



Polynomial Regression and Response Surface Model Analysis on the Impact of the Consistency of Self-regulated Learning and Interaction on Online Learning Performance Based on Python

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Abstract. Based on the constructivism learning theory, through the use of Python computer technology for polynomial regression and response surface modelling, data analysis and graphic rendering, this study clarifies the differential influence of the configuration of self-regulated learning (SRL) and three kinds of interaction (INT) on online learning performance (OLP) and the mediating effect of self-efficacy (SFE). A total of 765 students in electrical-related majors participated in this online survey. The results show that: firstly, the higher the consistency of SRL and student-teacher interaction (STI), the more conducive to the improvement of SFE; when the consistency of the two is higher, the configuration of “high SRL-high STI” on SFE is stronger than the configuration of “low SRL-low STI”; when the two are in inconsistency, the configuration of “high SRL-low STI” has a stronger effect on SFE than the configuration of “low SRL-high STI”; Secondly, when the consistency of SFE and student-student interaction (SSI) is high, the configuration of “high SRL-high SSI” has a stronger effect on SFE than the configuration of “low SRL-low SSI”. Thirdly, SFE plays a mediating role in the configuration of SFE and three kinds of interaction on OLP. The practical significance and the specific mechanism of teachers’ training students to become better self-regulated and high-performance students in online courses, as well as teachers’ improving the quality of online courses also be discussed in the context of intelligent and distance education. And an application reference for computer modelling and data analysis also be provided.

Keywords: self-regulated learning · interaction · online learning performance · self-efficacy · Python · polynomial regression and response surface model

1 Introduction

Due to the influence of the COVID-19 epidemic, teachers and students in Chinese universities are isolated at home. In line with the requirement of “Suspended class, Ongoing

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learning”, various colleges and universities have carried out online learning through various platforms such as “Nail”, “Super Star Learning APP”, “Zoom” and so on. But with the development of intelligent and distance, the discussion of online learning performance (OLP) is also increasing. Many studies have shown that the following problems are common in online classrooms: high dropout rate, difficulty in learning process evaluation, low curriculum satisfaction, and difficulty in concentration of students [12]. Compared with traditional learning, whether and how online learning can produce better results is an urgent issue to be discussed. There are many factors affect the OLP, including students’ individual factors [6], social factors in the learning environment and so on. Among them, self-efficacy (SFE) is the main performance of learners’ active constructiveness, and it will affect some key aspects, thus affecting the learning effect [4]. Previous studies on SFE in online learning have mostly focused on technology, thus ignoring the research on the relationship between students and specific online learning technology or results [14]. With the development of technology, college students’ confidence and comfort in online learning activities have been significantly improved, and the focus of research should be shifted from technical SFE to students’ confidence in their ability to successfully carry out, learn, participate in and complete online courses; Self-Regulated learning (SRL) refers to the process in which learners voluntarily set goals, adopt various strategies, monitor and evaluate their behaviours and learning effects in order to achieve their learning goals [7]. SRL focuses on learners and emphasizes learners’ initiative in the learning process. Through observation and judgment of individual behaviour, SRL process is carried out under the influence of surrounding environment. Social factors of learning environment mainly include interaction (INT). According to the constructivist learning theory, learning is a process in which learners actively construct meaning based on their original knowledge and experience in social interaction with others. The most prominent interaction framework in distance education includes three main aspects: student-teacher interaction (STI), student-student interaction (SSI), and student-content interaction (SCI) [11].

Previous studies have focused on social factors in learning environment or individual psychology of learners [2]. Most of them ignored separately exploring the relationship between three types of INT and OLP, subjective learning experience and the mechanism of OLP from a broader perspective, such as the synergistic effect of individual and social environment factors. It’s rare to find studies on how students adjust themselves through INT to affect OLP.

Hence, under the guidance of constructivism learning, this study provides us with an opportunity to explore how the configuration of individual level and social factors variables in learning environment can affect OLP through individual internal psychological variables based on three types of INT, that is, how the configuration of students’ SRL and three types of INT affect OLP through the exertion of SFE, and whether there are differences in the impact. In looking forward, we provide research reference for the allocation of individual and social environment factors in the process of online learning, and to improve the OLP and teaching quality of universities which suggest directions for the future.

After the following Theoretical development and research hypothesis, Sect. 3 outlines the method. Section 4 details the results: descriptive statistics and quantitative

results of the studies. Section 5 discusses the conclusions and implications for future research.

