about the science subject.

In both Studies 1 (Physics) and Study (Chemistry) it showed that perceived relatedness significantly influenced the students' motivation in using the Science e-learning tool. When the qualitative data from the individual interview was examined, the majority of the interviewees agreed that the increase of perceiving relatedness with their teachers would increase their motivation in learning science subject online. A student mentioned that a caring teacher could make the students felt enjoyable in the lecture and love the subject as well. Another student mentioned that a teacher who is more caring for students, the students would tend to seek for more recognition from this teacher. They will then put in more effort in their studies to draw more recognition from the teacher.

Hypothesis 7 and 8 were partially supported such that the increase in motivation for using the Science e-learning tool (MSE) could increase students' motivation to learn with e-learning (ME) (H7) and motivation to learn Science (MS) (H8). The findings from the two studies were inconsistent. In Study 1 (Physics), students' motivation on using the Science e-learning tool (MSE) did not impact students' motivation to learn with e-learning (ME) in Physics. However, such connection was found in Study 2 (Chemistry). Therefore, Hypothesis 7 was only partially supported.

Results also partially supported that motivation to use Science e-learning tool (MSE) predicted students' motivation to learn Science (MS). In Study 1 (Physics), higher motivation to use science e-learning tool would predict higher motivation to learn physics. However, such connection was not found in Study 2 (Chemistry). It could only be concluded that the hypothesis is only partially satisfied in Physics e-learning context but not in Chemistry e-learning context. These results showed that although students might be motivated to use e-

learning tools in science, this motivation might not generalize to motivation to use e-learning tools or motivation to learn science.

Hypothesis 9 was mostly supported such that the three basic psychological needs (competence, autonomy, and relatedness) were tested as mediators that could explain the effect of needs-satisfying teaching approaches on the motivation of using e-learning tool to learn science (MSE). In Study 1 (Physics) and 2 (Chemistry), the needs-satisfying teaching approaches predicted all three needs. However, perceived autonomy was not a significant predictor of motivation of using e-learning tool to learn science. Mediation analysis showed that the indirect effects of perceived competence and perceived relatedness on the connection between the intervention and motivation of using e-learning tool to learn science were significant.

As a whole, we could conclude that perceived competence and perceived relatedness would explain why needs-satisfying teaching approaches (intervention) can increase motivation to use the science e-learning tool (MSE). However, perceived autonomy did not show significant mediation effect for the intervention to influence the MSE when it is considered together with perceived competence and relatedness. It is important to note that when perceived autonomy was evaluated as individually, in both Studies 1 and 2, it was a significant mediator. In other words, autonomy would account for the mechanism between the current needs-satisfying teaching approaches and motivation to use the science e-learning tool. However, autonomy might have overlap with competence and relatedness such that when they were evaluated together, the unique impact of autonomy might not be evident.

5.1.1 Supporting student's needs through SDT research and practice

There is ample data indicating that using educational practices that fulfill basic needs can enhance autonomous motivation, initiative, engagement, and adjustment. However, implementing autonomy-supportive teaching can be challenging, particularly due to

limitations in terms of time, money, and curricula. Furthermore, teachers, just like their students, possess basic psychology needs for autonomy, competence, and relatedness. SDT asserts that in order for instructors to effectively assist students' needs, they must themselves receive assistance for their own needs. For instance, the study conducted by Roth, Assor, Kanat-Maymon, and Kaplan (2007) revealed that professors who had a higher level of autonomous motivation to teach were perceived by students as being more supportive of their autonomy. Consequently, the students themselves were more inclined to be autonomously driven to learn. In their 2012 study, Klassen, Perry, and Frenzel conducted three experiments that demonstrated a positive correlation between teachers' satisfaction of the need for connection, particularly with their students, and their level of engagement. Additionally, the study found that teachers who had higher levels of relatedness reported lower levels of emotional weariness. However, school regulations and leadership styles might hinder teachers' fulfillment of their needs and result in more authoritarian and less enjoyable classroom approaches.

Pelletier, Séguin-Lévesque, and Legault (2002) proposed that teachers must navigate the dual challenges of external needs (such as accountability policies or controlling administrators) and internal pressures (such as disengaged pupils or demanding parents). Their study revealed that both external pressures and internal pressures were negatively correlated with teachers' intrinsic enthusiasm for teaching, as well as their ability to provide autonomy support to students. In their study, Fernet, Guay, Senécal, and Austin (2012) discovered that teachers who faced excessive work demands or disruptive pupils had a decrease in their intrinsic desire for teaching, as well as a decline in their perceived competence. Consequently, these factors contributed to heightened emotional tiredness and a diminished sense of success among the teachers.

Bartholomew, Ntoumanis, Cuevas, and Lonsdale (2014) shown that the stressors experienced by teachers in their jobs were linked to burnout. This connection was influenced by the teachers' frustration of their basic psychological needs. In a recent study, Cuevas, Ntoumanis, Fernandez-Bustos, and Bartholomew (2018) showed that the pressure on instructors to improve student performance resulted in reduced autonomous motivation for teaching, decreased teacher vitality, and increased weariness. Nie, Chua, Yeung, Ryan, and Chan (2015) discovered that in Chinese schools, instructors who experienced greater autonomy support from their supervisors reported better levels of intrinsic motivation to teach and greater psychological well-being. Undoubtedly, when teachers' independence is hindered by external influences, whether from higher authorities or lower levels, they tend to exert more control over children and exhibit less positive engagement. This dynamic extends beyond teachers.

Principals are more effective when they are provided with autonomy support from their superintendents and experience reduced pressure from both higher and lower levels of authority (Maxwell & Riley, 2017). Chang, Leach, and Anderman (2015) found that principals had stronger emotional attachment to their schools and greater levels of job satisfaction when they believed their superintendents were more supportive of their autonomy. The support and motivation provided to teachers and administrators by higher authorities directly impacts their ability to support and effectively motivate the students and teachers under their supervision. This also elucidates that successful reform in schools is more than just altering teachers' behaviours; it involves providing support for the basic psychological needs of both teachers and principals.

Several interventions based on Self-Determination Theory (SDT) have focused on instructors as the primary impacts on students' engagement and learning. Research has mostly

focused on investigating the effectiveness of educating teachers to enhance their autonomy supportiveness in order to bring about changes in classroom practices and enhance teacher experiences. Reeve, Jang, Carrell, Jeon, and Barch (2004) instructed teachers to integrate autonomy support into their teaching methods. Afterwards, they monitored both the teachers who received training and the teachers in the control group in their classes on three separate occasions. The results indicated that the instructors who received training demonstrated a considerably higher level of autonomy support compared to the teachers in the control group. Furthermore, it is noteworthy that the students in the classes of the trained teachers exhibited a greater level of engagement in the learning process.

Su and Reeve (2011) discovered nineteen studies in which educators underwent training in ways that promote autonomy. A meta-analysis revealed a substantial (0.63) impact size favouring improvement in intervention groups across the included studies. In a recent study, Cheon, Reeve, Lee, and Lee (2018) documented an additional intervention aimed at enhancing teacher autonomy support. The findings indicated that the anticipated enhancements in teacher autonomy support were linked to heightened perceptions of efficacy and the embrace of more intrinsic objectives. Interventions grounded in Self-Determination Theory (SDT) have received substantial empirical support compared to alternative theoretical frameworks (Lazowski & Hulleman, 2016). Intervention studies play a crucial role in establishing the cause-and-effect relationship between teacher need supports and improved educational outcomes. They also demonstrate the practical significance of motivation research.

The research on Self-Determination Theory (SDT) and its practical applications has significantly grown over the past two decades since our previous article in the CEP special issue by Ryan and Deci (2000). This growth can be attributed to the dedicated work of

numerous scholars from various countries, who have explored the theory's connection to educational processes and outcomes with diverse interests. Within this concise analysis, we can only address a small portion of these endeavours, which are comprehensively detailed in Ryan and Deci's (2017) work. Currently, SDT consists of six distinct mini-theories that encompass various aspects such as intrinsic motivation, internalization, basic needs, life goals and aspirations, individual differences in motivation, and motivation in personal relationships (Ryan et al., 2019). Furthermore, SDT encompasses a substantial collection of research that establishes connections between concepts such as mindfulness, vitality, identity development, and eudaimonia with motivation and needs. These connections are applicable to educational processes. The commentators in this special issue have brought up the crucial inquiry of whether it is necessary to have various viewpoints on motivation or have expressed dissatisfaction with the abundance of terminology and specialized language used in theories, which can be perplexing for professionals. SDT is a comprehensive framework that offers a unified perspective on various phenomena that are relevant to educators. These phenomena include expectancies, rewards, efficacy, evaluations and feedback, praise, values, approach and avoidance motives, achievement goals, ego- and task-engagement, contingencies of self-esteem, life aspirations, self-concepts, epistemic emotions, identity, culture, and other constructs.

The predictions and findings of SDT frequently align with those of other models, although not always. SDT's formulations have been developed through a systematic approach to constructing theories, relying on incremental expansions supported by converging empirical evidence. This strategy aims to prevent errors of commission. In order to evaluate opposing hypotheses and further refine SDT's formulations, we have deliberately invited "paradigm clashes" when contradictions arise. These clashes involve several models such as behaviourist, cultural relativist, social cognitive, and objectivist, among others. The clarity,

reliability, and coherence of SDT indicate that it can still play a significant role in coordinating and synthesizing various concepts and research findings.

The Journal of Personality recently published a special edition (Sheldon & Prentice, 2019) that specifically examined the suitability of SDT as a meta-framework or basis for research in social/personality psychology. Ryan, Vansteenkiste, and Soenens (2019) stated that regardless of one's acceptance of SDT as a comprehensive method to personality studies, it is undeniably applicable to the significant questions posed by modern viewpoints. SDT has the ability to be applied in education, offering a methodical, pragmatic, analytical, and inclusive structure for examining and advancing the aspects that have true significance for students, instructors, and administrators. This is a matter that Anderman (2020) considers to be of utmost importance. It possesses both predictive and practical significance, not only by improving motivation and performance, but also by promoting wellness and flourishing. The approach's strength rests in its empirical foundation and direct connection to the experiences of learners and teachers. It aims to combine rigor and relevance by establishing a cohesive set of principles and recommendations.

Roca and Gagné (2008) proposed that the application of Self-Determination Theory (SDT) to e-learning could be beneficial in anticipating individuals' intents to continue learning in the workplace, particularly in response to the significant dropout issue that emerged over a decade ago. Due to potential disparities in the influence of fulfilling basic needs on the motive for online and offline learning, it is not feasible to directly apply existing statistics to the unique circumstances of e-learning. Recent research indicates that fulfilling the basic psychology needs of autonomy, competence, and relatedness has a notable and favourable impact on intrinsic motivation, hence enhancing students' psychological engagement in Massive Open Online Classes (MOOCs) (Sun et al., 2019). In addition, as

stated by Fang et al. (2019), need fulfilment serves as a complete mediator for the influence of social interaction on academic engagement in a MOOC. Nevertheless, contrasting outcomes have also been achieved. Therefore, when determining the factors that influence the ongoing use of C-MOOC, an investigation was conducted on self-determination factors. Surprisingly, these factors did not have a significant impact on satisfaction with the course itself. However, they did have a significant influence on students' intention to continue using the course. According to Joo, So, and Kim (2018), satisfaction was positively influenced only by the convenience of use and utility.

SDT has been applied not only in studies on MOOC, but also in studies on the utilization of mobile training applications (Jeno et al., 2019; Yang, Zhou, & Cheng, 2019). The primary findings demonstrate the impact of self-determination elements, such as the fulfilment of basic needs and the distinction between intrinsic and extrinsic motivation, on engagement and the intention to persist in mobile learning. Furthermore, it is observed that the structure of mobile learning has a role in fulfilling the requirement for independence, which subsequently influences academic performance and the effective absorption of educational content (Jeno et al., 2019).

Several researches have addressed the subject of how SDT factors affect learning results. Inconsistent data have been acquired about this matter. Chen and Jang (2010) found that the SDT-based model is not effective in predicting learning outcomes in online programs. After a thorough examination of the techniques employed by Chen and Jang (2010), Hsu, Wang, and Levesque-Bristol (2019) made adjustments to the measurement methodologies and carried out a study using the SDT model. Their findings demonstrated that the fulfilment of basic psychological needs enhanced self-regulatory motivation, which

in turn correlated with greater success in acquiring knowledge and attaining learning objectives in online courses.

The satisfying of many basic psychological needs has varying implications on distinct dimensions of e-learning. According to Fang et al. (2019), whereas meeting the need for competence strongly predicted participation in MOOC learning, meeting the need for autonomy had the least impact. Durksen et al. (2016) established probabilistic connections between the basic psychological needs of learners in a specific MOOC. The study found that participants with a high level of autonomy had an 80.01% likelihood of experiencing an average level of competence. Additionally, the study revealed that relatedness was distinct from both autonomy and competence.

Research has discovered that a mobile application has a beneficial effect on intrinsic motivation, perceived competence, and student accomplishment. The utilization of ArtsApp, a specialized program tailored for biology students, resulted in elevated levels of intrinsic motivation, perceived competence, and academic accomplishment as compared to the control group that relied on a conventional textbook. Conversely, intrinsic motivation was found to be a strong predictor of academic accomplishment, as reflected by higher grades. Additionally, it was associated with a greater interest in the course material and a heightened recognition of the significance of the acquired knowledge. The optimal outcomes were linked to the fulfilment of students' psychological requirements for independence, proficiency, and connection. The mobile application incorporated built-in functions such as interest, choice, and feedback, which were identified as contributing elements (Jeno, Grytnes, & Vandvik, 2017).

Individuals have the freedom to decide when and where to utilize mobile education technologies, as stated by Hamidi and Chavoshi (2018). This characteristic enhances

autonomy. An entirely distinct scenario may occur regarding the fulfilment of another basic psychology need, namely the need for interpersonal connection. The desire for belonging is a potent, fundamental, and very pervasive motive that exerts significant influence on emotional and cognitive functions (Baumeister & Leary, 1995). Within the framework of Self-Determination Theory (SDT), it holds a significant position. MOOCs establish a novel educational setting where the significance of relatedness can have a particularly crucial impact. According to scientists, MOOCs offer exceptional potential for both connection and seclusion. The research conducted by Durksen et al. (2016) provides confirmation that relatedness is definitely a significant demand in this particular situation. According to Vanslambrouck et al. (2018) and Zaitseva et al. (2020), students have observed that organizing group work is more challenging in online courses. This poses a greater difficulty in addressing this need, particularly for individuals who prefer working in groups. Additional scholars contend that online courses frequently restrict the cultivation of connectedness, a crucial factor for achieving success in any educational setting (Butakova et al., 2020; Butz & Stupnisky, 2017; Raes et al., 2020). This not only adds another dimension to the examination of digital technologies in education, but it can also provide a challenge to them. Deci and Ryan (2014) have suggested that not all interactions are of superior quality and fulfil the requirement for relatedness. Can high-quality connections be achieved within the framework of e-learning technologies?

Scientists are seeking solutions to this inquiry. One study exemplified the significance of arranging and engaging in forums to uphold the necessity for connectedness (Butz & Stupnisky, 2017). In this context, the forum serves as a platform for fostering connections among those participating in online courses. Consequently, the organizational structure of the online course itself is capable of fulfilling fundamental requirements. Alternative options exist, such as the inclusion of mentors. Baranik, Wright, and Reburn (2017) proposed that

mentoring in online courses fulfils students' desire for relatedness and contributes to their success in online activities by satisfying basic psychological needs.

5.2 Implications

One of the most important factors influencing learning is motivation, according to researchers in the field of education (Lim, 2004). Several significant learning outcomes, including perseverance, retention, achievement, and course satisfaction, have been linked to learner motivation, according to previous research (Eccles et al., 1993; Fujita-Starck & Thompson, 1994; Vallerand & Bissonnette, 1992; Lepper & Cordova, 1992). According to the research, e-learning environments should give substantial consideration to motivation. When "learners separated by time, distance, or both" are "used to receive instruction through the Internet," we say that the setting is an e-learning environment (Dempsey & Van Eck, 2002, p. 283). Web facilitated courses (1-29%), blended/hybrid courses (30-79%), and online courses (80%) were further defined by the Sloan Consortium (Allen & Seaman, 2006) based on the proportion of content and activities offered online. Courses in higher education where online delivery of information and activities exceeds 80% are the primary focus of this study.

