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# The Antecedents of University Students' E-Learning Outcome under the COVID-19 Pandemic: Multiple Mediation Structural Path Comparison

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**Abstract:** The COVID-19 pandemic in late 2019 has severely affected the education sector. In order to avoid clustering, higher education has begun to implement a large number of e-learning courses. Although modern technologies are relatively mature, learning outcomes do not entirely depend on advanced technologies. The purpose of this study is to explore how self-directed learning and the information literacy of university students affect their e-learning attitude, and to understand the variables that mediate their effects on the learning effectiveness. This is a survey research and a survey questionnaire was used to collect data. A total of 714 valid samples were retrieved. A confirmatory factor analysis was used to determine the reliability and validity of each variable, and the latent variable modeling was utilized to test the research hypotheses. The results showed that self-directed learning and information literacy had a significant positive impact on e-learning attitudes and learning effectiveness, and e-learning attitudes had a significant positive influence on the learning effectiveness. Through the structural model verification analysis, it was found that e-learning attitudes are the main intermediary mechanism among all of the variables. By comparing multiple intermediary variables, it was found that self-directed learning, as an independent variable, exerted indirect effects on the learning effectiveness through e-learning.

**Keywords:** self-directed learning; information literacy; e-learning attitudes; learning effectiveness



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## 1. Introduction

Nowadays, network technology and service innovation are gaining momentum. In recent decades, the development of science and technology has changed people's behavior patterns and lifestyles [1]. The internet provides diversified services and applications in communication, searching, shopping, multimedia, information exchange, etc., making the internet an essential part of life.

Technology advancements not only change the living environment, but also the lives of individuals. Digital natives is one of the names that refer to individuals born in the last decades of the 20th century [2]. Growing up in a world surrounded by mobile phones, internet, computers, and video games, these individuals have developed a set of features that adhere to the world around them. These features are multitasking, a preference for graphic over textual content, and heavy use of the internet, to name a few [3]. Thompson pointed out that the internet changed the lives of college students and affected their future development, and also believed that they could not live without it. The internet has become indispensable to a student's life. A university student would need a personal computer,

even though he cannot afford it, in order to accomplish learning assignments, access the internet to enroll in university courses, and search for information, etc. Previous studies observed that students utilize the internet mainly to search for information needed for learning tasks, to chat online, and manage websites or social networking pages. The internet is a learning tool for college students used to obtain learning resources, in accordance with their learning requirements [4].

Moreover, in the contemporary information-based society, it has become a basic requirement for individuals to acquire timely information. The current international trend in education development involves the application of knowledge and the skills in information technology in object teaching [5]. E-learning is a global learning method which covers students at all ages. Students are now able to study, in accordance with their aptitude [6]. The globalization of e-learning facilitates the acquisition of knowledge, according to the needs of the students, which boosts their competitiveness. Extensive use of information technology tools could improve the learning effectiveness, promote active learning, and develop the desire for lifelong learning. The effective use of information technology tools, the application of learned knowledge and skills to various learning areas, and the improvement of the overall learning effectiveness should be the central topic of information education [7].

Prior to the COVID-19 pandemic, e-learning was promoted in higher education in numerous ways, such as MOOCs and the flipped classroom [8]. However, the pandemic forced higher education to stop physical classes and prevented students from reaching university campuses, to learn. The use of distance learning to help students continue to education became the world's leading teaching activity, or even the only sustainable form of education [9]. As a result, there has been a huge change in higher education, and the use of distance learning technology has increased significantly, that is, the long-promoted digital teaching model is finally widely used in the world because of COVID-19. Consequently, e-learning courses in universities aim at replacing classroom teaching. In order to ensure the quality of e-learning courses, to increase public recognition, to encourage the participation of teachers and students, and to promote the realization of continual learning, the development of e-learning needs to be integrated with formal education, to help students learn, based on their ability and realize their goal of lifelong learning [10]. E-learning provides a flexible environment for education providers to help cultivate college students' actual digital learning ability through the use of readily available resources [11].

The present study believes that it is important to determine whether college students in Taiwan, during the COVID-19 pandemic, could adapt to e-learning and actively use digital resources to enrich their knowledge and skills. As the learning environment is increasingly diverse, understanding whether the information literacy of university students can improve their e-learning attitudes is an important research object. Moreover, it is important for educators to ensure the learning effectiveness of digital resources. Based on these, the present study constructed a theoretical model to explore the relationships between self-directed learning, information literacy, e-learning attitudes, and the learning effectiveness.

