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# Exploring the Higher Order Thinking Skills Elements on College Students' Snowball Effects in the Context of Hybrid Learning in China

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**Abstract**

This study aims to explore Higher Order Thinking skills (HOTs) elements and the internal snowball effect in the context of Outcome-based Education (OBE)-based hybrid learning in China's higher education. In this study, 150 first-year students at a Chinese university were collected by questionnaires. Descriptive analysis and multiple linear regression analysis were employed to explore Analyzing, Evaluating, Creating, Critical Thinking and Problem Solving skills, and reveal the relationship between these factors. The results showed that four of the six hypotheses proposed in this study were supported, Analyzing and Creating abilities have direct impact on Critical Thinking and Problem Solving skills of student, and Evaluating has insignificance statistically on Critical Thinking and Problem Solving. This study provides valuable guidance for educators to design more effective teaching strategies to enhance students' HOTs and improve inner relationship to realize virtuous cycle of learning.

**Keywords:** Higher Order Thinking Skills, Snowball Effect, Hybrid Learning, Problem Solving, Critical Thinking

## Introduction

In the rapidly evolving landscape of higher education, the cultivation of higher order thinking skills (HOTs) has emerged as a critical focus for educators and researchers alike

(Almulla & Al-Rahmi, 2023; Ba et al., 2024; Paralikar et al., 2022). HOTs, which include skills such as Analyzing, Evaluating, Creating, Problem Solving, and Critical Thinking, are essential for students to navigate complex challenges and adapt to a rapidly changing social environment. As educational paradigms shift, particularly with the widespread adoption of hybrid learning environments, there is an urgent need to explore effective strategies for fostering these skills. This exploration is not only vital for enhancing students' academic performance but also for equipping them with the adaptability and innovative capabilities required in their future careers.

This study aims to investigate the impact of specific elements of HOTs—Analyzing, Evaluating, and Creating—on college students' Problem Solving and Critical Thinking abilities within hybrid learning contexts. By examining these relationships, we seek to uncover the mechanisms that contribute to the development of HOTs and assess whether this influence manifests as a "snowball effect," where improvements in one area lead to enhancements in others. The significance of this research extends beyond enriching theoretical frameworks surrounding HOTs; it also provides practical guidance for educators and policymakers. By identifying effective strategies for cultivating HOTs, this study aims to inform the design of curricula and teaching methods that enhance student learning outcomes in hybrid environments. Ultimately, by promoting critical thinking and problem-solving skills, we aspire to empower students to become independent, creative, and innovative thinkers, equipping them with the necessary tools to confidently face a variety of challenges in their academic and professional endeavors.

## Literature Review

### *Higher Order Thinking Skills*

HOTs include higher cognitive processes such as analysis, assessment, creativity, problem solving, and critical thinking, and are critical to improving students' cognitive abilities and academic performance (Ba et al., 2024; Sinha et al., 2023). Research has shown that integrating HOTs into educational practice can improve student engagement, motivation, and academic achievement(Almulla & Al-Rahmi, 2023; Huang et al., 2024). By developing these skills, students are better able to tackle complex problems and make informed decisions in today's rapidly changing world. Research shows that developing students' HOTs not only helps them succeed in the academic world, but also gives them a solid foundation for their future careers and lives.

### *Problem Solving Skills*

Problem solving skills refer to the ability to effectively identify, analyze, and solve problems. Individuals with strong problem-solving skills are able to approach complex problems in a systematic and logical way of thinking, evaluate different solutions, and make informed decisions. These skills are vital in all aspects of life, including academics, work, and relationships (Permana et al., 2019). Developing problem-solving skills enhances critical thinking, creativity, and resilience, enabling individuals to tackle challenges and succeed.

### *Critical Thinking Skills*

Critical thinking skills refer to the ability to analyze and evaluate information objectively and make reasoned judgments(Almulla & Al-Rahmi, 2023; Haffejee, 2021). Individuals with strong critical thinking skills are able to question assumptions, consider different perspectives, and draw logical conclusions. These skills are essential in various aspects of life, including academics, work, and decision-making. Developing critical thinking skills can

enhance problem-solving abilities, creativity, and effective communication, enabling individuals to make informed decisions and navigate complex situations successfully (Mitra, 2023).

*Snowball Effect*

The snowball effect is a chain reaction phenomenon in which a small change or action can trigger a series of related positive effects that gradually increase in scope, similar to a snowball. This effect can be seen in various fields, including sociology, psychology, and economics. By gradually expanding the sphere of influence, the snowball effect can lead to unexpected positive results, prompting change and progress. In this study, Snowball effect refers to the idea that by developing students' higher order thinking skills such as analysis, assessment, creativity, problem solving, and critical thinking, a chain reaction of positive effects can be triggered. When students are equipped with these key skills, they are more likely to succeed academically and demonstrate innovation and leadership in their future careers. This snowball effect can not only improve the cognitive abilities and overall literacy of individuals, but also help to push the entire education system towards a more dynamic and accomplished direction.

*Hybrid Learning*

Saichaie (2020) observed that a hybrid class combines in-person teaching with technology-based training, which is not usually substituted by traditional classroom time. Hybrid classrooms allow students to gain knowledge through online learning, video conferences, and other methods outside regular classroom teaching. The hybrid learning process materials used in this study are Fundamental of Computer Application (FCA) courses tarried out beginning in 2023 at a Chinese college, recorded and documented at the Chaoxing platform, and made available thereafter. In this research, hybrid learning refers to asynchronous online learning with Outcome-based Education (OBE) elements such as real need, clear content, interrelated outcome and real output, which adopted from Budhrani y Lloyd (2015) at De La Salle University in Manila.

*Theoretical Framework*

Constructivism learning theory is a theory based on observation and scientific study about how people learn. Constructivism learning theory is developed based on the ideas and theories of Piaget, Kohlberg, and Vygotsky (Erbil, 2020; George, 1991; Kristjánsson & Egeth, 2020; Zajda, 2021). Its basic views are as follows: Students do not enter the classroom with an empty head, they have a wealth of experience in the past study and daily life, have their understanding and views on everything when they are faced with problems, they can make specific reasoning based on the relevant experience. People construct their understanding and knowledge of the world by experiencing and reflecting on these experiences (Cleland & Durning, 2015; Kristjánsson & Egeth, 2020). However, with the rapid development of digital information, the improvement of educational environment and the various teaching facilities and the enhancement of students' quality that provides strong support for the teaching conditions required by constructivism. This makes the combination of constructivism learning theory and teaching practice more common.

The application of this theory in the first-line classroom is more in line with the requirements of the new curriculum reform, in line with the cultivation of students' quality education in China (Chen et al., 2018; Cui et al., 2021). So that the constructivism learning theory has become the guiding ideology of deepening the teaching reform in Chinese

universities. As a guide and organizer, teachers should recognize the leading position of students and create a suitable learning environment. At the same time, they should actively guide students to construct knowledge. In teaching, teachers can make the situation, ask questions, stimulate students' interest in learning, guide students through the collaborative learning approach to problem-solving (Chen et al., 2018). Students enhance their skills in several areas while actively engaging in challenges related to meaningful construction. This study pertains constructivism learning theory in utilizing methods to resolve issues at the higher levels of instruction to enhance students' critical thinking skills.