Despite its importance on learning outcomes, motivation has not gotten the same amount of focus in e-learning (Miltiadou and Savenye, 2003; Jones and Issroff, 2005). Teachers may have overlooked students' affective and socio-emotional processes in favour of their students' cognitive processes in the past (Kreijns, Kirschner, & Jochems, 2003). Researching online learner motivation, including its causes and effects, is crucial in light of the fact that high attrition rates are a big problem for e-learning and a big worry for online teachers (Carr, 2000; Clark, 2003). In their literature review, Miltiadou and Savenye looked at six different types of motivation and talked about what they mean for online education. According to Miltiadou and Savenye, additional research is required to evaluate theories and

constructions of motivation in e-learning settings with the goal of lowering attrition rates and increasing student success.

Gabrielle (2003) used Keller's (1983) ARCS (attention, relevance, confidence, and satisfaction) paradigm to develop technology-based teaching strategies for online students, in agreement with Miltiadou and Savenye's (2003) assertion. Students' motivation, achievement, and self-directed learning were all positively impacted by the ARCS-based learning support, according to the results. Finding that self-efficacy (Bandura, 1982) and task value (Eccles, 1983) were substantial predictors of online students' pleasure and performance, Lee (2002) conducted an investigation into these constructs. Instructional design and facilitation have benefited greatly from the theoretically grounded research conducted by Lee and Gabrielle. Since this is the case, there is a need to study how each individual student establishes his or her own level of intrinsic motive in an online classroom.

Deci and Ryan's self-determination theory (SDT)—described by Pintrich and Schunk (2002) as one of the most comprehensive and empirically supported theories of motivation available today—deserves extensive investigation in e-learning contexts. Studies have shown that self-determination theory can be useful in many different contexts, such as health care, religion, physical education, politics, general education, and health (Williams et al., 2006; Neyrinck, Lens, & Vansteenkiste, 2005; Standage, Duda, & Ntoumanis, 2005; Niemiec et al., 2006). Online education, however, has not yet provided enough evidence to support self-determination theory (Chen, 2007). Researchers have hardly come across research that use SDT in an e-learning setting, with a couple of notable outliers like Xie, Debacker, and Ferguson (2006) and Roca and Gagné (2008).

According to research on student perceptions conducted by Mullen and Tallent-Runnels (2006), students' impressions of classroom surroundings and instructors' support and

needs differed between online and in-person settings. Perceptional variations were associated with students' intrinsic motivation, level of course satisfaction, and level of learning. Instructors should be careful not to assume that teaching the same in both environments will create similar results, according to Mullen and Tallent-Runnels (2006). Similarly, researchers shouldn't make unfounded claims about applying motivation theories developed for use in more conventional classroom settings to e-learning without providing evidence. This is due to the fact that e-learning environments and the dynamics of student motivation differ in many ways, including the degree to which they are able to adapt to new circumstances, the ease with which they can access course materials, and the prevalence of computer-mediated communications. As a result, there has to be research on what drives online students, particularly how self-determination theory holds up in this setting. Here we will go over the main points of SDT, and then we will talk about why SDT could be a good framework for dealing with student motivation in online classes.

An overarching theory of motivation, self-determination theory (Deci and Ryan, 1985; Deci and Ryan, 2002) aims to provide a systematic explanation of how human needs, motivation, and well-being are influenced by our immediate social environment. One aspect of human functioning that includes the ability to make one's own decisions is what Deci and Ryan (1985) call self-determination. What matters most is the ability to make choices, and those choices should ultimately dictate how one acts (p. 38). According to proponents of self-determination theory, there are three fundamental human needs: first, the ability to make one's own decisions; second, the confidence to carry out one's own work; and third, a sense of belonging to a community. When people's basic needs are met, they feel better emotionally and develop a stronger sense of self. In contrast, selves that are severely fragmented, reactive, or alienated are the result of not meeting these three fundamental requirements.

In contrast to theories like Bandura's social cognitive theory, which views human motivation as a unifying whole, SDT divides it into three distinct types: intrinsic motivation, which refers to doing something because it's enjoyable, optimally challenging, or aesthetically pleasing; extrinsic motivation, which refers to doing something because it leads to a separable outcome; and amotivation, which is the absence of any intention to act. There are four distinct phases or kinds of extrinsic motivation: (1) external regulation, (2) introjected regulation, (3) identifiable regulation, and (4) integrated regulation. Figure 1 displays the three forms of motivation which are situated on a spectrum of individual agency (Ryan & Deci, 2000). There are two types of motivation at the two extremes: amotivation, which is the least self-determined, and intrinsic motivation, which is the most self-determined. As per SDT, results can be positively influenced by self-determined forms of motivation (intrinsic motivation and identified regulation) and negatively impacted by non-self-determined forms of motivation (amotivation, external, and introjected regulations) (Deci & Ryan, 1991). Connell and Ryan (1985) devised a method to determine "the relative autonomy index, RAI," a single score that takes into account many forms of motivation to reflect the level of self-determination that individual possesses, by utilizing the self-determination continuum.

One important idea in self-determination theory is contextual support. People take in "nutrients" from their social interactions when those connections help them meet their fundamental requirements for autonomy, competence, and relatedness. When people's basic needs are met, they gain confidence, independence, and a sense of psychological well-being. There are a lot of reasons why SDT seems like a good foundation for dealing with motivation in virtual classrooms. As a first step, SDT has the potential to incorporate problems with online education by providing a theoretical foundation. As factors that influence motivation, self-determination theory takes into account relatedness, competency, and autonomy.

Features of e-learning such as computer-mediated communication and social interaction (Gunawardena, 1995), flexible learning (Moore, 1993), and difficulties in learning technical skills (Howland & Moore, 2002) are reflected in these three conceptions. Online students require a wide range of supports from teachers, classmates, administrators, and even tech assistance (Mills, 2003; Tait, 2000; Tait, 2003), making the concept of contextual support all the more important. For example, according to Deci and Ryan (1985) who reviewed the literature on the topic, self-determination theory can predict many different learning outcomes, such as performance, persistence, and course satisfaction. Student attrition in online courses is one learning issue that self-determination theory may help solve.

Not only does SDT describe the process of motivation, but it also generates prescriptions for enhancements to motivation. Research grounded in self-determination theory has uncovered methods that encourage personal initiative and motive. Example: Reeve and Jang (2006) found that eight different kinds of teacher behaviours—like letting students choose, explaining why something is important, and providing useful feedback—improved students' sense of agency, engagement, and achievement. The tactics based on SDT have the potential to be used in a range of educational contexts, including e-learning.

A contextual perspective of motivation is currently popular, and self-determination theory is in line with it since it places an emphasis on the significance of social environment. According to Järvelä (2001), it is no longer possible to explain an individual's readiness to act or learn by looking at their motivation; rather, motivation is a reflection of their social and cultural surroundings . The goal of self-determination theory is to provide light on how people's needs, motivations, and happiness are shaped by their local social environments. Researchers can use the SDT framework to look at how things like teacher actions and student-teacher interactions affect online students' motivation. E-learning support solutions

can be better identified with the use of the SDT framework by both instructors and instructional designers.

Researchers studying online education have paid scant attention to self-determination theory (SDT), and even fewer studies have sought to verify SDT in online classrooms. A study that can be retrieved is the one that Xie et al. (2006) did recently. The writers used SDT to look at what motivated students on an online forum. Xie et al. used a mixed-methods approach to study students' levels of interest, value, perceived autonomy, course engagement (as indicated by login and discussion board postings), and attitudes toward the class. Online students' attitude and engagement with the course were found to be favourably connected with the three SDT-based indicators: perceived interest, value, and choice, according to correlation analyses. Online students' motivation was also found to be highly correlated with instructors' involvement, direction, and feedback, according to interview and open-ended question responses. Online students were more likely to see the benefit of discussion activities when they had a well-defined purpose, lending credence to self-determination theory. In contradiction to SDT, the research by Xie et al. found no significant relationships between perceived competency and participation or course attitude.

The study conducted by Xie et al. (2006) demonstrated some initial success when implementing SDT in an e-learning setting. However, Xie et al. did not investigate the connections between contextual support, need fulfilment, motivation, and learning outcomes. Also, the Xie et al. study didn't look at how perceived relatedness affected motivation and well-being, even though SDT mentions that perceived autonomy, relatedness, and competency are three factors that determine the former two. Finally, the authors may have reached the conclusion that online learners' perceived competency did not adequately explain learning outcomes, but their definition of "competency" appears to be lacking. Competency

for online conversation may encompass additional dimensions like communication and metacognitive abilities; nevertheless, the writers only utilized computer/Internet capabilities as the competency metric. If these dimensions are not included, the results will be biased. The study's limitations make it look like the data from Xie et al. aren't enough to draw any conclusions regarding the tenability of SDT. The validity of SDT in an online classroom requires additional research.

A model for online learner motivation was suggested, based on SDT. We postulate that contextual support, as measured by competency support and autonomy support, is an external latent variable in our model. We omitted relatedness support from our model since SDT is better suited to handle autonomy and competency supports (Ryan & Deci, 2002). While some research have used SDT to gauge relatedness support, the vast majority have focused on measuring perceived relatedness.

An endogenous latent variable called need satisfaction was used to represent the overall satisfaction of basic needs among online students. It was measured by indicators such as perceived autonomy, perceived competency, and perceived relatedness. According to SDT, meeting one's most basic needs acts as a mediator between an individual's motive and their capacity for self-determination. A number of empirical research have provided evidence for the mediating impact; for instance, Standage et al. (2005) discovered that students reported higher levels of need fulfilment when they felt their environment supported their needs. The fulfilment of needs is a predictor of intrinsic motivation, which is a form of self-determined motive. For this reason, we postulated that self-determination is positively correlated with contextual support, which is a favourable predictor of need satisfaction.

Positive outcomes are produced by autonomous/self-determined forms of motivation, according to self-determination theory, whereas negative consequences are the product of

non-autonomous/non-self-determined forms of motivation. Higher levels of self-determination and RAI were positively associated with students' engagement, affect, conceptual learning, and effective coping mechanisms, according to studies (Grolnick and Ryan, 1987, Grolnick and Ryan, 1989, Grolnick et al., 1991). In addition, research by Roca and Gagne (2008) links self-determination to job satisfaction, and research by Vallerand and Bissonnette (1992) shows that students who stay in school are more likely to be self-determined than those who leave. We reasoned that students' ability to direct their own learning would be a good indicator of their success in online courses.

To gain a better grasp of the dynamics and interplay between motivating factors and learning outcomes, the model examined two hypotheses. The model was designed to evaluate the direct effect of contextual support and need satisfaction on learning outcomes by drawing additional causal chains that connect contextual support to learning outcomes and need satisfaction to self-determination. For students who exhibited low levels of self-determination to begin with, Black and Deci (2000) discovered in the SDT literature that students' performance was favourably and directly correlated with teachers' autonomy support. Need fulfilment was determined to be a direct and positive predictor of engagement, overall self-esteem, and reduced anxiety by Deci et al. (2001). Thus, we postulated that the two factors of contextual support and need satisfaction, when combined, would serve as strong predictors of learning outcomes.

Even though the pandemic is declared over, e-learning still have huge demands in education and educators have discovered more benefits of applying e-learning. Therefore, after the pandemic, many teachers are still providing online class to students. For example, online tutorial classes are still popular to be provided by the private tutorial centres and overseas online diploma programs are still popular to be provided by the overseas universities

or institutes. However, e-learning is limited by the environmental setting, the social interaction and the way to exchange information. Therefore, many traditional secondary school teachers and tertiary institution lecturers still possess the thoughts that e-learning is not allowed to have any teaching approaches or pedagogies. If e-learning is lacking of pedagogies, students would have less support for their learning. Students' basic need supports maybe ignored by the teachers. However, basic psychological need supports have shown a lot of positive influences on learning outcomes (Ryan & Deci, 2020). Researches showed that students, who received more needs-supportive teaching approaches, would have higher intrinsic motivation and self-esteem (Ryan & Grolnick, 1986) and better academic performance (Guay & Vallerand, 1997). Therefore, implementing needs-satisfying teaching approaches to daily online lessons should become a common practice and basic requirement for e-learning.

The current findings supported that needs-satisfying teaching approaches could be essential to Science e-learning. The needs-satisfying teaching approaches did not only increase the students' competence to use the e-learning tool, but also raise their learning motivation to use the Science e-learning tool (MSE). The students found that the e-learning content is easier to understand and they felt more caring from the teachers. These are part of the factors leading to an increase in motivation. The intervention in this research could be transferrable to other e-leaning courses as well. When teachers are going to conduct e-learning courses with students or introduce any new e-learning tool to students, it is highly recommended to provide needs-satisfying teaching approaches to satisfy students basic psychological needs in terms of competence, autonomy and relatedness.

5.2.1 Implications of the competence-satisfying teaching approaches

To satisfy the needs for competence, teachers should provide demonstration of the e-learning tool or demonstration of the handling procedure on the e-learning exercises. According to social cognitive theory (Bandura, 1986), demonstration and modelling is very powerful to bring a vicarious experience to an observer. The observer would believe that they would have the cognitive understanding to utilize a tool or to perform a task. This cognitive understanding could be treated as a source of perceived competence. Besides, setting a series of scaffolding and guiding questions in the e-learning class is also a good way to raise students' competence. Scaffolding and guiding questions aim to check students' understanding on the e-learning content and provide gradual steps for them to address the technical skills learnt in the e-learning class. Students mentioned that the guiding questions would ensure to be familiar with the knowledge easily and gradually. This helps the students to gain the competence of the skill to use the e-learning tool step by step. Moreover, providing evaluative feedback and self-reflection to students is very important for them to raise their perceived competence. Student mentioned that they were not confident to ensure their understanding entirely correct. They need feedback and self-reflection to confirm their knowledge and the room for improvement. After self-reflection or receiving the feedback from teachers, they would have more solid concept on the knowledge of the e-learning tool. This is also related to the rise of perceived competence.

Students mentioned in the individual interview that once they have higher competence of grasping the technique of the Science e-learning tool, their learning motivation will be raised. If the e-learning educators wish to raise their students' competence as well as the learning motivation, it is highly recommended that they should put more time to prepare for the demonstration of the e-learning task, the guiding questions to check student understanding, a session to collect students' reflection and providing feedback to students. Some other researchers also suggested that setting an optimal level of challenge and

supporting the skills development to meet the related challenge (Lyness et al., 2013) could also help students to build the perceived competence.

The essential concepts of SDT are applied not only in research, but also in the creation of digital instructional tools. In their 2018 publication, Martin, Kelly, and Terry put out a comprehensive framework for the creation of Massive Open Online Courses (MOOCs) that is rooted in Self-Determination Theory (SDT) principles. This framework establishes the correlation between intrinsic motive and the basic psychology needs of self-governance, proficiency, and social connectedness.

5.2.2 Implications of the autonomy-satisfying teaching approaches

According to Hartnett (2015), Xie et al. (2006), Vonderwell et al. (2007), and Xie & Ke (2011), teachers can motivate their online and distance learning students by promoting student autonomy, ensuring learning, and engaging in interpersonal interactions. According to SDT, there are three main aspects of teaching practices: autonomy support, competence, and relatedness (Lietaert et al., 2015; Sierens et al., 2009; Vansteenkiste et al., 2009; Vollet et al., 2017). When students are encouraged and helped to follow their own goals, it shows that they are being supported in their learning practices. Teachers that promote student autonomy in e-learning take student perspectives into account, provide options for learning, explain why some choices are not available, refrain from using controlling language, and alleviate students of needless stress and demands (Alamri et al., 2020; Lee et al., 2015; Trenshaw et al., 2016; Xie et al., 2006).

For instance, according to Bedenlier et al. (2020) and Hartnett (2015), teachers should make a variety of learning materials available to students in multiple languages and offer navigational support so that students can easily choose what they need. Alamri et al. (2020) and Lee et al. (2015) argue that teachers should also provide students the chance to tailor

their learning experiences based on their interests. After that, students can take charge of their own learning by deciding what they want to accomplish and how confident they feel in their abilities; speaking out when they need help; and ultimately, they will feel empowered (Alamri et al., 2020; Lee et al., 2015; Trenshaw et al., 2016). Students are more likely to participate in class when teachers encourage their independence (Lee et al., 2015). Students whose instructors encourage greater independence in their work show higher levels of behavioural engagement (improved focus and efficiency with class time; Vansteenkiste et al., 2005), emotional engagement (increased enjoyment of class; Skinner et al., 2008), and agency engagement (more dialogue between instructor and student about course material; Reeve, 2013). Students may be more actively engaged in their learning if given greater autonomy to set their own learning objectives; however, this has not been investigated in a systematic way (Bedenlier et al., 2020).

