

EVALUATING THE IMPACT OF SELF-EFFICACY ON ONLINE LEARNING OUTCOMES OF STEM COLLEGE STUDENTS

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Abstract: With the development of Internet globalization and the ongoing pandemic, online education has become the mainstream of higher education. While endowed with great convenience and efficiency, virtual education was also doubted of its impact on self-efficacy and academic performance of college students. This study aims to analyze the mediating effect of self-efficacy on the learning outcomes of college students majoring in STEM (science, technology, engineering and mathematics). This is achieved through reviewing mainstream studies on self-efficacy and learning outcomes to descriptively analyze the correlation between them, especially among college STEM students who received online education. Under the theoretical guidance of Bandura's ternary interaction theory and Self-Determination Theory, our study investigated diverse variables, including the level of self-efficacy and learning outcomes of college STEM students, by a questionnaire with 36 items from existing scales. Through random sampling, a total of 250 college students from 53 universities in 61 cities in China participated in the survey. The primary data were analyzed using linear regression, along with reliability and validity analysis in SPSS. Findings illustrated that college STEM students' self-efficacy in online learning has a positive and noteworthy impact on learning outcomes. Findings of our study have broad implications for theory and practices. This paper made an effort to provide possible applications and avenues to encourage the overall development of online education in STEM fields by examining self-efficacy in such context. Meantime, it offered recommendations on designing appropriate learning methods to facilitate college students learning motivation and maximize their full potential to improve online learning systems.

Keywords: self-efficacy, learning outcomes, online education

Introduction

The advancement of technology has accelerated the implementation of online learning and its facilities in the recent few years, which is a significant part of the education system in many universities. With the epidemic raging, college students have to acquire knowledge and learn effectively through online education and the Internet. However, disciplines in science, technology, engineering, and mathematics (STEM) was greatly affected by the online learning environment with strong practicality and operability (O'Hara & Sparrow, 2019). This makes the universities that set up STEM courses fall into a dilemma, that is, how to get rid of the constraints of online education to help STEM college students better complete relevant course training and learning (Zhang & Guo, 2019).

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Previous studies have shown that college students hold various attitudes towards online and offline education, some even shown their preferences for hybrid courses. (Bergeler & Read, 2021). For those learners with relatively low self-regulation, online learning mode might exacerbate their learning stress. Although online education is often criticized for lack of face-to-face communication and inefficiency, its mode still could be a great opportunity to learn various subjects in terms of different layers of depth which also implies the ability to transform education. Especially online learning platforms can close the gaps created by long-suppressed equality in society due to poor access to person-to-person teaching. As shown from our questionnaire data, some students could make better academic communication and interaction with others through online platform. Meanwhile, the pandemic has accelerated the requirement for high-quality education transformation among the stakeholders in higher education. Through specific responses about online learning environment, educators could accordingly adjust their focus of teaching and allocate appropriate resources to help online learners build strong learning motivation and sense of self. Thereby, our research analyzed the influences of STEM college students' online learning self-efficacy on their learning outcomes, explored various factors affecting the online learning environment of college STEM students with a linear regression method, and proposed corresponding practical strategies, with a view to providing a scientific basis for reforming and improving college STEM students' online learning.

Relevant Literature

Online Learning

Online learning refers to the dynamic process of resource acquisition and absorption through computer networks, with high spatial and temporal flexibility, durable effectiveness and diversity. As per MacKenzie (2019), the annual Online Learning Consortium study has shown that the increased rate of students opting for distance education still remained the same for the fourteenth year; however, the overall enrollments decreased gradually in the last four years. Aslanian and Clinefelter (2014) stated that a minimum of one single entire online course is offered by almost 80 per cent of the public universities and half of the private colleges. The application of online learning has been accelerated as the suggestion of not having much difference in in-person and distance learning outcomes has been made. A ten-year research by Tanyel & Griffin (2014) has concluded that there is a difference of 12 percent in terms of learners who received credit for face-to-face interactions for the same course and received around 0.15 percent more GPA.

