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# The Impact of E-Learning Technologies on Entrepreneurship and Sustainability Performance

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**Abstract:** After the pandemic, education will not go back to 100% offline mode since the application of E-Learning Technologies (ELT) cannot be avoided. Therefore, its impact should be studied for future education development. Most future entrepreneurs are attending school today. Therefore, universities need to supply necessary education to encourage students to cope with future conditions and development. At the same time, due to the increasing attention being paid to the harmony between ecology and prosperity, the sustainability aspect of entrepreneurship education needs to be emphasized as well. This study investigates on the impact of ELT on entrepreneurial education performance (including personal skills, product skills and business skills), and the sustainability efficacy and their impact on sustainability awareness. Data were collected from a master class on entrepreneurship in a Hong Kong university and SmartPLS was used to analyze the data. It was found that ELT have significant relationship with entrepreneurial performances and sustainability efficacy. Meanwhile, sustainability efficacy also has significant relationship with sustainability awareness. However, no significant relationship between entrepreneurial skills and sustainability awareness was identified. Implications are explored finally for entrepreneurship and sustainability education.

**Keywords:** E-Learning Technologies (ELT); Entrepreneurship education; Sustainable efficacy; Sustainability awareness

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## 1. Introduction

### *1.1. E-Learning and entrepreneurship education*

Technology has the ability to change the ways in which knowledge is acquired in human society, and to restructure traditional teaching and learning models 1. As information and communication technologies (ICT) growing more sophisticated and convenient, they are increasingly penetrating into the teaching environment of education, has made it one of the alternative teaching methods besides traditional face-to-face teaching. There are a few synonyms of E-Learning such as online learning, digital learning, and computer-based learning, etc. 2. Volery (2000) believes that the spreading of the Internet and ITC, coupled with insufficient financial investment and societal demand for improving the accessibility of higher education, have provided significant incentives for universities to introduce E-Learning courses 3. Ribiero (2002) supports that the best way to maximize the potential of ELT as a method of providing higher education is to fully recognize the introduction of online education models to improve traditional education modes 4.

The pandemic has stimulated the application of ELT, which has brought changes to the teaching process in universities and has expanded the channels of interaction between teachers and students. During this period, many universities shifted from offline teaching to online teaching 5. Universities around the world have adopted online learning since then 6.

In the post epidemic era, most higher education institutions have resumed offline teaching, but the E-Learning method and technologies have not been completely abandoned and are still widely used in universities in Hong Kong and many other places. On-site teaching was once considered good, while other teaching methods aimed at coping with the pandemic, which was simply a temporary approach 7. Today, this paradigm shift may change the views of teachers and students on this teaching method 8. This paper aims to demonstrate this change with entrepreneurship education as an example.

The field of entrepreneurship has received increasing academic attention worldwide 9. Universities offer entrepreneurship education programs to cultivate entrepreneurial talents and provide opportunities for new startup 10.

### *1.2. Sustainability and entrepreneurship education*

Sustainable development is about balance and harmony of the economy, society, and environment aspects, which is why it can provide benefits to stakeholders in multiple different fields 11. Entrepreneurship has been recognized as one of the main channels for achieving sustainable development, and new enterprises are seen as a solution to social and environmental problems 12. Entrepreneurship can contribute to promoting sustainable social and environmental development. It also has a positive impact on financial inclusion, female empowerment, green agriculture, and minority integration [13]. Therefore, the United Nations (UN) is increasingly encouraging and supporting ambitious young people in starting new businesses and creating more employment for themselves and others 14.

In summary, sustainability and entrepreneurship are interconnected. Entrepreneurs play a key role in driving sustainability, while sustainability opens new opportunities for entrepreneurship. Sustainable entrepreneurship, which combines these two concepts, can contribute to the three aspects of sustainability, namely, economic, environmental, and social dimensions. Therefore, sustainability is increasingly emphasized in the process of entrepreneurship [15, 16] , but there is few research to verify how sustainability in entrepreneurship education affects the entrepreneurial philosophy of future entrepreneurs. This study will explore students' awareness of sustainability by setting questions about sustainable development in the questionnaire.

### *1.3. Structure of the paper*

This paper uses a survey method to study the impact of ELT on entrepreneurship education performance and sustainability efficacy of students in a Hong Kong university after the pandemic. The objectives include:

1. The impact of ELT on students' learning in personal skills.
2. The impact of ELT on students' learning in product skills.
3. The impact of ELT on students' learning in business skills.
4. The impact of ELT on students' sustainability efficacy.
5. The impact of entrepreneurial skills and sustainability efficacy on students' sustainable awareness.
6. Suggestions for entrepreneurial and sustainable education in the future.

## 2. Literature Review and Model Development

### *2.1. Definition and Concepts*

#### 2.1.1. Changing of delivery modes on education

Both communication media and delivery modes changed in education 17. Previous researches have shown that IT has the potential to change education at the very basis 18, and the use of IT to support teaching and learning is defined as E-Learning, where the technology used is called E-Learning Technology (ELT) 19. There are other definitions of E-Learning. It can also be defined as the using of ITC technologies to assist the learning growth and delivery of educational institutions. Some people emphasize E-Learning by

using electronic media to support distance education 20. To be brief, E-Learning indicates the transfer of knowledge using different electronic devices 21. This can be understood better when the concept is placed in a learning environment [22] such as entrepreneurship education studied in this paper.

The early forms of E-Learning went back to the 19th century, in which time teachers began to use mail and shorthand technology for teaching activities 23. The word E-Learning officially appeared in education field until the middle of 1990s 24. E-Learning is a special teaching system that uses electronic resources as a medium to send information to a large audience, making education and training more qualitative 25. The basic elements of this system are computers and the internet, which enable the system to be in motion 26.