*Research Questions*

Research question 1: What are the dominant elements of college student' HOTs in the context of hybrid learning in China?

Research question 2: Do the HOTs elements (Creating, Evaluating, Analyzing) of college students promote the Snowball Effect (Problem Solving and Critical Thinking abilities)?

*Research Hypotheses*

The following hypotheses guided the research at a 0.05 significance level.

$H^1$: HOTs elements (Creating, Evaluating, Analyzing) of college students have direct impacts on the Snowball Effect (Problem Solving ability).

- $H^{1a}$: Creating ability of college students have direct impacts on the Snowball Effect (Problem Solving ability).
- $H^{1b}$: Evaluating ability of college students have direct impacts on the Snowball Effect (Problem Solving ability).
- $H^{1c}$: Analyzing ability of college students have direct impacts on the Snowball Effect (Problem Solving ability).

$H^2$: HOTs elements (Creating, Evaluating, Analyzing) of college students have direct impacts on the Snowball Effect (Critical Thinking ability).

- $H^{2a}$: Creating ability of college students have direct impacts on the Snowball Effect (Critical Thinking ability).
- $H^{2a}$: Evaluating ability of college students have direct impacts on the Snowball Effect (Critical Thinking ability).
- $H^{3a}$: Analyzing ability of college students have direct impacts on the Snowball Effect (Critical Thinking ability).
-

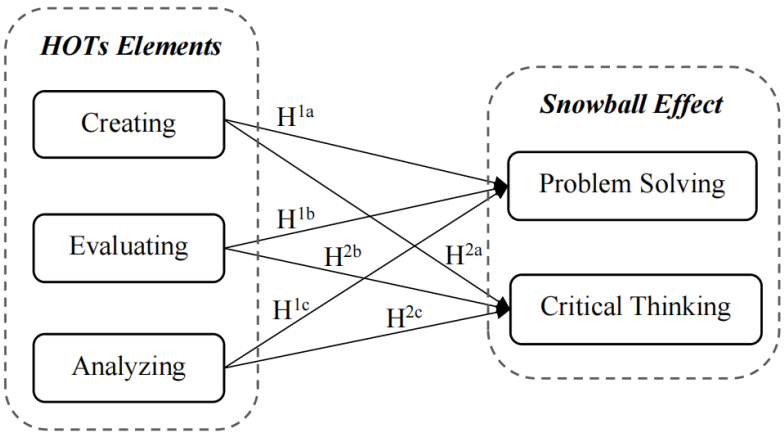



Fig 1 Hypotheses Model of the Study

## Methodology

The researcher used a quantitative approach to collect data from freshman from different majors at a Chinese University to explore and investigate factors of HOTs and test the hypotheses proposed for this study (Fig 1). This study employs hybrid learning of CFA courses to explore and investigate college students' HOTs factors and snowball effect among them. Due to the background of students' subject of Information Technology was consistent, the researcher conducted stratified sampling method according to students' major. Stratified sampling is suitable for populations with diverse traits, ensuring each attribute is proportionally included in the sample.

*Experimental Procedure*

The whole research procedure can only be completed under the cooperation of multiple related parties. Since the Computer Teaching and Research Section belongs to the College Information Center, the researcher first proposed to the director of the College Information Center in June 2021 that OBE-based hybrid pattern should be taken as the program of the two courses of FCA for students of the grade of 2021. In August 2021, the researcher was allowed to introduce OBE-based hybrid pattern to three instructors in the computer Teaching and Research Section. In 2022, the researcher applied to conduct a pilot study and completed it. In September 2023, these three instructors were invited to implement hybrid learning courses toward OBE framework which attached the four elements. The researcher would audit the course by scanning the corresponding course number or QR code on the Chaoxing platform. The study lasts for a whole semester, a total of 4 months. The researcher got the approval of ethical clearance from the selected University. At the end of the semester, the researcher submitted a written application to the director of the College Information Center to collect data for main study related to the two courses employed in this study.

*Hybrid Learning Model of the Research*

According to the models of Zhao et al. (2020) and Hapke et al. (2021), aiming at the current situation of education, a hybrid learning pattern based on OBE construction is proposed, which is equipped with Chaoxing platform to solve local problems. In hybrid learning pattern, teaching and learning contents before, during and after class are shown in Fig 2. Hybrid learning includes 18 times of remote synchronous teaching and 2 times of offline face-to-face teaching. The pattern describes technologies, content, patterns, and artifacts, as well as evaluations. In the 18 times of remote synchronous teaching, before class, students can use the Chaoxing app to browse the course guide and courseware recorded by the teacher in advance. They have an overall understanding of the goal and ability of the course to be achieved and use the group function to ask questions. In this course, one instructor can manage students' activities of three labs with the Chaoxing platform as a remote device. Students make use of the course catalogue function to browse the learning content of the course and carry out practical operation practice on the corresponding software. Instructor can monitor students' activities in real time. Finally, the task of the class by group demonstration will be completed. After class, instructors use the function of group discussion, question and answer board, homework link and peer evaluation to ensure that students review the past and learn new things.

In the last two face-to-face lessons, students are mainly tested after learning the course in the computer lab, including output review, four process tests (Word, Excel, Powerpoint and Comprehensive Skill), learning points test and comprehensive ability output. Finally, the final exam will be conducted. Teachers and students in different labs can take classes

simultaneously using the Chaoxing app. In class, teachers use group demonstrations and quizzes to strengthen students' foundations before moving on to the next level of learning. After class, students can still use the software to replay and watch recordings of lessons.