The results of the studies conducted on the efficacy of the online learning system before the Covid-19 pandemic has given mixed results when assessed in different contexts. Means et al. (2013) claimed that the online learners slightly perform superior to those who receive traditional learning. Concurrently, the surroundings of online learning had been considered influencing in terms of

productivity by the educators (Mosquera, 2017). On the contrary, Mathew et al. (2019) has pointed out that online mode often leads to a lack of responses from students, along with difficulty for teachers to teach for a longer time online and not being able to analyze the different learning processes of students. The previous studies focused on online learning have examined the research area from a vast number of aspects. Abdullah et al. (2016) has analyzed the impact of factors such as self-efficacy, poor knowledge of computer, enjoyment, and more on usefulness and ease of use. Besides, Hung et al. (2010) provided a five-dimensional instrument to analyze the readiness in e-learning systems: online communication self-efficacy, motivation for learning, self-directed learning, Internet or computer efficacy, and learner control. The transition from conventional learning to online learning under the pandemic context was also noticed (Al-Hattami, 2020). In the study by (Alqahtani & Rajkhan, 2020), the key success factors of the online study during the pandemic have been assessed, including the downsides of online learning and the acceptance of learners in terms of the migration of online learning.

Self- Efficacy

Self-efficacy refers to an individual's confidence or belief in his ability to achieve behavioral goals in a specific field. The term self-efficacy is considered one of the acute aspects of effective online education (Yokoyama, 2019). Many studies have criticized different categories of self-efficacy in terms of online learning system, such as per Choi et al. (2007), which is technology self-efficacy, whereas Kim & Park (2018) identifies computer self-efficacy, academic self-efficacy, internet self-efficacy, e-learning system self-efficacy, communication-internet self-efficacy and online learning self-efficacy and knowledge sharing self-efficacy. Shen et al. (2013) have identified five aspects associated with self-efficacy concerning online learning:

1. To accomplish an online course
2. To have conversations and socialize with peers.
3. To interact with tutors or instructors
4. To use equipment in an online course of learning
5. To have interaction with classmates for academic tenacities

Learning self-efficacy is derived from the specific expression of Bandura's concept of "self-efficacy" in the learning aspect (Yi & Rui, 2021). Learning self-efficacy means the individual's academic strength belief and the assessment of their confidence or abilities to finish their learning tasks and refers to one's effective analysis of own understanding to control own learning behaviour and results. Various researchers have shown how learning self-efficacy could positively influence mindset, regulation, motivation, learning outcomes, and performance in classes. According to theoretical analysis, online learning self-efficacy includes four dimensions: the individual's own "sense of

ability", "sense of effort", "sense of the environment", and "sense of control" over behaviour (Yi & Rui, 2021). Online learning self-efficacy is highly correlated with e-learning performance and affects learners' academic anxiety. In addition, the self-efficacy of online learning and self-regulated learning would interact and promote each other; the mental image realization can affect the network learning activities, and it is a medium for attribution feedback and online learning performance. Learners with a high level of self-efficacy can use cognitive strategies, manage time and learning environment effectively, and monitor and regulate their learning more closely than those with low self-efficacy. Consequently, online learning self-efficacy plays a crucial role in one of the most important influencing factors of higher education.

Learning Outcomes

Learning outcomes can be characterized as the scores received by students in tests which are the values of their efficiency and results achieved in the learning procedure (Kustyarini, 2020). Learning outcomes are the abilities that students possess in the learning process, which are divided into five main parts: (1) intellectual skills, (2) cognitive strategies, (3) language information, (4) motor skills, and (5) attitudes, and they could provide the value of measuring alternative methods under different conditions because there are tangible and desirable results (Kustyarini, 2020). The core issue with the wide application of online learning is the confusion of its effectiveness compared to traditional learning. In terms of performance, Helms (2014) recalled that students who received online education performed poorly compared to students who received traditional learning in psychology. Furthermore, Xu and Jaggars (2013) also identified that community college students who have received online courses performed poorly compared with their peers who received in-person classes, irrespective of their backgrounds, gender, age, race and more. On the contrary, Schoenfeld Tacher et al. (2001) resulted in the positive results of attending a science course online where students who attended online classes performed a lot better than their face-to-face counterparts. There had been increased students who have shown high interest and engagement to be a part of the online instructional module and did perform better than others who were part of traditional learning.

Neuhauser (2002) and Brown and Park (2016) were able to find out several differences between in-person and e-learning. Findings of the study from Xu and Jaggars (2013) revealed the similar problem identified in in-person courses existed to a deeper extent in online mode, specifically for some demographic indicators; i.e., the gaps between white/ minority performance and male/ female performance and are greater in online mode. Also, students' learning styles could influence their attainment in several learning contexts (Cavanaugh and Jacquemin, 2015). Relevant research found that, similar to offline courses, students' capacity spent on online course learning is positively correlated with their academic achievement, such as GPA indicator (Cavanaugh and Jacquemin,

2015). Lastly, it is widely accepted that teaching and learning are of great complexity in the review study, which means they could be influenced by more than just the pattern educator is using while teaching." Generally, online classes and students require a relatively high level of self-discipline, organization, as well as time management skills and a higher motivation level in order to be successful.