## 2. Literature Review and Hypotheses Inference

Self-directed learning is defined as proactive and independent learning. Basic learning skills can be employed to improve one's ability to self-train, develop a strong learning confidence, and increase the desire to carry out plans and activities for learning [12]. Self-directed learning is diverse and variable, and scholars have varied viewpoints on it [13], giving it plenty of definitions. Self-directed learning is a learning process, in which students are determined to actively study, make plans for learning activities, and put what they learned into practice, to achieve their goals. Self-directed learning is an independent learning activity that is carried out systematically to achieve learning goals. It is a process that involves making judgments about one's learning needs, establishing learning goals, searching for manpower and learning materials, selecting learning strategies, and evaluating learning results without obtaining help from others. This process also

involves setting learning goals, estimating needs, forming plans, putting them into effect, and accomplishing goals [14].

According to Christie et al., self-directed students are individuals who can figure out their learning needs and establish their respective aims and motives to pursue success when they find unsolved problems or want to acquire skills and information. In order to meet the learning goals, individuals pay extra attention to the relevant information, learn the required knowledge and skills, and evaluate the acquired knowledge and skills until the goals are achieved. In view of this, self-directed learning is an independent learning activity [15].

People with information literacy are “those who have the ability to find the required information with great efficiency and use it to solve related problems” [16]. It is not only valuable in the workplace, where technology is needed to acquire certain skills and techniques, but also in daily life activities for problem solving. New information technologies emerge one after another. Weiner described individuals with information literacy “as those who have the ability to acquire and evaluate information, to meet one’s information needs” [17]. In other words, it involves the efficient acquisition and evaluation of the needed information. Information literacy is needed to efficiently communicate and interact with the outside world by using information and its carrier. It is essential that individuals appreciate the value and power of information and evaluate its appropriateness.

With the innovation of information technology, information literacy has acquired increasingly extensive definitions. It is closely related to functional literacy, and includes the ability to read and use information in daily life, realize personal needs for information, obtain information to make decisions, and learn new information technology and knowledge. Moreover, it is vital to understand the nature of information and the diversity of its forms, become familiar with the methods of information acquisition, and be able to evaluate, explain, organize, and integrate information. In order to obtain as much information as needed, individuals should learn to operate tools and systems for information retrieval, processing, and dissemination through the use of computers, media systems, and networks. The 21st century can be characterized as an information era, in which information literacy is considered essential. People are not born with information literacy, but acquire it through education, learning, and application. Information literacy, apart from the traditional skills of reading, writing, and counting, also involves the ability to perceive, retrieve, organize, and use the obtained information [18].

This study believes that information literacy can facilitate individuals to develop their own opinions and experience the pleasure of pursuing knowledge. It will not only prepare individuals to become lifelong students, but will also allow them to pursue knowledge and to become motivated in learning throughout their lives. Information literacy is also described as the ability to know, find, evaluate, organize, and use the information needed [18]. Information literacy can motivate an individual to continuously search for knowledge and make one a lifelong learner. Several studies have observed the importance of information literacy and its benefits to individuals, companies, and organizations [19].

Learning attitudes refer to one’s orientation towards learning all kinds of things. It is acquired and developed over time. A positive learning attitude can be obtained through various means, including tutorials, and formal education. Cultivating students with a positive learning attitudes is highly beneficial to learning. Generally speaking, learning attitudes refer to one’s internal state of readiness, and is composed of three components, including cognition, affect, and intention. Learning attitudes include one’s attitude towards the education curriculum, class, preview lessons, examinations, and reading scales; meanwhile, learning attitudes include those towards learning activities, teachers, campus, identification, and ceremonies [20]. Aryadoust et al. defined learning attitudes as an individual’s perception towards learning activities, and is the result of experience obtained through learning without conscious thinking or mental activity [21]. Therefore, learning attitudes are the tendency to react favorably or unfavorably to instructors, textbooks, and general learning environments

Generally speaking, learning attitude refers to one's internal state of readiness, and is composed of three components including cognition, affect, and intention. Learning attitude involves interaction among teachers, classmates, and the learning environment, in order to expound one's ability, experience, and background. A positive attitude is the ideal foundation of learning. Pruet et al. defined "computer attitude" as an individual's general opinion on computers, and one's likelihood and long-term behavioral tendency to use it. "Computer attitude" is one of the important variables that influence computer learning. Students' attitudes affects their learning results and the acquisition of computer skills [22]. According to Demirdag, "computer attitude" is a multi-dimensional concept, having affective, cognitive, and behavioral components, and involves people's feelings, faith, and behavior towards computer use [19].

Cazan et al. described learning effectiveness as the degree to which individuals acquire knowledge, skills, affection, and other capacities through learning or training in a certain field, for a certain period of time [23]. Further, Scherer and Siddiq defined learning effectiveness as the learning behavioral results through the process of teaching and self-study [24]. Furthermore, Riemer and Schrader considered the learning effectiveness as a fundamental indicator or a measure of whether students realize their predetermined learning goals (e.g., test scores or behavior changes) [25]. Gregory et al. divided the learning effectiveness into learning retention and the learning effectiveness. The former refers to the impression, understanding, and application of learning contents after a period of time, while the latter refers to the impression, understanding, and ability to apply learning contents [26].