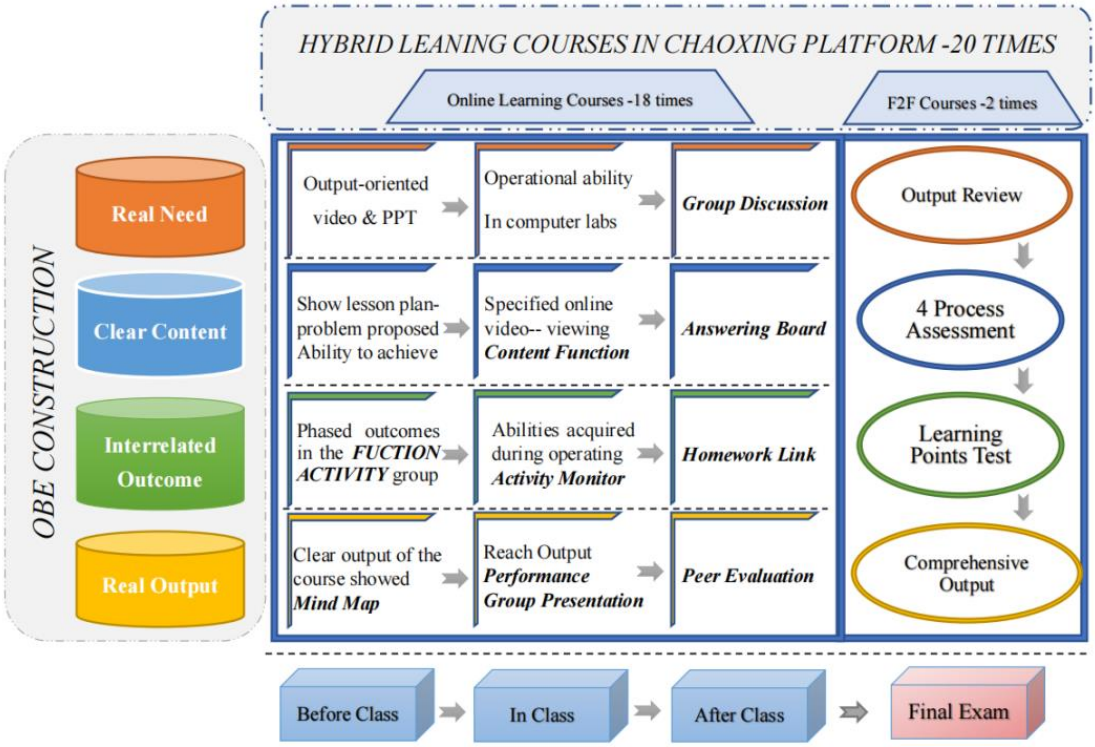


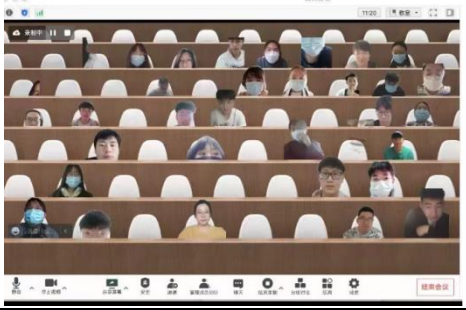

Fig 2 Hybrid Learning Process toward OBE of the Research

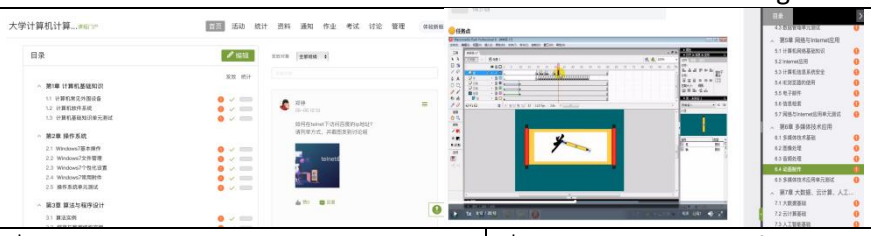
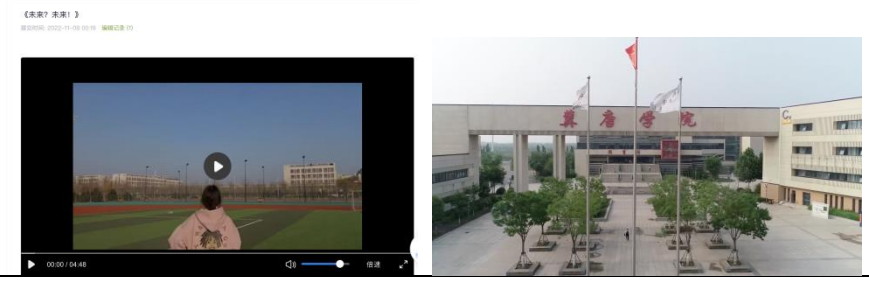
*Lesson Plan*

In this study, FCA, being a focused course in this study, is a public basic computer skill course designated by the University Computer Course Teaching Steering Committee of the Ministry of Education, which is required to be set up for Chinese undergraduate students not majoring in computer science. It aims to cultivate learners' basic literacy and ability to acquire, store, process, and apply information. In the information age, the application ability of computers has become a basic cultural requirement for every Chinese citizen, especially for college students. Basic computer skill is a prerequisite for mastering all professional courses and skills. This course carries out the concept of computational thinking, involves the concepts and knowledge of various fields of computer as well as the essential computer application skills of college students, and improves students' ability to correctly understand, analyze and solve problems. Through the study of this course, students can develop good information quality so that they can use computer means to express and communicate and use the Internet to actively learn, to lay the necessary foundation for later course learning. The sample of lesson plan of FCA course is shown in Table 1.

Table 1
*Lesson Plan of FCA Course*

<table>
<tr><td rowspan="2">Course Title</td><td>Chinese</td><td colspan="3">大学计算机基础上机</td></tr>
<tr><td>English</td><td colspan="3">Fundamental of Computer Application</td></tr>
<tr><td>Students</td><td colspan="2">2023-All Majors Undergraduate Level</td><td>Period</td><td>90mins</td></tr>
<tr><td>Teaching Objective</td><td colspan="4">Content: Make Propaganda Videos of Jitang College by Camstudio and Microsoft PowerPoint.<br>Ability: Improve students' ability to analyze and evaluate problems by asking questions in class. Through group discussion, creativity, critical thinking, and problem solving skills can be developed.</td></tr>
<tr><td>Teaching Environment</td><td colspan="4">   <br>Nine computer laboratories with 576 students’ computers provide a good hardware and software environment for the implementation of hybrid teaching</td></tr>
<tr><td>Teaching Materials & Teaching AIDS</td><td colspan="4">Teaching materials: Computer Culture and Application (Medical Edition), Computer Culture and Application Experiment (Medical Edition), Xi’an Jiaotong University Press, 2015<br>Teaching aid:<br>Hardware: Multimedia facility, Teacher’s workstation, Students computers<br>Software: Chaoxing APP, Microsoft Office, Camstudio, Rain classroom APP, Tencent Conference, Courseware</td></tr>
<tr><td>Chaoxing Fuctions in Hybrid Course</td><td colspan="4"> 

 </td></tr>
<tr><td colspan="5">Make Propaganda Videos of Jitang College by Camstudio and Microsoft Powepoint</td></tr>
<tr><td>OBE Instruction</td><td colspan="4">Operation</td></tr>
<tr><td>Real Need</td><td colspan="4">Video production reflects a variety of software application ability, students need to master video software and Microsoft Office (Word, Excel and Ppt) based on creative project work. It is of great help to check the students' learning of previous knowledge.</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">  </td></tr>
<tr><td>Clear Content</td><td colspan="2">✧ Video prologue setting<br>✧ Audio and video file import<br>✧ Ppt inserted in video presentation<br>✧ Transition effect shall be added<br>✧ Music file cutting<br>✧ Blank area filling<br>✧ MP4 format generation<br>✧ Video rendering<br>  </td></tr>
<tr><td>Interrelated Outcomes</td><td>✧ Correctly use the track<br>✧ Master media and annotations<br>✧ Transition increase animation<br>✧ Enhance the video effect<br>✧ Master the pointer</td><td>✧ Noise reduction function<br>✧ Voice narration post-dubbing<br>✧ Add subtitles<br>✧ Quickly make the the title<br>✧ Correctly export the video</td></tr>
<tr><td></td><td colspan="2">  </td></tr>
<tr><td>Real Output</td><td colspan="2">1. Group presentation: Each group made a video<br>2. Learned their own strengths and weaknesses through teacher score and group mutual evaluation<br>3. Mastered Camstudio production skills<br>4. Skillful use Microsoft PowerPoint<br>  </td></tr>
</table>

*Participants*

The study used freshmen at a Chinese university as an experimental sample. They have the same background in information technology disciplines to remove distractions from research. The researchers informed the participants about the purpose of the study and the criteria for selecting participants. After a 4-month OBE-based hybrid learning teaching intervention, the participants had a higher perception of hybrid learning, which was confirmed by previous studies. The questionnaire was collected anonymously. Stratified sampling method identified 160 samples to participate in this study, and 158 samples were actually collected. After data screening and cleaning, 8 samples were found to have dupicated cases, and 150 samples were retained for data analysis.