2 Theoretical Development and Research Hypothesis

2.1 The Consistency Effect of SRL and INT on SFE

Student-teacher, student-student and student-content interactions are the core elements of the learning experience in an online environment. These interactions will continue to inform current research on instructional design, teaching practice and student learning in a broader context. According to the perspective of social cognition, learning is produced through the interaction between various individual factors and the environment. In the social context of learning, students learn knowledge through interaction, correct interpretation and action, that is interaction does not happen automatically, but is realized by interaction frame-work built by technology and teachers [10]. Online learning is a self-regulated learning process, consequently, active interaction with others in an online learning environment requires a certain degree of SRL. Once learners get better external resources, such as STI, SSI, SCI, they will activate internal resources (SRL). The other way round, the quality of learners' internal resources will also affect their demand for external resources. Internal and external factors work together. Self-efficacy is defined as "people's judgment on their ability to organize and execute actions required to achieve a certain goal". In other words, self-efficacy is related to individual confidence in the ability to successfully accomplish goals, motivation intensity, positive and negative emotions accompanying the learning process, and the degree of preparation for participation INT as an external factor and SRL as an internal factors may have a combined impact on self-efficacy.

Consequently, from the perspective of external social level and individual internal level consistency, this study speculates that students' SRL and INT can achieve the complementary advantages and synergistic effects of constructivism learning and SFE. Based on this, the hypothesis 1 is proposed:

H1: SFE increases when SRL and INT are congruent or at similar levels and decrease when they are incongruent or at different levels.

H1a: SFE increases when SRL and SCI are congruent or at similar levels and decrease when they are incongruent or at different levels.

H1b: SFE increases when SRL and STI are congruent or at similar levels and decrease when they are incongruent or at different levels.

H1c: SFE increases when SRL and SSI are congruent or at similar levels and decrease when they are incongruent or at different levels.

2.2 Difference Effect in the Case of Consistency Effect

The consistency state of SRL and INT is not always the only one. There are also high and low levels in the consistency state, that is, “high SRL-high INT” and “low SRL-low INT”. The difference between the two in the same state will also have a difference effect on SFE. The interaction between students and teachers can make students’ emotions rise, improve their enthusiasm, confidence, and motivation [5]. The higher the learning motivation and confidence of students, the higher the initiative to construct knowledge, the higher the SFE, the better the academic performance. Students who master higher SRL ability can adjust motivation, emotion, cognition, behaviour, and metacognition, choose appropriate learning strategies, constantly carry out self-monitoring, improve learning self-confidence, so that can optimize learning performance. INT and SRL both have a positive impact on the improvement of SFE. Hence, it can be inferred that under the dual high state of SRL and INT, students’ SFE is obviously stronger than the dual low state of SRL and INT. In other words, individual constructivism learning and social constructivism learning rise from the consistency of two at low levels to the high levels, students’ SFE and OLP will improve in a good direction. Based on this, hypothesis 2 is proposed:

H2: When the intensity of SRL and INT is congruent or at similar levels, high level of SRL and INT configuration is more conducive to SFE than they are in the low level.

H2a: When the intensity of SRL and SCI is congruent or at similar levels, high level of SRL and SCI configuration is more conducive to SFE than they are in the low level.

H2b: When the intensity of SRL and STI is congruent or at similar levels, high level of SRL and STI configuration is more conducive to SFE than they are in the low level.

H2c: When the intensity of SRL and SSI is congruent or at similar levels, high level of SRL and SSI configuration is more conducive to SFE than they are in the low level.

2.3 Asymmetric Effect in the Case of Inconsistency

When the SRL and INT are in a state of inconsistency, two configurations of “high SRL-low INT” and “low SRL-high INT” are distinguished. According to the hypothesis put forward above, the effect of the inconsistency between the two on SFE is less than that of the consistency. However, students’ SRL and INT can still play a role through the route of “one dominant, one auxiliary”, but which one plays a dominant role and which one is supplementary needs to be further explored. Individual learning and social learning are not mutually exclusive, but contradictory unity: individual learning is the basis of social learning. If there is no foreshadowing of individual learning in online learning, it is difficult to achieve ideal results. Individual learning is the cornerstone of social learning. It has been found that the increase of platform resources in universities has not improved the quality and performance of online courses, which is attributed to the lack of discipline among students [15]. Accordingly, this study infers that the high SRL can better induce their learning initiative and interest, and make more effective use

of interaction. Students play a leading role in the learning process. Compared with low SRL-high INT, it can improve their SFE and optimize OLP better. Based on the above, hypothesis 3 is proposed:

H3: When the intensity of SRL and INT is not consistent, the configuration of high SRL-low INT is more conducive to SFE than the configuration of low SRL-high INT.