In the post epidemic era, the learning environment is no longer a single online or face-to-face teaching, but a multi-channel one that can be a complex interactive platform [27]. Higher education institutions should learn and analyze interesting data from the development of educational institutions in the past few years, rethink and update their teaching models to benefit from technological changes and explore the potential of new teaching models through various technological means to improve teaching efficiency [28]. Therefore, if technology is incorporated into effective teaching strategies, it can contribute to improving traditional learning procedures without limiting learning practices 29.

#### 2.1.2. Entrepreneurship Education Performance

Entrepreneurship skills refer to the abilities that entrepreneurs may possess to run a business [30, 31]. **Personal skills**, **Interpersonal skills**, and **Business skills** are widely accepted entrepreneurship education performance in the entrepreneurial community 32. Many entrepreneurial experts and researchers recognize that these three skill areas are key to cultivating a successful entrepreneurial mindset and skills 33. In addition, with the intensification of competition and the continuous changes in customer taste and preferences, the modern business environment has become very unstable. Therefore, enterprises must create new products that can meet customer needs and desires to be sustainable 34. This entrepreneurial skill enables entrepreneurs to identify customer needs, and entrepreneurial opportunities 35, generate new creative ideas, and develop products or services 36. This skill is defined as **Product skill** in the field of entrepreneurial education.

#### 2.1.3. Sustainability and Entrepreneurship

Sustainability refers to the continuity of economic, environmental, and social development. Sustainability was elaborated into 17 Sustainable Development Goals (SDGs) and 169 specific goals. SDGs are the most widely accepted plan for achieving sustainable development today [37, 38].

The goal of sustainable development has become a global challenge, and its achievement requires global cooperation and multilateral action by the economic, social, political, and environmental sectors, while also utilizing the opportunities that come with it. Entrepreneurship and SGDs complement each other, for entrepreneurs can seek economic opportunities through green innovation, political and social opportunities through reducing inequality and enhancing social cohesion, and environmental opportunities through environmental protection 39. For example, supporting women's entrepreneurship can enhance women's empowerment, thereby enhancing entrepreneurial diversity and promoting economic growth 40, therefore enhance SDG 5. Immigration and refugee entrepreneurship can promote social integration, reduce their dependence on welfare and foreign aid, and stimulate domestic entrepreneurship 41, which provides clear evidence for entrepreneurship's contribution to inequality reduction and social cohesion enhancement. This is related to SDG10. In addition, green entrepreneurship and innovation have recently made new progress in the fields of agriculture, packaging, energy, and manufacturing, which may directly promote sustainable production and consumption and support SDG12 42.

2.1.4. Sustainability awareness and entrepreneurship education

Sustainability awareness is the understanding of environmental vulnerability and the importance of its protection from the perspective of ecological awareness 43. At the macro technical level, it is about the awareness of the biophysical environment, human interactions and influences 44. Our resources and ecosystems need to be respected and protected, and humans should take more responsible and conscious actions 45. At the micro level with, universities have begun to make significant contributions to raising public awareness by entrepreneurial education 46, and, at the same time, can motivate students to find solutions to these sustainability problems 47. Universities should seek to promote a positive attitude in the process of curriculum environment creation through their substantive functions 48, and engage in greening from different perspectives, in order to achieve sustainable environmental education 49. This can be integrated into entrepreneurial education as well.

*2.2. Theoretical Model and Hypotheses Formulation*

This paper uses constructivist theory and cognitive load theory to hypothesize the relationship between ELT and entrepreneurial education performance, sustainability efficacy and awareness.

The first entrepreneurship course appeared in the 1940s and was offered by Harvard University 50. In the half century since then, entrepreneurship education (EE) began to receive more attention, and many business schools began offering one or more courses on small business or entrepreneurship. From the 21st century to the present, the past 20 years have witnessed the strong rise of global entrepreneurship research 51. Research has proven that EE is not only aimed at supporting the development of entrepreneurship as a discipline, but also at providing young potential entrepreneurs with the skills and attitudes necessary for entrepreneurship and successful business operations 52.

With the advancement of technology and the transformation of teaching methods, how to better apply electronic learning technology to entrepreneurship education has become a new research topic. Constructivist theory [53, 54]believes that learning is the process of constructing meaning with the help of necessary learning resources in a certain context. Piaget pointed out that study is a positive construction process, ELT can provide learners with opportunities to explore and experiment with new information, leading to deeper learning 55. Traditional entrepreneurship courses with ELT helped university graduates to find jobs in large public organizations, multinational companies or start their own businesses 56. The cognitive load theory 57 assumes that human cognitive structure consists of working memory and long-term memory and to store knowledge in the form of patterns in long-term memory is the main purpose of teaching. A schema organizes facts based on the usage of information components, providing a mechanism for knowledge organization and storage, which can lessen the workload of working memory. Research has shown that electronic learning tools may significantly improve students' learning and memory, using images, videos, and other methods to enhance long-term memory 58.

2.2.1. Entrepreneurial Skills

ELT is currently crucial for universities and general lifelong learning because they help instill skills including organization, teamwork, and communication through allowing students to collaborate with each other, such as discussion forums and group projects, without being limited by time or location 59. ELT adopted in universities can dela with either synchronous or asynchronous learning which students can personally experience in their learning environment 60, which enhances student engagement and their focus on goals 61. The flexibility of electronic learning technology provides students with the possibility of autonomous control over learning activities. The scope, the depth of learning, the types of electronic devices used, and the amount of time on learning can all be adjusted

independently 62. It can also enhance personalized learning with the clear content 63. This is very helpful for cultivating students' time management skills, as they will learn to spend different amounts of time learning different types of knowledge. Ten years ago, the most common purpose of applying ELT in education has been to support communication and collaboration (through email, social platforms, group support systems, etc.) 64.