The demographic information for this study includes 3 factors, namely gender, age and major. Table 2 provides descriptive statistics for each demographic factor. For gender factor, the proportion was 44% male and 56% female. As can be seen from the age factor, the number of students under the age of 18 is 0, indicating that there are no minors in the participants, while there are 2 students over 25. It can be confirmed from the proportion of major that this study is stratified sampling according to this factor. It should be noted that one of the age set in the population information referred to people over 25 years old. This was because surveys had found that there were a small number of freshmen who were larger than their peers. This part of the population had the following experiences to successfully enter the university, such as taking a break from school, or after several college entrance examinations, and finally enter the university. In addition, stratified sampling was conducted based on 8 majors, all of which were freshmen with the same educational background.

Table 2
*Demographic Information*

| Demographic factor | categories | Frequency | Valid % | Cumulative % |
|---|---|---|---|---|
| ***Gender*** | Male | 66 | 44.0 | 44.0 |
| | Female | 84 | 56.0 | 100.0 |
| | | 150 | 100.0 | |
| ***Age*** | <18 | 0 | 0 | 0 |
| | 18-25 | 148 | 98.7 | 98.7 |
| | >25 | 2 | 1.3 | 100.0 |
| | | 150 | 100.0 | |
| ***Major*** | Traditional Chinese Medicine | 18 | 12.0 | 12.0 |
| | Stomatology | 20 | 13.3 | 25.3 |
| | Clinical Medicine | 48 | 32.0 | 57.3 |
| | Medical Imaging | 10 | 6.7 | 64.0 |
| | Pharmacy | 8 | 5.3 | 69.3 |
| | Nursing | 32 | 21.3 | 90.7 |
| | Medical Law | 7 | 4.7 | 95.3 |
| | English | 7 | 4.7 | 100.0 |
| | | 150 | 100.0 | |

*Data Analysis*

The instrument in this study was composed of 27 items with a total of 5 constructs. The Level of Students' HOTs questionnaire is measured following the factors defined in Brookhart (2010) and revised by Widana (2017). The dimensions and items of this instrument are shown in Table 3. This questionnaire has been adapted from Heppner y Baker (1997), Kobylarek et al., (2022) and Syarifah et al., (2019) and has been modified to use for this study. The 5-point Likert scale ranging from 1 ''strongly disagree'' to 5 ''Strongly agree'' to measure the responses to the questionnaire items.

Table 3
*HOTs Assessment Components and Definition*

| HOTs assessment components | Definition |
|---|---|
| Analyzing (4 items) | Ability to analyze the surrounding reality thoroughly and like to find dependencies even between phenomena that differ from each other. |
| Evaluating (4 items) | Ability to assess and verify the information and use multiple sources to evaluate information. |
| Creating (6 items) | Ability to invent and create something completely new as well as combine various opinions and form their own on this basis. |
| Problem solving (7 items) | Ability to use information to solve problems. |
| Critical thinking (6 items) | Ability to examines the ideas and information critically and to judge from the dimensions of knowledge. |

Once the 27 items were developed, they were sent to two experts in education and educational technology to review the clarity and revise their opinions to ensure the validity of the research instrument.

A total of four stages of data analysis are performed to answer the two research questions. First, the researchers used the Cronbach's Alpha coefficient to test the reliability of the research instrument. As is shown in Table 4, Cronbach alpha coefficient values of five constructs are all greater than 0.7, and Corrected Item-Total Correlation values of all items are greater than 0.3, which meet the research requirements, indicating a good correlation between analysis items and a good reliability level. In summary, the reliability coefficient values of the research data are all higher than 0.8, which indicates that the data reliability quality is high and can be used for further analysis.

Table 4
*HOTs,Item-Total Statistics*

| Dimension | Item | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|---|
| Analyzing | 1 | 0.769 | 0.865 | |
| | 2 | 0.744 | 0.876 | |
| | 3 | 0.796 | 0.855 | |
| | 4 | 0.772 | 0.866 | 0.895 |
| Evaluating | 1 | 0.709 | 0.830 | |
| | 2 | 0.735 | 0.818 | |
| | 3 | 0.674 | 0.843 | |
| | 4 | 0.762 | 0.808 | 0.863 |
| Creating | 1 | 0.753 | 0.866 | |
| | 2 | 0.665 | 0.880 | |
| | 3 | 0.736 | 0.870 | |
| | 4 | 0.718 | 0.873 | |
| | 5 | 0.675 | 0.879 | |
| | 6 | 0.737 | 0.869 | 0.892 |
| Problem Solving | 1 | 0.690 | 0.907 | |
| | 2 | 0.716 | 0.903 | |
| | 3 | 0.720 | 0.902 | |
| | 4 | 0.771 | 0.897 | |
| | 5 | 0.783 | 0.895 | |
| | 6 | 0.738 | 0.901 | 0.913 |

| | | | | |
|---|---|---|---|---|
| | 7 | 0.771 | 0.897 | |
| | 1 | 0.679 | 0.874 | |
| | 2 | 0.641 | 0.880 | |
| Critical Thinking | 3 | 0.778 | 0.858 | |
| | 4 | 0.641 | 0.880 | |
| | 5 | 0.759 | 0.861 | |
| | 6 | 0.749 | 0.863 | 0.889 |

Second, Exploratory Factor Analysis (EFA) was used to test the structural validity of questionnaire data. The adequacy and suitability of the samples were determined by Bartlett's Test of Sphericity and Kaiser-Meyer-Olkin (KMO) test. As shown in Table 5, the KMO value is 0.859, which is suitable for factor analysis. The total variance of the model constructs explained in this study is 68.87%, as shown in table 6. Next, the researcher uses the rotation method and the principal axis factorization method to determine the factor load of each item in its dimension, as shown in table 7.