The evaluation of the learning effectiveness can be divided into two categories: one is the test or evaluation of trainees' learning results; the other is the trainees' satisfaction in learning, change in their learning behavior or attitude, and after-class performance [24]. Panter and Williford [27] categorized learning assessments into direct and indirect assessments. While direct assessments examine student work products, straight from the student, indirect assessments examine the secondary information about what students have learned (e.g., student opinions about what they learned or course-taking patterns within a department). Panter and Williford highly recommended using multiple methods to assess the learning effectiveness, and further asserted that course grades were poor measures of the learning effectiveness, especially across different courses or disciplines, for several reasons: the grading criteria and standards are matters decided by the individual instructor, the grades in one course cannot be assumed to be equivalent to grades in other courses. Therefore, the present study used self-perceived questionnaires to collect data of the learning outcomes instead of course grades.

In terms of the online learning behavior, learning behavior is closely related with academic performance. Previous studies have found that better online learning results and a higher level of participation in all kinds of learning activities, led to a better academic performance. A research on the relationship among individuals, teams, as well as organizational learning, and learning performance, showed that learning behavior had a significant positive relationship with learning performance [28].

The above literature indicated that college students who are active in self-learning and are responsible for their learning results, are more likely to care about the learning effectiveness, and cultivate computer skills and information literacy in a time when e-learning is prevalent. They are also likely to hold an open attitude towards various mobile devices and computer equipment, actively face and pursue learning challenges, and improve learning deficiencies. In addition to learning assignments, these students are better in solving daily life problems by making use of information literacy. Therefore, college students who are good at self-directed learning have a better information literacy and a positive attitude to computer-oriented e-learning, allowing them to acquire knowledge and learning achievements. In addition, college students with a higher information literacy are good at using information technology tools, and understand the advantages of e-learning, which can be used to overcome challenges in learning and in daily life. They tend to employ

digital information media and devices to obtain the knowledge they need, allowing them to obtain a good performance in the learning effectiveness.

To mitigate the spread of a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is the cause of the coronavirus disease 2019 (COVID-19), the Central Epidemic Command Center, Nation Health Command Center (CECC) enacted a series of nonpharmaceutical interventions. School closures were among the most consistently applied of these interventions. School closures were not limited to Taiwan. By mid-April, 192 countries had closed schools, affecting more than 90% (nearly 1.6 billion) of the world's students [29]. At this time, e-learning opened up learning opportunities for students at all levels. Physical courses were replaced by online courses. Without actual contact with instructors, students' self-directed ability has become an important driving factor for learning. In addition, the success of digital learning also depends on the students' information literacy and a positive attitude towards learning with computers. In view of this, the following hypotheses are put forward:

**Hypothesis 1 (H1).** *In an e-learning environment during the pandemic, self-directed learning has a significant positive impact on the information literacy of university students.*

**Hypothesis 2 (H2).** *In an e-learning environment during the pandemic, self-directed learning has a significant positive impact on the e-learning attitudes of university students.*

**Hypothesis 3 (H3).** *In an e-learning environment during the pandemic, self-directed learning has a significant positive impact on the learning effectiveness of university students.*

**Hypothesis 4 (H4).** *In an e-learning environment during the pandemic, information literacy has a significant positive impact on the e-learning attitudes of university students.*

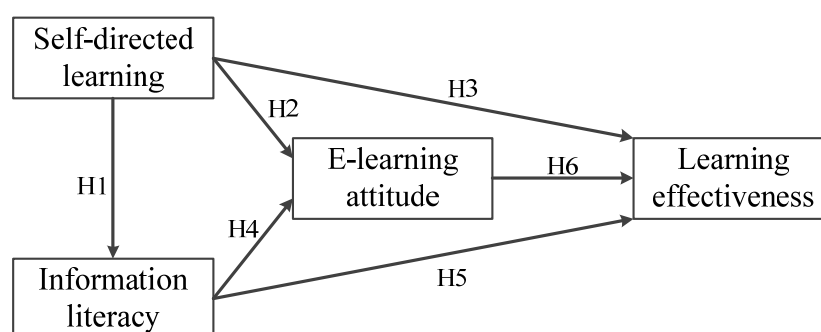
**Hypothesis 5 (H5).** *In an e-learning environment during the pandemic, information literacy has a significant positive impact on the learning effectiveness of university students.*

**Hypothesis 6 (H6).** *In an e-learning environment during the pandemic, e-learning attitudes have a significant positive impact on the learning effectiveness of university students.*

### 3. Method

#### 3.1. Research Framework

Based on a literature review, the theoretical deduction, and the logical deduction of past studies and the literature, this study proposes six research hypotheses (see above). In order to ensure that the research logic is clear, and the main relationships among independent and dependent variables and the role of intermediary variables are easily understood, the research framework is constructed (see Figure 1).