ELT also perform well in business and entrepreneurship courses. In the increasingly fierce competition business environment with shorter product life cycle, employees must possess more advanced business skills and continuously improve themselves 65. E-Learning provides learners with additional knowledge about the market, customer, product, and business activities, as well as rapid updates on new products and skills 66. It also helps student to understand more and be more confident in professional fields such as marketing 67. Improving inventory management, strengthening marketing and communication strategies are also skills that E-Learning can provide 68. Russell (2005) listed hundreds of studies using standard methods to compare cognitive learning outcomes of courses taught online and offline using statistical tests such as final grades, paper grades, student evaluations, etc. 69. "*No significant difference*" is his conclusion. Dellana, Collins, and West (2000) also support the view that online education is equally effective as face-to-face education, as there is no significant difference in their final grades in undergraduate management science courses 70. In a summary, the application of ELT in entrepreneurship and business courses has a positive impact on students' learning initiative, learning outcomes, and learning engagement 71.

Entrepreneurial students attempt to envision their new products/services based on the satisfaction of target markets and potential customer needs 72. ELT provides a flexible and interactive learning environment that can enhance students' understanding, collaboration, problem-solving, and critical thinking abilities, which are crucial for cultivating strong product design abilities.

Therefore, the following hypotheses are proposed:

**H11: ELT can improve students' personal skills.**

**H12: ELT can improve students' product skills.**

**H13: ELT can improve students' business skills.**

#### 2.2.2. Sustainability efficacy

In the past decade, there has been significant development in guidelines for embedding student sustainability efficacy (SSE) into education, but it is still quite complicated with many different definitions and operations framework. Compared to developing concepts, focusing on learning outcomes is more useful because the learning outcomes provide important information with academic staff for course design and interaction with students 62. When studying sustainability issues, students need both theoretical knowledge and the ability to discover and solve problems 73. Given the limitations of traditional classroom lectures, Lambach proposed that flipped class model may be a more suitable choice for students to pursue analysis and complex knowledge acquisition 74. Students are supposed to develop the skills of communication, leadership, product design, business model development and presentation. These skills can be developed with ELT such as electronic learning forums, real-time chats, or uploading videos. E-Learning can facilitate the integration of real-world examples and case studies into lessons, allowing students to see the practical application of sustainability principles. Through virtual field trips, interviews with sustainability experts, and interactive case studies, students can gain insights on how sustainability is implemented in various industries, organizations, and communities. This practical exposure helps students understand the relevance and impact of sustainability in their own lives and careers 75. Commitment to action is important, and it is expected that 'changes in values, attitudes, and behaviors' will be the result of effective sustainability education. As a result, the following hypothesis is proposed:

**H14: ELT can improve students' sustainability efficacy.**

2.2.3. Entrepreneurship skills and sustainability awareness

Entrepreneurship skills were identified by the United Nations in 2016 as a key factor in promoting social cohesion, reducing disparities, and opening doors for all76. People are gradually realizing that entrepreneurial skills can affect social development, promoting the improvement of production capacity, promoting enterprise creation, and expanding the pool of opportunities to all individuals. Entrepreneurs with excellent entrepreneurial skills have the opportunity to participate in sustainable economic development and benefit from it77.

Entrepreneurial skills can significantly enhance a student's sustainability awareness in several ways78. Skills like communication and collaboration can help students understand the complexity of sustainability issues and the need for flexible, innovative solutions79. Skills related to product development, such as product design, can help students understand how products can be designed or modified to be more sustainable80. This may include using renewable materials, using green energy, reducing resource consumption，or creating products that solve environmental problems. Knowledge in business area can help students understand the business for sustainability81. They can learn how sustainable practices can lead to cost savings, meet consumer demand, and provide product advantage. These skills can help students understand how individuals and organizations can contribute to sustainability. They can learn to lead sustainability initiatives, influence others to adopt sustainable practices, and work effectively in teams to achieve sustainability goals.

The willingness of students to participate in the sustainable development agenda is related to their entrepreneurial skills, for example, students with rich entrepreneurial skills are more willing to engage in decent employment82. Providing students with entrepreneurial skills will help them accommodate constantly changing conditions as well as meet the requirements of sustainable development for employees and entrepreneurs 77. In terms of above discussion, we propose following hypotheses:

**H21: Personal skills can enhance sustainability awareness.**

**H22: Product skills can enhance sustainability awareness.**

**H21: Business skills can enhance sustainability awareness.**

2.2.4. Sustainability efficacy and sustainability awareness

Researchers have shown that targeting sustainability awareness may be a way to promote an increase in sustainable behavior 83. Theory of planned behavior (TPB) believes that all factors that may affect behavior are indirectly influenced by behavioral intention 84. Ajzen (2011) defines intention as *"a person's readiness to perform a given behavior"* 85. And "*Behavioral intention is determined by three factors: attitude towards behavior, subjective norms, and perceived behavioral control*" 86, as shown in Figure 1.

