# Research on the Improvement Path of College Students' Online Self-regulated Learning Ability

Ling Zhang[1], Yueyao Wang[2], Shaodong Xia[3]

{heuzl@126.com[1], w18631240285@163.com[2], 353181147@qq.com[3]}

School of Economic and Management, Harbin Engineering University, Hei Longjiang Harbin, 150001, China

**Abstract:** Using fuzzy set qualitative comparative analysis method, the influence of four variables——learning experience(LE), learning motivation(LM), learning strategy (LS)and environmental fitness(EF)——on college students' online self-directed learning ability(OSLA) is explored. Through configuration analysis, the improvement path of college students' online self-directed learning ability is found. The results show that the three ways to improve OSLA always contain LM, and the combination of LM with any two variables of LE, LS and EF can improve OSLA. The absence of any of the three variables can reduce college students' OSLA.

**Keywords:** qualitative comparative analysis of fuzzy sets; learning experience; learning motivation; online self-directed learning ability

## 1    Introduction

In order to accelerate the formation of a diversified online education management service pattern, the Chinese Ministry of Education proposed to construct a policy system to support the development of online education in 2019[1]. To meet the needs of students' online self-directed learning, many schools have relied on online learning platforms such as MOOC, Chaoxing Learning Connect, and Wisdom Tree to release learning resources since 2020. Online learning has become one of the important learning methods for college students. The phenomenon of relatively low self-directed learning ability among college students is reflected through the process of online self-directed learning, so it is crucial to find ways to improve online self-directed learning ability. To seek the best path to improve college students' self-directed learning ability, college students were selected as the research object, and the combination of key elements affecting college students' online self-directed learning ability was comprehensively analyzed by using the qualitative comparative analysis of fuzzy sets.

The improvement of the online self-directed learning ability of college students is influenced by four factors: learning experience, learning motivation, learning strategy and environmental fitness.

### 1.1    Learning experience

Learning experience refers to students' feelings and reactions to various aspects such as the learning environment, learning activities, and learning interactions. Joo(2015) found that there is a significant relationship between students' self-directed learning ability and perceived

positive emotions such as usefulness, usability, fun, and interest during online learning, so students' learning experience may affect the effectiveness of self-directed learning [2]. From the perspective of the information system (IS) model [3], students' experience of online interactive activities is considered to be the key factor to stimulate students' learning motivation [4].

## 1.2 Learning motivation

Learning motivation is a psychological state that leads students to believe that learning activities are meaningful and valuable. It can guide and promote students to engage in learning activities. And it is an inherent driving force that motivates students to progress and strive towards designated learning goals. Self-directed learning is decomposed by scholars into the process of conducting learning activities and achieving learning goals under certain learning motivation conditions [5].

## 1.3 Learning strategy

Learning strategies are a series of learning activities in which students use effective learning methods to improve learning efficiency and effectiveness, and ultimately complete the learning content under specific backgrounds, tasks, and requirements. Self-directed learning emphasizes learning autonomy, which is mainly reflected in self-generated goals (learning motivation) and self-regulated behaviors (learning strategies). Therefore, learning strategy is an indispensable component of the influencing factors of college students' online self-directed learning ability.

## 1.4 Environmental fitness

Environmental fitness is a personal characteristic of the student, mainly referring to the ability to adapt to the constantly changing learning environment by regulating thoughts, behaviors, and emotions. Online learning environment fitness is an important factor for students to play a self-directed learning role in a given environment.

The above four influencing factors were selected as the antecedent variables, and college students' online self-directed learning ability was taken as the result variable. To find out the paths to improve college students' online self-directed learning ability, the Qualitative Comparative Analysis of the Fuzzy Set (fsQCA) is used for configuration analysis, as shown in Figure 1.
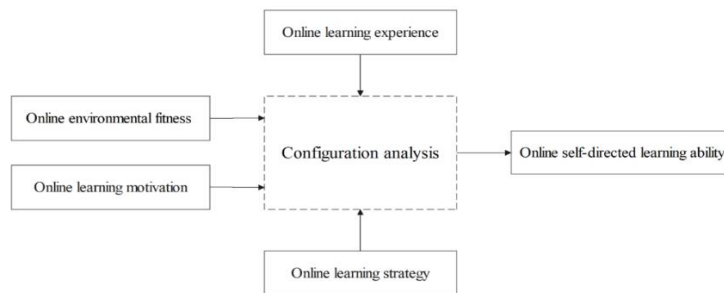