**Figure 1.** The research framework.

### 3.2. Research Participants

This study recruited students enrolled in day school and in the continuing education department at a university in Taipei, as participants. The general size of the student numbers enrolled in this university is accounted as the top three in Taiwan. The total number of students is around 30,000, the number of faculty members is around 3000, and the number of academic departments is as many as 60. The participants were affiliated with the colleges of law, business administration, social sciences, agriculture, environment design, and education. Considering the large number of students enrolled in the two school systems, there are plenty of pluralistically-developed students. Therefore, this study collected and synthesized as many questionnaires as needed, to meet the requirement of the quantitative research. In addition, the two school systems of this university enjoy complete information devices, and the students are endowed with relatively ample resources to understand e-learning; thus, students from this university were chosen so that the main research variables can be better explained. According to Krejcie and Morgan, the minimum of a representative sample depends on the size of a sample population [30]. In this study, the minimum valid sample size is 384.

The present study developed and administered a structured questionnaire. The questionnaire was distributed from November to December 2020. With the help of teachers and administrative staff, 400 questionnaires were distributed to students enrolled in day school, and 600 to students from the continuing education department. A total of 756 questionnaires were returned, among which 42 with exactly the same answers were regarded as invalid questionnaires. All in all, 714 questionnaires were analyzed with an effective recovery rate of 71.4%, which is more than the minimum requirement for a representative sample size, as suggested by Krejcie and Morgan. Among the participants, 57% ( $n = 403$ ) were females and 43% (311) were males. Further, 46% (328) of the students were from the day school and 54% (386) were from the continuing education department. Lastly, 59% (423) were freshmen and sophomores, and 41% (291) were junior and senior students, at the time of the survey administration.

### 3.3. Research Instrument: The Questionnaire

The scales used in the questionnaires were adapted from foreign journals and/or books, which have been found to have a good reliability and validity. The “self-directed learning” scale was developed by Caffarella and Caffarella [31]; a total of four items were included in the present study, which are: (1) I can set my learning plans and arrange the learning contents; (2) I can figure out my learning needs and know which are the urgent ones; (3) I know what I want to learn; and (4) I can adjust my pace when I fall behind.

For “information literacy”, four items were adapted from Çoklar, Yaman, and Yurdakul [3], which measure the variables being observed, and the psychological perception of the participants in forming constructs. The items are: (1) I have the knowledge of where to look for the required information; (2) I know how to use electronic resources to reach the information; (3) I can systematically organizing the gathered information to form problem solutions; and (4) I access and use information legally.

Meanwhile, the scale for “e-learning attitude” was adapted from Loyd and Gresard’s [32] research and measured the students’ cognitive reactions in e-learning. The items include: (1) E-learning can provide flexible learning contents to meet my learning needs; (2) E-learning can coordinate my time and further facilitate my study; (3) I am interested in acquiring new knowledge by e-learning; and (4) I am willing to enhance my learning effectiveness through e-learning.

For “learning effectiveness”, the items were adapted from Paas et al. [33] which measure the learning results through subjective cognition. The items are: (1) I have a better understanding of the professional knowledge of this course; (2) I feel a sense of fulfillment during the process of studying; and (3) I can apply the knowledge and skills I learned in this course.

Since the structural equation model (SEM) was employed for the data analysis in this study, only a small number of precise items were needed to process the latent variables, as observed variables. According to Kenny, each latent variable is composed of two to four observed variables; additional items are unnecessary, they will only result in a poor model fit, and will not increase the explanatory capability [34]. Therefore, the number of observable variables of the latent constructs in this research did not exceed four. Bentler and Chou argued that the number of samples must be at least five times of the estimated parameters, which should be about two of the questionnaire items [35]. The questionnaire in this research has 15 questions; thus, only 150 valid samples are needed. The 714 valid samples were received, and therefore exceeded the requirement.

The subjective cognition was analyzed to measure the participants' subjective feelings, since the variables studied in this research cannot be measured by objective indicators; therefore, the questionnaire was designed as a self-administered questionnaire, which is a relatively effective way to obtain accurate information. Moreover, the items were scattered in the questionnaire, to avoid the common method variance (CMV) [36].