According to Seiers et al. (2009), establishing clear behavioral expectations for students is an important part of a well-structured classroom. E-learning is facilitated by instructors who are skilled in structuring the following: well-structured discussion forums (Vonderwell et al., 2007) and multiple user-friendly functions (Xie et al., 2006). They also organize peer moderation so that students can share information with each other (Xie & Ke, 2011). During online lessons, instructors should provide strong guidance, define the boundaries of learning activities (Chiu & Mok, 2017). Students should receive feedback that is relevant to their competence (Chiu & Mok, 2017).

Instructors should also demonstrate confidence in their students' abilities (Hartnett, 2015). Finally, they should distribute effective learning materials (Chiu et al., 2020; Chiu & Lim, 2020; Chiu & Mok, 2017; Ng & Chiu, 2017). Structure is shown to have a correlation with active participation in the classroom. According to Skinner et al. (2008), a crucial

motivator for student cognitive engagement is a well-designed learning structure that makes students feel competent, effective, and challenged while learning. Students will have a better attitude toward the course, participate more actively in class activities, and have a deeper understanding of the material when this need is satisfied. Improved behavioural and emotional engagement will result from this (Reeve, 2013). The connection between structure and agentic engagement has been explored in a few studies, but not in a comprehensive manner (Reeve, 2013).

To satisfy the needs for autonomy, teachers should provide more freedom and choice to students. Here the freedom and choice mean giving students a large room to submit their learning tasks, giving them choice of tasks and the flexibility of skipping some non-fundamental tutorial session. SDT (Ryan and Deci, 2020) explained while students perceived a sense of choice, they feel more ownership of activities and greater autonomy. It will further result in an increase of intrinsic motivation (Reeve, Nix, & Hamm, 2003). On the other hand, students' sense of choice could lead to better academic outcome (Murayama et al., 2015). It seems that providing freedom and choice to students brings many positive influence. Instructing students with the rationale of learning is also a good way to raise students' perceived autonomy. Once a student knows the rationale of learning, they could realize the meaningfulness of the knowledge. Hence they could choose to learn the knowledge and pay more attention to it. Students' sense to acquire certain required knowledge would allow them to decide their future for themselves. This gives them a strong sense of autonomy. It would further develops into autonomous motivation (Ryan and Deci, 2020) which is the ultimate goal for a learner to learn by their own intention. Moreover, providing self-reflection session is an alternative way to raise students' perceived autonomy. Students explained that the reflection session could help them to evaluate their mistakes and realize the improvement by their own effort. If the students could realize their own mistakes, this is very meaningful for

them to develop to be an independent learner. This is also an ultimate dream for the teachers to achieve if their students are able to learn and evaluate by themselves.

Many researches also pointed out that a rise in autonomy would lead to a rise in intrinsic motivation (Bao & Lam, 2008; Patall, Cooper, and Robinson, 2008). It is worthy for a teacher to spend some time to prepare for the autonomy-supportive teaching approaches. Research showed that students with more autonomy-support showed less decline in well-being, received higher grades and performed better in the profession exam (Sheldon and Krieger, 2007). In this paper, autonomy-supportive teaching approaches include providing more choice and freedom, telling meaningful rationale and providing self-reflection session to students. Some other researchers also suggested that asking people for their perspective and minimize controlling words (Lyness et al., 2013) could also help students to build the perceived autonomy.

According to the findings of this study, there is a scarcity of research undertaken from the perspective of self-determination theory on the specific aspects of e-learning in many cultures. The authors of a study on the factors influencing students' acceptance of massive open online courses (MOOC) stated that their findings were applicable to a developing country (Khan et al., 2018), however they did not compare these findings with other cultures. Limited research has been undertaken in Hong Kong, where online training is still in its early phases of deployment.

We believe that such researches are pertinent to the establishment and advancement of the e-learning system in Hong Kong. Furthermore, it is evident that the Self-determination Theory (SDT) not only proved beneficial in elucidating the efficacy of e-learning for students but also in enhancing the learning experience for employees (Belkhamza & Bin Abdullah, 2019). Nevertheless, there are limited research that address the distinct investigations on e-

learning in various demographic groups, such as age and occupation, from the perspective of self-determination theory.

The application of self-determination theory in the field of digital learning has gained significant traction in recent years, with numerous studies published and valuable data collected. The research areas include predicting students' intents to persist in digital learning, motivation for learning, predicting students' academic achievement, and teachers' willingness to utilize digital resources. SDT serves as a crucial foundation for developing digital materials and establishing a system of engagement with students across different formats of e-learning, such as MOOCs, hybrid virtual courses, and mobile applications.

Ensuring the fulfilment of fundamental necessities has been demonstrated to be the paramount concern when it comes to addressing the motive to persist in a course. E-learning effectively fulfils the requirement for autonomy, allowing individuals to independently decide when, in what manner, and how they want to engage in learning. Conversely, e-learning poses a significant obstacle to the requirement for connectedness, as it allows for highly personalized learning routes and organizational learning circumstances. This is particularly true for asynchronous online courses, as opposed to synchronous ones, where there exists the possibility for immediate contact between students and the instructor. The requirement for proficiency is mostly determined by the methods used to create training material, the organization of task sequences based on their level of complexity, and the quality of feedback provided, regardless of whether the training is conducted online or offline.

The data collected from reviewed literature on online training provide a basis for re-evaluating the connections between basic needs. It has been found that the need for competence is reliant on being part of a community. Therefore, in order to sustain this need,

recognition of success is necessary not only from the teacher or the individual themselves, but also from the community. One can discuss the reciprocal impact of fulfilling basic needs on student achievement in the context of e-learning, as well as recognize e-learning as a potent instrument for addressing these needs in the learning process. The task at hand is to broaden the scope of research to encompass other communities and civilizations, notwithstanding the existence of some comparative studies that have already been carried out.

5.2.3 Implications of the relatedness-satisfying teaching approaches

First, the digital support strategies in the proposed model that is based on the teacher classroom support dimensions—autonomy, structure, and involvement (Lietaert et al., 2015; Roorda et al., 2011)—can better satisfy the needs for autonomy, competence, and relatedness in e-learning. This is in line with what was hypothesized. Despite the absence of face-to-face contacts, this suggests that the fundamental requirements that students have for learning in traditional classroom settings are applicable to distance learning as well. Students experience a stronger sense of autonomy to choose their preferred technologies to learn with, a stronger sense of competence to access e-learning (login, materials, platforms), and a stronger sense of relatedness to connect with teachers for communication when teachers successfully satisfy these three needs in e-learning. They are able to learn more effectively. For learners, the only alternative available to them during a school shutdown is e-learning; yet, they may experience a variety of technological difficulties. As a result, it is of utmost importance for them to have the perception that they are capable of utilizing the technology, even if they are unable to receive online assistance immediately.

Young learners also have limited opportunities to connect with other learners and their teachers during the epidemic than they would have under normal circumstances, such as when they were in school. During the time that the school is closed, it is possible that this

will imply that satisfying perceived relatedness becomes more crucial. The following three strategies for digital support were put to the test in this study: (i) autonomy, which involves providing a variety of resources for learning, allowing students to make choices regarding digital format and sharing tools, and agreeing to flexible hours for learning; (ii) structure, which involves teaching with digital materials that are well-designed (i.e. demanding less cognitive load), utilizing multimedia for student feedback, and making helpful information available for solving technical problems; and (iii) involvement, which involves adopting small support groups and real-time lessons, as well as applying an emotionally aware approach to teaching and communications.

Additionally, additional and more in-depth studies are required to confirm this result. This is due to the fact that the one-group pretest–post-test design may threaten internal validity (Shadish et al., 2002), such as confounding factors related to the perception of need satisfaction. The findings from the t-tests suggested that the proposed strategies may satisfy the basic needs of students within the SDT framework. Another empirical implication is that satisfying the educational needs is likely to foster the student engagement dimensions in e-learning. This implies that the three digital support strategies could motivate students to engage in learning with technology in several different ways, including behaviourally, emotionally, cognitively, and agentically. The findings of this study are in line with those of other studies that were carried out in face-to-face situations (Lietaert et al., 2015; Sierens et al., 2009; Vansteenkiste et al., 2009; Vollet et al., 2017).

In e-learning, perceived relatedness is the primary predictor of behavioural, emotional, and agentic engagement; perceived competence is the most important predictor of cognitive engagement; and perceived autonomy is a significant factor for all of the dimensions in student engagement, but it is not the most influential factor for any of them.

The majority of studies on SDT needs have given autonomy support the highest priority and have emphasized the significance of this aspect in terms of fostering intrinsic incentives for learning (La Guardia, 2009; Ruzek et al., 2016; Trenshaw et al., 2016). These findings, on the other hand, contradict the recommendations of the majority of these studies.

This finding is impacted by contextual circumstances such as societal and/or public health issues, as well as unfamiliar remote learning. Due to the fact that they are unable to play outside, interact with their peers, or participate in activities at school that take place in person, children have reported experiencing decreased levels of affect (Singh et al., 2020). Regarding the postponement of competitions and examinations, they are experiencing a great deal of anxiety. Some of them are concerned about the financial circumstances of their families as a result of the current state of the world economy (Singh et al., 2020). Therefore, during times of crises that prompt social distancing, school closures, and city lockdowns, as well as during unusual learning scenarios that learners have never before seen, the focus should be on providing support for relatedness.

In addition, the ways in which young students interact with materials in different learning venues, such as classrooms and e-learning, are distinct. Students in traditional classroom settings have less discretion over how they spend their time and what they study when compared to students who participate in e-learning. It is not only their job to educate themselves, but also the responsibility of their teachers and their parents. As an illustration, teachers often check to see if their pupils have finished their homework and remind them if they have not. As a result, the interactions between teachers and students, which include participation and relatedness, play a significant part in the process of learning (Ryan & Deci, 2017, 2020; Vansteenkiste et al., 2009).

The opportunity to connect with schools, teachers, and other students is one of the primary advantages of attending school in person for pupils. This is in addition to the additional benefit of gaining subject-matter knowledge. According to Chen and Jang (2010) and Lam et al. (2018), e-learning in comparison to traditional classroom settings is characterized by a lower level of supervision, which provides more support for autonomy, and a lack of actual human connections, which provides less support for relatedness. As a result, the majority of learners have fewer needs for autonomy and greater needs for relatedness as a result of e-learning. In conclusion, it is possible that our findings are a reflection of cultural differences between collectivistic and individualistic cultures, as well as between Eastern and Western cultures (Iyengar & Lepper, 1999; Ryan & Deci, 2020). As a result of the numerous empirical investigations that have been conducted, the functional significance of autonomy is universally acknowledged.

On the other hand, students from many cultures internalize their cultural customs in a variety of ways. The manner in which pupils perceive surroundings and the manner in which their basic needs are satisfied differs from culture to culture (Ryan & Deci, 2020). It is possible that some of the consequences of this study can be explained by the fact that the need for autonomy varies from culture to culture. Furthermore, the measures that were utilized in the data collection process for this study were validated among children from Hong Kong; hence, it is possible that they may not adequately measure the perceived autonomy needs of Asian pupils.

To satisfy the needs for relatedness, teachers are suggested to provide more caring on students' learning progress. Students reflected that such a caring action would lead to a caring image of the teacher which would further lead to more respect to the teacher and more motivation to learn. Alternatively, giving students more recognition is also another good way

to raise the perceived relatedness. It would lead to a feeling of encouragement and bring them confidence. Students reported that the recognition from teacher could show teacher's caring on student which would further enhance the relationship with the students. Besides, allowing students to give more reflection is also a good way to promote the relatedness. Student stated that allowing them to give reflection could make the them feel cared for by the teacher. The reflection section allowed students to show their understanding or misunderstanding to the teachers. The students would think that the teachers have more willingness to concern their learning progress. It would raise the feeling of relatedness as well.

It is worthy for an e-learning provider to spend time to prepare for the relatedness supportive teaching approaches. The relatedness support does not only benefit the students but benefit the teachers. A research reported that once teachers gained higher satisfaction of relatedness, they would be more engaged in their profession and having less emotional exhaustion due to the workload pressure (Klassen, Perry, and Frenzel, 2012). Some other researchers also suggested that observing more another's emotional state and conveying empathy could also build a sense of trust and acknowledgement of others' feelings (Lyness et al., 2013). The development of trust and relationship could also help to build the perceived autonomy.

5.3 Limitations of the study

This study is an applied field experimental research implementing the needs-satisfying teaching approaches from the Self-determination Theory in the context of e-learning within the Science subjects for Hong Kong secondary school students. Despite the strengths of the study, there were a few limitations that could be addressed in future studies.

Firstly, due to the constraint of data collection, only year 8 students (secondary level 2) from a local school were permitted to join the project. In total, there were four year 8

classes of students invited with maximum 25 students in each class. Even though the sample size is enough for the data analysis, the number of participants could be increased if higher reliability would be achieved. In the future, students from different year levels (e.g. year 7 and year 9) and schools should be invited to be the participants.

Secondly, the students from the institution have a limited range of demographics. The participated school adopted the International Baccalaureate (IB) teaching approaches, the students generally have good command of English and high information literacy. Students with good command of English could read the instructions on the Edpuzzle video (the tool in the intervention) smoothly. Moreover, most of the students came from the middle class family and every students have at least 2 mobile or smart devices at home as requested by the school, such that every student have one iPad and one Macbook. So that the students could also address the technical skills on using the e-learning tool easily. However, the students from the participated school could not represent the majority of secondary school students in Hong Kong. It is suggested that schools with different demographics should be involved to participate in the research project. In Hong Kong, the Education Bureau distinguished the secondary school students into Band 1 (high), 2 (medium), and 3 (low) according to their general learning ability. If possible, student participants should be invited from Band 1, 2, 3 schools with a wider range of ability in spoken language. Moreover, students should be invited from different family backgrounds like lower-classes level and grass roots level. In the future, students from a family with less information technology equipment and low information literacy should also be invited.

Thirdly, the e-learning tool adopted in the experiment is technique-oriented which could not represent all e-learning platform. The equipment utilized in the experiment are called PhET Simulation Experiment. A simulated electric circuit platform is selected for the

Physics context and a simulated chemical mixing lab is selected for Chemistry. Simulation labs are techniques oriented on the configuration which could not represent all e-learning tools, especially those tools with low technical requirement. If the study targets to study the students' e-learning motivation with more comprehensive perspectives in the future, we should also involve different e-learning platform with less technical requirement, such as google classroom or Moodle, etc.

Fourthly, the research context in this study has been adopted the learning tasks in Physics and Chemistry in junior secondary level. However, if we are going to understand the full picture of the e-learning attitude in Science context, we should extend to disciplines in Science like Biology, Environment Science, and STEM curriculum (Black and Deci, 2000). Moreover, the study should not limit the Science context in junior secondary levels. Future studies could involve the Science students from both primary schools, senior secondary levels and tertiary education institutions. Besides, the researcher in this study has put his focus mainly on psychology literatures and e-learning literatures while "Science" is only a research context. To make the research study more convincing to the Science learning, it is highly recommended that the future research should implement a more specialized teaching pedagogies and subject characteristics of Science Education to the design of the methodology and intervention.

Lastly, the research participants in this study had been limited to the Science students in the junior secondary level. Future studies could be conducted with other subject disciplines like humanities subjects, mathematics, languages, arts, sports and cross-disciplinary subjects like STEM (Black & Deci, 2000) or professional subjects (Sheldon and Krieger, 2007).

5.4 Further Suggestions

In this study, the significant influence of the needs-satisfying teaching approaches in e-learning among Hong Kong junior secondary students in Science context has been illustrated. Since e-learning is a very convenient teaching medium, it will become more and more popular. Even though the pandemic is over and the face-to-face lessons are resumed, the e-learning application still have their huge demand in the academic field because of the needs from distant learning and the flexibility of virtual environment. With the development of Edtech and STEM, e-learning tools would become more popular and fully-utilized in the daily lesson. It is highly recommended for every educators to implement the needs-satisfying teaching approaches in their e-learning classes or any knowledge related to e-learning application techniques. In this study, the needs-satisfying teaching approaches (the intervention) show significant influence to raise students' perceived competence, autonomy and relatedness. The most important thing is that the rise of perceived competence, autonomy and relatedness would further lead to a rise of students' motivation to use the science e-learning (MSE) tool as well. The study also finds that the perceived competence, autonomy and relatedness act as a significant mediator between the intervention and the MSE. It means that the perceived competence, autonomy and relatedness play a very important role to influence students' intrinsic learning motivation. Educators are highly encouraged to pay more attention to students' competence, autonomy and relatedness and their powerful influence if they would like to see their students to show higher engagement and achieve better performance in the Science and STEM related learning (Black and Deci, 2000).