**Figure 1.** Factors influencing online self-directed learning ability of college students

## 2    Research method and data source

### 2.1    Research method

Qualitative Comparative Analysis (QCA) is a new method based on Boolean Algebra and Set Theory to analyze complex causal relationships in configuration problems. QCA, as a new method combining quantitative and qualitative comparative analysis, provides a new approach to the study of recurrent causal relationships such as asymmetry, concurrent causality, and equivalence in management [6]. It also provides strong support for the research of configuration problems that combine phenomenon-driven and theoretical-driven [7]. The main reasons for choosing the fsQCA method to explore the improvement path of college students' self-directed learning ability include the following: Firstly, it can explore multiple pathways for the same result; Secondly, it reflects the asymmetry between causality; Thirdly, it can effectively handle the complexity of the antecedent variables.

### 2.2    Variable measurement

A survey questionnaire was developed by searching and reading relevant literature and based on expert interviews, as shown in Table 1. The research variables were all measured using the Likert 5-point scale for construct measurement, with 1 indicating "very inconsistent" and 5 indicating "very consistent".

**Table 1.** Questionnaire composition

| Scale | Dimension | Item | Basis |
|---|---|---|---|
| Learning experience | Teaching mode experience | 4 | Albalbisi (2019) designed the translation, organization, and localization modification of the "Network Environment Scale" [8] |
| | Interactive activity experience | 5 | |
| | Platform environment experience | 5 | |
| Learning motivation | Internal motivation | 6 | Chi Liping(2006) compiled an adaptation design of the "Learning Motivation Scale", adding elements of the online environment [9] |
| | External motivation | 6 | |
| Learning strategy | Metacognitive strategy | 5 | Zhou Guotao (2002) developed an adapted design for the "Learning Strategy Scale", adding online environmental elements [10] |
| | Cognitive strategy | 6 | |
| | Resource management strategy | 8 | |
| Environmental fitness | Learning environmental fitness | 6 | Guo Jidong (2021) adapted the "College Students' Adaptability Scale for Foreign Language Learning" and deleted English learning elements [11] |
| Online self-directed | Information processing | 4 | Adapted the design using Lin Lilan's |

| learning ability | ability | | (2013) [12] and Zhu Zude's (2005) |
|---|---|---|---|
| | Online planning ability | 4 | [13]"Self-learning Assessment |
| | Online execution ability | 4 | Measurement Table" and added online |
| | Online evaluation ability | 4 | environmental elements |

## 2.3 Data collection and reliability and validity analysis

Undergraduate students from five science and engineering universities − including Harbin Engineering University, China University of Mining and Technology, Harbin Institute of Technology, Heilongjiang University, and Harbin University of Science and Technology − were selected as the research subjects. 728 valid questionnaires were finally collected and the reliability and validity of the questionnaire data were tested and the results are shown in Table 2.

**Table 2.** Questionnaire Reliability and Validity Checklist

| Scale | Item | α | CR | AVE |
|---|---|---|---|---|
| Teaching mode experience | 6 | 0.833 | 0.835 | 0.561 |
| Platform Environment Experience | 6 | 0.847 | 0.85 | 0.535 |
| Interactive activity experience | 5 | 0.857 | 0.86 | 0.554 |
| Internal motivation | 6 | 0.873 | 0.877 | 0.546 |
| External motivation | 8 | 0.866 | 0.87 | 0.53 |
| Metacognitive strategy | 4 | 0.834 | 0.836 | 0.508 |
| Cognitive strategy | 4 | 0.869 | 0.873 | 0.536 |
| Resource management strategy | 4 | 0.905 | 0.906 | 0.549 |
| Learning environmental fitness | 6 | 0.883 | ＞0.6 | ＞0.5 |
| Information processing ability | 4 | 0.834 | 0.841 | 0.573 |
| Online planning ability | 4 | 0.812 | 0.815 | 0.527 |
| Online execution ability | 5 | 0.807 | 0.811 | 0.521 |
| Online evaluation ability | 5 | 0.831 | 0.833 | 0.557 |

## 2.4 Variable calibration

The first step is to calibrate the original data. Because the measured values of the questionnaire data are relative, most of the results will appear in the range of 3, 4, and 5. The data appears to be Normal distribution, which is taken into fsQCA for analysis. The results may not be ideal, and it is difficult to generate simple solutions. Therefore, the original data should be normalized. The second step is to convert the processed data into membership scores within the [0,1] interval by setting anchor points. Based on the summary of existing literature, the maximum value is set as the full membership point, and the minimum value is set as the full non-membership point. Select the mean or median as the most ambiguous point according to whether the variable data conforms to the Normal distribution. The final variable calibration is shown in Table 3.