Table 5
*HOTs-Q, KMO and Bartlett's Test*

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.859 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2641.318 |
| | df | 351 |
| | Sig. | 0 |

Table 6
*Total Variance Explained*

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 9.722 | 36.007 | 36.007 | 9.722 | 36.007 | 36.007 | 4.708 | 17.439 | 17.439 |
| 2 | 2.676 | 9.912 | 45.919 | 2.676 | 9.912 | 45.919 | 4.000 | 14.814 | 32.253 |
| 3 | 2.385 | 8.834 | 54.753 | 2.385 | 8.834 | 54.753 | 3.966 | 14.687 | 46.940 |
| 4 | 2.050 | 7.594 | 62.347 | 2.050 | 7.594 | 62.347 | 2.964 | 10.976 | 57.916 |
| 5 | 1.760 | 6.518 | 68.865 | 1.760 | 6.518 | 68.865 | 2.956 | 10.949 | 68.865 |
| 6 | .743 | 2.752 | 71.617 | | | | | | |
| 7 | .688 | 2.547 | 74.164 | | | | | | |
| 8 | .664 | 2.460 | 76.624 | | | | | | |
| 9 | .613 | 2.269 | 78.893 | | | | | | |
| 10 | .600 | 2.223 | 81.116 | | | | | | |
| 11 | .554 | 2.053 | 83.169 | | | | | | |
| 12 | .525 | 1.946 | 85.116 | | | | | | |

| | | | |
|---|---|---|---|
| 13 | .455 | 1.684 | 86.800 |
| 14 | .415 | 1.543 | 88.342 |
| 15 | .407 | 1.485 | 89.828 |
| 16 | .351 | 1.317 | 91.145 |
| 17 | .335 | 1.223 | 92.367 |
| 18 | .330 | 1.215 | 93.583 |
| 19 | .288 | 1.061 | 94.644 |
| 20 | .256 | .933 | 95.577 |
| 21 | .229 | .848 | 96.425 |
| 22 | .219 | .777 | 97.202 |
| 23 | .190 | .705 | 97.907 |
| 24 | .180 | .666 | 98.573 |
| 25 | .156 | .577 | 99.150 |
| 26 | .128 | .475 | 99.625 |
| 27 | .101 | .375 | 100.000 |

Table 7
*Rotated Component Matrix*[a]

| Dimension | Item | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| ***Analyzing*** | 1 | | | | 0.750 | |
| | 2 | | | | 0.819 | |
| | 3 | | | | 0.838 | |
| | 4 | | | | 0.779 | |
| ***Evaluating*** | 1 | | | | | 0.807 |
| | 2 | | | | | 0.804 |
| | 3 | | | | | 0.774 |
| | 4 | | | | | 0.828 |
| ***Creating*** | 1 | | | 0.778 | | |
| | 2 | | | 0.687 | | |
| | 3 | | | 0.797 | | |
| | 4 | | | 0.749 | | |
| | 5 | | | 0.749 | | |
| | 6 | | | 0.763 | | |
| ***Problem Solving*** | 1 | 0.704 | | | | |
| | 2 | 0.733 | | | | |
| | 3 | 0.739 | | | | |
| | 4 | 0.806 | | | | |
| | 5 | 0.806 | | | | |
| | 6 | 0.803 | | | | |
| | 7 | 0.791 | | | | |

| | | |
|---|---|---|
| ***Critical Thinking*** | 1 | 0.758 |
| | 2 | 0.723 |
| | 3 | 0.797 |
| | 4 | 0.692 |
| | 5 | 0.809 |
| | 6 | 0.812 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization

*Rotation converged in 6 iterations*

These values show good structural validity of the instrument. Last, descriptive statistics and two times multiple liner regression have been employed to investigate the snowball effect among elements of HOTs. Data analysis in this study is performed in SPSS 27 version.

**Results**

*Research Question 1- Descriptive Statistics*

The students' HOTs level means for the students in the hybrid learning are in the range of 3.26 to 3.97 shown in Table 8. These values indicate moderate to high students' thinking skill level with the delivery for the hybrid learning courses (Landell, 1997). As can be seen from descriptive statistics analysis, Analyzing, Evaluating, Creating, Problem Solving and Critical Thinking are five dominant elements of students' HOTs assessment in the context of hybrid learning in China.

Table 8
*Descriptive Statistics of Students' HOTs Level in Hybrid Learning Context*

| | Items | N | Min | Max | Mean | Std. Deviation | Level |
|---|---|---|---|---|---|---|---|
| Analyzing | A1 | 150 | 1 | 5 | 3.66 | .933 | Moderate |
| | A2 | 150 | 1 | 5 | 3.60 | 1.003 | Moderate |
| | A3 | 150 | 1 | 5 | 3.26 | .965 | Moderate |
| | A4 | 150 | 1 | 5 | 3.43 | .870 | Moderate |
| Evaluating | E1 | 150 | 1 | 5 | 3.67 | .864 | Moderate |
| | E2 | 150 | 1 | 5 | 3.97 | 1.114 | High |
| | E3 | 150 | 1 | 5 | 3.50 | .841 | Moderate |
| | E4 | 150 | 1 | 5 | 3.57 | 1.101 | Moderate |
| Creating | C1 | 150 | 1 | 5 | 3.67 | .988 | Moderate |
| | C2 | 150 | 1 | 5 | 3.59 | .868 | Moderate |
| | C3 | 150 | 2 | 5 | 3.61 | .843 | Moderate |
| | C4 | 150 | 1 | 5 | 3.42 | 1.057 | Moderate |
| | C5 | 150 | 2 | 5 | 3.85 | .839 | High |
| | C6 | 150 | 1 | 5 | 3.49 | 1.015 | Moderate |
| Problem Solving | P1 | 150 | 1 | 5 | 3.57 | 1.131 | Moderate |
| | P2 | 150 | 1 | 5 | 3.61 | .858 | Moderate |
| | P3 | 150 | 1 | 5 | 3.82 | 1.030 | High |
| | P4 | 150 | 1 | 5 | 3.45 | .909 | Moderate |
| | P5 | 150 | 1 | 5 | 3.52 | 1.122 | Moderate |
| | P6 | 150 | 1 | 5 | 3.55 | .894 | Moderate |
| | P7 | 150 | 1 | 5 | 3.42 | .950 | Moderate |
| Critical Thinking | CT1 | 150 | 1 | 5 | 3.68 | .929 | Moderate |
| | CT2 | 150 | 1 | 5 | 3.37 | .886 | Moderate |
| | CT3 | 150 | 1 | 5 | 3.40 | 1.036 | Moderate |
| | CT4 | 150 | 1 | 5 | 3.38 | 1.066 | Moderate |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | CT5 | 150 | 1 | 5 | 3.57 | 1.083 | Moderate |
| | CT6 | 150 | 1 | 5 | 3.48 | 1.163 | Moderate |
| Valid N (listwise) | | 150 | | | | | |

**Research Question 2: Multiple Liner Regression Analysis**

*Do the HOTs elements (Creating, Evaluating, Analyzing) of college students promote the Snowball Effect (Problem Solving)?*

Before the regression analysis, the normal histogram is used to roughly determine whether the normal distribution is in line with it. It can be seen from Figure 2, Figure 3 and Figure 4 that the distribution is basically in line with the normal distribution. It can be seen from the PP diagram that the variables approximate a straight line, which is called linear correlation. It can be seen from the residuals scatter plot that the residuals are randomly distributed in general, and there is no other trend with the increase of independent variables, and the variance can be basically considered homogeneous. It suitable for regression analysis.