The idea of paying more attention to the students' competence, autonomy and relatedness is not only limited to Hong Kong students. This study could also be treated a reference to the East-Asian countries whose public examination involves high-stakes assessments. The students in Hong Kong adapted the highly competitive and intensive

learning environment which is very similar to those students in Japan, Korea, China, India and Singapore, etc. Moreover, the idea of implementing needs-satisfying teaching approaches to the daily lessons is not only limited to Science e-learning context. It could be further transfer to different subjects like humanities subjects and language subjects. According a detailed recent research summary from Ryan and Deci (2020), the hypothesis of SDT could be applied to a wide range of diverse subjects. This study showed the convincing finding of the SDT could also be applied to the Hong Kong secondary education context. It is very exciting to see if the future researches could be conducted in more East-Asian countries or different discipline of subjects in Hong Kong.

One piece of advice is for educators to hone their digital communication abilities in preparation for lessons that make use of technology. Teachers can improve their ability to connect with their pupils on an emotional level and encourage them to learn by practicing online positive attitude and excitement. For instance, forum answers might make use of emoji, and constructive criticism can take the form of welcoming audio greetings. Further, in the event of a public health or social emergency, schools and instructors should be prepared to immediately switch to online instruction. Referring to the last empirical implications, our results showed that, out of the three needs for student engagement, relatedness was the most essential. Teachers and schools should make sure that fostering relatedness is the main focus of e-learning. In light of the findings, the authors recommend the following changes to school policy: (i) schedule online social interactions between teachers and students to help them feel more connected; (ii) plan mental health activities so students can talk about how they're feeling, for instance, about what it's like to be home during a school closure; and (iii) create online strategies for teaching or guidelines for curricula, such as creating online peer support groups, using "learning more and evaluating less" assessment methods, and incorporating more interdisciplinary learning activities.

It is worthy to mentioned the finding by Zhou (2016) again. Zhou (2016) examines Chinese university students' acceptance of Massive Open Online Courses (MOOCs) using the Theory of Planned Behaviour and Self-Determination Theory. He finds that attitude towards MOOCs and perceived behavioural control significantly influence intention to use them. It reveals that universities in the e-learning environment must consistently enhance the quality of their e-learning services to ensure student satisfaction (Lee, 2010). Various research in the domain of traditional services and online services have demonstrated that customer satisfaction has a beneficial impact on customer loyalty (Dehghan, Dugger, Dobrzykowski, & Balazs, 2014). Research on e-learning also affirms that student satisfaction is highly likely to result in enhanced student loyalty (Kilburn et al., 2016).

Zhou's study (Zhou, 2016) also discovered the significance of students' acceptance as a substitute for measuring the success of online learning environment. If an online learning environment is not well-accepted by the students in order to satisfy their psychological needs for autonomous learning, the online learning platform will be given up by the students very quickly. Our argument is that in order for e-learning to be successful, the focus should be switched from the preparedness of e-learning to the acceptance of students. This is similar to how other technologies, such as e-government, are adopted and spread. (Zhao et al., 2018). This implies that although the infrastructure, computerisation, and system are essential for e-learning, its effectiveness also depends on the active participation and approval of its users. Therefore, based on prior research conducted by Abdullah & Ward (2016) and Hsu et al. (2018), we argue that it is imperative to reevaluate the success of e-learning by considering students' acceptance.

Moreover, we contend that the implementation of e-learning at the onset of the COVID-19 pandemic might be considered as a compulsory procedure, necessitating students

to transition to online education (Bao, 2020; Dhawan, 2020). Given these conditions, it is unfeasible to assess the effectiveness of e-learning in meeting students' requirements for educational or emotional assistance when participation is obligatory. According to Linders (2012), if students are not required to participate in e-learning, they must be driven to do so, just like any other behaviour. Therefore, the level of self-motivation among students is an indicator of e-learning success from the perspective of need. Students who are content with their e-learning experience are more likely to have a strong intention to continue, but the contrary is also likely to be true. This is supported by research conducted by Hsu et al. (2018) and Szopiński & Bachnik (2022).

According to Hsu et al. (2018), the findings indicate that the Technology Acceptance Model (TAM) is a widely recognised and effective framework for explaining students' acceptance of e-learning. In the current research, SDT model was adopted. SDT emphasized how teachers satisfy students' needs but did not focus on the technical capability of the students. E-learning should not be seen solely as an educational approach, but also as a novel technology where its perceived usefulness and convenience of use play a vital role. If technology acceptance could relate to student's competence, it is important to take into account the technical usage of e-learning user experience. Our first contribution to the field of e-learning research was to highlight the importance of rethinking e-learning's effectiveness from the perspective of students' technology acceptance. The positive implications of e-learning for education accessibility and flexibility have been emphasized by a number of recent research (Bao, 2020; Dhawan, 2020; Grey et al., 2020; Mailizar et al., 2021; Szopiński & Bachnik, 2022). They do, however, highlight that the full acceptance and engagement of users on the other side of the relationship is necessary for this type of technology to be effective. In order to obtain a comprehensive understanding of the cognitive process involved in students' acceptance of e-learning during the COVID-19 pandemic, they developed a

learner-oriented behavioural model. Technology Acceptance Model (TAM) is a widely recognised as an effective framework for explaining students' acceptance of e-learning. According to Hsu et al. (2018), it is important to reexamine the students' real acceptance of e-learning, in order to have a comprehensive understanding of the success of e-learning. Undoubtedly, e-learning is the convergence of education and technology, and the significance of the technological aspect should not be disregarded.

In addition, a valuable contribution is made to enhance the understanding of the factors that influence the acceptancy of e-learning. This study aligns with Lin et al.'s (2015) claim that the e-learning environment should consider the psychological needs of students, in addition to emphasising the educational function, as most e-learning research has done. Utilising social support theory, we incorporated educational support and emotional support as separate factors to examine their individual impact on the acceptability of e-learning. The results of our study indicate that there is a distinct pattern of influence between the two aspects of social support. Specifically, perceived educational support is strongly linked to both perceived ease of use and perceived usefulness. On the other hand, perceived emotional support is only significantly related to perceived ease of use.

An essential implication of this study for universities and higher education is that the deployment of e-learning should consider the acceptance of students from the demand side. While e-learning technologies are advancing quickly, it is crucial to reassess their ability to meet the needs of students, who are its intended users. Our research findings suggest that students' attitudes and intentions to continue using e-learning can be positively influenced by a significant level of perceived emotional support. Hence, it is imperative for universities and higher education institutions to give greater attention to the emotional and educational requirements of students while implementing e-learning technologies.

The implications of our findings are significant for educators in terms of properly motivating college students towards e-learning. It is contended that students' persistence in e-learning is influenced not only by the quality of education delivered (perceived educational support), but also by the level of emotional support perceived. In particular, in a stressful atmosphere such as during the COVID-19 pandemic, or when social connection is lacking, students may experience a reduced perception of how easy it is to use e-learning platforms. In addition to providing intellectual help, offering emotional support might potentially enhance students' perception of the ease of using e-learning. In the context of e-learning, instructors and professors should expand their obligations beyond the transmission of knowledge to encompass additional tasks related to emotional support, such as offering companionship, demonstrating empathy, and providing care.

Our final implication is for technology developers to enhance the human-computer interface to facilitate increased social connections. The absence of direct interpersonal communication is a primary concern associated with e-learning. Improving the human-computer interface can reduce the negative effects of limited social connection. There are two potentially valuable concepts that could be beneficial for technology developers. Initially, it is important to avoid implementing e-learning technologies solely as a unidirectional video broadcast from teachers to students. Instead, these technologies should incorporate additional interactive elements such as quizzes, audio files, videos, simulations, and gamification to actively engage students in the learning process. Features that enhance the perceived degree of educational assistance would lead to an increase in the perceived level of ease of use and usefulness. In addition, an increased perception of emotional support is likely to result in a higher reported level of ease of use. Therefore, to enhance social interactions, it may be necessary to incorporate instant communication features, such as an instant messenger, to facilitate students in expressing their fears, sharing their feelings, and exchanging support.

This is because a higher perception of emotional support is also associated with a higher perception of ease of use.

The qualities of the e-learning system, as well as the quality of e-learning instructors and course materials are important factors in determining the overall quality of e-learning services. Additionally, the quality of e-learning administrative and support services also plays a key role in contributing to the overall quality of e-learning services. This factor is also corroborated by research conducted in industrialised nations (Martinez-Arguelles & Batalla-Busquets, 2016). Several colleges in developing economies, such as Hong Kong, have yet to adopt the perspective of treating students as customers to be served. This perspective can have a highly negative impact on universities. Therefore, universities must regard students as clients and deliver dedicated services to them. Efficient, precise, and convenient handling of students' information enquiries, course selection, enrolment, tuition, and other administrative operations is essential before, during, and after e-learning courses. Universities must establish and maintain both physical and online offices in order to effectively address students' information enquiries at all times, around the clock. University faculty can enhance student satisfaction by consistently valuing their interests.

This study has identified three e-learning service quality qualities that universities in Hong Kong must consistently improve. Enhancing the qualities of e-learning service quality will result in an overall improvement in e-learning service quality. Greater e-learning service quality leads to increased satisfaction among e-learning students. There is a direct correlation between the level of satisfaction among e-learning students and their loyalty to the university. As e-learning students develop stronger allegiance to the university, their enrolment in e-learning courses is expected to increase. Furthermore, upon graduation, there is a high probability that they will pursue graduate programmes either online or on campus.

Additionally, they can serve as advocates, freely promoting the university as a whole and specifically endorsing e-learning programmes to their acquaintances and family members.

5.5 Future Research

Besides the reflection mentioned in the limitation of the study, we could still foresee more possible room to develop for future studies. Due to limited resources and manpower, many valuable variables are not analysed in this research. They are the enjoyment, the curiosity and engagement, etc. Especially, adding engagement as a measurable variable in future research is very important to know how significant the increased motivation could further influence the students' participation. It is interesting to investigate if an increased motivation does or does not lead to an increase of engagement. We could observe the quality of students' works and their participation in the e-learning class to justify their engagement.

Only inviting year 8 students to be the participants was a huge limitation of the current study. We could look into a wider spectrum. Students from different ages are encouraged to be invited in order to see the changes across ages from a developmental psychology perspective. Students from different ages may show different pattern of e-learning acceptance or different tendency in learning science. Students from different ages may also have different level of relatedness need from the teachers. It is interesting to find out if specific needs-satisfying teaching approaches could be more effective on specific ages of students.

In this study, most of the students came from the middle class families whose information literacy were generally higher than average. They may have a higher readiness to accept e-learning teaching approaches and new e-learning tool. Students from different demographics are encouraged to be invited to the future research project. Students from different demographics may show different pattern of e-learning acceptance or different

tendency in learning science as well. It is interesting to find out if some specific needs-satisfying teaching approaches may fit students from a specific demographics. For example, even male and female could show different preferences on e-learning (Yang et al., 2011). In this sense, students with different learning ability may also show different pattern of e-learning acceptance or different tendency in learning science as well. It is more interesting to find out if some specific needs-satisfying teaching approaches may fit students with learning diversity.

To differentiate the normal teaching practices for the control group and the needs-satisfying teaching approaches for the intervention group, the normal teaching practices were acquired from the appraisal record of the lesson observation from ELCHK Lutheran Academy. The normal science e-learning lessons performed by the science teachers from ELCHK Lutheran Academy were recorded in the appraisal form, which is kept under the HR Department. The teaching performance was not kept as a checklist but just recorded as some grades under the appraisal descriptors of how a teacher meets the school's expectations of teaching. The appraisal descriptors were quite general in teaching, which were hard to transfer to any data related to SDT teaching practices. It only showed that the school did not promote needs-satisfying teaching practices in the appraisal form, hence the teachers would not emphasize needs-satisfying teaching approaches in their lesson. A fidelity check is essential in future studies. We need to evaluate whether the teacher-researchers are really following the instructed protocols for the intervention. It is also important to ensure those interventions delivered are adequately trained and supported to maintain fidelity throughout the study. By conducting fidelity checks, we can provide evidence that the observed effects are due to the intervention itself rather than discrepancies in its implementation. This enhances the reliability and generalizability of the research findings.

It is essential to broaden our scope to include STEM curricula, biology, and environmental science. Furthermore, the study shouldn't restrict the use of science in junior secondary education. Subsequent research endeavours may encompass Science students from elementary schools, upper secondary schools, and university colleges. Furthermore, "Science" is merely a research context in this study; the researcher's primary attention has been on psychology and e-learning literatures. It is strongly advised that future research incorporate more specific teaching pedagogies and topic features of Science Education into the design of the methodology and intervention in order to strengthen the research study's argument for Science learning. In this sense, future research could also include other topic areas, such as professional subjects (Sheldon and Krieger, 2007) or cross-disciplinary subjects like STEM (Black & Deci, 2000). Other subject areas include mathematics, languages, arts, sports, and humanities.

As mentioned, the science e-learning tool adopted in this study was called PhET simulation lab. Simulation lab is a good example of subject knowledge involved e-learning tool, however, it should not be only limited to simulation experiment. Zhou (2016) investigated university students' acceptance in China on the Massive Open Online Courses (MOOCs) using Self-Determination Theory. This is a good example that the measurement tool could be extended from e-learning tool to online learning platform, learning management system or even extended to other learning-related media, like online learning games or social media with e-learning purpose. Online social universe could become a new media for students to interact and exchange idea online in a more causal way but it definitely enhance the online social life which is further linked to the relatedness.

Due to the extensive scope of the framework and the wide range of scholars now advancing it, it is challenging to predict the future trajectories of SDT study and practice. However, we will emphasize a few areas that we expect will become more prominent. SDT's

current research exhibits important qualities, such as the utilization of several ways to test convergent ideas. These methods encompass both classic quantitative approaches and qualitative ones. Indeed, the development of SDT has been enhanced by a continuous cycle of experimental investigations and field research, together with insights gained from interventions and consultations conducted in educational environments. Similar to Nolen's (2020) perspective, we consider the utilization of many techniques and information sources essential for comprehensively understanding the intricacies of learning environments worldwide.

The main goal of current SDT research is to examine the possible advantages and difficulties of new technology for learning. Keeping students' attention and encouraging engagement in learning activities is a major challenge in modern education. In response, educators are using the influence of games to achieve learning goals and are implementing "gamification" strategies to increase student motivation (e.g., McKernan et al., 2015; Rigby, 2014). A considerable amount of research in the field of Self-Determination Theory (SDT) has demonstrated that people's strong motivation towards successful video games can primarily be attributed to the features of these games that satisfy their needs for autonomy, competence, and relatedness (Rigby & Ryan, 2011).

In order to enhance motivation and facilitate learning, future SDT research is expected to focus on exploring the effective development of the media of teaching resources, e-learning platforms, remote classrooms, and other technology possibilities (Ryan & Rigby, 2019). In addition, research into teachers' and students' willingness to use technology for educational purposes will become increasingly common and usual (Peters, Calvo, & Ryan, 2018; Sørebø, Halvari, Gulli, & Kristiansen, 2009). The concept of learning theory played a pivotal role in behaviouristic psychologies of the past, enabling the identification of precise

reinforcement procedures linked to exertion and achievement. Currently, it is well-established that psychological factors such as interest and value have a substantial impact on engagement and learning (Froiland & Worrell, 2016). Moreover, there is a growing understanding of the settings that either promote or hinder these factors. Furthermore, it is established that conditions that provide support for needs also enhance various internal resources for learning, such as improved executive functioning (Bindman, Pomerantz, & Roisman, 2015), enhanced critical thinking (Manganelli et al., 2019), and improved integrative decision-making (Di Domenico, Fournier, Ayaz, & Ruocco, 2013).

SDT encompasses a profound theory of learning that is rooted in an active organismic framework. In this framework, a motivated learner encounters either supporting or obstructive components within the learning environment and subject matter. SDT offers a comprehensive range of methods, derived from its theory of functional significance (Deci & Ryan, 2000), to analyse the circumstances and reasons behind the effects of various factors, such as rewards, feedback, evaluations, recognition, competition, and social comparison, on learners' fulfilment of their basic needs. However, it is necessary to establish a stronger link between these dynamics and their underlying mechanisms. Furthermore, a more comprehensive and specific approach is required to analyse various categories and types of cognitive performance. The mechanisms that drive motivation can also be directly connected to particular teaching methods and curricula that encourage and support learning in many academic disciplines (e.g., Kadir, Yeung, Ryan, Forbes, & Diallo, 2018; Rogat et al., 2014). An organismic learning theory would focus on both external methods of shaping and controlling learning, as well as understanding and supporting the innate tendencies to learn within self-determination theory (SDT) in various circumstances, and the valuable educational results they can produce.