Research Problem

As an essential indicator of college students' academic performance, self-efficacy substantially impacts students' self-regulation and learning habits in online education, motivating students to achieve better learning outcomes (Bradley et al., 2017). Although studies about the impact of self-efficacy on college students' learning and online education have made progress, a lack of literature shows the direct connection between online learning self-efficacy and the learning outcomes of college STEM students. Regarding the learning outcomes of college students, current studies surveyed the overall students of a particular university, and less attention was paid to the college students in different disciplines such as STEM. In addition, the efficiency and effects of college students' learning outcomes are studied from the perspective of input-output by many goal-and-result oriented studies (Zhang & Guo, 2019). Based on the findings from Means et al. (2013), the mixed education encompassing online platforms was slightly superior to the conventional in-person curricula. Another view supported that the traditional schooling mode and the integrated one with online platform have no significant difference in students' academic performance (Neuhauser ,2002; Lack, 2013). While online learning might be appropriate for group learners, overall, learning styles and requirements of students are heterogeneous (Dunn, Beaudry, & Klavas, 2002). Relevant studies also show that diverse student groups have different academic attainments in online education. This paper focuses on exploring the impact of STEM college students' learning self-efficacy on their learning outcomes in online learning, and the following is the research questions:

1. *Could college STEM students form a high sense of learning self-efficacy in the context of online education?*
2. *Could college STEM students achieve qualified learning outcomes in the context of online education?*
3. *What is the influence of self-efficacy on the learning outcomes of STEM college students in online learning environment?*

Theoretical Framework

This study adopts ternary interaction theory and self-determination theory as the theoretical framework to guide the research execution jointly.

Ternary Interaction Theory

Projected by American psychologist Bandura (1960), Ternary Interaction Theory discusses three interactive factors, Physical and Mental Condition, Individual Behaviour and External Environment. The theory explains the relationship between human behaviour, personal factors, and external environment. It highlights the role of human cognitive, emotional and physiological factors in human behaviour while emphasizing the interaction between individual, behaviour and environment (Wu, 2020). The sense of self-efficacy in network learning is the main factor of individual network learning, which is also the product of the interaction of the three elements. It affects other individual factors, which in addition affect their feelings about the environment and the sense of control over behaviour. The individual, his or her behaviour, and the environment influence each other and decide each other, therefore people are no longer passive recipients of environmental stimulation changes but active creators who can change the environment through themselves and behaviour (Olson et al., 2010).

Self-Determination Theory (SDT)

The SDT (Self-determination theory) is related to the process of motivation for the self-deterministic behaviour of humans (Deci & Ryan, 1985). It states that an individual's social functioning, motivation, and personal well-being are associated with an individual's behaviour alignment with a sense of self and to which an individual's choices are self-determined. As a theoretical framework, our study utilized SDT for providing a lens to document online learners' motivation to achieve higher academic performance. SDT is helpful to understand how STEM students' basic psychological needs of autonomy, competency, and relatedness change as universities abruptly transition to online mode and how such changes may have influenced students' self-determination (performance and persistence) as online learners. Intrinsic motivation is understood as a progressed, spontaneous and inherent tendency to develop through activity, to play, discover, and manipulate things to ultimately advance the capacities and competencies (León et al., 2015).

Materials and Methodology

Methods

This descriptive study will use quantitative methods to explore the impact of self-efficacy on STEM college students' learning results in the online learning environment. By collecting and analyzing the data on STEM college students' online learning self-efficacy and academic performance, the research will objectively and concretely find out the correlation, reveal the essence and answer the questions deductively. Participants of the study were 250 STEM college students from 53 Chinese universities in 61 cities by randomly sampling. All participants confirmed that they had received systematic

STEM online courses during their education. A total of 196 valid questionnaire results remained. Data collection applied a questionnaire with 36 items, including whether students can confidently deal with various difficulties in online learning, whether they believe they can obtain more learning resources on the Internet, whether they can reasonably arrange online learning schedule, whether they have conducted academic research with their tutors, also their GPA (Grade-Point Average) for college so far and weekly online learning time. Our questionnaire referred to the Likert scale of "college students' online learning self-efficacy scale" by Xie et al. (2011) with high reliability of 0.964.