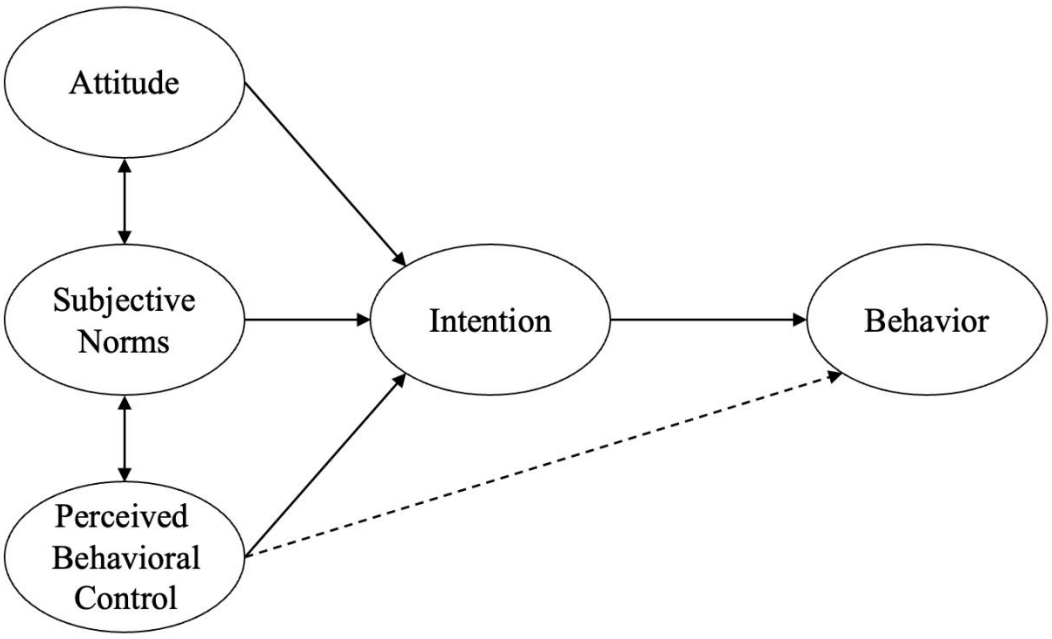



**Figure 1.** TPB model 87.

Under the premise of adopting appropriate measurement standards, there is a highly corresponding strong relationship between self-efficacy and behaviors 88. Self-efficacy affects individuals' choices, short-term expenditures, and long-term persistence in activities [89, 90]. People who have a lower sense of efficacy in completing a task may not make corresponding efforts, and those who believe in their abilities will be more actively involved 91. According to this theory, there is a positive relationship between a person's cognitive level and their sustainable development behavior [92, 93]. It indicates that improving an individual's awareness of environmental protection can be achieved by improving their level of knowledge, especially environmental knowledge94. Therefore, we propose following hypothesis:

**H24: Sustainable efficacy can enhance sustainability awareness.**

2.2.5. Control variables (CV)

In addition to skills and efficiency, some past studies have shown that there are other factors that may affect sustainability awareness, such as gender, academic performance and contacts with entrepreneurial role models.

Barnas and Ridwan all believe that girls have a better awareness of sustainability, they exhibit more or demonstrate greater concern for the environment than boy [95, 96], while Demaidi et al. argue that boys have a better awareness of environmental and climate change than girls 97. There are also studies suggest that there is no difference between genders in terms of sustainable awareness 98. These differences indicate that gender may be one of the influencing variables and need to be included in the model. During the teaching process, we found that some students have had contact with entrepreneurs before. We support that the exemplary role of entrepreneurs may also affect students' sustainability awareness 99. In addition, it will be interesting to test whether students' academic performance in terms of all courses' GPA (grade point average) in the previous semester may also has an impact on sustainability awareness 100.

Based on the above hypotheses and the three control variables (CV1, CV2, and CV3), a conceptual model is proposed below (Figure 2).

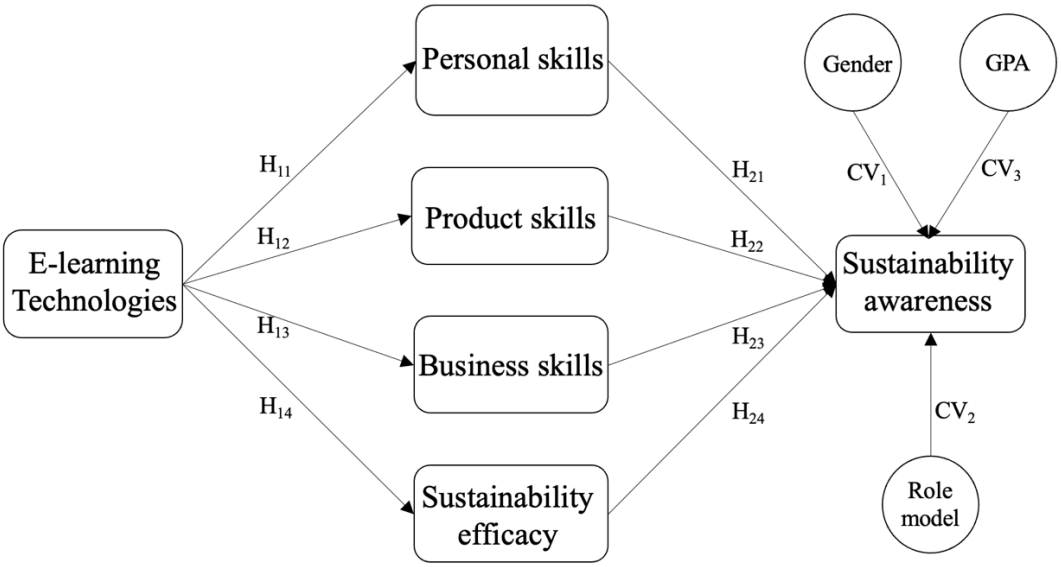



**Figure 2.** The Conceptual Model.

## 3. Methodology and Data Collection

### *3.1. Questionnaire design*

Most of the previous studies on teaching methods and technologies have emphasized that single online teaching in an epidemic environment is used as an alternative tool to traditional learning processes, focusing on the exclusive use of E-Learning platforms. This study aims to investigate students' views on ELT as supplementary and complementary tools to offline learning. The measure of ELT in this study covers a learning platform called Canvas, ZOOM, e-mail system, social media, internet as well as the latest technologies like chat GPT etc. A questionnaire survey was conducted to collect relevant data.