Research on Self-Determination Theory (SDT) has revealed significant connections between teachers' motivation and well-being, and their ability to provide help to their pupils based on their needs. Research is currently being conducted to examine the influences that administrators, policies, students, and parents have on teachers. However, further investigation is needed to understand the motivations behind teaching and ongoing professional development. It is crucial to study the works of Gorozidis & Papaioannou (2014), Guay, Valois, Falardeau, & Lessard (2016), and Jansen in de Wal, den Brok, Hooijer, Martens, and van den Beemt (2014) to gain insights into this area. Additionally, it is important to explore teachers' instructional and career goals, as demonstrated by the research of Jang (2019). Furthermore, it is imperative to conduct further research on the impact of leadership, as different leadership styles have a substantial influence on both the effectiveness and retention of teachers (e.g., Nie et al., 2015). With the advancement of SDT, quantitative research has shown broad principles that are both dependable and capable of making accurate predictions. Additional qualitative research is required in the field of SDT to provide a more comprehensive understanding of the experiences, practices, and reasons related to need supportive schools. This study will also aid in the application of findings to practical everyday use.

Qualitative research is necessary to thoroughly examine educational innovations that create supportive environments to meet specific needs. These studies can serve as exemplars for initiating change, as demonstrated by the work of Barrable and Arvanitis (2019). Additionally, they promote the integration of any application SDT's framework into the diverse influences that affect instructors and students, both inside and outside the classroom. SDT is characterized by its emphasis on the importance of providing fundamental assistance for basic needs in order to create a conducive educational environment. SDT, in contrast to relativistic viewpoints, assesses curricula, instructional methods, educational leadership

approaches, and policies by examining how well they promote or hinder the basic psychological needs of learners and teachers. By employing these fundamental and quantifiable standards, SDT offers a foundation for conducting insightful research on instructional methodologies for educational institutions and policy development. Based on this premise, Ryan and Niemiec (2009) contended that although SDT relies on empirical methods for knowledge, it aligns with constructivist and post-modern educational approaches in its focus on cultural internalizations and impositions, as well as its acknowledgement of layered forms of hegemony. This theory serves as an exemplar of a theoretical framework that is based on empirical evidence and incorporates critical analysis. Therefore, it deserves to be taken into account alongside other critical educational theories. The significance of basic psychological needs lies not only in their role as motivators of performance results, but also in their ability to promote students' overall well-being in many cognitive, personal, and social aspects within educational settings.

References

Abdullah, F., & Ward, R. (2016). Developing a General Extended Technology Acceptance Model for E-Learning (GETAMEL) by analysing commonly used external factors. Computers in human behavior, 56, 238-256.

Aelterman, N., Vansteenkiste, M., & Haerens, L. (2019). Correlates of students' internalization and defiance of classroom rules: A self-determination theory perspective. *British journal of educational psychology*, *89*(1), 22-40.

Ahn, I., Patrick, H., Chiu, M. M., & Levesque-Bristol, C. (2019). Measuring teacher practices that support student motivation: Examining the factor structure of the teacher as social context questionnaire using multilevel factor analyses. Journal of Psychoeducational Assessment, 37(6), 743-756.

Alamri, H., Lowell, V., Watson, W., & Watson, S. L. (2020). Using personalized learning as an instructional approach to motivate learners in online higher education: Learner self-determination and intrinsic motivation. Journal of Research on Technology in Education, 52(3), 322-352.

Anderson, R. D., & Mitchner, C. P. (1994). Research on science teacher education. In D. L. Gabel (Ed.), Handbook of science teaching and learning (pp. 32–37). New York: Macmillan.

Apker, J. (2022). College student accounts of coping and social support during COVID-19 impacted learning. Communication Quarterly, 70(3), 296-316.

Assor, A., Kaplan, H., Kanat-Maymon, Y., & Roth, G. (2005). Directly controlling teacher behaviors as predictors of poor motivation and engagement in girls and boys: The role of anger and anxiety. *Learning and instruction*, *15*(5), 397-413.

Assor, A., Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. *British journal of educational psychology*, *72*(2), 261-278.

Assor, A., & Tal, K. (2012). When parents' affection depends on child's achievement: Parental conditional positive regard, self-aggrandizement, shame and coping in adolescents. Journal of adolescence, 35(2), 249-260.

Baard, P. P., Deci, E. L., & Ryan, R. M. (2004). Intrinsic need satisfaction: A motivational basis of performance and well-being in two work settings. Journal of Applied Social, Psychology, 34(10), 2045–2068.

Bachman, C. M., & Stewart, C. (2011). Self-Determination Theory and Web-Enhanced course Template Development. Teaching of Psychology, 38(3), 180-188. https://doi.org/10.1177/0098628311411798

Bandura, A. (1971) *Psychological Modelling*. New York: Lieber-Antherton

Bandura, A. (1986) Social Foundations of Thought and Action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). Self-Efficacy: The Exercise of Control. New York: Freeman.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual review of psychology*, *52*(1), 1-26.

Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human behavior and emerging technologies*, *2*(2), 113-115.

Bao, X.-H., & Lam, S.-F. (2008). Who makes the choice?: Rethinking the role of autonomy and relatedness in Chinese children's motivation. Child Development, 79(2), 269–283.

Barak, M., Watted, A., & Haick, H. (2016). Motivation to learn in massive open online courses: Examining aspects of language and social engagement. Computers and Education, 94, 49-60. https://doi.org/10.1016/j.compedu.2015.11.010

Baranik, L. E., Wright, N. A., & Reburn, K. L. (2017). Mentoring relationships in online classes. The Internet and Higher Education, 34, 65-71.

Bartholomew, K. J., Ntoumanis, N., Cuevas, R., & Lonsdale, C. (2014). Job pressure and ill-health in physical education teachers: The mediating role of psychological need thwarting. *Teaching and Teacher Education*, *37*, 101-107.

Barrable, A., & Arvanitis, A. (2019). Flourishing in the forest: Looking at Forest School through a self-determination theory lens. *Journal of Outdoor and Environmental Education*, *22*(1), 39-55.

Baumeister, R. F. & Leary, M. R. (1995). The need to belong. Psychological Bulletin, 117(3), 497-529.

Bedenlier, S., Bond, M., Buntins, K., Zawacki-Richter, O., & Kerres, M. (2020). Facilitating student engagement through educational technology in higher education: A systematic review in the field of arts and humanities. Australasian Journal of Educational Technology, 36(4), 126-150.

Black, A. E., & Deci, E. L. (2000). The effects of student self-regulation and instructor autonomy support on learning in a college-level natural science course: A self-determination theory perspective. Science Education, 84(6), 740–756.

Broadbent, J., & Poon, W. L. (2015). Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. The internet and higher education, 27, 1-13.

Bubnova, I. S., Khvatova, M. A., Chernik, V. E., Popova, O. V., Prokopyev, A. I., Naumov, P. Yu., & Babarykin, O. V. (2018). Research of Professional Activity Features of Ecologist at Carrying Out Public Ecological Examination. Ekoloji, 106, 999-1006, Article No: e106183

Buhr, E. E., Daniels, L. M., & Goegan, L. D. (2019). Cognitive appraisals mediate relationships between two basic psychological needs and emotions in a massive open online course. *Computers in Human Behavior*, *96*, 85-94.

Butz, N. T., & Stupnisky, R. H. (2017). Improving student relatedness through an online discussion intervention: The application of self-determination theory in synchronous hybrid programs. Computers & Education, 114, 117-138.

Chang, Y., Leach, N., & Anderman, E. M. (2015). The role of perceived autonomy support in principals' affective organizational commitment and job satisfaction. *Social Psychology of Education*, *18*, 315-336.

Chen, C. H. (2014). An adaptive scaffolding e-learning system for middle school students' physics learning. *Australasian Journal of Educational Technology*, *30*(3).

Chen, K. C., & Jang, S. J. (2010). Motivation in e-learning: Testing a model of self-determination theory. *Computers in Human Behavior*, *26*(4), 741-752.

Chen, K. C., Jang, S. J., & Branch, R. M. (2010). Autonomy, affiliation, and ability: Relative salience of factors that influence online learner motivation and learning outcomes. *Knowledge Management & E-Learning: An International Journal*, *2*(1), 30-50.

Cheon, S. H., & Reeve, J. (2015). A classroom-based intervention to help teachers decrease students' amotivation. *Contemporary educational psychology*, *40*, 99-111.

Cheon, S. H., Reeve, J., Lee, Y., & Lee, J. W. (2018). Why autonomy-supportive interventions work: Explaining the professional development of teachers' motivating style. *Teaching and Teacher Education*, *69*, 43-51.

Chirkov, V., Vansteenkiste, M., Tao, R., & Lynch, M. (2007). The role of self-determined motivation and goals for study abroad in the adaptation of international students. *International Journal of Intercultural Relations*, *31*(2), 199-222.

Chiu, T. K., & Lim, C. P. (2020). Strategic use of technology for inclusive education in Hong Kong: A content-level perspective. ECNU Review of Education, 3(4), 715-734.

Chiu, T. K., Lin, T. J., & Lonka, K. (2020). Call for Papers-Motivating e-learning: The challenges of COVID-19 and beyond.

Chiu, T. K. (2022). Applying the self-determination theory (SDT) to explain student engagement in e-learning during the COVID-19 pandemic. Journal of Research on Technology in Education, 54(sup1), S14-S30.

Chiu, T. K., & Mok, I. A. (2017). Learner expertise and mathematics different order thinking skills in multimedia learning. Computers & Education, 107, 147-164.

Christenson, S., Reschly, A. L., & Wylie, C. (2012). *Handbook of research on student engagement* (Vol. 840). New York: Springer.

Cincinnato, S., De Wever, B., Dunantlaan, H., & Zhu, C. (2016, July). How need-supportive teaching practices can be promoted: a Self-Determination Approach. In The 21th Conference of the JUnior REsearchers of EARLI 2016: Education in a dynamic world: Facing the future.

Cobb, S. (1976). Social support as a moderator of life stress. Psychosomatic medicine, 38(5), 300-314.

Cochran, K. F., King, R. A., & DeRuiter, J. A. (1993). Pedagogical content knowledge: An integrative model for teacher preparation. Journal of Teacher Education, 44(4), 263–272.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohen, S. (1985). Issues in the study and application of social support.

Cohen, S., & Hoberman, H. M. (1983). Interpersonal support evaluation list. *Journal of Applied Social Psychology*.

Cohen, S., & Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. Psychological bulletin, 98(2), 310.

Collie, R. J., Granziera, H., & Martin, A. J. (2019). Teachers' motivational approach: Links with students' basic psychological need frustration, maladaptive engagement, and academic outcomes. *Teaching and Teacher Education*, *86*, 102872.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage publications.

Csikszentmihalyi, M., Abuhamdeh, S., & Nakamura, J. (2005). Flow. Handbook of competence and motivation. AJ Elliot and CS Dweck, eds.

Cuevas, R., Ntoumanis, N., Fernandez-Bustos, J. G., & Bartholomew, K. (2018). Does teacher evaluation based on student performance predict motivation, well-being, and ill-being?. *Journal of school psychology*, *68*, 154-162.

Danowitz, A. M., Brown, R. C., Jones, C. D., Diegelman-Parente, A., & Taylor, C. E. (2016). A combination course and lab-based approach to teaching research skills to undergraduates. Journal of chemical education, 93(3), 434-438.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. Management Science, 35(8), 982–1003.

Davis, F. D. (1986). A technology acceptance model for empirically testing new end-user information systems: Theory and results. Doctoral dissertation. Cambridge, MA: MIT Sloan School of Management.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly,13(3), 319–339.

de Araujo Guerra Grangeia, T., de Jorge, B., Franci, D., Martins Santos, T., Vellutini Setubal, M. S., Schweller, M., & de Carvalho-Filho, M. A. (2016). Cognitive load and self-determination theories applied to e-learning: Impact on students' participation and academic performance. PloS one, 11(3), e0152462.

de Barba, P. G., Kennedy, G. E., & Ainley, M. D. (2016). The role of students' motivation and participation in predicting performance in a MOOC. *Journal of Computer Assisted Learning*, *32*(3), 218-231.

Deci, E. L. (1972). The effects of contingent and noncontingent rewards and controls on intrinsic motivation. Organizational behavior and human performance, 8(2), 217-229.

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. Psychological bulletin, 125(6), 627.

Deci, E. L., & Ryan, R. M. (1985). The general causality orientations scale: Self-determination in personality. *Journal of research in personality*, *19*(2), 109-134.

Deci, E. L., & Ryan, R. M. (1986). The dynamics of self-determination in personality and development. Self-related cognitions in anxiety and motivation, 171-194.

Deci, E. L., & Ryan, R. M. (2000). The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological inquiry*, *11*(4), 227-268.

Deci, E. L., & Ryan, R. M. (2012). Self-determination theory. Handbook of theories of social psychology, 1(20), 416-436.

Deci, E. L., & Ryan, R. M. (2013). Intrinsic motivation and self-determination in human behavior. Springer Science & Business Media.

Deci, E. L., & Ryan, R. M. (2000). The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior. Psychological inquiry, 11(4), 227-268.

Deci, E. L., Ryan, R. M., Gagné, M., Leone, D. R., Usunov, J., & Kornazheva, B. P. (2001). Need satisfaction, motivation, and well-being in the work organizations of a former eastern bloc country: A cross-cultural study of self-determination. Personality and social psychology bulletin, 27(8), 930-942.

Dehghan, A., Dugger, J., Dobrzykowski, D., & Balazs, A. (2014). The antecedents of student loyalty in online programs. International journal of educational management, 28(1), 15-35.

De Meyer, J., Soenens, B., Aelterman, N., De Bourdeaudhuij, I., & Haerens, L. (2016). The different faces of controlling teaching: implications of a distinction between

externally and internally controlling teaching for students' motivation in physical education. *Physical Education and Sport Pedagogy*, *21*(6), 632-652.

Dempsey, J. V., & Eck, R. V. (2003). Modality and placement of a pedagogical adviser in individual interactive learning. British Journal of Educational Technology, 34(5), 585-600.

Dhawan, S. (2020). E-learning: A panacea in the time of COVID-19 crisis. Journal of educational technology systems, 49(1), 5-22.

Durksen, T. L., Chu, M. W., Ahmad, Z. F., Radil, A. I., & Daniels, L. M. (2016). Motivation in a MOOC: a probabilistic analysis of online learners' basic psychological needs. Social Psychology of Education, 19, 241-260.

Eccles, J. S., Wigfield, A., Midgley, C., Reuman, D., Iver, D. M., & Feldlaufer, H. (1993). Negative effects of traditional middle schools on students' motivation. The elementary school journal, 93(5), 553-574.

Fang, J., Tang, L., Yang, J., & Peng, M. (2019). Social interaction in MOOCs: The mediating effects of immersive experience and psychological needs satisfaction. Telematics and Informatics, 39, 75-91.

Farkas, M. S., & Grolnick, W. S. (2010). Examining the components and concomitants of parental structure in the academic domain. *Motivation and Emotion*, *34*, 266-279.

Faye, C., & Sharpe, D. (2008). Academic motivation in university: The role of basic psychological needs and identity formation. Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement, 40(4), 189.

Federici, R. A., & Skaalvik, E. M. (2014). Students' Perceptions of Emotional and Instrumental Teacher Support: Relations with Motivational and Emotional Responses. *International education studies*, *7*(1), 21-36.

Fernet, C., Guay, F., Senécal, C., & Austin, S. (2012). Predicting intraindividual changes in teacher burnout: The role of perceived school environment and motivational factors. *Teaching and teacher education*, *28*(4), 514-525.

Filak, V. F., & Nicolini, K. M. (2018). Differentiations in motivation and need satisfaction based on course modality: a self-determination theory perspective. *Educational Psychology*, *38*(6), 772-784.

Fousiani, K., Van Petegem, S., Soenens, B., Vansteenkiste, M., & Chen, B. (2014). Does parental autonomy support relate to adolescent autonomy? An in-depth examination of a seemingly simple question. Journal of Adolescent Research, 29(3), 299-330.