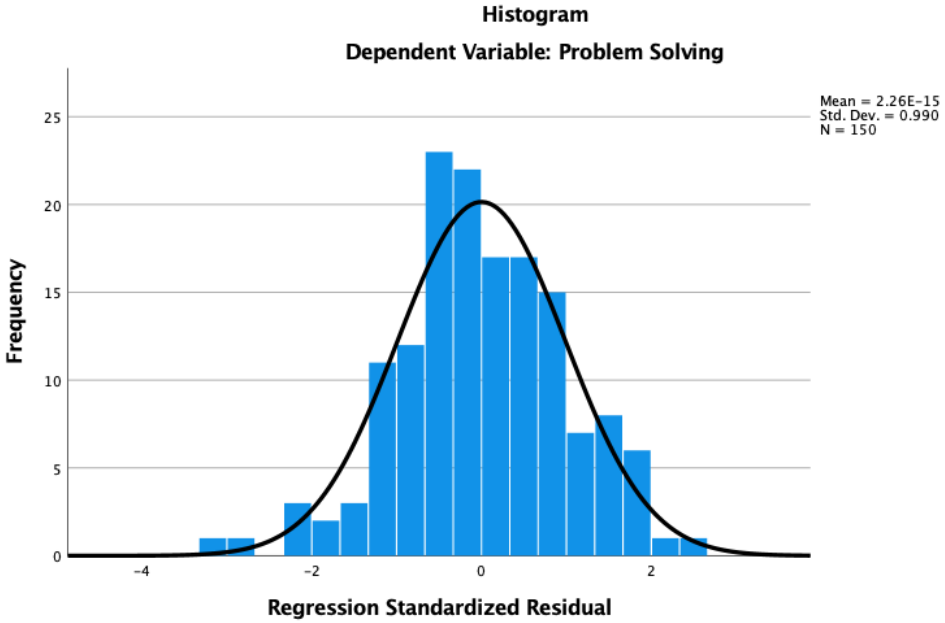



Fig 2 Histogram of Frequency versus Regression Standardized Residuals (between HOTs elements and Problem Solving for Snowball Effect)

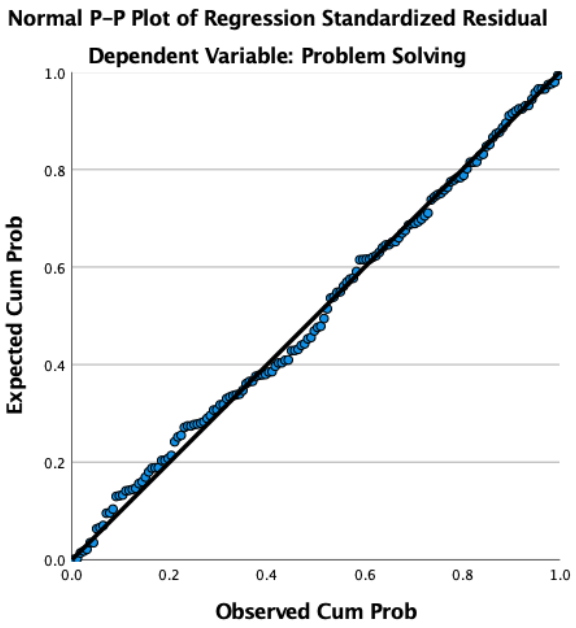



Fig 3 P-P Plot of Regression Standardized Residuals (between HOTs elements and Problem Solving for Snowball Effect)

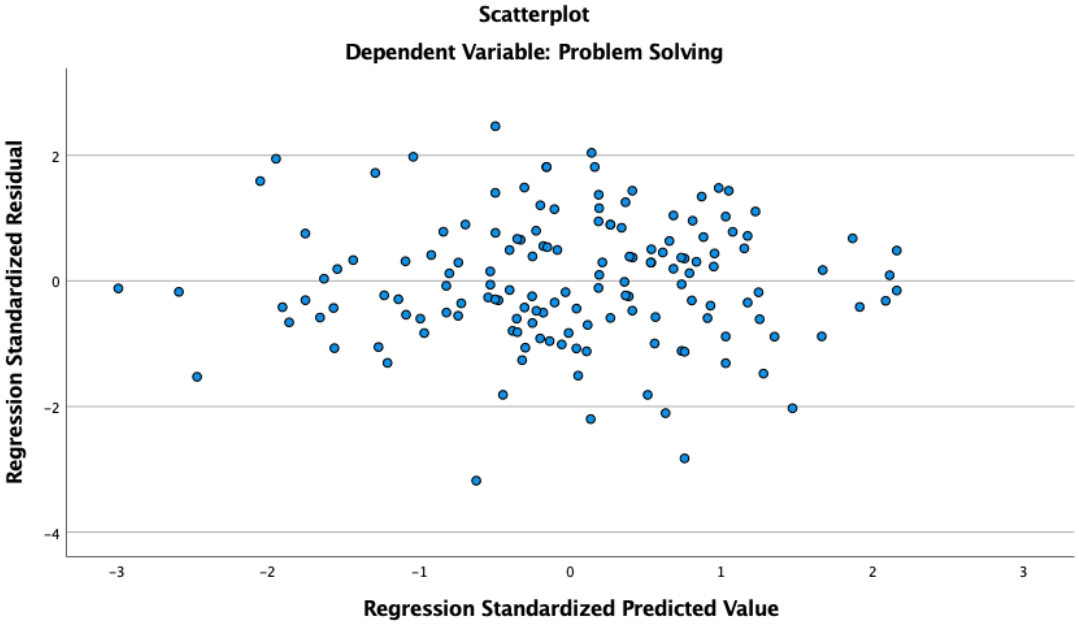



Fig 4 The Scatterplot of ZRESID against ZPRED (between HOTs elements and Problem Solving for Snowball Effect)

Table 9
*Finding on the Coefficients[a] to Test the Assumption of Collinearity (between HOTs elements and Problem Solving for Snowball Effect)*

| | Unstandardized Coefficients | | Standardized Coefficients | *t* | *p* | VIF | *R Square* | Adjusted R Square | *F* |
|---|---|---|---|---|---|---|---|---|---|
| Model | B | Std. Error | Beta | | | | | | |
| (Constant) | 1.043 | 0.323 | | 3.255 | 0.002 | | 0.312 | 0.297 | 22.022 (p=0.000) |
| Analyzing | 0.308 | 0.077 | 0.316 | 3.991 | 0.000 | 1.331 | | | |
| Evaluating | 0.131 | 0.075 | 0.136 | 1.759 | 0.081 | 1.266 | | | |
| Creating | 0.267 | 0.084 | 0.251 | 3.169 | 0.002 | 1.334 | | | |

a. Dependent Variable: Problem Solving
D-W Value：2.151
*p<0.05 ** p<0.01

Analyzing, Evaluating and Creating are taken as independent variables while Problem Solving is taken as dependent variable for linear regression analysis. As can be seen from Table 9, the formula of the model is as follows: Problem Solving =1.043+Analyzing*0.308+Evaluating*0.131+Creating*0.267, and the R-square value adjusted by the model is 0.312, which means that Analyzing, Evaluating, Creating can explain 31.2% of the change in Problem Solving. It was found that the model passed the F test (F=22.022, p=0.000<0.05), that is, at least one of Analyzing, Evaluating, Creating will have an impact on the Problem Solving. In addition, the multicollinearity test of the model shows that all VIF values in the model are less than 5, which means that there is no collinearity problem. Moreover, the D-W value 2.151 which is near the number 2, which indicates that there is no autocorrelation in the model, and there is no correlation between the sample data, and the model is good. The final concrete analysis shows that the regression coefficients of Analyzing and Creating are 0.316 and 0.251, respectively, and the p values are all less than 0.05, indicating that Analyzing and Creating have positive and significant impact on the Problem Solving, and the regression coefficient of Evaluating is 0.136, and the p values is 0.081 which greater than 0.05, indicating that Evaluating has no statistically significant impact on the Problem Solving.