Questions measuring ELT, personal skills, product, skills, business skills, sustainability efficacy and sustainability awareness are designed based on previous studies as shown in Table 1.

In addition, this study also designed three control variables, namely gender, GPA, and role model, to determine whether sustainability awareness is influenced by external variables.

**Table 1.** The items in the questionnaire and references.

| | Questions | Reference |
|---|---|---|
| **E-learning Technology** | I took all the lecturing as long as there is an online ZOOM link | [101, 102, 103, 104, 105, 106] |
| | I reviewed lecturing recorded in ZOOM video | |
| | I interact or provide feedback with lecturer using the chat of ZOOM | |
| | I use Canvas for downloading PPT and other teaching materials. | |
| | I use Canvas for submitting assignment | |
| | I frequently check E-mails for education purposes of this course | |
| | I use internet to search information about my learning in this course | |
| | I use Wechat or WhatsApp for group work and communication | |
| | I use other technologies for learning (e.g., AIchat, survey monkey, etc) | |

| | | |
|---|---|---|
| **Personal skills** | Communication skills | [107, 108] |
| | Leadership | |
| | Responsibility | |
| | Team coordination | |
| | Team meeting | |
| | Time management | |
| **Product skills** | New idea generation (creativity) | [107, 108] |
| | New idea assessment and selection | |
| | Product design | |
| | IP search and protection | |
| | Technology road-map | |
| **Business skills** | Business Plan | [107, 108] |
| | Business model | |
| | Marketing plan | |
| | Financial plan | |
| | Investment | |
| | Presentation skill | |
| **Sustainability efficacy** | 1: No Poverty | [14, 38] |
| | 2: Zero Hunger | |
| | 3: Good Health and Well-being | |
| | 4: Quality Education | |
| | 5: Gender Equality | |
| | 6: Clean Water and Sanitation | |
| | 7: Affordable and Clean Energy | |
| | 8: Decent Work and Economic Growth | |
| | 9: Industry, Innovation and Infrastructure | |
| | 10: Reduced Inequality | |
| | 11: Sustainable Cities and Communities | |
| | 12: Responsible Consumption and Production | |
| | 13: Climate Action | |
| | 14: Life Below Water | |
| | 15: Life on Land | |
| | 16: Peace and Justice Strong Institutions | |
| | 17: Partnerships to achieve the Goal | |
| **Sustainability awareness** | Entrepreneurs should take care of the overall wellbeing of employees. | [95, 109, 110] |
| | Entrepreneurs should care about social problems at large outside the enterprise. | |
| | Entrepreneurs should make sure its operations will not pollute the environment. | |
| | Entrepreneurs should contribute to reduce pollution in the society. | |
| | Entrepreneurs should lead the company to receive continuous income and profit. | |
| | Entrepreneurs should pay attention to and to be sensitive to cash flow. | |

### *3.2. Data collection and data profile*

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Data were collected from a class of technological innovation and entrepreneurship in a Hong Kong university in April 2023 via a questionnaire. The course runs for one semester from January to June 2023. The class size is 101 and all students were invited to fill in the survey as part of the study feedback. To avoid any common method variance, the feedback questionnaire was not marked, and only generic feedback was provided to students afterwards. The profile of the students is shown on Table 2. These group of students are mostly fresh graduates from the previous years and working experience was not relevant to this study.

**Table 2.** Demographics of surveyed students.

| | Frequency | Percentage % |
|---|---|---|
| ***Gender*** | | |
| Male | 62 | 61.4 |
| Female | 39 | 38.6 |
| ***Bachelor background*** | | |
| Mechanical | 18 | 17.8 |
| Electronic and electrical | 15 | 14.9 |
| Computer sciences and engineering | 6 | 5.9 |
| Energy engineering and related | 4 | 4.0 |
| Agricultural engineering | 7 | 6.9 |
| Bio engineering and medical related | 4 | 4.0 |
| Ocean engineering and water related | 5 | 5.0 |
| Chemistry related | 5 | 5.0 |
| Physics related | 3 | 3.0 |
| Mathematics or statistics related | 2 | 2.0 |
| Systems engineering or IE | 12 | 11.9 |
| Others | 20 | 19.8 |
| ***Role model*** | | |
| Yes | 45 | 44.6 |
| No | 56 | 55.4 |

### *3.3. Data analysis method*

Since the model includes factors and mediating effects, this study opts for Partial Least Squares (PLS) as the means to test its hypotheses. PLS can be the preferred solution if the problem has the following characteristics [111, 112, 113]. Small sample size due to limited experimental design or survey subjects.

1. The conditions relating to independence or normal distribution are not met that cannot be applied to SEM.
2. The issues to be investigated are relatively novel and require the development of new measurement models.
3. Prediction is more important than parameter estimation.

Due to our small sample data and relatively new research topic, PLS was chosen as the research tool.

## 4. Results

### *4.1. Validity and reliability tests*

For the validation of constructs, we used the threshold of 0.7 114. However, when it comes to E-Learning, technologies like Canvas learning platform, internet searching, E-mail, and social media did not pass the test and were deleted accordingly since these technologies have been very popular and the averages are close to 5. This does not mean these technologies do not have impact but there are no variances with these questions about

Canvas, internet E-mail and social media. Finally, three items were found to be valid and reliable into this construct as shown in Table 3.