Froiland, J. M., & Worrell, F. C. (2016). Intrinsic motivation, learning goals, engagement, and achievement in a diverse high school. *Psychology in the Schools*, *53*(3), 321-336.

Fujita-Starck, P. J. (1994). The effects of motivation and classroom environment on the satisfaction of noncredit continuing education students (Doctoral dissertation).

Gabrielle, D. (2003). The effects of technology-mediated instructional strategies on motivation, performance, and self-directed learning. In EdMedia+ Innovate Learning (pp. 2568-2575). Association for the Advancement of Computing in Education (AACE).

Gillet, N., Lafreniere, M. A. K., Huyghebaert, T., & Fouquereau, E. (2015). Autonomous and controlled reasons underlying achievement goals: Implications for the 3× 2 achievement goal model in educational and work settings. *Motivation and Emotion*, *39*, 858-875.

Grey, I., Arora, T., Thomas, J., Saneh, A., Tohme, P., & Abi-Habib, R. (2020). The role of perceived social support on depression and sleep during the COVID-19 pandemic. Psychiatry research, 293, 113452.

Grolnick, W. S., & Ryan, R. M. (1989). Parent styles associated with children's self-regulation and competence in school. *Journal of educational psychology*, *81*(2), 143.

Grolnick, W. S., Ryan, R. M., & Deci, E. L. (1991). Inner resources for school achievement: Motivational mediators of children's perceptions of their parents. *Journal of educational psychology*, *83*(4), 508.

Guay, F., Ratelle, C. F., Roy, A., & Litalien, D. (2010). Academic self-concept, autonomous academic motivation, and academic achievement: Mediating and additive effects. *Learning and individual differences*, *20*(6), 644-653.

Guay, F., & Vallerand, R. J. (1997). Social context, student's motivation, and academic achievement: Toward a process model. Social Psychology of Education, 1(3), 211–233.

Gunawardena, C. N. (1995). Social presence theory and implications for interaction and collaborative learning in computer conferences. International journal of educational telecommunications, 1(2), 147-166.

Hamidi, H., & Chavoshi, A. (2018). Analysis of the essential factors for the adoption of mobile learning in higher education: A case study of students of the University of Technology. Telematics and Informatics, 35(4), 1053-1070.

Hardre, P. L., & Reeve, J. (2003). A motivational model of rural students' intentions to persist in, versus drop out of, high school. *Journal of educational psychology*, *95*(2), 347.

Hartnett, M. (2015). Student and teacher perceptions of online student engagement in an online middle school. *Journal of Open, Flexible and Distance Learning*, *19*(1), 27-44.

Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational research review*, *12*, 45-58.

Hewson, P.W., & Hewson, M. G. A. B. (1988). An appropriate conception of teaching science: A view from studies of science learning. Science Education, 72(5), 597–614.

Ho, C. H. (2010). Continuance intention of e-learning platform: Toward an integrated model. *International Journal of Electronic Business Management*, *8*(3), 206.

Hornstra, L., Stroet, K., van Eijden, E., Goudsblom, J., & Roskamp, C. (2018). Teacher expectation effects on need-supportive teaching, student motivation, and engagement: a self-determination perspective. *Educational Research and Evaluation*, *24*(3-5), 324-345.

House, J. S. (1983). Work stress and social support. *Addison-Wesley series on occupational stress*.

Howland, J. L., & Moore, J. L. (2002). Student perceptions as distance learners in Internet-based courses. Distance education, 23(2), 183-195.

Hoyt, J. E., & Howell, S. L. (2011). Beyond customer satisfaction: Reexamining customer loyalty to evaluate continuing education programs. The Journal of Continuing Higher Education, 59(1), 21-33.

Hsu, H. C. K., Wang, C. V., & Levesque-Bristol, C. (2019). Reexamining the impact of self-determination theory on learning outcomes in the e-learning environment. Education and Information Technologies, 24(3), 2159-2174.

Hsu, J. Y., Chen, C. C., & Ting, P. F. (2018). Understanding MOOC continuance: An empirical examination of social support theory. Interactive Learning Environments, 26(8), 1100-1118.

Hsu, M. H., & Chiu, C. M. (2004). "Internet self-efficacy and electronic service acceptance". Decision Support Systems, 38(3), 369–381.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural equation modeling: a multidisciplinary journal, 6(1), 1-55.

Huang, M. H. (2003). "Designing website attributes to induce experiential encounters". Computers in Human Behavior, 19(4), 425–442.

Hughes, A., Galbraith, D., & White, D. (2011). Perceived competence: A common core for self-efficacy and self-concept?. Journal of personality assessment, 93(3), 278-289.

Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. Journal of Technology and Teacher Education, 13(2), 277–302.

Hu, X., Song, Y., Zhu, R., He, S., Zhou, B., Li, X., ... & Liu, B. (2022). Understanding the impact of emotional support on mental health resilience of the community in the social media in Covid-19 pandemic. Journal of affective disorders, 308, 360-368.

Hu, X., Zhang, J., He, S., Zhu, R., Shen, S., & Liu, B. (2022). E-learning intention of students with anxiety: Evidence from the first wave of COVID-19 pandemic in China. Journal of affective disorders, 309, 115-122.

Igbaria, M., Parasuraman, S., & Baroudi, J. J. (1996). “A motivational model of microcomputer usage”. Journal of Management Information Systems, 13(1), 127–143.

Iyengar, S. S., & Lepper, M. R. (1999). Rethinking the value of choice: a cultural perspective on intrinsic motivation. Journal of personality and social psychology, 76(3), 349.

Jaakkola, T., & Veermans, K. (2020). Learning electric circuit principles in a simulation environment with a single representation versus “concreteness fading” through multiple representations. Computers & Education, 148, 103811.

Jang, H., Reeve, J., & Deci, E. L. (2010). Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. Journal of Educational Psychology, 102, 588-600.

Jang, H., Reeve, J., & Halusic, M. (2016). A new autonomy-supportive way of teaching that increases conceptual learning: Teaching in students' preferred ways. The Journal of Experimental Education, 84(4), 686-701.

Järvelä, S. (2001). Shifting research on motivation and cognition to an integrated approach on learning and motivation in context. Motivation in learning contexts: Theoretical advances and methodological implications, 3-14.

Jeno, L. M., Adachi, P. J., Grytnes, J. A., Vandvik, V., & Deci, E. L. (2019). The effects of m-learning on motivation, achievement and well-being: A Self-Determination Theory approach. *British Journal of Educational Technology*, *50*(2), 669-683.

Jeno, L. M., Grytnes, J. A., & Vandvik, V. (2017). The effect of a mobile-application tool on biology students' motivation and achievement in species identification: A Self-Determination Theory perspective. Computers & Education, 107, 1-12.

Joo, Y. J., So, H. J., & Kim, N. H. (2018). Examination of relationships among students' self-determination, technology acceptance, satisfaction, and continuance intention to use K-MOOCs. *Computers & Education*, *122*, 260-272.

Khan, A., Fornes, O., Stigliani, A., Gheorghe, M., Castro-Mondragon, J. A., Van Der Lee, R., ... & Mathelier, A. (2018). JASPAR 2018: update of the open-access database of transcription factor binding profiles and its web framework. Nucleic acids research, 46(D1), D260-D266.

Kasser, T., Davey, J., & Ryan, R. M. (1992). Motivation and employee–supervisor discrepancies in a psychiatric vocational-rehabilitation setting. Rehabilitation Psychology, 37(3), 175–188.

Katz, I., Eilot, K., & Nevo, N. (2014). "I'll do it later": Type of motivation, self-efficacy and homework procrastination. Motivation and Emotion, 38, 111-119.

Keating, T., & Evans, E. (2001, April). Three computers in the back of the classroom: Pre-service teachers' conceptions of technology integration. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

Kennedy, J. (2014). Characteristics of massive open online courses (MOOCs): A research review, 2009-2012. *Revista de Economia e Sociologia Rural*, *51*.

Klapp, A. (2015). Does grading affect educational attainment? A longitudinal study. *Assessment in Education: Principles, Policy & Practice*, *22*(3), 302-323.

Klassen, R. M., Perry, N. E., & Frenzel, A. C. (2012). Teachers' relatedness with students: An underemphasized component of teachers' basic psychological needs. Journal of Educational Psychology, 104, 150–165

Koehler, M. J., & Mishra, P. (2008). Introducing TPACK. In AACTE Committee on Innovation & Technology (Eds.), Handbook of technological pedagogical content knowledge for educators (pp. 3–29).New York, NY: Routledge.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? Contemporary issues in technology and teacher education, 9(1), 60-70.

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In Handbook of research on educational communications and technology (pp. 101-111). Springer New York.

Koh, C., Tan, H. S., Tan, K. C., Fang, L., Fong, F. M., Kan, D., ... & Wee, M. L. July 2010."Investigating the Effect of 3D Simulation-Based Learning on the Motivation and Performance of Engineering Students.". *Journal of Engineering Education*, *99*(3), 237-251.

Kop, R. (2011). The challenges to connectivist learning on open online networks: Learning experiences during a massive open online course. *International Review of Research in Open and Distributed Learning*, *12*(3), 19-38.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. Computers in human behavior, 19(3), 335-353.

Krijgsman, C., Vansteenkiste, M., van Tartwijk, J., Maes, J., Borghouts, L., Cardon, G., ... & Haerens, L. (2017). Performance grading and motivational functioning and fear in physical education: A self-determination theory perspective. *Learning and Individual Differences*, *55*, 202-211.

La Guardia, J. G. (2009). Developing who I am: A self-determination theory approach to the establishment of healthy identities. Educational Psychologist, 44(2), 90-104.

Lee, S. H. (2008). A study on the relationship between professional self-concept, self-efficacy and job satisfaction in clinical nurses. Korean Journal of Adult Nursing, 20(1), 10-20.

León, J., Núñez, J. L., & Liew, J. (2015). Self-determination and STEM education: Effects of autonomy, motivation, and self-regulated learning on high school math achievement. *Learning and Individual Differences*, *43*, 156-163.

Lepper, M. R., & Cordova, D. I. (1992). A desire to be taught: Instructional consequences of intrinsic motivation. Motivation and emotion, 16(3), 187-208.

Lietaert, S., Roorda, D., Laevers, F., Verschueren, K., & De Fraine, B. (2015). The gender gap in student engagement: The role of teachers' autonomy support, structure, and involvement. *British Journal of Educational Psychology*, *85*(4), 498-518.

Lin, Y., Liu, Z., Luan, H., Sun, M., Rao, S., & Liu, S. (2015). Modeling relation paths for representation learning of knowledge bases. *arXiv preprint arXiv:1506.00379*.

Liu, J., Bartholomew, K., & Chung, P. K. (2017). Perceptions of teachers' interpersonal styles and well-being and ill-being in secondary school physical education students: The role of need satisfaction and need frustration. *School Mental Health*, *9*(4), 360-371.

Liyanagunawardena, T. R., Adams, A. A., & Williams, S. A. (2013). MOOCs: A systematic study of the published literature 2008-2012. *International Review of Research in Open and Distributed Learning*, *14*(3), 202-227.

Losier, G. F., Perreault, S., Koestner, R., & Vallerand, R. J. (2001). Examining individual differences in the internalization of political values: Validation of the self-

determination scale of political motivation. *Journal of Research in Personality*, *35*(1), 41-61.

Lundeberg, M. A., Bergland, M., Klyczek, K., & Hoffman, D. (2003). Using action research to develop preservice teachers' beliefs, knowledge and confidence about technology [Electronic version]. Journal of Interactive E-learning, 1(4). Retrieved June 29, 2004, from http://ncolr.uidaho.com/jiol/archives/2003/spring/toc.asp

Lyness, J. M., Lurie, S. J., Ward, D. S., Mooney, C. J., & Lambert, D. R. (2013). engaging students and faculty: implications of self-determination theory for teachers and leaders in academic medicine. BMC medical education, 13(1), 1-7.

MacIntyre, B., Gardner, D., Parkinson, T., Rosemergy, B., & Suddaby, G. (2010). Engaging secondary school learners effectively in science: Voices of students and teachers. *XIV IOSTE*, 715-724.

Manganelli, S., Cavicchiolo, E., Mallia, L., Biasi, V., Lucidi, F., & Alivernini, F. (2019). The interplay between self-determined motivation, self-regulated cognitive strategies, and prior achievement in predicting academic performance. *Educational Psychology*, *39*(4), 470-488.

Margerum-Leys, J., & Marx, R. (2002). Teacher knowledge of educational technology: A study of student teacher/mentor teacher pairs. Journal of Educational Computing Research, 26(4), 427–462.

Marzouki, Y., Aldossari, F. S., & Veltri, G. A. (2021). Understanding the buffering effect of social media use on anxiety during the COVID-19 pandemic lockdown. Humanities and Social Sciences Communications, 8(1).

Maslach, C. (2003). Job burnout: New directions in research and intervention. *Current directions in psychological science*, *12*(5), 189-192.

Mills, S. (2003). Gender and politeness (No. 17). Cambridge University Press.

Miltiadou, M., & Savenye, W. C. (2003). Applying social cognitive constructs of motivation to enhance student success in online distance education. AACE Review (formerly AACE Journal), 11(1), 78-95.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical con-tent knowledge: A framework for teacher knowledge. Teachers College Record, 108 (6), 1017–1054.

Moller, A. C., Deci, E. L., & Ryan, R. M. (2006). Choice and ego-depletion: The moderating role of autonomy. *Personality and social psychology bulletin*, *32*(8), 1024-1036.

Mouratidis, A., Michou, A., Aelterman, N., Haerens, L., & Vansteenkiste, M. (2018). Begin-of-school-year perceived autonomy-support and structure as predictors of end-of-school-year study efforts and procrastination: the mediating role of autonomous and controlled motivation. *Educational Psychology*, *38*(4), 435-450.

Mouratidis, A. A., Vansteenkiste, M., Sideridis, G., & Lens, W. (2011). Vitality and interest–enjoyment as a function of class-to-class variation in need-supportive teaching and pupils' autonomous motivation. *Journal of Educational Psychology*, *103*(2), 353.

Mpungose, C. B. (2020). Emergent transition from face-to-face to e-learning in a South African University in the context of the Coronavirus pandemic. Humanities and social sciences communications, 7(1), 1-9.

Mullen, G. E., & Tallent-Runnels, M. K. (2006). Student outcomes and perceptions of instructors' demands and support in online and traditional classrooms. The Internet and Higher Education, 9(4), 257-266.

Murayama, K., Matusumoto, M., Izuma, K., Sugiura, A., Ryan, R. M., Deci, E. L., & Matsumoto, K. (2015). How self-determined choice facilitates performance: A key of the metromedial prefrontal cortex. Cerberal Cortex, 25(5), 1241–1251.

National Council for Accreditation of Teacher Education. (1997). Technology and the new professional teacher: Preparing for the 21st century classroom [Electronic version]. Washington DC: Author. Retrieved June 28, 2004, from http://www.ncate.org/projects/tech/TECH.HTM

National Science Teachers Association. (1999). NSTA standards for science teacher preparation [Electronic version]. Arlington, VA: Author. Retrieved June 28, 2004, from http://www.iuk.edu/faculty/sgilbert/nsta98.htm

Neiss, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. Teaching and Teacher Education, 21(5), 509–523.

Neyrinck, B., Lens, W., & Vansteenkiste, M. (2005). Goals and regulations of religiosity: A motivational analysis. na.

Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom: Applying self-determination theory to educational practice. Theory and research in Education, 7(2), 133-144.

Nie, Y., Chua, B. L., Yeung, A. S., Ryan, R. M., & Chan, W. Y. (2015). The importance of autonomy support and the mediating role of work motivation for well-being: Testing self-determination theory in a Chinese work organisation. *International Journal of Psychology*, *50*(4), 245-255.

Nunnally, J. C. (1978). Psychometric theory (2nd ed.). New York: McGraw-Hill.

Nunnally, J. C. (1979). Psychometric theory. Current Contents/Social & Behavioral Sciences(22), 12.

Núñez, J. L., & León, J. (2019). Determinants of classroom engagement: a prospective test based on self-determination theory. *Teachers and teaching*, *25*(2), 147-159.

Papamitsiou, Z., & Economides, A. A. (2019). Exploring autonomous learning capacity from a self-regulated learning perspective using learning analytics. *British Journal of Educational Technology*, *50*(6), 3138-3155.

Parasuraman, A., & Grewal, D. (2000). The impact of technology on the quality-value-loyalty chain: a research agenda. Journal of the academy of marketing science, 28(1), 168-174.

