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## \*CORRESPONDENCE

Hongze Yang  
✉ 82890524@qq.com

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# Impact of active learning instruction in blended learning on students' anxiety levels and performance

Bo Li<sup>1</sup>, Jiajing Yu<sup>1</sup>, Lichen Sun<sup>2</sup> and Hongze Yang  <sup>1\*</sup>

<sup>1</sup>College of Home and Art Design, Northeast Forestry University, Harbin, China, <sup>2</sup>College of Mechanical and Electrical Engineering, Northeast Forestry University, Harbin, China

**Introduction:** Contemporary educational research has extensively explored the link between anxiety and student performance, yet there's a gap in understanding this relationship in classrooms with varying levels of active learning. This study aims to establish connections between instructional design, anxiety levels, and student performance, ultimately creating a comprehensive theoretical framework.

**Methods:** This study was conducted during the pandemic. Data from 186 respondents at Northeast Forestry University were collected through an online survey, and 25 students were randomly selected for interviews to gather feedback. In the practical application of the introductory course "Basics Product Design," the Rain Class software was used to facilitate an active learning environment. Data from the online survey were organized in SPSS, then imported into the structural model framework in AMOS to calculate fit indices and other values to test hypotheses, applying structural equation modeling. Additionally, the relationship between anxiety levels and student performance was analyzed based on data from five classes using different instructional designs.

**Results:** The results indicated that cold calling was significantly positively correlated with anxiety levels ( $SE = 0.632, P < 0.001$ ), group work was significantly positively correlated with anxiety ( $SE = 0.166, P < 0.05$ ), clickers were not significantly positively correlated with anxiety ( $SE = 0.188, P > 0.05$ ), and anxiety levels were not significantly negatively correlated with student performance ( $SE = -0.306, P > 0.05$ ). Mediation effect tests revealed that anxiety levels fully mediated the relationship between the use of clickers and student performance. Comparing student performance and anxiety levels across the five classes, the relationship between anxiety levels and student performance did not show a simple positive or negative correlation but followed a fluctuating curve, with an interval of anxiety levels that promotes student performance.

**Discussion:** In a blended learning environment, different designs and frequencies of active learning activities can lead to varying levels of anxiety, which in turn affect student performance. One prominent factor in increasing student anxiety is cold calling. The findings can serve as a basis for teachers to design educational plans, helping to create classroom environments that foster active participation and maintain a positive state among students. Furthermore, in this instructional environment, it is worth further investigating the factors influencing student anxiety and the impact of anxiety on student academic performance.

## KEYWORDS

anxiety, active learning, testing, student performance, pedagogical impact

# 1 Introduction

## 1.1 Active learning

With the rise of the internet and the arrival of the pandemic, the integration of online and traditional teaching methods has become increasingly prevalent and is becoming a trend. Online teaching offers the advantages of convenience, flexibility, and freedom from spatial limitations (Yang et al., 2022), making it a necessary instructional design solution in response to the pandemic (Long et al., 2021). After the outbreak of the pandemic, teachers and students continuously explored and improved the application of internet-based teaching methods, leading to the widespread adoption of blended learning approaches that combine online and offline elements. Blended learning refers to the systematic integration of face-to-face and online learning within the same course to support the development of students' comprehension abilities (Bliuc et al., 2012). Even in the post-pandemic era, such models continue to be widely used by numerous educators, for example, in vocational education where blended learning integrates workplace activities into educational design (Bliuc et al., 2012), in undergraduate courses on Python programming (Chu et al., 2018), and in enhancing pharmacy students' learning efficiency and convenience with hybrid methods (Phosri and Lertnattee, 2021), yielding good results (Du et al., 2022).

The hybrid model of online and offline learning continues today, such as the establishment of communication groups for courses during the pandemic, which has continued post-pandemic and become the norm. Meanwhile, China has developed "XueXiTong," an online classroom software that integrates with offline classroom settings. It is evident that using online devices to support offline learning and teaching has also become the norm, with online mobile teaching gradually becoming a regular part of education. Due to the widespread adoption of blended classrooms today, this project applies this teaching method to assess the general applicability of the results. Another innovative approach to enhancing instructional effectiveness is the active learning classroom model. In this study we used an active learning approach focusing on student engagement using group work, clicker questions and cold calling (Driessen et al., 2020). Active learning is a broad term used to describe students actively constructing their own knowledge through activities and discussions in the classroom, rather than passively listening to lectures. Active learning practices, while thought to increase student engagement and motivation, also provide opportunities for formative assessment and peer group work (England et al., 2017). Whereas this article applies active learning strategies into the art and design subject area classroom, the definition of active learning changes slightly with the characteristics of the applied subject area (Lombardi et al., 2021), while Lombardi et al. advocate that an explicit definition of active learning should be included in the article (Lombardi et al., 2021). Therefore, this article defines active learning as applied to the subject area of art and design as a pedagogical strategy that promotes students' participation through practical classroom activities, problem solving through creative thinking and the development of independent understanding of aesthetic, technical and conceptual understandings through in-depth reflections on the process of art making, thus further developing their autonomy,

creativity and critical thinking in the field of art and design. In addition, the active learning classroom in this study refers to a classroom that incorporates active learning strategy activities based on the traditional lecture classroom.