### 3.4. Analysis of the Variable Characteristics

It is almost impossible to have a true normal distribution, based on the collected sample data in the survey studies. However, statistically, to determine the multivariate and univariate normality of given sample data, Statistical Product and Service Solutions (SPSS Version 21.0) software was used to determine the skewness and kurtosis of the data, as well as the Mardia co-efficient. First, in this study, since the absolute value of the skew obtained was less than three and that of the kurtosis was less than 10, the samples of this study are considered in accordance with the univariate normal distribution [37].

Second, according to Bollen, if Mardia's coefficient is less than  $p(p + 2)$ , where  $p$  equals the number of observed variables, then the combined distribution of the variables is multivariate normal [38]. Such a criterion has been widely used to determine whether sample data are normally distributed multivariate and hence appropriate for the structural equation modeling [39–41]. In this study, there are 15 observed variables, so the control value is  $15 \times (15 + 2) = 255$ . It can be seen from Table 1 that Mardia's coefficient was 77.213, which is less than 255. Therefore, the data of this research could be estimated by the structural equation model using the maximum likelihood estimation.

**Table 1.** Univariate and multivariate normality test.

| Variable        | Min | Max | Skew   | c.r.   | Kurtosis | c.r.   |
|-----------------|-----|-----|--------|--------|----------|--------|
| Effectiveness 3 | 2   | 5   | −0.004 | −0.047 | −0.269   | −1.465 |
| Effectiveness 2 | 1   | 5   | −0.183 | −1.995 | 0.784    | 4.275  |
| Effectiveness 1 | 1   | 5   | 0.017  | 0.191  | 0.175    | 0.957  |
| Attitude 4      | 1   | 5   | −0.674 | −7.352 | 1.085    | 5.919  |
| Attitude 3      | 1   | 5   | −0.568 | −6.195 | 0.488    | 2.659  |
| Attitude 2      | 1   | 5   | −0.618 | −6.747 | 0.848    | 4.625  |
| Attitude 1      | 1   | 5   | −0.605 | −6.602 | 1.190    | 6.489  |
| Literacy 4      | 1   | 5   | −0.044 | −0.477 | −0.428   | −2.337 |
| Literacy 3      | 1   | 5   | −0.509 | −5.557 | 0.565    | 3.080  |
| Literacy 2      | 1   | 5   | −0.468 | −5.106 | 0.400    | 2.180  |
| Literacy 1      | 1   | 5   | −0.174 | −1.899 | 0.014    | 0.078  |
| Self 4          | 1   | 5   | −0.252 | −2.750 | 0.228    | 1.245  |
| Self 3          | 1   | 5   | −0.240 | −2.622 | 0.297    | 1.622  |
| Self 2          | 1   | 5   | −0.064 | −0.694 | 0.438    | 2.388  |
| Self 1          | 1   | 5   | −0.337 | −3.681 | 0.610    | 3.327  |
| Multivariate    |     |     |        |        | 130.514  | 77.213 |

## 4. Results

### 4.1. Confirmatory Factor Analysis and the Reliability and Validity Analyses

The confirmatory factor analysis (CFA) is a part of the SEM analysis. The results of the CFA showed that the standardized regression weights reached over 0.5 and the squared multiple correlation (SMC) was more than 0.25; these indicate a good adaptability. Moreover, the composite reliability and the average variance extracted (AVE) of the constructs reached over 0.6 and 0.5, respectively, as shown in Table 2, indicating that the convergent validity of the variables selected in this study has a good performance.

**Table 2.** Confirmatory Factor Analysis and Convergent Validity.

| Construct              | Item            | Parameter Significant Estimation |       |         |     | Factor Loading | Parameter Reliability | Composite Reliability | Convergent Validity |
|------------------------|-----------------|----------------------------------|-------|---------|-----|----------------|-----------------------|-----------------------|---------------------|
|                        |                 | UnStd.                           | S.E.  | t-Value | P   | Std            | SMC                   | CR                    | AVE                 |
| Self-directed learning | Self 1          | 1.000                            |       |         |     | 0.746          | 0.557                 | 0.933                 | 0.778               |
|                        | Self 2          | 1.291                            | 0.050 | 26.072  | *** | 0.919          | 0.845                 |                       |                     |
|                        | Self 3          | 1.325                            | 0.050 | 26.758  | *** | 0.942          | 0.887                 |                       |                     |
|                        | Self 4          | 1.290                            | 0.050 | 25.645  | *** | 0.906          | 0.821                 |                       |                     |
| Information literacy   | Literacy 1      | 1.000                            |       |         |     | 0.807          | 0.651                 | 0.898                 | 0.688               |
|                        | Literacy 2      | 1.049                            | 0.041 | 25.522  | *** | 0.850          | 0.723                 |                       |                     |
|                        | Literacy 3      | 1.063                            | 0.042 | 25.546  | *** | 0.850          | 0.723                 |                       |                     |
|                        | Literacy 4      | 1.150                            | 0.048 | 23.993  | *** | 0.810          | 0.656                 |                       |                     |
| E-learning attitude    | Attitude 1      | 1.000                            |       |         |     | 0.728          | 0.530                 | 0.880                 | 0.648               |
|                        | Attitude 2      | 1.092                            | 0.052 | 20.983  | *** | 0.822          | 0.676                 |                       |                     |
|                        | Attitude 3      | 1.157                            | 0.053 | 21.680  | *** | 0.853          | 0.728                 |                       |                     |
|                        | Attitude 4      | 1.182                            | 0.057 | 20.689  | *** | 0.810          | 0.656                 |                       |                     |
| Learning effectiveness | Effectiveness 1 | 1.000                            |       |         |     | 0.780          | 0.608                 | 0.853                 | 0.659               |
|                        | Effectiveness 2 | 1.148                            | 0.053 | 21.555  | *** | 0.803          | 0.645                 |                       |                     |
|                        | Effectiveness 3 | 1.122                            | 0.050 | 22.597  | *** | 0.851          | 0.724                 |                       |                     |