Parasuraman, A. B. L. L., Zeithaml, V. A., & Berry, L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. 1988, 64(1), 12-40.

Patall, E. A., Cooper, H., & Robinson, J. C. (2008). The effects of choice on intrinsic motivation and related outcomes: A meta-analysis of research findings. Psychological Bulletin, 134, 270–300.

Patall, E. A., Dent, A. L., Oyer, M., & Wynn, S. R. (2013). Student autonomy and course value: The unique and cumulative roles of various teacher practices. *Motivation and Emotion*, *37*, 14-32.

Patall, E. A., Pituch, K. A., Steingut, R. R., Vasquez, A. C., Yates, N., & Kennedy, A. A. (2019). Agency and high school science students' motivation, engagement, and classroom support experiences. *Journal of Applied Developmental Psychology*, *62*, 77-92.

Patall, E. A., & Zambrano, J. (2019). Facilitating student outcomes by supporting autonomy: Implications for practice and policy. *Policy Insights from the Behavioral and Brain Sciences*, *6*(2), 115-122.

Pedrotti, M., & Nistor, N. (2016). User motivation and technology acceptance in e-learning environments. In Adaptive and Adaptable Learning: 11th European Conference on Technology Enhanced Learning, EC-TEL 2016, Lyon, France, September 13-16, 2016, Proceedings 11 (pp. 472-477). Springer International Publishing.

Pelletier, L. G., Séguin-Lévesque, C., & Legault, L. (2002). Pressure from above and pressure from below as determinants of teachers' motivation and teaching behaviors. *Journal of educational psychology*, *94*(1), 186.

Plant, R. W., & Ryan, R. M. (1985). Intrinsic motivation and the effects of self-consciousness, self-awareness, and ego-involvement: An investigation of internally controlling styles. Journal of personality, 53(3), 435-449.

Polatoglu, V. N., & Ekin, S. (2001). An empirical investigation of the Turkish consumers' acceptance of Internet banking services. International journal of bank marketing, 19(4), 156-165.

Porumbescu, G., Bellé, N., Cucciniello, M., & Nasi, G. (2017). Translating policy transparency into policy understanding and policy support: Evidence from a survey experiment. Public Administration, 95(4), 990-1008.

Proulx, J. N., Romero, M., & Arnab, S. (2017). Learning mechanics and game mechanics under the perspective of self-determination theory to foster motivation in digital game based learning. Simulation & Gaming, 48(1), 81-97.

Pulfrey, C., Buchs, C., & Butera, F. (2011). Why grades engender performance-avoidance goals: The mediating role of autonomous motivation. *Journal of Educational Psychology*, *103*(3), 683.

Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., & Koole, M. (2020). Online university teaching during and after the Covid-19 crisis: Refocusing teacher presence and learning activity. Postdigital science and education, 2, 923-945.

Ratelle, C. F., Guay, F., Vallerand, R. J., Larose, S., & Senécal, C. (2007). Autonomous, controlled, and amotivated types of academic motivation: A person-oriented analysis. *Journal of educational psychology*, *99*(4), 734.

Razumovskaya, M., Zaitseva, N. A., Larionova, A. A., Chudnovskiy, A. D., & Breusova, E. A. (2018). Prospects for applying various forms of organizational integration to improve the quality of education. *Astra Salvensis*, *6*(2), 348.

Reschly, A. L., & Christenson, S. L. (2012). Jingle, jangle, and conceptual haziness: Evolution and future directions of the engagement construct. In Handbook of research on student engagement (pp. 3-19). Boston, MA: Springer US.

Reichert, F., Lam, P., Loh, E.K.Y. & Law, N. (2020). Hong Kong Students' Digital Citizenship Development. Initial Findings. Hong Kong: The University of Hong Kong.

Pekrun, R., Lichtenfeld, S., Marsh, H. W., Murayama, K., & Goetz, T. (2017). Achievement Emotions and Academic Performance: Longitudinal Models of Reciprocal Effects. Child Development, 88(5), 1653-1670.

Raes, A., Vanneste, P., Pieters, M., Windey, I., Van Den Noortgate, W., & Depaepe, F. (2020). Learning and instruction in the hybrid virtual classroom: An investigation of students' engagement and the effect of quizzes. Computers & Education, 143, 103682.

Reeve, J., Bolt, E., & Cai, Y. (1999). Autonomy-supportive teachers: How they teach and motivate students. *Journal of educational psychology*, *91*(3), 537.

Reeve, J., & Jang, H. (2006). What teachers say and do to support students' autonomy during a learning activity. *Journal of educational psychology*, *98*(1), 209.

Reeve, J., Nix, G., & Hamm, D. (2003). Testing models of the experience of self-determination in intrinsic motivation and the conundrum of choice. Journal of Educational Psychology, 95, 375–392.

Reeve, J., Ryan, R. M., Cheon, S. H., Matos, L., & Kaplan, H. (2022). *Supporting students' motivation: Strategies for success*. Taylor & Francis.

Reeve, J., & Tseng, C. M. (2011). Agency as a fourth aspect of students' engagement during learning activities. Contemporary educational psychology, 36(4), 257-267.

Roca, J. C., & Gagné, M. (2008). Understanding e-learning continuance intention in the workplace: A self-determination theory perspective. *Computers in Human Behavior*, *24*(4), 1585-1604.

Rogat, T. K., Witham, S. A., & Chinn, C. (2014). Teachers' autonomy-relevant practices within an inquiry-based science curricular context: Extending the range of academically significant autonomy-supportive practices. *Teachers College Record*, *116*(7), 1-46.

Roth, G., & Assor, A. (2010). Parental conditional regard as a predictor of deficiencies in young children's capacities to respond to sad feelings. Infant and Child Development, 19(5), 465-477.

Roth, G., Assor, A., Niemiec, C. P., Ryan, R. M., & Deci, E. L. (2009). The emotional and academic consequences of parental conditional regard: Comparing conditional positive regard, conditional negative regard, and autonomy support as parenting practices. Developmental psychology, 45(4), 1119.

Ruzek, E. A., Hafen, C. A., Allen, J. P., Gregory, A., Mikami, A. Y., & Pianta, R. C. (2016). How teacher emotional support motivates students: The mediating roles of perceived peer relatedness, autonomy support, and competence. Learning and instruction, 42, 95-103.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalizations – Examining reasons for acting in 2 domains. Journal of Personality and Social Psychology, 57(5), 749–761.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary educational psychology, 25(1), 54-67.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*, *55*(1), 68.

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford publications.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary educational psychology*, *61*, 101860.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 101860.

Ryan, R. M., & Grolnick, W. S. (1986). Origins and pawns in the classroom: Self-report and projective assessments of children's perceptions. Journal of Personality and Social Psychology, 50(3), 550–558.

Ryan, R. M., Soenens, B., & Vansteenkiste, M. (2019). Reflections on self-determination theory as an organizing framework for personality psychology: Interfaces, integrations, issues, and unfinished business. *Journal of personality*, *87*(1), 115-145.

Salikhova, N. R., Lynch, M. F., & Salikhova, A. B. (2020). Psychological Aspects of Digital Learning: A Self-Determination Theory Perspective. *Contemporary Educational Technology*, *12*(2).

Schutte, N. S., & Malouff, J. M. (2019). Increasing curiosity through autonomy of choice. *Motivation and Emotion*, *43*, 563-570.

Selim, H. M. (2007). Critical success factors for e-learning acceptance: Confirmatory factor models. Computers & education, 49(2), 396-413.

Semmer, N. K., Elfering, A., Jacobshagen, N., Perrot, T., Beehr, T. A., & Boos, N. (2008). The emotional meaning of instrumental social support. International journal of stress management, 15(3), 235.

Sheldon, K. M., & Krieger, L. S. (2007). Understanding the negative effects of legal education on law students: A longitudinal test of self-determination theory. Personality and Social Psychology Bulletin, 33(6), 883–897.

Shi, L., & Cristea, A. I. (2016). Motivational gamification strategies rooted in self-determination theory for social adaptive e-learning. In Intelligent Tutoring

Systems: 13th International Conference, ITS 2016, Zagreb, Croatia, June 7-10, 2016. Proceedings 13 (pp. 294-300). Springer International Publishing.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), 4–14.

Sierens, E., Vansteenkiste, M., Goossens, L., Soenens, B., & Dochy, F. (2009). The synergistic relationship of perceived autonomy support and structure in the prediction of self-regulated learning. British Journal of Educational Psychology, 79(1), 57-68.

Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). The challenges of defining and measuring student engagement in science. *Educational psychologist*, *50*(1), 1-13.

Singh, S., Roy, D., Sinha, K., Parveen, S., Sharma, G., & Joshi, G. (2020). Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. Psychiatry research, 293, 113429.

Skinner, E., Furrer, C., Marchand, G., & Kindermann, T. (2008). Engagement and disaffection in the classroom: Part of a larger motivational dynamic?. *Journal of educational psychology*, *100*(4), 765.

Skinner, E., Saxton, E., Currie, C., & Shusterman, G. (2017). A motivational account of the undergraduate experience in science: brief measures of students' self-system appraisals, engagement in coursework, and identity as a scientist. International Journal of Science Education, 39(17), 2433-2459.

Soenens, B., Sierens, E., Vansteenkiste, M., Dochy, F., & Goossens, L. (2012). Psychologically controlling teaching: Examining outcomes, antecedents, and mediators. *Journal of Educational Psychology*, *104*(1), 108.

Sørebø, Ø., Halvari, H., Gulli, V. F., & Kristiansen, R. (2009). The role of self-determination theory in explaining teachers' motivation to continue to use e-learning technology. *Computers & Education*, *53*(4), 1177-1187.

Standage, M., Duda, J. L., & Ntoumanis, N. (2005). A test of self-determination theory in school physical education. British journal of educational psychology, 75(3), 411-433.

Summers, J. J., Waigandt, A., & Whittaker, T. A. (2005). A comparison of student achievement and satisfaction in an online versus a traditional face-to-face statistics class. *Innovative Higher Education*, *29*, 233-250.

Sun, J., Dunne, M. P., Hou, X. Y., & Xu, A. Q. (2013). Educational stress among Chinese adolescents: Individual, family, school and peer influences. *Educational Review*, *65*(3), 284-302.

Sun, Y., Ni, L., Zhao, Y., Shen, X. L., & Wang, N. (2019). Understanding students' engagement in MOOCs: An integration of self-determination theory and theory of relationship quality. *British Journal of Educational Technology*, *50*(6), 3156-3174.

Szopiński, T., & Bachnik, K. (2022). Student evaluation of e-learning during the COVID-19 pandemic. *Technological Forecasting and Social Change*, *174*, 121203.

Taylor, S., & Todd, P. A. (1995). "Understanding information technology usage: a test of competing models". Information Systems Research, 6(2), 144–176.

Trenshaw, K. F., Revelo, R. A., Earl, K. A., & Herman, G. L. (2016). Using self-determination theory principles to promote engineering students' intrinsic motivation to learn. International Journal of Engineering Education, 32(3), 1194-1207.

Tsai, Y. M., Kunter, M., Lüdtke, O., Trautwein, U., & Ryan, R. M. (2008). What makes lessons interesting? The role of situational and individual factors in three school subjects. *Journal of Educational Psychology*, *100*(2), 460.

Tschofen, C., & Mackness, J. (2012). Connectivism and dimensions of individual experience. *International Review of Research in Open and Distributed Learning*, *13*(1), 124-143.

Urdan, T., & Kaplan, A. (2020). The origins, evolution, and future directions of achievement goal theory. *Contemporary Educational Psychology*, *61*, 101862.

Vallerand, R. J., & Blssonnette, R. (1992). Intrinsic, extrinsic, and amotivational styles as predictors of behavior: A prospective study. Journal of personality, 60(3), 599-620.

Vallerand, R. J., Pelletier, L. G., Blais, M. R., Briere, N. M., Senecal, C., & Vallieres, E. F. (1992). The Academic Motivation Scale: A measure of intrinsic, extrinsic, and amotivation in education. Educational and psychological measurement, 52(4), 1003-1017.

Vanslambrouck, S., Zhu, C., Lombaerts, K., Philipsen, B., & Tondeur, J. (2018). Students' motivation and subjective task value of participating in online and blended learning environments. The Internet and Higher Education, 36, 33-40.

Vansteenkiste, M., Lens, W., Elliot, A. J., Soenens, B., & Mouratidis, A. (2014). Moving the achievement goal approach one step forward: Toward a systematic examination of the autonomous and controlled reasons underlying achievement goals. *Educational Psychologist*, *49*(3), 153-174.

Vansteenkiste, M., Niemiec, C. P., & Soenens, B. (2010). The development of the five mini-theories of self-determination theory: An historical overview, emerging trends, and future directions. *The decade ahead: Theoretical perspectives on motivation and achievement*, 105-165.

Vansteenkiste, M., Sierens, E., Soenens, B., Luyckx, K., & Lens, W. (2009). Motivational profiles from a self-determination perspective: The quality of motivation matters. *Journal of educational psychology*, *101*(3), 671.

Vansteenkiste, M., Sierens, E., Goossens, L., Soenens, B., Dochy, F., Mouratidis, A., ... & Beyers, W. (2012). Identifying configurations of perceived teacher autonomy support and structure: Associations with self-regulated learning, motivation and problem behavior. *Learning and instruction*, *22*(6), 431-439.

Vollet, J. W., Kindermann, T. A., & Skinner, E. A. (2017). In peer matters, teachers matter: Peer group influences on students' engagement depend on teacher involvement. Journal of Educational Psychology, 109(5), 635.

Vonderwell, S., Liang, X., & Alderman, K. (2007). Asynchronous discussions and assessment in e-learning. *Journal of Research on Technology in Education*, *39*(3), 309-328.

Wallace, T. L., Sung, H. C., & Williams, J. D. (2014). The defining features of teacher talk within autonomy-supportive classroom management. *Teaching and Teacher Education*, *42*, 34-46.

Wang, M. T., Fredricks, J. A., Ye, F., Hofkens, T. L., & Linn, J. S. (2016). The math and science engagement scales: Scale development, validation, and psychometric properties. Learning and Instruction, 43, 16-26.

Weng, C., Tsai, C. C., & Weng, A. (2015). Social support as a neglected e-learning motivator affecting trainee's decisions of continuous intentions of usage. *Australasian Journal of Educational Technology*, *31*(2).

Wiechman, B. M., & Gurland, S. T. (2009). What happens during the free-choice period? Evidence of a polarizing effect of extrinsic rewards on intrinsic motivation. Journal of research in Personality, 43(4), 716-719.

Williams, G. C., GagneÅL, M., Ryan, R. M., & Deci, E. L. (2002). Facilitating autonomous motivation for smoking cessation. Health Psychology, 21, 40–50.

Williams, G. C., Saizow, R., Ross, L., & Deci, E. L. (1997). Motivation underlying career choice for internal medicine and surgery. *Social science & medicine*, *45*(11), 1705-1713.

White, D. W. (2014). What is STEM education and why is it important. Florida Association of Teacher Educators Journal, 1(14), 1-9.

Wortman, C. B., & Dunkel-Schetter, C. (1987). Conceptual and methodological issues in the study of social support.

Xie, K., & Ke, F. (2011). The role of students' motivation in peer-moderated asynchronous online discussions. British Journal of Educational Technology, 42(6), 916-930.

Xie, K. U. I., Debacker, T. K., & Ferguson, C. (2006). Extending the traditional classroom through online discussion: The role of student motivation. Journal of educational computing research, 34(1), 67-89.

Yu, S., Chen, B., Levesque-Bristol, C., & Vansteenkiste, M. (2018). Chinese education examined via the lens of self-determination. *Educational Psychology Review*, *30*, 177-214.

Zaitseva, I., Bogdanova, S., Vanina, A., Marenchuk, J., Novikova, E., & Poddubnaya, N. (2020). Economic and Organizational Problem Research Accompanying the Processes of Replacing Labor Resources in the Condition of Incomplete Information. In IOP Conference Series: Materials Science and Engineering (Vol. 753, No. 7, p. 072010). IOP Publishing.

Zhao, L., Lu, Y., Wang, B., & Huang, W. (2011). What makes them happy and curious online? An empirical study on high school students' Internet use from a self-determination theory perspective. *Computers & Education*, *56*(2), 346-356.

Zhao, Y. (Ed.). (2003). What teachers should know about technology: Perspectives and practices. Greenwich, CT: Information Age.