*Do the HOTs elements (Creating, Evaluating, Analyzing) of college students promote the Snowball Effect (Critical Thinking abilities)?*

Before the regression analysis, the normal histogram is used to roughly determine whether the normal distribution is in line with it. It can be seen from Figure 5, Figure 6 and Figure 7 that the distribution is basically in line with the normal distribution. It can be seen from the PP diagram that the variables approximate a straight line, which is called linear correlation. It can be seen from the residuals scatter plot that the residuals are randomly distributed in general, and there is no other trend with the increase of independent variables, and the variance can be basically considered homogeneous. It suitable for regression analysis.

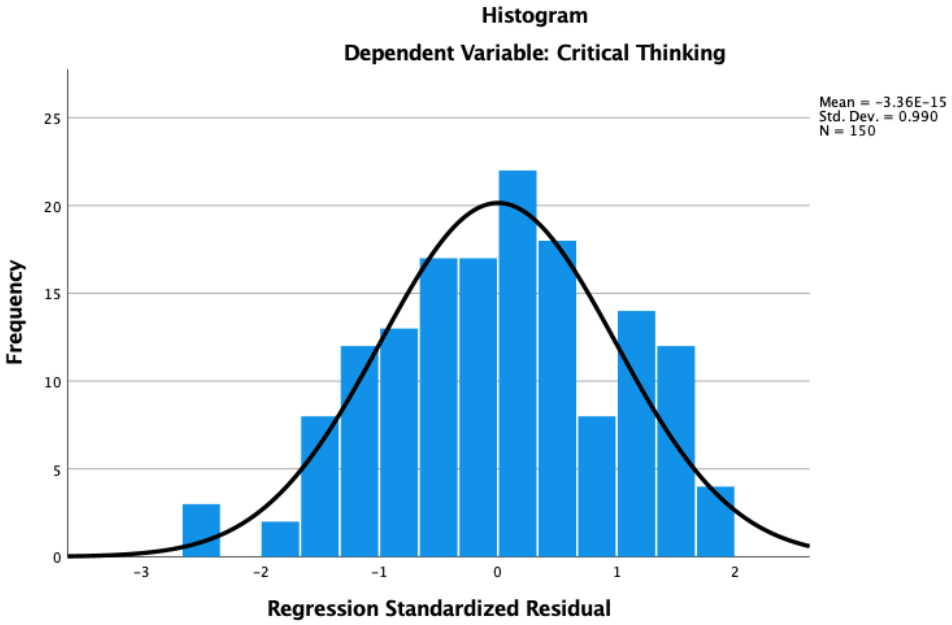



Fig 5 Histogram of Frequency versus Regression Standardized Residuals (between HOTs elements and Critical Thinking for Snowball Effect)

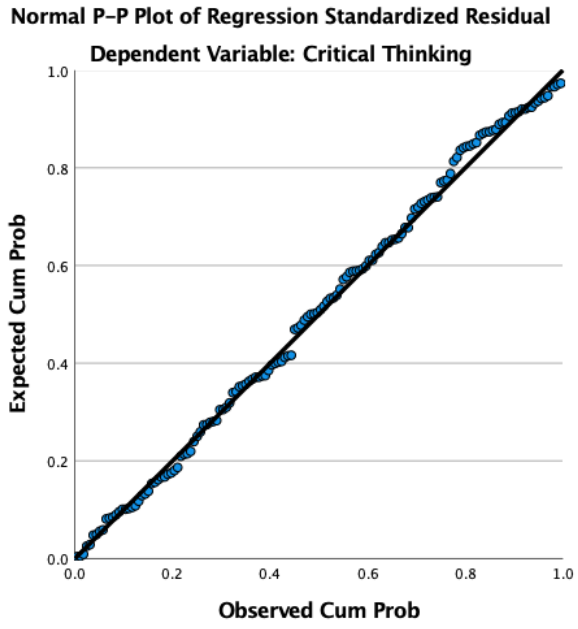



Fig 6 P-P Plot of Regression Standardized Residuals (between HOTs elements and Critical Thinking for Snowball Effect)

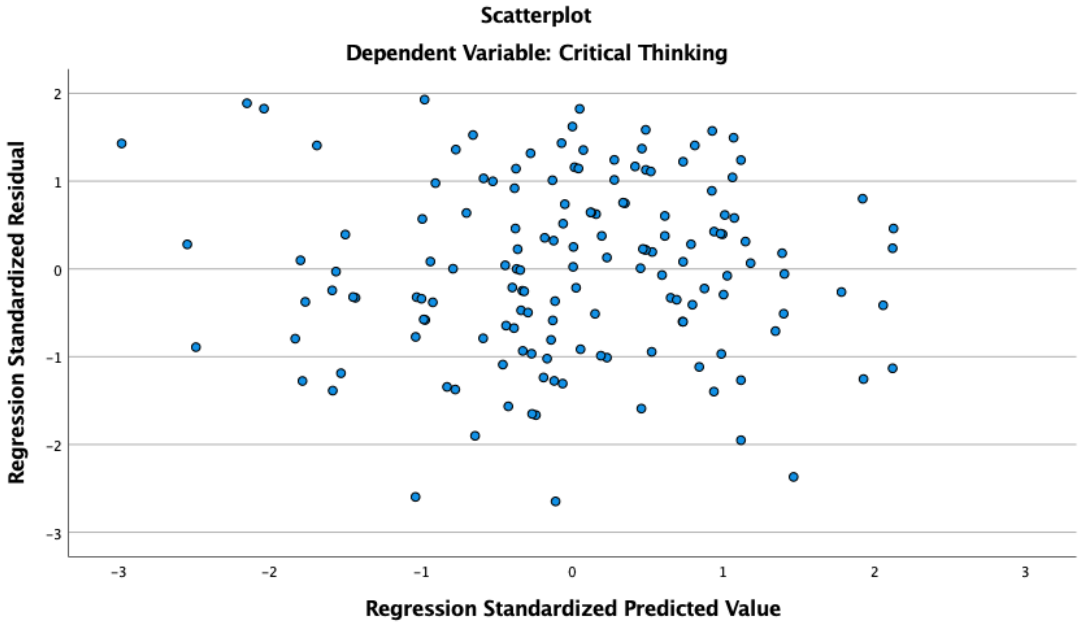



Fig 7 The Scatterplot of ZRESID against ZPRED (between HOTs elements and Critical Thinking for Snowball Effect)