The sustainability efficacy construct contains 17 items but some of them were deleted since to the loadings are below 0.7. This may be because the target students majored in a few limited engineering fields as shown in their background profile in Table 2. About 51% students are in electronic, mechanical and systems engineering fields and may not feel they are able to solve some the SDG problems. The leading and validation are shown in Table 3. The loading in brackets are the loadings after deleting those items below 0.6 in ELT or below 0.7 in other constructs. The loading of one item is 0.686 which is close to 0.7 if it is rounded into one digital. This is accepted since this construct is relatively new and few studies tested the construct yet.

To verify the adequacy of the model and the reliability of the data, we choose the following criteria: Composite Reliability, Cronbach's Alpha, and Convergent Validity 115. Composite reliability is the most commonly used method 116, in which reliability values between 0.60 and 0.70 are considered "acceptable in exploratory research", and values between 0.70 and 0.90 range from "satisfactory to good". Values of 0.95 and higher are problematic as they indicate that these items are redundant, thereby reducing the effectiveness of the construct 117. In this study, all CR values were between 0.7 and 0.9, indicating very satisfactory reliability. Cronbach's alpha values exceeding 0.7 are generally considered reliable [114]. All items except ELT have values greater than 0.7. The value of ELT is 0.690, very close to 0.7. Similarly, since this construction is relatively new, we believe that a value of 0.690 is acceptable. The AVE criterion was established by Fornell and Larker to quantify convergent validity by extracting mean variance and believe that when the value of AVE is greater than 0.5, the construct converges [118]. In this study, all constructs conform to convergence effectiveness.

**Table 3.** Outer loading.

| Item | Initial loading | Final loading |
|---|---|---|
| ***E-Learning technologies (α = 0.690, AVE = 0.617, CR = 0.827)*** | | |
| I took all the lecturing as long as there is an online ZOOM link | 0.091 | |
| I reviewed lecturing recorded in ZOOM video | **0.760** | **0.867** |
| I interact or provide feedback with lecturer using the chat of ZOOM | **0.681** | **0.793** |
| I use Canvas for downloading PPT and other teaching materials. | -0.198 | |
| I use Canvas for submitting assignment | -0.189 | |
| I frequently check E-mails for education purposes of this course | 0.632 | |
| I use internet to search information about my learning in this course | 0.458 | |
| I use Wechat or WhatsApp for group work and communication | 0.353 | |
| I use other technologies for learning (e.g., AIchat, survey monkey, etc) | **0.582** | **0.686** |
| ***Personal skills (α = 0.815, AVE = 0.644, CR = 0.878)*** | | |
| Communication skills | **0.679** | **0.726** |
| Leadership | 0.614 | |
| Responsibility | **0.799** | **0.796** |
| Team coordination | **0.854** | **0.867** |
| Team meeting | **0.813** | **0.815** |
| Time management | 0.679 | |
| ***Product skills (α = 0.878, AVE = 0.671, CR = 0.911)*** | | |
| New idea generation (creativity) | **0.795** | **0.818** |
| New idea assessment and selection | **0.816** | **0.811** |
| Product design | **0.783** | **0.790** |

| | | |
|---|---|---|
| IP search and protection | **0.820** | **0.805** |
| Technology road-map | **0.872** | **0.869** |
| ***Business skills (α = 0.911, AVE = 0,691, CR = 0.930)*** | | |
| Business Plan | **0.896** | **0.897** |
| Business model | **0.873** | **0.867** |
| Marketing plan | **0.791** | **0.778** |
| Financial plan | **0.780** | **0.785** |
| Investment | **0.851** | **0.852** |
| Presentation skill | **0.792** | **0.801** |
| ***Sustainability efficacy (α = 0.885, AVE = 0.554, CR = 0.908)*** | | |
| 1: No Poverty | **0.726** | **0.757** |
| 2: Zero Hunger | **0.705** | **0.745** |
| 3: Good Health and Well-being | **0.744** | **0.758** |
| 4: Quality Education | 0.655 | |
| 5: Gender Equality | **0.680** | **0.711** |
| 6: Clean Water and Sanitation | 0.673 | |
| 7: Affordable and Clean Energy | 0.593 | |
| 8: Decent Work and Economic Growth | 0.634 | |
| 9: Industry, Innovation and Infrastructure | 0.462 | |
| 10: Reduced Inequality | **0.722** | **0.758** |
| 11: Sustainable Cities and Communities | **0.726** | **0.709** |
| 12: Responsible Consumption and Production | 0.695 | |
| 13: Climate Action | **0.706** | **0.707** |
| 14: Life Below Water | 0.598 | |
| 15: Life on Land | 0.588 | |
| 16: Peace and Justice Strong Institutions | **0.775** | **0.760** |
| 17: Partnerships to achieve the Goal | 0.616 | |
| ***Sustainability awareness (α = 0.824, AVE = 0.652, CR = 0.881)*** | | |
| Entrepreneurs should take care of the overall wellbeing of employees. | **0.731** | **0.763** |
| Entrepreneurs should care about social problems at large outside the enterprise. | **0.817** | **0.818** |
| Entrepreneurs should make sure its operations will not pollute the environment. | **0.765** | **0.765** |
| Entrepreneurs should contribute to reduce pollution in the society. | **0.833** | **0.877** |
| Entrepreneurs should lead the company to receive continuous income and profit. | 0.418 | |
| Entrepreneurs should pay attention to and to be sensitive to cash flow. | 0.602 | |

*4.2. Model test results*

Partial Least Squares (PLS) software was used to test the hypotheses in the conceptual model and the impact of three control variables. The result of the model test is shown in Table 4 and Figure 3, corresponding to the conceptual model in Figure 1. According to the test results, H11, H12, H13, H14 and H24 are supported while H21, H22 and H23 are rejected. It is found there is no significant differences in term of sustainability awareness among the three control variables (gender, GPA, role model). The significance level thresholds are set at p=<0.001** and p=<0.05*, respectively.