Zhou, N., Lam, S. F., & Chan, K. C. (2012). The Chinese classroom paradox: A cross-cultural comparison of teacher controlling behaviors. Journal of educational psychology, 104(4), 1162.

Appendices

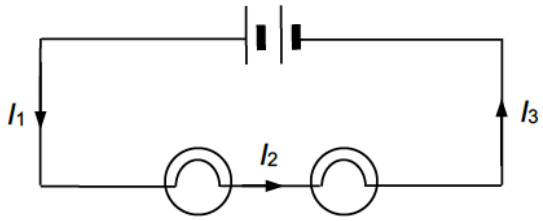
A The Worksheet of Task for Study 1

Task 1.

Connect the following circuit diagram by using the simulation device in the online lab below. Set the resistance of Bulb A and Bulb B as 1Ω and 3Ω. Set the battery voltage as 6V.

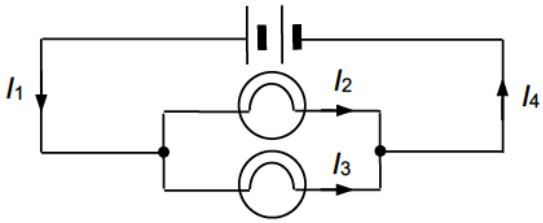
https://phet.colorado.edu/sims/html/circuit-construction-kit-dc-virtual-lab/latest/circuit-construction-kit-dc-virtual-lab_en.html

(a) In series



Blub A Blub B

(b) In parallel



Upper bulb: Bulb A ; Lower bulb: Bulb B

Task 2.

Measure the value of I1, I2, I3 and the voltage across Bulb A and Bulb B by using the simulation devices.

Part A. for the "In-series" circuit:

I1 = _____ I2 = _____ I3 = _____

The voltage across Bulb A = _____

The voltage across Bulb B = _____

Part B. for the "In-parallel" circuit:

I1 = _____ I2 = _____ I3 = _____

The voltage across Bulb A = _____

The voltage across Bulb B = _____

*Only for the intervention group:

The video Edpuzzle - the demo with guiding questions and feedback

https://edpuzzle.com/assignments/65af3472cb5ed1a811012c78/watch

B The Worksheet of Task for Study 2

Go to the following website for the online simulation pH indicator.
https://phet.colorado.edu/sims/html/ph-scale/latest/ph-scale_en.html

Part A. Using the Macro mode

a) Add 0.6L of "battery acid" with 0.1L of tap water.

Measure the pH value. The pH value is :_____

b) Add 0.8L of "drain cleaner" with pressing 2 times of the water tap to fill in water.

Measure the pH value. The pH value is :_____

Part B. Using the Micro mode.

a) Add 0.7L of "soda pop" with pressing 4 times of the water tap to fill in water.

Measure the concentration of water. The value is :_____

b) Count the number of water molecules. The number is :_____

Measure the pH value. The pH value is :_____

Part C. Using the My solution mode.

a) In the 0.5L of solution with pH value 7,

the number of H3O+ ions is _____. It represents the (acidic/ alkaline) ions.

The number of OH- ions is _____. It represents the (acidic/ alkaline) ions.

b) Make the pH value of the solution become 9.85.

The number of H3O+ ions is _____ mole. The number of OH- ions is _____ mole.

The solution is recognized as an (acidic/ alkaline) solution.

*Only for the intervention group: The video Edpuzzle - the demo with guiding questions and feedback: https://edpuzzle.com/assignments/65af4247bf420d6c4da5d3ab/watch

C The Questionnaires

The Student Questionnaire (Quantitative Survey)

An applied experimental research on the influence of needs-satisfying teaching approaches on e-learning motivation

This project aims to study how the needs-satisfying teaching approaches are associated with students' e-learning motivation and the intrinsic motivation in learning Science.

Time expected to participate in the data collection

1) Introduction of the research study in a normal classroom of the campus	2 mins
2) Obtain consent from the student by asking to sign the official consent form	1 mins
3) Pre-test survey will be conducted before the start of intervention	2 mins
4) Students are asked to work on the learning task by using online simulation	5 mins
5) a. Need-satisfying teaching supports for intervention group will be provided.	5 mins
b. The control groups will be given extra 5 mins to work on the learning task, however, they have to submit within these 5 mins.	
6) Post-test survey will be conducted after the learning task	5 mins
7) Free-choice Period 1: Extra simulation lab task is assigned to the students	5 mins
8) Free-choice Period 2: A Science article is assigned to the students to read	5 mins
Total: 30 mins	

The Questionnaire is split into three parts

Part A (Pre-experiment questions)
- General feeling on e-learning before the intervention, to be filled in before the experiment.

Part B (Questions for intervention)
- Perceived competence, autonomy and relatedness affected by the intervention

Part C (Post-experiment questions)
- General feeling on e-learning after the intervention to be filled in after the experiment).

Please read each statement carefully and choose the most appropriate answer. The answer choice for each question is defined as 7-point likert scales ranging from 'strongly disagree' to 'strongly agree'.

1	2	3	4	5	6	7
Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree

Part A - General feeling on e-learning before intervention (Pre-experiment questions)
Enjoyment (Hsu & Chiu, 2004)

EN1a. I think doing the e-learning task is interesting.

1 2 3 4 5 6 7

EN2a. I think doing the e-learning task is enjoyable.

1 2 3 4 5 6 7

EN3a. I think doing the e-learning task is exciting.

1 2 3 4 5 6 7

EN4a. I think doing the e-learning task is fun.

1 2 3 4 5 6 7

Curiosity (Huang, 2003)

CU1a. Doing the e-learning task excites my curiosity.

1 2 3 4 5 6 7

CU2a. Doing the e-learning task makes me curious.

1 2 3 4 5 6 7

CU3a. Doing the e-learning task arouses my imagination.

1 2 3 4 5 6 7

Teacher support (Igbaria et al., 1996; Taylor & Todd, 1995)

TS1a. My teachers always encourage me to use the Internet.

1 2 3 4 5 6 7

TS2a. My teachers are providing most of the necessary help and resources to get us used to the Internet quickly.

1 2 3 4 5 6 7

TS3a. I am always supported and encouraged by my teachers to use the Internet.

1 2 3 4 5 6 7

Basic Need Satisfaction at Work Scale (Kasser, Davey, Ryan, 1992 & Baard, Deci, Ryan, 2004)

General sense of competence

GSC1a. I feel very competent when I use e-learning in my learning.

1 2 3 4 5 6 7

GSC2a. I have been able to learn interesting new skills in e-learning.

1 2 3 4 5 6 7

GSC3a. When I am using e-learning I often feel very capable.

1 2 3 4 5 6 7

General sense of autonomy

GSA1a. I feel like I can make a lot of inputs to deciding how I use e-learning in my study.

1 2 3 4 5 6 7

GSA2a. I feel pressured at using e-learning in my study.

1 2 3 4 5 6 7

GSA3a. I am free to express my ideas and opinions on using e-learning in my study.

1 2 3 4 5 6 7

GSA4a. When I am using e-learning, I have to do what I am told.

1 2 3 4 5 6 7

GSA5a. I feel like I can pretty much use e-learning as I want to.

1 2 3 4 5 6 7

GSA6a. There is not much opportunity for me to decide for myself how to use e-learning in my study.

1 2 3 4 5 6 7

General sense of relatedness

GSR1a. I really like the people I study with.

1 2 3 4 5 6 7

GSR2a. I get along with people at school.

1 2 3 4 5 6 7

GSR3a. I pretty much keep to myself when I am at school.

1 2 3 4 5 6 7

GSR4a. I consider the people I study with to be my friends.

1 2 3 4 5 6 7

GSR5a. People at school care about me.

1 2 3 4 5 6 7

GSR6a. People at school are pretty friendly towards me.

1 2 3 4 5 6 7

General Feeling on learning Science with e-learning tool. (newly designed)

GFM1a. I am enjoyable in completing the online task by using the e-learning tool.

1 2 3 4 5 6 7

GFM2a. I have motivation to use the e-learning tool for online experiment.

1 2 3 4 5 6 7

GFM3a. I have motivation in learning Science with e-learning.

1 2 3 4 5 6 7

GFM4a. I have motivation to learn with e-learning for any subjects.

1 2 3 4 5 6 7

GFM5a. I have motivation to learn Science.

1 2 3 4 5 6 7

Part B - Perceived Needs Satisfaction affected by the intervention

Perceived Competence

C1. After watching the demonstration of using the online lab, I am confident to use the online lab.

1 2 3 4 5 6 7

C2. The guiding questions in the demonstration video make me confident in using the online lab.

1 2 3 4 5 6 7

C3. The feedbacks of the guiding questions make me confident in using the online lab.

1 2 3 4 5 6 7

C4. As a whole, the video demonstration, the guiding questions and the feedbacks make me confident in using the online lab.

1 2 3 4 5 6 7

C5. I could complete the online experiment task by myself.

1 2 3 4 5 6 7

Perceived Autonomy

A1. Choosing to watch the demonstration video or skip it makes me feel free to explore my knowledge.

1 2 3 4 5 6 7

A2. Choosing to watch the demonstration video or skip it to watch it makes me construct my knowledge freely.

1 2 3 4 5 6 7

A3. Demonstration video has raised my feeling of autonomy.

1 2 3 4 5 6 7

A4. Choosing to reflect on the guiding questions or skip them makes me feel free to explore my knowledge.

1 2 3 4 5 6 7

A5. Choosing to reflect on the guiding questions or skip them makes me construct my knowledge freely.

1 2 3 4 5 6 7

A6. Giving reflection of my own thoughts in the guidingquestion has raised my feeling of autonomy.

1 2 3 4 5 6 7

A7. Unlimited time to complete the e-learning task makes me feel free to handle the task.

1 2 3 4 5 6 7

A8. Unlimited time to complete the e-learning task makes me feel free to construct my knowledge freely.

1 2 3 4 5 6 7

A9. Unlimited time to complete the e-learning task has raised my feeling of autonomy.

1 2 3 4 5 6 7

A10. As a whole, the supports from the demonstration video and the guiding questions have raised my feeling of autonomy.

1 2 3 4 5 6 7

Perceived Relatedness

R1. The appreciation from the teacher supervisor received after the submission of the learning task gives me a feeling of caring.

1 2 3 4 5 6 7

R2. The teacher supervisor gives me a feeling of caring.

1 2 3 4 5 6 7

R3. The e-learning support gives me a feeling of caring.

1 2 3 4 5 6 7

Part C - General feeling on e-learning after the experiment (Post-experiment questions - fill in after the experiment)

Enjoyment

EN1b. I think the online simulation lab task is interesting.

1 2 3 4 5 6 7

EN2b. I think the online simulation lab task is enjoyable.

1 2 3 4 5 6 7

EN3b. I think the online simulation lab task is more exciting.

1 2 3 4 5 6 7

EN4b. I think doing the online simulation lab task is funny.

1 2 3 4 5 6 7

Curiosity

CU1b. Doing the online simulation lab task excites my curiosity.

1 2 3 4 5 6 7

CU2b. Doing the online simulation lab task makes me curious.

1 2 3 4 5 6 7

CU3b. The online simulation lab task aroused my imagination.

1 2 3 4 5 6 7

Teacher support

TS1b. The teacher supervisor encouraged me to use the Internet.

1 2 3 4 5 6 7

TS2b. The teacher supervisor provided most of the necessary help and resources to get me used to the online lab work quickly.

1 2 3 4 5 6 7

TS3b. I am supported and encouraged by the teacher supervisor.

1 2 3 4 5 6 7

Section of Perceived competence, Perceived relatedness, Perceived autonomy
General sense of competence

GSC1b.I feel more competent after I do the online simulation lab.

1 2 3 4 5 6 7

GSC2b.I could learn interesting new skills in online simulation lab.

1 2 3 4 5 6 7

GSC3b.The online simulation lab makes me feel very capable.

1 2 3 4 5 6 7

General sense of autonomy

GSA1b. I feel like I can make a lot of inputs to deciding how I use e-learning in my study after doing the online simulation lab.

1 2 3 4 5 6 7

GSA2b. I feel pressured at using e-learning after the online simulation lab.

1 2 3 4 5 6 7

GSA3b. I am free to express my ideas and opinions on using e-learning after doing the online simulation lab.

1 2 3 4 5 6 7

GSA4b. After doing the online simulation lab, I have to do what I am told.

1 2 3 4 5 6 7

GSA5b. After doing the online simulation lab, I feel like I can pretty much use e-learning as I want to.

1 2 3 4 5 6 7

GSA6b. There is not much opportunity for me to decide for myself how to use e-learning after doing the online simulation lab,

1 2 3 4 5 6 7

General sense of relatedness

GSR1b. I really like the supervisor after doing the online simulation lab.

1 2 3 4 5 6 7

GSR2b. I get along with the supervisor at school after doing the online simulation lab.

1 2 3 4 5 6 7

GSR3b. I pretty much keep to myself after doing the online simulation lab.

1 2 3 4 5 6 7

GSR4b. I consider the people I study with to be my friends after doing the online simulation lab.

1 2 3 4 5 6 7

GSR5b. I consider the people at school care about me after doing the online simulation lab.

1 2 3 4 5 6 7

GSR6b. I consider the people at school are pretty friendly after doing the online simulation lab.

1 2 3 4 5 6 7

General Feeling on learning Science with e-learning tool. (newly designed by Frank)

GFM1b. I am enjoyable in completing the online task by using the e-learning tool after doing the online simulation lab.

1 2 3 4 5 6 7

GFM2b. I am motivated in doing the online simulation lab.

1 2 3 4 5 6 7

GFM3b. I am motivated in learning Science with e-learning after doing the online simulation lab.

1 2 3 4 5 6 7

GFM4b. I am motivated to learn with e-learning for any subjects after doing the online simulation lab.

1 2 3 4 5 6 7

GFM5b. I am motivated to learn Science after doing the online simulation lab.

1 2 3 4 5 6 7

End of the student questionnaire

D The Questions for Individual Interview

The Student Individual Interview

An applied experimental research on the influence of needs-satisfying teaching approaches on e-learning motivation

This project aims to study how the needs-satisfying teaching approaches are associated with students' e-learning motivation and the intrinsic motivation in learning Science.

Time expected to participate in the individual qualitative interview is about 30 minutes.

Below are the sample questions for the interview. Different follow-up questions will be asked according to different responses provided by the interviewees replied from the sample questions.

Part B - Perceived Needs Satisfaction affected BY THE INTERVENTION
Perceived Competence

C1-3. How do you feel about the demonstration video, the scaffolding questions and the feedback support with respect to your competence?

C4. As a whole, how is your overall experience on the supports of the demonstration video?

C5. As a whole, how confident are you to complete the online experiment task by yourself?

Perceived Autonomy

A1,4,7. How do you feel about the freedom to skip the demonstration video, freedom to skip the guiding questions and the unlimited time to complete the task respectively?

A2,5,8. How do you feel on the construction of knowledge if you could skip the demonstration video, skip the guiding questions and have unlimited time to complete the task?

A3,6,9. How do you feel about the feeling of autonomy on the demonstration video, the guiding questions and the unlimited time to complete the task?

A10. As a whole, how much autonomy do you feel on the supports from the demonstration video and the guiding questions?

Perceived Relatedness

R1-3. How do you feel about the appreciation, caring and overall support given by the teacher supervisor upon submission of the learning task?

Part C - General feeling on e-learning after the experiment (Post-experiment questions)

Enjoyment & Intrinsic motivation
EN1b-4b & IM1b-2b. How do you feel on the simulation lab in terms of interestingness, joy, excitement and fun?

Curiosity
CU1b-3b. How do you feel on the simulation lab in terms of the irritation of curiosity and imagination?

Teacher support
TS1b-3b. How do you feel on the helpfulness on the support from the teacher supervisor in terms of the encouragement and effectiveness?

Section of Perceived competence, Perceived relatedness, Perceived autonomy
General sense of competence

GSC1b-3b. After doing the online simulation lab, how do you feel on your ability, skill and capability?

General sense of autonomy
GSA1b-7b. After doing the online simulation lab, how do you feel on the freedom of knowledge construction and the freedom of decision?

General sense of relatedness

GSR1b-5b. After doing the online simulation lab, how do you feel on the caring support from the teacher?

General Feeling on learning Science with e-learning tool.
GFM1b. After doing the online simulation lab, how do you feel on your experience in simulation lab?
GFM2b-5b. After doing the online simulation lab, how is your motivation on using simulation lab, your motivation on learning Science with e-learning, motivation to learn with e-learning and motivation on learning Science?