Note: \*\*\*  $p < 0.001$ .

In addition to the convergent validity, the correlation coefficient of each latent variable was compared with the square root of its AVE. If the latter is larger than the former, it indicates that the theoretical constructs have a poor tightness and that they cannot become easily mixed up [42]. As shown in Table 3, all square roots of the AVE were higher than the correlation coefficients; thus, the variables in this research have a good discriminant validity.

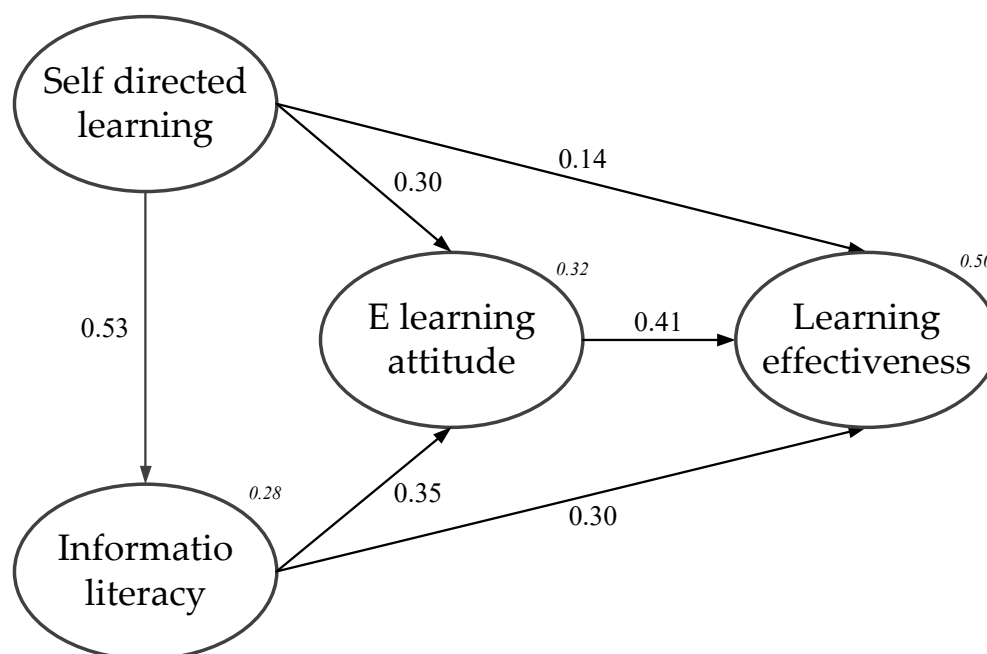
**Table 3.** Correlation coefficient and discriminant validity.

|                        | CR    | AVE   | E-Learning Attitude | Self-Directed Learning | Information Literacy | Learning Effectiveness |
|------------------------|-------|-------|---------------------|------------------------|----------------------|------------------------|
| E-learning attitude    | 0.880 | 0.648 | (0.805)             |                        |                      |                        |
| Self-directed learning | 0.933 | 0.778 | 0.479               | (0.882)                |                      |                        |
| Information literacy   | 0.898 | 0.688 | 0.503               | 0.530                  | (0.830)              |                        |
| Learning effectiveness | 0.853 | 0.659 | 0.627               | 0.498                  | 0.580                | (0.812)                |

Note: The diagonal value is the square root of the AVE of the constructs.