Variables

The dependent variable in our research was the GPA of STEM college STEM students. Six single choices from 1 to 6 were set to investigate their GPA. The first five choices were accordingly coded from below 2.0 (0 to 60 points) to 3.6 to 4.0 (91 to 100 points), applying every half a point in GPA as a differentiation stage. The sixth option was set as "other", representing other scores in some exceptional colleges due to different conversion rules. The reason we adopted GPA as the indicator of their academic performance is that GPA stands for the learner's academic success, learning input and output, the ability to utilize learning materials and tools, and the absorption of current curriculum design and teaching models (Pathak, 2019). Due to the algorithm varies with different countries, regions and schools, we applied and transformed the data through a unified standard of a four-point evaluation system.

The independent variable was those STEM college students' online learning self-efficacy, which was based on the participant's response to 20 single questions on that scale. By applying confirmatory factor analysis, and judging from the focus of those questions from that scale, online learning self-efficacy could be divided into four dimensions: sense of ability, sense of effort, sense of environment and sense of control. The five-point response items of the scale were: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree. The internal consistency reliabilities of each dimension test ranged from 0.83 to 0.93, which indicated that the whole scale has a high homogeneity.

The controlled variables in our research are those participants' gender and grade level (Xie et al., 2011). Specifically, female students were coded 1, and male students were coded 0. According to the response answers, 112 female students and 84 male students. As for the grade level, those participants included freshman, sophomore, junior, senior and graduates, and the corresponding number of them is 21, 37, 42, 24 and 72, respectively. Those fresh graduates who have completed their required curriculum learning were still involved in some certain form of an additional credit-related educational project, which could also contribute to our practical research.

Analyses

This study used linear regression. Linear regression enables coefficients to be interpreted directly as probabilities, which are safe when the model contains fixed effects or interaction terms. Conversely, logit and probability coefficients could not be immediately explained. Converting them to probabilities requires additional method complexity, such as marginal normalization, mean prediction, or pattern prediction (Angrist & Pischke, 2009). In addition, in the presence of interaction terms or fixed effects, nonlinear models such as logit and probit become inappropriate (nested models, for example) (Beck, 2019).

The study has reviewed the significant definitions of variables, including learning outcomes and online learning self-efficacy. It is given in the below:

Table 1: Operation Variable

Variable	Indicator	Source
Online learning self-efficacy	Sense of ability Sense of effort Sense of environment Sense of control	Xie et al., (2011)
Learning outcome	Cognitive Affective Psychomotor	Kustyarini, (2020)

Combining the development of problems, goals, and research hypotheses, the data analysis used in the study is factor analysis followed by linear regression. As the dependent variable could be directly measured by those participants' GPA in college so far, the independent variable needs to be figured out from the samples' results of that online learning self-efficacy scale, which includes 20 single questions divided into four dimensions. Before conducting the impact and correlation tests, testing the data should be done as a part of the research model. The appropriateness of indicators against variables is mainly provided by data validity. The validity of online learning self-efficacy is identified by the Kaiser-Meyer-Olkin (KMO) value. Gomila (2021) has explained that if the significance value of the factor analysis is below 0.05, then the questionnaire data is suitable for factor analysis. If the KMO value of the factor analysis is higher than 0.9, then the scale used has a very high level of validity, which means the scale used is very suitable for this research. Based on table 2, the results show that the significance value is below 0.05 and the KMO value is 0.949, so the scale applied is entirely valid and ideal for this study.

Table 2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.949
Bartlett's Test of Sphericity	Approx Chi-Square	3111.657
	Df.	190
	Sig.	.000

Through factor analysis, the result of the total variance interpretation showed that the variance contribution rate of the extracted common factor is 71.91%, which indicated that the four extracted factors could well interpret this research phenomenon. The regression result of those four factors based on the dependent variable is as follows:

Table 3: Linear Regression

Model	Unstandardized Coefficients		Standardized Coefficients			Collinear Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constants)	4.235	.059		71.326	.000		
Sense of Ability	.006	.060	.008	.108	.914	1.000	1.000
Sense of Effort	.060	.060	.072	1.004	.317	1.000	1.000
Sense of Environment	-.062	.060	-.075	-1.044	.298	1.000	1.000
Sense of Control	-.096	.060	-.115	-1.609	.109	1.000	1.000