H3a: When the intensity of SRL and SCI is not consistent, the configuration of high SRL-low SCI is more conducive to SFE than the configuration of low SRL-high SCI.

H3b: When the intensity of SRL and STI is not consistent, the configuration of high SRL-low STI is more conducive to SFE than the configuration of low SRL-high STI.

H3c: When the intensity of SRL and SSI is not consistent, the configuration of high SRL-low SSI is more conducive to SFE than the configuration of low SRL-high SSI.

2.4 The Mediating Effect of SFE

Learners with strong SRL ability are not only aware of task needs, but also be able to choose appropriate learning strategies [8], constantly carry out self-monitoring, greatly improve their confidence level so that can improve their sense of SFE, and then optimize their learning performance. Hence, this study speculates that when the intensity of SRL is consistent with three kinds of INT, each configuration exists in the form of “complementary advantages”, which can promote the improvement of students’ SFE. Past research, such as the expectancy value theory of motivation, indicates that individual learning motivation is directly related to individual ability belief, expectation of success and subjective task value. SFE can directly affect learning performance [3]. Learners with high SFE are more likely to believe that they will succeed and make more efforts when facing difficult tasks, so their online learning performance will be better and they prefer online learning environment, so that they can use the Internet to explore problems, show the sources of various problems, and elaborate knowledge through learning activities. Learners with low SFE are less likely to fully participate in online systems or content due to a lack of self-confidence. In conclusion, due to the importance of SFE in online learning and the lack of research on emotional results, this study proposes that SFE is an important factor beyond INT, and SFE is a mediated variable between the configuration of SRL and INT and OLP. Accordingly, hypothesis 4 is proposed:

H4: SFE plays a mediating role in the relationship between the configuration of SRL-INT and OLP.

H4a: SFE plays a mediating role in the relationship between the configuration of SRL-SCI and OLP.

H4b: SFE plays a mediating role in the relationship between the configuration of SRL-STI and OLP.

H4c: SFE plays a mediating role in the relationship between the configuration of SRL-SSI and OLP.

3 Method

3.1 Sample and Data Collection

In terms of sample selection, we mainly focus on university students in electrical related majors, including vocational education and undergraduate education as much as possible. Online questionnaire service website “Questionnaire Star” was selected for online data collection. 900 questionnaires are expected to be sent out to ensure the authenticity and validity of the collected data. The data collecting lasted for one month in April 2022, and 887 questionnaires were recovered, among which 122 invalid questionnaires such as missing selection and logic error were eliminated, 765 valid questionnaires were obtained. The effective questionnaire recovery rate was 86.40%.

Use Python for data modelling and data analysis. The main characteristic of the sample is shown in Table 1. In terms of gender, 53.86% of the respondents were men and 46.14% were women. From the perspective of whether they have online learning experience before the epidemic, the proportion of students who have had online learning experience is 25.62%, the proportion of students without online course learning experience is 74.38%, indicating that most of the samples have no online learning experience before the epidemic, and online learning may have challenges. In terms of the number of online learning courses, the samples are mainly 7–9 courses, accounting for 51.63%, followed by 4–7 courses, accounting for 31.38%, which means that during the epidemic, most of the courses of most of the students were learned online.

3.2 Measures

The questionnaire mainly uses the self-report method, and uses Likert five level scale to investigate the degree of identification of the respondents to the items. Among them, “1” represents “strongly disagree” and “5” represents “strongly agree”. SRL was measured by “self-regulated learning” scale with 10 items in total [9]. SCI adopts the “student-content interaction scale” with 4 items in total. STI was measured by “student-teacher interaction scale” with 6 items in total. SSI adopts the “student-student interaction scale”

Table 1. Characteristics of the sample.

Variable	Classification	Frequency	Percent
Gender	Female	353	46.14%
	Male	412	53.86%
Previous online course experience	Yes	196	25.62%
	No	569	74.38%
Number of online courses	1–3	32	4.18%
	4–7	240	31.38%
	7–9	395	51.63%
	More than 10	98	12.81%

with 8 items in total. SFE was measured by “online learning self-efficacy scale” which contains 8 items totally. OLP adopts the “online learning performance scale” with 5 items [13].