#### 4.2. Structural Model and Hypotheses Testing

Following the CFA, the hypotheses of this study were further tested and corrected using the Bollen–Stine bootstrap method. Figure 2 shows that there is a good model fit. In addition, the following values were obtained: chi-square value = 105.539; degree of freedom = 84; ratio of the chi-square to the degree of freedom = 1.304; goodness-of-fit index (GFI) = 0.987; adjusted goodness of fit index (AGFI) = 0.978; comparative fit index (CFI) = 0.997; non-normed fit index (NNFI) = 0.996; incremental fit index (IFI) = 0.997; root mean square error of approximation (RMSEA) = 0.021; and standardized root mean square residual (SRMR) = 0.048. All indexes met the standard of the SEM [43], confirming that the structural model in this research has a good fit.



**Figure 2.** Standardized structural modeling and hypotheses testing.

The hypotheses in this study were estimated using the bootstrap method, and the results showed that the standardized path coefficient met the standard of significance; therefore, all hypotheses are supported. The standardized regression coefficient and significance are shown in Table 4.

**Table 4.** Standardized regression coefficients and their significance.

|                        | Parameter |                        | Estimate | Lower | Upper | P     |
|------------------------|-----------|------------------------|----------|-------|-------|-------|
| Information literacy   | ←         | Self-directed learning | 0.530    | 0.446 | 0.596 | 0.008 |
| E-learning attitude    | ←         | Self-directed learning | 0.296    | 0.220 | 0.372 | 0.008 |
| E-learning attitude    | ←         | Information literacy   | 0.347    | 0.255 | 0.436 | 0.008 |
| Learning effectiveness | ←         | E-learning attitude    | 0.407    | 0.273 | 0.527 | 0.008 |
| Learning effectiveness | ←         | Self-directed learning | 0.145    | 0.070 | 0.240 | 0.011 |
| Learning effectiveness | ←         | Information literacy   | 0.298    | 0.179 | 0.400 | 0.008 |

To further explore the mediated relationship among self-directed learning, information literacy, e-learning attitude, and the learning effectiveness, the bootstrap method and visual

basic language were employed to calculate the different confidence intervals of the direct effects, the individual indirect effects, and the three independent indirect effects [44]. Table 5 shows that the confidence interval range of the self-directed learning on the learning effectiveness excluded zero, indicating that a direct effect exists. Moreover, the confidence interval of the e-learning attitudes, as a mediator variable (Path *a*) in the relationship between the self-directed learning and the learning effectiveness, excluded zero, indicating that there was a significant indirect effect. The confidence interval ranges of the information literacy and the e-learning attitude as mediator variables (Path *b*) in the relationship between self-directed learning and the learning effectiveness, also excluded zero, indicating that the significant indirect effects exist. Furthermore, the confidence interval ranges of the information literacy, as a mediator variable (Path *c*) in the relationship between self-directed learning and the learning effectiveness, excluded zero, indicating that an indirect effect exists significantly. Because of the existence of the direct effects, it was found that the partial mediated effects varied; that is, Path *a* is different from Path *b*, and Path *b* is different from Path *c*. Although Paths *a* and *b* had significant effects, the indirect effect of Path *c* was stronger.

**Table 5.** Multiple mediation model testing and the comparative analysis.

| Parameter                                                   | Estimate | Lower  | Upper  | P     |
|-------------------------------------------------------------|----------|--------|--------|-------|
| Self → Attitude → Effectiveness (Path <i>a</i> )            | 0.111    | 0.065  | 0.162  | 0.008 |
| Self → Literacy → Attitude → Effectiveness (Path <i>b</i> ) | 0.069    | 0.041  | 0.105  | 0.008 |
| Self → Literacy → Effectiveness (Path <i>c</i> )            | 0.146    | 0.081  | 0.204  | 0.008 |
| Path <i>a</i> compared to Path <i>b</i>                     | 0.042    | 0.002  | 0.089  | 0.023 |
| Path <i>b</i> compared to Path <i>c</i>                     | −0.077   | −0.148 | −0.003 | 0.038 |
| Path <i>a</i> compared to Path <i>c</i>                     | −0.035   | −0.124 | 0.062  | 0.438 |
| Direct effects                                              | 0.405    | 0.244  | 0.561  | 0.008 |

## 5. Discussion

Based on the results of the analysis, the variables had a significant positive relationship amongst each other. That is, self-directed learning can actually improve information literacy, e-learning attitudes, and the learning effectiveness, which are in line with the work of Sumner [45], Morris [46] and Robinson and Persky [47]. However, this study further discovered that the development of self-directed learning not only accumulates information literacy, but also develops positive e-learning attitudes, leading to the learning effectiveness. This information is important for educational and administrative personnel because it is necessary to understand the characteristics of students, in order to stimulate their learning motivations and incorporate proper learning activities, while introducing e-learning courses.