From table 3, the linear regression equation about the independent variable (online learning self-efficacy) with its four dimensions is derived: Y (Online Learning Self-efficacy) $= 4.235 + 0.006 * X_1 + 0.06 * X_2 - 0.62 * X_3 - 0.96 * X_4$. According to that equation, the value of each participant's online learning self-efficacy could be calculated. The coefficient value of those four dimensions could indicate the relationship between those dimensions and an individual's online learning self-efficacy. If the coefficient of that dimension is minus, it means the students' scores on this dimension are inversely related to their self-efficacy. Consequently, a positive value indicated that the learners' self-efficacy would improve as the scores on that dimension increased. Based on the definition of those four dimensions and the focuses of responding questions, dimension 1 and 2 could be included as students' self-efficacy on internal factors, while dimension 3 and 4 could be included as self-efficacy on external factors. It can be said that the values of participants' online learning self-efficacy are influenced by both students' internal perception of themselves and external cognition about the environment.

Results and Discussion

Findings

Based on the linear regression equation, the value of college STEM students' online learning self-efficacy could be calculated. Integrated with those students' GPA, the descriptive statistic results are provided in table 4 below.

Table 4: Descriptive Statistics

				Mean			
	N	Minimum	Maximum		Sta. Error	Std. Deviation	Variance
GPA in College So Far	196	1	6	4.23	.059	.833	.693
Self-efficacy	196	1.309	3.425	2.145	.037	.516	.267
Number of Valid Cases (Column)	196						

As presented in Table 4, the mean of those participants' GPA was 4.23 (5 as full marks, six stands for other marking criteria), which indicated that STEM college students could also achieve qualified learning outcomes within online education. The mean of those students' online learning self-efficacy was 2.145. Based on the linear regression equation of self-efficacy and those four factors, the value of self-efficacy could reach 3.619 at most, while each of the chosen answers of X1 and X2 is 5, and that of X3 and X4 is 1. Similarly, the value of self-efficacy could be 0.129 at least, while each of the chosen answers of X1 and X2 is 1, and that of X3 and X4 is 5. Moreover, about half of the participants' values of online learning self-efficacy were more than 2.223 (60% of the full mark), and 15 students' values were over 2.921 (80% of the full mark). In general, those samples' online learning self-efficacy showed a relatively high number, which indicated that college STEM students own the ability to form a high sense of learning self-efficacy in the context of online education. College STEM students' overall self-efficacy is relatively high; female students' self-efficacy is relatively low compared to male students' self-efficacy, and liberal art students' self-efficacy is significantly lower than that of science. After calculating those students' online learning self-efficacy, the result of a linear regression of the independent and dependent variables was shown.

Table 5: Correlation

		GPA in College So Far	Self-efficacy
Pearson Correlation Coefficient	GPA in College So Far	1.000	.044
	Self-efficacy	.044	1.000
Significance (One-tailed)	GPA in College So Far		.270
	Self-efficacy	.270	
Number of Cases	GPA in College So Far	196	196
	Self-efficacy	196	196

As provided above, the Pearson correlation coefficient of those students' self-efficacy and GPA was 0.044, indicating that e-learning self-efficacy of individual learners has a positive and notable influence on their learning outcomes in college STEM education. As mentioned earlier, college students' self-efficacy in an online learning environment could not only play a role in encouraging and stimulating students' desire and motivation to learn, but also maximize students' potential and desire to learn in all aspects, so as to improve their academic performance and professional level. In order to make further analysis of the relationship between those two variables, the results of their correlation coefficients were calculated and provided as follows:

Table 6: Correlation Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients			Collinear Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constants)	4.083	.255		16.000	.000		
Self-efficacy	.071	.116	.044	.613	.045	1.000	1.000

According to the table above, the linear regression equation about the independent variable (self-efficacy) and dependent variable (learning outcomes) could be presented as Y (Learning Outcomes) $=4.083+0.071*X$ (Online learning self-efficacy). While receiving online education at the university, an individual learner's learning outcomes would be affected by a great deal of other factors besides self-efficacy, such as the college's teaching model, experimental equipment (especially in STEM), students' academic background, and their relationship with educators and classmates. Consequently, it is acceptable that the proportion of self-efficacy in students' learning outcomes is not very large in terms of numbers. However, from what has been presented above, online learners' self-efficacy could surely positively impact their learning outcomes in college STEM education.