The research on students’ SFE and online INT should consider the demographic variables of students, including age, gender, previous online learning experience, and online learning preferences. Accordingly, we controlled for the following factors: (1) Gender. (2) Previous online learning experience. (3) Popularity of Teachers [1].

4 Analyses and Results

4.1 Reliability and Validity

All constructs’ Cronbach alphas and the composite reliabilities (CRs) are higher than the commonly recommended 0.7. All of them have high reliability, which indicates that there is high internal consistency and reliability between the items of each variable. The factor load of all items is more than 0.7. Besides, the results show that the square root of AVE of each structure is larger than the correlation between potential variables and other variables, which also proves the validity of the discrimination. Thirdly, through confirmatory factor analysis, a multi factor competition model is constructed. The six-factor model has the best fit index compared with other models ($\chi^2/df = 4.824$, CFI = 0.911, TLI = 0.905, AGFI = 0.762, RMSEA = 0.078). It is proved that SRL, SCI, STI, SSI, SFE and OLP all have good differential validity.

4.2 Common Method Variance

The results of factor analysis showed that the six factors with characteristic root greater than 1 explained 74.618% variance, and the percentage of variance was 28.836%, 11.272%, 10.338%, 9.306%, 8.235% and 6.631%, respectively. There is no general factor that can accounts for most of the variance, so it can be considered that the problem of common method biases will not have a significant impact in this study.

The results show that the average value of VIF of each model is about 3, which is far less than 10 and shows that the multicollinearity problem is under control and will not affect the accuracy of the regression results.

4.3 Main Effect Testing Results

Model 1, 2, and 3 in Table 2 respectively show the results of SCI, STI, SSI on SFE’s polynomial regression and response surface model analysis. We calculate the coefficients and significance of the slope and curvature in the sections corresponding to the consistency line and the inconsistency line in turn, and draw the three-dimensional response surface according to the data in the results, as shown in Fig. 1, Fig. 2, and Fig. 3 by python.

According to the Model 1, SRL, SCI, SCI² and SFE have significant positive correlation. Under the condition of consistent matching ($X = Y$), the slope is significantly positive and the curvature is significantly negative (slope = 0.84, $P < 0.001$, curvature = -0.05, $P < 0.001$). That is, when the SRL and SCI are consistent, the combined effect

Table 2. Polynomial regression and response surface analysis results (n = 765)

Variables	Model1 SCI_SFE	Model2 STI_SFE	Model3 SSI_SFE
SEX	0.01	0.029	0.019
EXP	0.016	-0.012	-0.025
LIK	0.120***	0.045	0.083*
Independent variables	-	-	-
SRL	0.498***	0.554***	0.437***
SRL ²	-0.098	-0.225**	-0.205
SCI	0.290***	-	-
SCI ²	0.156**	-	-
SRL*SCI	-1.113	-	-
STI	-	0.181**	-
STI ²	-	0.170**	-
SRL*STI	-	0.052	-
SSI	-	-	0.061
SSI ²	-	-	0.326***
SRL*SSI	-	-	0.078
Congruence line ($X = Y$)	-	-	-
Slope ($b_1 + b_2$)	0.84***	0.84***	0.82***
Curvature ($b_3 + b_4 + b_5$)	-0.05***	-0.02	-0.06
Incongruence line ($X = -Y$)	-	-	-
Slope ($b_1 - b_2$)	0.32***	0.45***	0.19
Curvature ($b_3 - b_4 + b_5$)	0.11	-0.09***	-0.14
Model fit	-	-	-
F-value	127.217***	123.789***	140.560***
Adj-R2	0.569	0.563	0.561

Note: 1. Gender (SEX); Previous online course experience (EXP); Popularity of Teachers (LIK); Self-regulated learning (SRL); Student-content interaction (SCI); Student-teacher interaction (STI); Student-student interaction (SSI); Online learning performance (OLP). 2. Table entries are standardized regression coefficients (β). 3. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

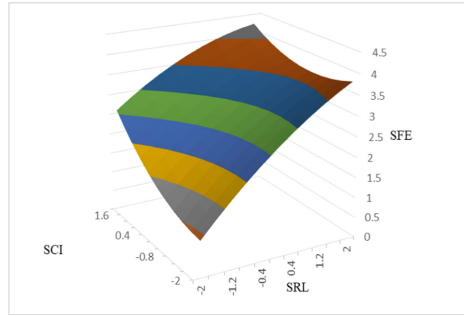


Fig. 1. Congruence and Incongruence Effects of SRL and SCI.

of the two has a negative curve relationship with SFE, assuming that Hypothesis 2a is not tenable; under the condition of inconsistent matching ($X = -Y$), the slope is significantly positive, and the curvature is not significant (slope = 0.32, $P < 0.001$, curvature = 0.11, $P > 0.05$). That is, when the SRL and SCI are inconsistent, the combined effect of the two has a positive linear relationship with SFE, as shown in Fig. 1, assuming that neither Hypothesis 1a and Hypothesis 3a are valid.