The results imply that ELT have significant impact on the learning performance of personal skills, product skills, business skills and sustainability efficacy. The significance

levels are all equal or less than 0.001. However, only sustainability efficacy is significantly related to sustainable awareness and other entrepreneurial skills (personal, product and business skills) do not have significant impact on sustainability awareness. The impact of sustainability efficacy on sustainability awareness is significant but at the level of 0.03. The three control variables are not related to sustainability awareness, indicating that gender, grades, and model will not affect students' sustainability awareness.

**Table 4.** Model test result.

| Code | Hypotheses | Path loading | T | P | Test result |
|---|---|---|---|---|---|
| H11 | E-Learning→Personal skills | 0.350** | 3.837 | 0.000 | Support |
| H12 | E-Learning→Product skills | 0.261** | 2.496 | 0.012 | Support |
| H13 | E-Learning→Business skills | 0.359** | 4.872 | 0.000 | Support |
| H14 | E-Learning→Sustainability efficacy | 0.281** | 3.007 | 0.003 | Support |
| H21 | Personal skills→ Sustainability awareness | 0.209 | 1.522 | 0.135 | Reject |
| H22 | Business skills→ Sustainability awareness | 0.160 | 0.951 | 0.347 | Reject |
| H23 | Product skills→ Sustainability awareness | -0.244 | 1.395 | 0.165 | Reject |
| H24 | Sustainability efficacy→ Sustainability awareness | 0.232* | 2.176 | 0.033 | Support |
| CV1 | Gender→ Sustainability awareness | -0.043 | 1.916 | 0.450 | Reject |
| CV2 | GPA→ Sustainability awareness | -0.186 | 0.754 | 0.054 | Reject |
| CV3 | Role model→ Sustainability awareness | 0.062 | 0.575 | 0.570 | Reject |

*p<0.05, **p<0.001.

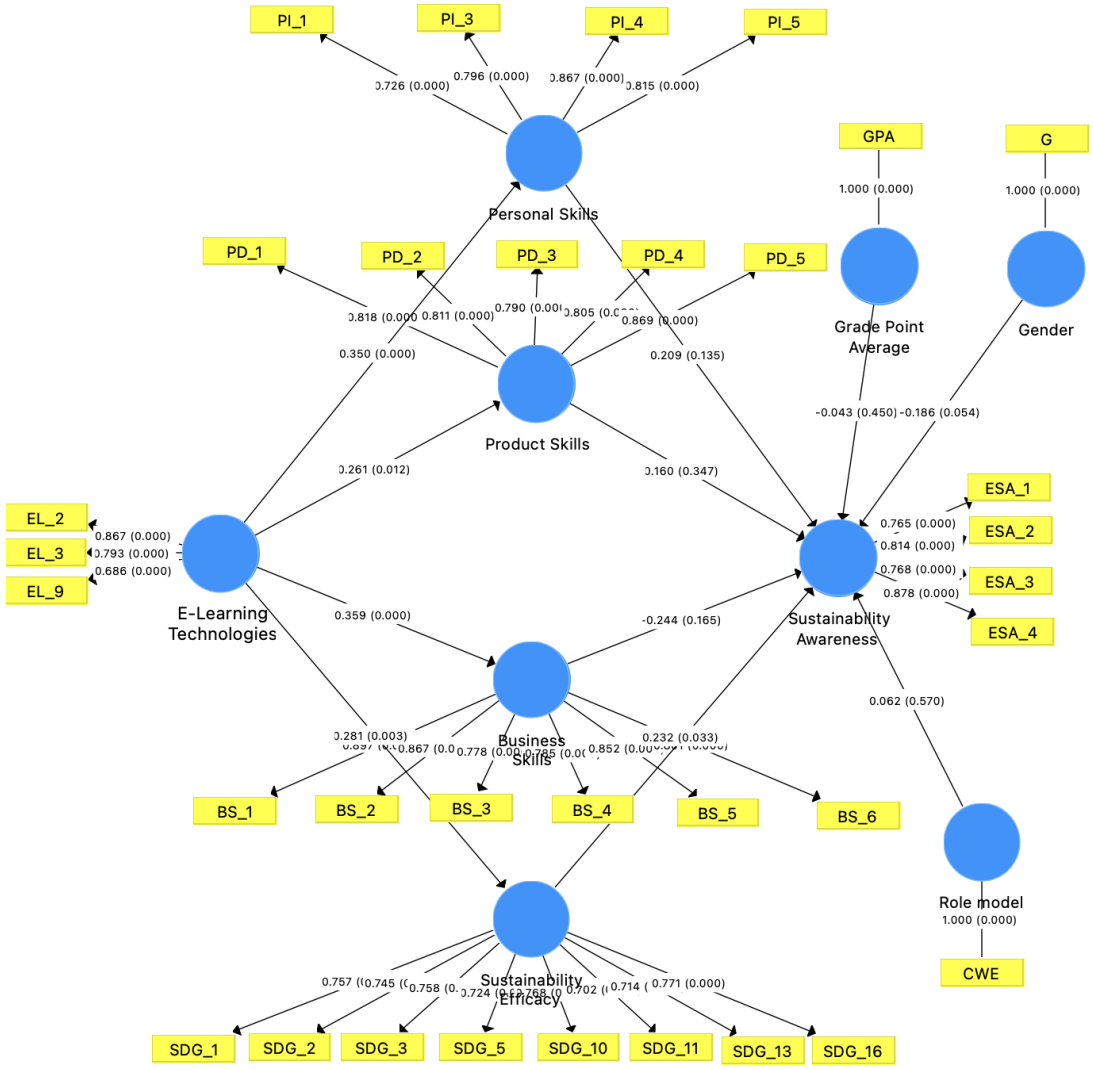



**Figure 3.** Result model.

## 5. Discussions and Implications

This study reveals that ELT have significant impact on entrepreneurial skills and sustainability efficacy, but entrepreneurial skills do not enhance sustainability awareness. The implication of the results will be explored below from entrepreneurship education and future education paradigm perspectives.