Discussion

To begin with, self-determination theory laid a solid theoretical basis for explaining students' continuous learning motivation, which could lead to better academic performance and expected learning outcomes. Associated with ternary interaction theory, a college student would achieve higher scores in a specific field with great self-efficacy and a suitable and effective learning environment. Consequently, while analyzing the mediating impact of self-efficacy on students' learning outcomes, taking the overall quality and suitability of the online education environment into consideration would be important. Secondly, where existing literature has mainly focused on few factors which could affect students' online learning outcomes such as teaching methods, education resources, classroom interaction and teaching instruments, findings of this study highlight the need for attention toward individual learners' self-efficacy in receiving the opportunity of education. This paper can be considered as a small but important step in comprehending the complex understanding of college STEM education and the online learning context.

Our research showed that the self-efficacy of STEM college students could play a significant positive role in academic performance. Studies have shown that high self-efficacy could make students learn more actively, which is one of the benign and effective learning modes (Jeong et al., 2019). Logically, students' learning outcomes are greatly influenced by how active they are throughout the learning process (Kustyarini, 2020). The involvement of students in the learning process is mostly on emotional and intellectual facets, then they would cognize intangible changes in such a process. Specifically, students with high self-efficacy could be seen in terms of becoming a part of group work, actively discussing the material provided on classes, interacting, and persisting well during lessons (Kustyarini, 2020). Subjectivity also brings better academic quality, such as the improvement of the learning process in the classroom, which would boost students' learning motivation. In the research of Kustyarini (2020), similar findings concluded that better academic performance could be achieved by the implementation of a positive learning model with learners' high levels of self-efficacy. Chang and Chien (2015) state that self-efficacy can be considered in terms of accomplishing studies, having control over behavioural skills, and analyzing academic performance. Self-efficacy effectively can estimate the overall performance of students while analyzing their emotions in the learning process. Students' academic satisfaction is well determined by the presence of self-efficacy and academic achievement are well-improved by efficacy belief. Noreen et al. (2018) revealed that one of the major drivers of success is self-efficacy, thus students' learning outcomes are highly impacted by self-efficacy. Therefore, low self-efficacy learners are likely to be defeated by academic challenges. Still, those who have a higher level of self-efficacy can manage any adverse situation and overcome them eventually.

Although the positive effect of online learning for STEM students has been questioned by several colleges and educational organizations, the flexibility of online learning, the diversity of learning resources, and the stable and orderly learning environment constructed by the online platform could also give users a large sense of learning belonging. In addition, as traditional offline teaching might make some educators ignore students' learning experience and participation, the environment and platform of online learning have always received attention from educators and learning organization administrators from all walks of life. As a result, in the online learning platform, college students' sense of participation and connection to coursework is tightly expanded, allowing STEM students to get a certain amount of attention and supervision in the online learning environment, thereby enhancing their learning self-efficacy. STEM education plays an essential role in higher education. This paper takes the influencing factors of the learning and harvest of college STEM students as the research perspective, mainly studies the influencing mechanism of the learning outcomes of those learners, and the path of influencing factors on the academic output, and gives suggestions for improving the learning and harvesting strategies for them, also enriching the connotation of college students' learning theory.

Conclusion

Our research focused on STEM college students under Covid-19, and through investigating their academic performance and self-efficacy in online education, we find that online learning self-efficacy has a prominent and positive impact on learning outcomes. It provided possible applications and enlightenment for all stakeholders in the college online education system. For STEM college students, it is essential to enhance their self-efficacy in online learning. During the boosting process, several active and positive behaviours and states would be activated to help them achieve better learning outcomes. Students would more actively participate in academic activities and interact with others to develop the self-evaluating competency for performing an activity, overcome hindrances and finally attain their goals. Emotional intelligence and positive mood would also be aroused to avoid procrastination and fear of failure in the online learning process. For school decision-makers, it is required to construct flexible and effective online learning systems to facilitate STEM college students' learning motivation and improve online channels to maximize their full potential.

Certainly, our research has its limitations. First, the GPA of STEM college students should include their experimental comprehensive ability and classroom hands-on performance, which was neglected under the pandemic context. Second, more factors should be taken into account like unequal motivations, learning styles, different learning resources, etc. Third, our research is limited to the Chinese background. Although some demographic factors have been considered, we would like to

know the progress of similar research in different contexts, so as to enlighten higher education under the epidemic

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Declaration of Interest Statement

The authors declare that they have no conflicts of interest.

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