From the Model 2 and Fig. 2, there are significant positive correlation among SRL, STI, STI^2 and SFE, and significant negative correlation between SRL^2 and SFE. Under the condition of consistency matching ($X = Y$), the slope is significantly positive but the curvature is not significant (slope = 0.84, $P < 0.001$, curvature = -0.02 , $P > 0.05$). That is, when SRL and STI are in consistency, the combined effect of SRL and STI has a significant positive linear relationship with SFE. The higher the consistency of SRL and STI is, the larger the SFE is, supporting the Hypothesis 2b. Under the condition of inconsistent matching ($X = -Y$), the slope is significantly positive and the curvature is significantly negative (slope = 0.45, $P < 0.001$, curvature = -0.09 , $P < 0.001$), indicating that there is an inverted U-shaped surface relationship among SRL, STI and SFE. Specifically, the curvature is significantly negative, indicating that in the process of changing from high STI-low SRL inconsistency to low STI-high SRL inconsistency, when SRL and STI become more and more discrepant, SFE decreases, that is, SFE increases when SRL and STI are congruent or at similar levels, supporting the Hypothesis 1b and 3b.

From the Model 3, SRL, SSI^2 and SFE have significant positive correlation. Under the condition of consistent matching ($X = Y$), the slope is significantly positive and the curvature is not significant (slope = 0.82, $P < 0.001$, curvature = -0.06 , $P > 0.05$). When the SRL and SCI are in consistency, the combined effect of the two has a significant positive linear relationship with the SFE. The higher the consistency of the SRL and SCI is, the greater the SFE is, supporting the Hypothesis 2c; but under the condition of inconsistent matching ($X = -Y$), the slope and curvature are not significant (slope = 0.19, $P > 0.05$, curvature = -0.14 , $P > 0.05$), as shown in Fig. 3, assuming that Hypothesis 1c and Hypothesis 3c are not valid.

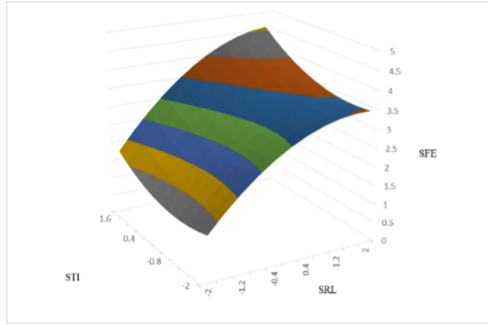


Fig. 2. Congruence and Incongruence Effects of SRL and STI.

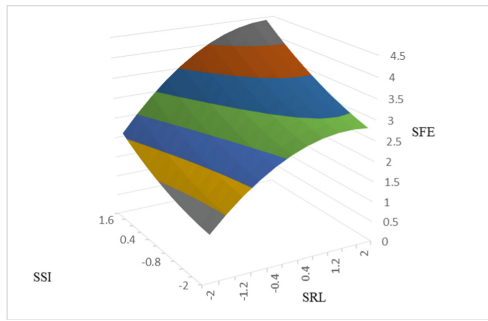


Fig. 3. Congruence and Incongruence Effects of SRL and SSI.

4.4 Mediating Effect Testing Results

In order to test the mediating effect of SFE between three kinds of INT and OLP respectively, block variable approach is used to analyse Specifically, a block variable is constructed based on the polynomial regression coefficient to represent the synergistic effect of SRL and INT on SFE. On this basis, the calculation results of bootstrap 5000 times are used for analysis. It can be seen from Table 3 that the 95% confidence interval of the indirect effect of block variable 1 on online learning performance is [0.0202, 0.1686], the 95% confidence interval of the indirect effect of block variable 2 on online learning performance is [0.1533, 0.3625], and the 95% confidence interval of the indirect effect of block variable 3 on online learning performance is [0.0452, 0.1940], none of which contains 0, indicating that SFE has significant mediating effect on the relationship between SRL and three configurations of SCI, STI, SSI and OLP, which proves that mediating effects exist, and Hypothesis 4a, 4b and 4c are verified.