Table 10

*Finding on the Coefficients[a] to Test the Assumption of Collinearity (between HOTs elements and Critical Thinking for Snowball Effect)*

| | Unstandardized Coefficients | | Standardized Coefficients | *t* | *p* | VIF | *R Square* | Adjusted R Square | *F* |
|---|---|---|---|---|---|---|---|---|---|
| Model | B | Std. Error | Beta | | | | | | |
| (Constant) | 1.221 | 0.351 | | 3.476 | 0.001 | | | | |
| Analyzing | 0.217 | 0.084 | 0.216 | 2.587 | 0.011 | 1.331 | 0.234 | 0.218 | 14.854 ( p=0.000 ) |
| Evaluating | 0.100 | 0.081 | 0.101 | 1.239 | 0.217 | 1.266 | | | |
| Creating | 0.314 | 0.091 | 0.288 | 3.436 | 0.001 | 1.334 | | | |

a. Dependent Variable: Critical Thinking

D-W Value：1.978

*p<0.05 ** p<0.01

Analyzing, Evaluating and Creating are taken as independent variables while Critical Thinking is taken as dependent variable for linear regression analysis. As can be seen from Table 10, the formula of the model is as follows: Critical Thinking =1.221+Analyzing*0.217+Evaluating*0.100+Creating*0.314, and the R-square value adjusted by the model is 0.234, which means that Analyzing, Evaluating, Creating can explain 23.4% of the change in Critical Thinking. It was found that the model passed the F test (F=14.854, p=0.000<0.05), that is, at least one of Analyzing, Evaluating, Creating will have an impact on the Critical Thinking. In addition, the multicollinearity test of the model shows that all VIF values in the model are less than 5, which means that there is no collinearity problem. Moreover, the D-W value 1.978 which is near the number 2, which indicates that there is no autocorrelation in the model, and there is no correlation between the sample data, and the model is good. The final concrete analysis shows that the regression coefficients of Analyzing and Creating are 0.216 and 0.288, respectively, and the p values are all less than 0.05,

indicating that Analyzing and Creating have positive and significant impact on the Critical Thinking, and the regression coefficient of Evaluating is 0.101, and the p values is 0.217 which greater than 0.05, indicating that Evaluating has no statistically significant impact on the Critical Thinking.

*Hypotheses Test*

The multiple linear regression analysis results showed that six hypotheses proposed in this research. Table 11 demonstrated detailed information between independent variables and dependent variables.

Table 11
*Hypotheses of this Study*

| Hypothesis | Independent Variables | Dependent Variables | P value | Test |
|---|---|---|---|---|
| $H^{1a}$ | Creating | Problem Solving | 0.002 | Supported |
| $H^{1b}$ | Evaluating | Problem Solving | 0.081 | Unsupported |
| $H^{1c}$ | Analyzing | Problem Solving | 0.000 | Supported |
| $H^{2a}$ | Creating | Critical Thinking | 0.001 | Supported |
| $H^{2b}$ | Evaluating | Critical Thinking | 0.217 | Unsupported |
| $H^{2c}$ | Analyzing | Critical Thinking | 0.011 | Supported |

**Discussion**

This study measured the level of college students' HOTs including five dimensions, Analyzing, Evaluating, Creating, Problem Solving and Critical Thinking. The results presented showed that the mean values with medium to high of students' perceived abilities in these five dimensions were respectively 3.49, 3.68, 3.61, 3.56 and 3.48. This outcome is consistent to some previous studies. Liu and colleagues (Liu et al., 2022) found that international research on HOTs has been increasing steadily, particularly since 2014, when it entered a phase of significant growth. Research on HOTs was still at its peak globally, especially in China. Therefore, cultivating students' HOTs was a gradual process that required time, patience, and sustained effort (Friyatmi et al., 2020; Haryanto & Arty, 2019; Setyahastuti et al., 2021; Widana, 2017; Yusuf et al., 2021). On the other hand, through OBE, students were encouraged to think about and solve problems, fostering their critical thinking and creative thinking(M. Chabeli, 2006; Jadhav et al., 2020; Raof et al., 2021; Wang, 2021; Zamir et al., 2022). Applying the knowledge and skills they learned to the real world helped them develop HOTs.

The results of snowball effect of Analyzing on Critical Thinking are consistent with the findings of Permana et al., (2019). The results showed that the predictor variable analytical skill gave effective contributions toward students' critical thinking skills, with the percentages of 54.26%, which is the most contribution to critical thinking among three predictor variables. Hence, the research conducted by Permana et al. could serve as a fundamental guide for developing educational strategies that enhance students' critical thinking abilities and supported findings of this study. In addition, Kim et al., (2018) found innovation behavior was identified as a key parameter that partially mediated the relationship between opportunity recognition and problem solving ability. Creating ability showed a direct impact on Problem Solving which is inconsistent with the findings of Kim et al. According to Ülger's (2016) finding, the strong correlation between creative and critical thinking in students studying Visual Arts or Religion & Ethics Education. However, there is lack of research on impact of Evaluating

abilities on Critical Thinking and Problem Solving. Therefore, previous research demonstrated Analyzing and Creating abilities have direct or moderate impact on Critical Thinking and Problem Solving skills of students, and this study has contributed to the empirical findings on previous studies, and more suggestion in hybrid learning context.

**Limitations of the Study and Future Research**

The current study has certain limitations in terms of research period, and future studies can observe and analyze the learning process of students over a longer period of time. By continuously tracking changes in student performance and motivation over time, researchers can gain greater insight into the impact of developing analytical, evaluative, and innovative skills on student learning. This longitudinal research approach can not only reveal the persistence and effectiveness of these skills in the student learning process, but also provide valuable guidance for educators to design more effective teaching strategies to enhance students' intrinsic motivation, external motivation, and learning outcomes.

In addition, the findings of this study can guide decision-makers at Chinese higher education institutions to suggest hybrid teaching and learning methods that enhance students' higher-order thinking skills through appropriate interactive learning settings. Utilize the snowball effect between students' HOTs to conduct thorough studies and enhance the sustainable and beneficial growth of hybrid learning methods.

**Conclusion**

This study first verified and determined five dimensions of HOTs of college students in OBE-based hybrid learning through EFA. Students' perception of the five dimensions of HOTs is medium to high, which indicates that students have good perceptions of HOTs in hybrid learning courses. Second, the researcher analyzes the five dimensions of HOTs through the method of multiple linear regression and draws the conclusion that Analyzing and Creating have a positive impact on Critical Thinking and Problem Solving, and the conclusion has statistical significance. However, Evaluating was not statistically significant for both Critical thinking and problem solving. Based on the research results, educators are suggested applying Analyzing and Creating a snowball effect on Critical thinking and problem solving to continuously improve the HOTs level of college students.

This study has contributed to development of a new approach or framework in enhancing HOTs amongst undergraduate students in the fundamental-application course like FCA, that needs to be acquired by them. Through this research, educators can better understand how to help students acquire the necessary higher order thinking skills as they study basic applied courses. This new approach or framework will not only help students better understand the course content, but also develop their critical thinking and problem solving skills, comprehensive for analyzing, evaluating and creating. At the same time, on this basis, educators can design more targeted teaching strategies and course content to promote the development of students' higher order thinking ability. This study also made this new approach or framework more widely promoted to help educators better guide students to develop higher order thinking skills.

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