### *5.1. The impact of ELT*

This study reveals that ELT do have positive impact on entrepreneurial and sustainability learning performance. This has a very practical implications for entrepreneurial education in the future. There has been a rule of thumb that entrepreneurial classes must be a small class from 30 to a maximum 50 students. However, with the increasing demands of entrepreneurial education, it seems impossible to maintain the small size of entrepreneurship classes. The class size in this case university was a little bit over 100 and expected to be 160 in the coming year. There has been a report of very large classes with over 200 students in entrepreneurship courses while entrepreneurship teachers are far from enough. ELT can be a supplementary to traditional education and help universities to offer entrepreneurship courses while main certain large size of the classes.

Having said that, the impact of ELT is different among the three entrepreneurial skills and sustainability efficacy. Both the impacts and the significance level are relatively lower

on product skills. The impact on product skills is about 0.26 with $p<0.05$, while the impact on personal and business skills are 0.35 and 0.36 at the significance level of $p<0.001$. That means the impact of ELT on physical and visible things are more limited and weaker. Therefore, offline components such as the laboratory support or physical prototype requirement much be accompanied to balance the online part of learning. The impact on sustainability efficacy is also relatively lower than personal and business skills. This may be because it is purely personal perception instead of personal experience. It is recommended that project related to sustainability be provided to students so that they can be involved with sustainability issues during the course learning.

### *5.2. The impact on sustainability awareness*

It is not very surprising that only sustainability efficacy positively influences sustainability awareness. This is consistent with the Theory of Planned Behavior [85, 86, 87, 88] where efficacy influences intention. However, the three entrepreneurial skills do not significantly influence sustainability awareness. As said before, the teaching of entrepreneurial courses has not been well linked with sustainability awareness at the learning stage. Sustainability awareness in terms of economic, social, and environmental concerns may be easier to be understood while a company has been established.

While entrepreneurial education can potentially enhance students' sustainability awareness, there might be several reasons why it does not always have this impact. First, not all entrepreneurial education programs emphasize sustainability. If sustainability is not integrated into the curriculum, students may not develop a strong awareness of sustainability issues. Second, many entrepreneurial programs focus on traditional business skills and objectives, such as profit maximization, rather than sustainable business practices. Third, entrepreneurship often involves a focus on short-term goals and immediate results, which may conflict with the long-term perspective required for sustainability. Forth, without applying what they've learned in the reality, \, students may not fully understand the relevance of sustainability to entrepreneurship. Finally, sustainability is a complex, interdisciplinary issue which may be related to engineering, technologies and social, culture issues. If entrepreneurial education is not integrated with other disciplines, such as environmental science or social studies, students may not develop a comprehensive understanding of sustainability. Future entrepreneurship education should address these issues properly. It is suggested that entrepreneurship education may cover topics such as sustainable business practices, social entrepreneurship, and environment and social issues. Students should also be encouraged to develop business ideas that contribute to sustainability, such as green products or services.

Finally, there are no significant differences in sustainability awareness in terms of gender, academic performance, and the contact with entrepreneurial role models. It is fine with the gender, but it triggers the question on whether other courses as well as the whole education have designed sustainability into the curriculum. Even the introduction of entrepreneurial role models does not have any influence on sustainability aware. Sustainability is not an issue in entrepreneurial education only, it should be incorporated into all courses and roles.

### *5.3. Implication for future learning paradigm*

It has been widely believed that, after COVID-19, education will not be the same as before. The pandemic has indeed speeded up the process towards digital online learning or E-Learning. However, education will not be 100% online or 100% offline. It will be a hybrid learning mode which combines both the online and the offline activities. The very original hybrid mode during COVID-19 mostly refers to the mode where some students were online due to sickness and/or geographical limitations while others were offline physically in the classroom. That hybrid mode simply aimed to cope with the pandemic then passively. ELT and the latest generative AI have brought sweeping, sudden and

uninvited changes in learning, teaching and assessment. As a result, there will be a paradigm-shift toward technology-supported hybrid learning mode for student learning. ELT and certain online learning will be part of the future hybrid education paradigm. This trend toward the new paradigm is not limited to entrepreneurship education but applies to all subjects.

## 6. Conclusions and future research

This study investigates the influence of ELT on entrepreneurial and sustainability performance in a master class. It was found that ELT have significant relationships with entrepreneurial performance, and sustainability efficacy. The result supports that paradigm shift from offline mode before the pandemic to online mode during the pandemic and then the hybrid mode after the pandemic. Efforts are needed to fully understand and leverage the ELT in future education. The research also reveals that the impact of entrepreneurial skills on sustainability awareness is very limited. The implications for integrating entrepreneurial education with sustainability was discussed.

There are a few limitations with this study which can be explored further in future research. First, the sample of this study was from one class which is sufficient in terms the power of statistical analysis, but the size is not very big. Future research can be expanded to other classes. Second, the effectiveness of ELT can be assessed from various perspectives such as learning outcomes or performance of the course, student engagement, completion rates, learner satisfaction, learning application, learning retention, cost-effectiveness and technology performance. This paper only covers the impact on learning performance. All other measures are left for future research. Finally, from entrepreneurship education perspective, this study only focuses on the influence of ELT on entrepreneurial and sustainable performance and sustainability awareness. Future research can be explained to attitude, intention and behavior following the theory of planned behavior or other models with ELT as influencing or moderating factors.

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