Table 3. Mediating effects test (Bootstrap)

Variables	Effects	Bootstrapping	
		Bias - Corrected 95%CI	
		Lower	Upper
BLOCK1⇒OLP	Direct effect	1.0429	1.1890
	Indirect effect	0.0202	0.1686
BLOCK2⇒OLP	Direct effect	1.1831	1.4056
	Indirect effect	0.1533	0.3625
BLOCK3⇒OLP	Direct effect	1.0012	1.1532

5 Conclusions and Implications

The higher the degree of consistency between students' SRL and STI, the greater the degree of improving OLP through SFE. Once the two are inconsistent, SRL plays a greater role than STI. Therefore, when learners' SRL ability is weak, their learning goal setting, strategy adjustment and time management need to be coordinated with external support. For the students with strong SRL ability, they have a strong sense of self-determination. Too much social environment support reduces the students' subjective initiative, which interferes with learning, and the interaction between teachers and students should play an auxiliary role. Consequently, online learning educators can consciously cultivate learners' SRL ability by designing specific learning tasks. When the consistency of learners' SRL and SSI are in a high state, the greater the degree of improving OLP through SFE. The development of online courses not only requires students to have strong interest in the content, but also requires real-time exchange and feedback of views and problems between students. A good online course discussion atmosphere and SSI can enhance students' motivation and sense of belonging in online learning, which can help to improve OLP. The consistency configuration of SRL and SCI has no significant effect on OLP through SFE. Accordingly, in terms of the provision and presentation of curriculum resources, educators should add relevant professional courses according to the needs of professional learning, and classify the courses according to the major, to facilitate learners' learning and access. In the aspect of curriculum content organization, educators should grasp the difficulty and continuity of curriculum, systematically organize and teach curriculum knowledge and content, instead of blindly emphasizing "short, flat and fast".

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References

1. Alqurashi E (2016) Self-efficacy in online learning environments: a literature review. *Contemp Issues Educ Res (CIER)* 9(1):45–52
2. Barratt JM, Duran F (2021) Does psychological capital and social support impact engagement and burnout in online distance learning students? *Internet High Educ* 51:100821
3. Cetin-Dindar A (2015) Student motivation in constructivist learning environment. *EURASIA J Math Sci Technol Educ* 12(2)
4. Dennen VP, Darabi AA, Smith LJ (2007) Instructor–learner interaction in online courses: the relative perceived importance of particular instructor actions on performance and satisfaction. *Distance Educ* 28(1):65–79
5. Domagk S, Schwartz RN, Plass JL (2010) Interactivity in multimedia learning: an integrated model. *Comput Hum Behav* 26(5):1024–1033
6. Hew KF, Cheung WS (2014) Students' and instructors' use of massive open online courses (MOOCs): motivations and challenges. *Educ Res Rev* 12:45–58
7. Kauffman DF, Zhao R, Yang Y-S (2011) Effects Of online note taking formats and self-monitoring prompts on learning from online text: using technology to enhance self-regulated learning. *Contemp Educ Psychol* 36(4):313–322
8. Koopmans M (2019) Education Is a complex dynamical system: challenges for research. *J Exp Educ* 88(3):358–374
9. Kuo Y-C, Walker AE, Schroder KEE, Belland BR (2014) Interaction, Internet self-efficacy, and self-regulated learning as predictors of student satisfaction in online education courses. *Internet High Educ* 20:35–50
10. Mamun, MdAA, Lawrie G, Wright T (2020) Instructional design of scaffolded online learning modules for self-directed and inquiry-based learning environments. *Comput Educ* 144:103695
11. Moore MG (1989) Editorial: three types of interaction. *Am J Distance Educ* 3(2):1–7
12. Mouratidis K, Papagiannakis A (2021) COVID-19, Internet, and mobility: the rise of telework, telehealth, E-learning, and E-shopping. *Sustain Cities Soc* 74:103182
13. Shen D, Cho M-H, Tsai C-L, Marra R (2013) Unpacking online learning experiences: online learning self-efficacy and learning satisfaction. *Internet High Educ* 19:10–17
14. Tang Y, Tseng HW (2013) Distance learners' self-efficacy and information literacy skills. *J Acad Librariansh* 39(6):517–521
15. Zhang Y, Yuan T, Yao L, Duan C, Sun X, Niu G (2022) Individual differences matter in the effect of teaching presence on perceived learning: from the social cognitive perspective of self-regulated learning. *Comput Educ* 179:104427

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