**Table 3.** Data calibration

| | Variable | Collection Target | Minimum | Average | Maximum |
|---|---|---|---|---|---|
| Result variable | Online self-directed learning ability (OSLA) | strong | 1.81 | 3.49 | 4.31 |
| Antecedent variables | Learning motivation (LM) | strong | 1.42 | 3.97 | 4.75 |
| | Learning strategy (LS) | multiple | 2.16 | 3.52 | 4.05 |
| | Learning experience (LE) | good | 2.07 | 3.41 | 4.36 |
| | Environmental fitness (EF) | high | 1.00 | 2.78 | 4.67 |

# 3  Data analysis and empirical results

## 3.1  Configuration analysis of improving online self-directed learning ability

### 3.1.1 Necessity analysis

Determine whether each antecedent variable is a necessary condition for improving online self-directed learning ability through necessity testing, as shown in Table 4. The results showed that the consistency of the antecedent variables did not exceed 0.9, so the presence of all antecedent variables did not constitute a necessary condition.

**Table 4.** Necessity test of improving online self-directed learning ability

| Antecedent variables | Consistency of antecedent variables | Coverage rate of antecedent variables |
|---|---|---|
| Learning motivation (LM) | 0.837616 | 0.720773 |
| ～Learning motivation (～LM) | 0.411392 | 0.791852 |
| Learning strategy (LS) | 0.771360 | 0.751628 |
| ～Learning strategy (～LS ) | 0.535931 | 0.817733 |
| Learning experience (LE) | 0.743262 | 0.811773 |
| ～Learning experience (～LE) | 0.624261 | 0.814925 |
| Environmental fitness (EF) | 0.642017 | 0.773003 |
| ～Environmental fitness (～EF) | 0.676938 | 0.795378 |

### 3.1.2 Adequacy analysis

Adequacy analysis is the exploration of the adequacy of results caused by different configurations of multiple antecedent variables. From the perspective of Set Theory, it is to study whether the configuration set composed of multiple antecedents is a subset of the set which can improve college students' online self-directed learning ability.

Firstly, the fuzzy values of all antecedent variables are converted into clear values (0 or 1) by constructing the fuzzy Truth table. Secondly, set the threshold of original coverage and the threshold of PRI consistency for the Truth table. Finally, three results were obtained through standardized analysis: complex solution, simple solution, and intermediate solution. Since there are many single samples in the Truth table results, too many final configurations are not conducive to the formation of effective results, so the number threshold of the Truth table is

set to 21, and the number of remaining samples exceeds 80% (more than 75%), which will not affect the analysis results. Set the original consistency threshold to 0.8, sort the PRI consistency values, select samples with PRI consistency values less than 0.75, and manually change the result variable to 0.

Based on Ragin's expression of configuration, "●" is used to indicate the existence of the antecedent variable, "⊗" is used to indicate the absence of the antecedent variable, blank is used to indicate whether the dependent variable can be absent or present, "●" is used to indicate the existence of the core condition, and "⊗" is used to indicate the absence of the core condition. The configuration combination table is drawn based on simple and intermediate solutions. The configuration analysis results for improving online self-directed learning ability are shown in Table 5.

**Table 5.** Configuration for improving online self-directed learning ability

|  | A1 | A2 | B |
| --- | :---: | :---: | :---: |
| Learning motivation | ● | ● | ● |
| Learning strategy | • |  | ● |
| Learning experience |  | • | ● |
| Environmental fitness | ● | ● |  |
| Consistency | 0.84 | 0.86 | 0.84 |
| Original coverage rate | 0.49 | 0.47 | 0.54 |
| Net coverage rate | 0.07 | 0.06 | 0.12 |
| Overall consistency | 0.82 | | |
| Overall coverage rate | 0.67 | | |

The consistency of the three paths is greater than 0.8, the overall consistency of the configuration is also greater than 0.8, and the overall coverage is greater than 0.5, indicating that the model results are good. Based on the configuration analysis results that improve online self-directed learning ability, the configuration is divided into the following two categories.

In the first category, configuration A1 and configuration A2 both have high environmental fitness and strong learning motivation. This represents a portion of students with strong learning motivation and environmental fitness, who have strong online self-directed learning abilities. Students in configuration A1 also have a large number of learning strategies, which directly proves that self-directed learning ability can be developed under the interaction of students' learning motivation, self-directed learning behavior, and learning environment. Learning motivation and learning environment are prerequisites for students' self-directed learning, therefore learning motivation and environmental fitness are the core conditions for configuration generation. Students in configuration A2 have a good learning experience, with learning motivation and environmental adaptability as the core conditions. These variables

work together to lead to the occurrence of results in the configuration. Configuration A2 also fully reflects that the core of this path lies in learning motivation and environmental fitness.