In addition, the present study found that both information literacy and e-learning attitudes have significant positive impacts on the learning effectiveness. Our findings of the relationship between information literacy and the learning effectiveness are supported by existing studies, such as those by Hamutoglu, Savaşçı, Sezen-Gultekin [48], and Chang and Chen [49]. Even though past studies have conflicting arguments concerning the relationship between e-learning attitudes and the learning effectiveness [50], our findings are parallel to Ho and Kuo [51], Elfaki1, Abdulraheem, and Abdulrahim [52], and Dewi and Hasibuan [53]. Our findings indicate that when preparing e-learning lessons, teachers should ensure that their students study actively, stimulate their information literacy, and improve their learning attitudes in class. Moreover, to further improve the learning effectiveness, the learning activities of university students after class should make use of computers or the internet, to

allow them to acquire the technological knowledge and become familiar with a different information environment.

It is worth mentioning that information literacy and e-learning attitudes were found to be intermediary variables. This research was the first to test both, as intermediary variables, and the first to use the multiple mediation statistical method to explore the strength of each mediation effect. Due to this, a new conclusion was made; that is, self-directed learning can improve the learning effectiveness through e-learning attitudes and/or information literacy. More interestingly, it was found that although information literacy and e-learning attitudes exerted significant indirect effects on the learning effectiveness, the strength of its effect was lower, compared to the influence of self-directed learning on the learning effectiveness. Therefore, the best strategy to increase the learning effectiveness is by developing activities that would stimulate the students' self-directed learning.

This research believes that there are two reasons for this result. One is the statistical limit; the indirect effect is equivalent to the product of the path coefficient, and it becomes weaker as the number of path coefficients increases. The other reason is related to teaching strategies. Proper teaching strategies for improving information literacy and e-learning attitudes should be chosen, because every student is unique. One strategy may be the best for some students but it may not be effective for others. Because of the limited resources, educators should also consider the characteristics of their students and apply different teaching methods. Although both information literacy and e-learning attitudes can be introduced to achieve the learning effectiveness, teachers should be able to distinguish which would be best for a particular type of student.

## 6. Conclusions and Recommendations

Although higher education institutions have been offering online courses for many years, the demand for online learning increased, due to the COVID-19 pandemic. Even as the pandemic slows down, technology-enhanced learning is likely to remain a critical part of higher education. This study attempts to explore the e-learning outcomes through the lenses of learning experiences during the COVID-19 pandemic. We believe that the results can help reimagine education and accelerate changes in learning and teaching.

This study aims to explore the relationship among self-directed learning, information literacy, e-learning attitudes, and the learning effectiveness of students enrolled in day school and in the continuing education department of a university in Taipei City, Taiwan. The research hypotheses were put forward, according to literature and theories. The results showed that (1) self-directed learning and information literacy had a significant positive impact on e-learning attitudes and the learning effectiveness, and e-learning attitudes also had a significant positive explanatory power on the learning effectiveness; (2) e-learning attitudes is the main intermediary mechanism among all of the variables, and (3) self-directed learning, as an independent variable, exerted indirect effects on the learning effectiveness through e-learning.

Modern educators often use e-learning as an aid, hoping to improve learning. This study was the first to explore the students' self-directed learning and information literacy and their effects on e-learning. In order to achieve the best learning effectiveness, several variables must be explored to formulate the best learning strategy for each type of student. Education administrative personnel can employ different e-learning strategies under different school systems to further improve e-learning in the future.

As educators, we will need to establish and activate automatic emergency mechanisms for e-learning, in times of a public health crisis [54]. While this outbreak is not over, all educators and students need to face more obstacles and challenges in future teaching and learning [55]. The data of this study shows that most of the information literacy of university students has a good foundation, when the self-directed learning ethos of higher education is becoming more and more prosperous, then e-learning can be more effective, even if human beings face more time and space difficulties in the field of education, they

have the opportunity to overcome and continue their learning activities in the form of e-learning.

We further recommend that university faculties should continue to improve their on-line teaching skills so they can incorporate useful strategies or learning activities into their e-learning courses, in order to enhance the students' information literacy. Furthermore, at the administrative level, the universities need to provide (1) systematic support and tutoring, especially for students in their first years at university, to develop competences, such as autonomy, digital competence, and self-regulation [56], and (2) sound infrastructures to support online teaching and learning activities, in order to comply with the trends of online learning [57].

Future research can focus on the satisfaction, acceptance, and behavior of students towards e-learning. The multiple mediation model in this research has a great explanatory power, but better models could still be designed in the future. The diversity of university students or the particularity and professionalism of different departments may influence the learning effectiveness. In addition, open interviews and opinions of educators should also be considered so that new research models can be made based on educational theories and the nature of e-learning. It is also suggested that different research orientations be considered. Through these, this research believes that the comprehensiveness of e-learning in the new era can be fully described.

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