In the second category, configuration B has good learning experience, strong learning motivation, and more learning strategies, and all three antecedents are core variables. This represents a portion of students who have gained good learning experience and possess strong learning motivation and multiple learning strategies, all of whom have strong online self-directed learning ability. The three variables are interconnected and jointly affect online self-directed learning ability. Since all three variables are core variables, they are essential, which indirectly proves that online learning experience has no direct effect on online self-directed learning ability, and can only be indirectly influenced through online learning motivation and online learning strategies.

## 3.2 Configuration analysis of reducing online self-directed learning ability

### 3.2.1 Necessity analysis

To analyze the configuration that reduces online self-directed learning ability, and the necessity test is shown in Table 6. When the outcome variable is a decrease in online self-directed learning ability, no variable has a consistency greater than 0.9, so there is no necessary condition for the outcome variable.

**Table 6.** Necessity test of reducing online self-directed learning ability

| Antecedent variables | Consistency of antecedent variables | Coverage rate of antecedent variables |
|---|---|---|
| Learning motivation (LM) | 0.841352 | 0.493498 |
| ～Learning motivation (～LM) | 0.523955 | 0.687442 |
| Learning strategy (LS) | 0.824752 | 0.547802 |
| ～Learning strategy (～LS) | 0.626059 | 0.651137 |
| Learning experience (LE) | 0.792010 | 0.589627 |
| ～Learning experience (～LE) | 0.747164 | 0.664848 |
| Environmental fitness (EF) | 0.744508 | 0.611025 |
| ～Environmental fitness (～EF) | 0.723414 | 0.579383 |

### 3.2.2 Adequacy analysis

Since there are many single samples in the Truth table results, too many final configurations are not conducive to the formation of effective results, so the number threshold of the Truth table is set to 21, and the number of remaining samples exceeds 80% (more than 75%), which will not affect the analysis results. Set the original consistency threshold to 0.8, then sort the PRI consistency values, select samples with PRI consistency values less than 0.65, and manually change the result variable to 0.

Similarly, the configuration expression method proposed is used to summarize the types of students who have reduced online self-directed learning ability and draw a configuration diagram. Draw the basic configuration based on the intermediate solution, and identify the

core conditions that lead to the results based on the simple solution. The analysis results are shown in Table 7.

**Table 7.** Configuration for reducing online self-directed learning ability

|  | C1 | C2 | D |
|---|---|---|---|
| Learning motivation | ⊗ | ● | ● |
| Learning strategy | ● | ⊗ | ● |
| Learning experience | ● | ● | ⊗ |
| Environmental fitness |  |  | ● |
| Consistency | 0.83 | 0.85 | 0.81 |
| Original coverage rate | 0.44 | 0.50 | 0.50 |
| Net coverage rate | 0.10 | 0.11 | 0.10 |
| Overall consistency | 0.73 | | |
| Overall coverage rate | 0.80 | | |

The consistency of the three paths is greater than 0.8, the overall consistency of the configuration is also greater than 0.8, and the overall coverage is greater than 0.5, indicating that the model results are good. Based on the configuration analysis results that reduce online self-directed learning ability, the configuration is divided into the following two categories.

In the first category, configuration C1 and configuration C2 have weak learning motivation and few learning strategies respectively. This represents a portion of students who lack learning motivation and strategies, and these students' online self-directed learning abilities are relatively weak. Configuration C1 lacks learning motivation, leading to a decrease in students' online self-directed learning ability, while configuration C2 lacks learning strategies, leading to a decrease in students' online self-directed learning ability.

In the second category, configuration D has strong environmental fitness and poor learning experience. This represents a portion of students who feel that the learning experience is not good. Although these students have strong learning motivation, more learning strategies, and strong environmental fitness, the lack of experience makes students unwilling to continue online learning, resulting in weaker online self-directed learning abilities.

## 4    Conclusions

Learning experience, motivation, strategies, and environmental fitness exhibit different characteristics in the impact on students' online self-directed learning ability through different combinations. Based on the configuration analysis results of improving online self-directed learning ability and reducing online self-directed learning ability, after discussing various variables, the following conclusions can be drawn:

Firstly, strong learning motivation is an important condition for students to demonstrate the ability to improve online self-directed learning. Learning motivation appears as the core condition in all three configurations (A1, A2, and B), so learning motivation will inevitably directly affect online self-directed learning ability. Overall, students with strong learning motivation tend to view learning as meaningful and valuable activities, are willing to actively manage the learning process, and exhibit high online self-directed learning abilities. Therefore, improving students' learning motivation is undoubtedly the primary condition for cultivating their online self-directed learning ability.

Secondly, environmental fitness and learning motivation are both core conditions in both configuration A1 and configuration A2, and these variables are key elements in enhancing students' learning motivation. Due to the fact that learning motivation is an individual's inner activity and not a controllable variable, it is difficult to directly enhance students' online self-directed learning ability. But environmental fitness and learning motivation can interact with each other, and the effect is positive. Environmental fitness is the feedback from students to the external environment, which can be improved by changing the external environment. Therefore, changing the online environment to enhance environmental adaptability and enhance learning motivation is a feasible path to improve students' online self-directed learning ability.

Thirdly, learning experience is similar to environmental fitness, with learning motivation and learning strategy as the core conditions in configuration B, which can promote learning motivation and learning strategy. Compared to environmental fitness, learning experience is more controllable and can work together with two variables: learning motivation and learning strategy. Learning experience can be decomposed into three dimensions, which can be improved by changing any dimension to promote learning motivation or learning strategies, and ultimately achieve the goal of improving students' online self-directed learning ability. Therefore, the effect of learning motivation on online self-directed learning ability can be enhanced by improving learning strategies.

Fourthly, learning strategies refer to students' behavior, which is not a determining factor in improving students' online self-directed learning ability and only serves as the core condition in configuration B. Therefore, enriching students' learning strategies can enhance the role of learning motivation in enhancing students' online self-directed learning ability.

The results show that the three ways to improve OSLA always contain LM, and the combination of LM with any two variables of LE, LS and EF can improve OSLA. The absence of any of the three variables can reduce college students' OSLA. Therefore, on the basis of enhancing students' learning motivation, by enriching learning experience and strategies, and improving the online learning environment, students' online self-directed learning ability can be improved.

# References

[1] Dong Yunning. Strategies for Improving College Students' Self-directed Learning Ability in an Online Learning Environment [J]. Shanxi Youth,2022,614(01):32-34.

[2] Joo, Y. J., So, H. J., Kim, N. H. Examination of relationships among students' self-determination, technology acceptance, satisfaction, and continuance intention to use K-MOOCS. Computers & Education, 2015, 122, 260–272.

[3] Petter, S., DeLone, W. H., McLean, E. R. Information systems success: The quest for the independent variables. Journal of Management Information Systems, 2013, 29(4), 7–61.

[4] Zimmerman, B. J., Kitsantas, A. Comparing students' self-discipline and self-regulation measures and their prediction of academic achievement. Contemporary Educational Psychology, 2014, 39(2), 145–155.

[5] Wang Jingqiong, Zhang Wei, Zhu zude ,Zhen Shuangju, Mai yujiao, Li Dongping. A Modulating Model for the Impacting Factors in Self-regulated Learning of College Students [J]. Acta Psychologica Sinica,2010,42(02):262-270.

[6] RAGIN C C. The comparative method moving beyond qualitative and quantative strategies[M]. California: University of California Press, 1987, 31-32.

[7] Du Yunzhou, Jia Liangding. Configuration Perspective and Qualitative Comparative Analysis (QCA): A New Path in Management Research [J]. Journal of Management World,2017(06):155-167.

[8] Albelbisi, N.A. The role of quality factors in supporting self-regulated learning(SRL) skills in MOOC environment. Educ Inf Technol 24, 2019,1681-1698.

[9] Chi Liping, Xin Ziqiang. The measurement of college students' learning motivation and its relationship with self-efficacy[J]. Psychological Development and Education, 2006(02):64-70.

[10] Zhou Guotao, Zhang Lin. Research on the Learning Strategy Scale Development for Middle School Students [J]. Psychological Research, 2002(03): 48-52.

[11] Guo Jidong, Li Yu, Liu Xiaohong. Construction and Verification of the College Students' Adaptability Scale for Foreign Language Learning [J]. Foreign Language World,2021:46-53.

[12] Lin Lilan. Development and testing of a scale for college students' English self-directed learning ability based on three-dimensional construction [J]. Foreign Language World,2013(04):73-80,96.

[13] Zhu Zude, Wang Jingqiong, Zhang Wei, Ye Qingqing. Constraction of Self-Regulated Learning Scale for College Students[J].Psychological Development and Education, 2005(03):60-65.