Numerous existing studies have demonstrated the advantages of classrooms that apply active learning strategies over traditional lecture classrooms. Classroom approaches that promote active learning strategies give students the opportunity to connect new information to their own experiences, provide students with models for applying new knowledge, and promote the cognitive skills of higher-order thinking (Chaplin, 2009). Freeman et al. (2014) conducted a meta-analysis of more than 200 published STEM studies and showed that active learning improves student achievement and reduces failure rates regardless of subject, class size, curriculum level and teacher experience. This study also concluded that active learning had the greatest impact in small group courses (50 or fewer students), suggesting that students may receive more individualized attention and opportunities for engagement in this setting (Freeman et al., 2014).

The content of active learning classroom activities primarily encompassed three factors: cold calling, clickers, and group work. Cold calling refers to the teacher randomly selecting students in the classroom and asking them to share their ideas with the entire class. Clickers involve the teacher presenting multiple-choice questions to all students, who then respond using personal response devices or clickers. Based on the responses and feedback from the clickers, teachers can make timely adjustments to their teaching methods (Gwo-Jen and Wong, 2014). Group work involves students participating in learning activities in a team format within the classroom (Si et al., 2014).

In the classroom, these three typical active learning strategy activities will have a corresponding positive impact on teaching and learning. Group work among learners in most subjects, levels and courses of study is one of the salient features of a learner-centered classroom (Hung and Long, 2019). Group work promotes enhanced learning and requires collaboration among students (Brigati et al., 2020), which is challenging (Michaelsen et al., 2004, 2008; Sibley and Ostafichuk, 2014). These challenges contribute to the transition of the curriculum from teacher-centered to student-centered teaching (Marbach-Ad et al., 2016). At the same time, team-based learning can be effective in improving student learning and performance, as well as energizing the classroom and making students more talkative (Do and Le, 2019) and engaged in classroom learning (Carmichael, 2009). In addition, Weir et al. showed that even relatively short periods of group activity can lead to increased student learning (6). Peer collaboration activities like group work are often used in conjunction with clickers (Dufresne et al., 1996). There is an additional cost associated with the use of clickers, but they continue to be of value in the classroom (Beekes, 2006; Caldwell, 2007) and further enhance learning outcomes (Stowell and Nelson, 2007; Anthis, 2011). Clickers have been shown to have a neutral or positive effect on student performance in the classroom (Weir et al., 2019). The clicker collects immediate responses from students, from which it can be inferred that it prompts students to focus in the classroom. It sets questions that actively engage students, allowing them to talk and think about class topics rather than simply taking notes, and to interact with the instructor for the duration of the lesson (Knight and Wood, 2005;

Liu et al., 2017). This likewise promotes student engagement in the classroom (Bode et al., 2009; Dallaire, 2011; Cooper et al., 2018) and meets the active learning strategy definition.

In addition to group work and clickers, cold calling was also applied in this study. Cold calling was one of the most prominent activities in Cooper et al.'s study in terms of inducing anxiety in students among all active learning practices (Cooper et al., 2018). It is also effective in promoting classroom engagement due to the fact that it makes students answer questions involuntarily (Dallimore et al., 2012), enlivens the classroom to some extent, and has been suggested as a pedagogical best practice because it helps to promote classroom equity (Eddy et al., 2015). The utility of cold calling is in line with the goals of an active learning classroom, and therefore cold calling was adopted as one of the instructional activities in this study.

Active learning is now being implemented within a blended learning environment. Implementing active learning activities is not uncommon in such settings, as evidenced by studies like those of Cooper et al. (2018), and Canaleta et al. (2014), who effectively implemented active learning through the use of information and communication technology. The blended learning model provides online tools and resources, facilitating active learning practices. It offers students flexible learning options and a wealth of resources, and gives teachers access to real-time information on student progress, allowing for personalized instruction. The blended learning environment enhances the positive effects of active learning, making it easier to transition classrooms from traditional formats to engaging, interactive modes. Therefore, this study has decided to apply active learning activities in a blended setting.

## 1.2 Anxiety

The isolation, social distance, and loss of personal freedom during the COVID-19 pandemic may have exacerbated students' anxiety and stress (Martínez-Libano et al., 2023). These changes might have led to students' uneasiness in adapting to the new learning environment, increased anxiety in the classroom, and activated stress signals (Buizza et al., 2022; Martínez Libano and Yeomans Cabrera, 2023), thereby resulting in impaired academic performance and socioeconomic status (3).

The anxiety variable in the theoretical framework is the fourth variable, which is defined as an unpleasant emotional state or condition characterized by subjective feelings of tension, apprehension and worry, and activation or arousal of the autonomic nervous system (Spielberger, 1972). Anxiety has been preliminarily linked to circuits in the brain involving the amygdala and prefrontal cortex (Bishop, 2007). Increased amygdala response to threat-related interference is a brain activity feature of individuals with anxiety (Bishop, 2004, 2007; Bishop et al., 2007), which also occurs during conditioned fear (Bremner et al., 2005). Anxiety, as it relates to neural circuitry, can influence students' willingness and efficiency in learning. Scholars have explored the relationship between anxiety and student performance or learning outcomes to understand how to keep students in a positive state during class.

Most scholars believe that anxiety, as a negative emotion, has a detrimental impact on learning. For instance, England et al. (2017) practiced five active learning classroom activities and analyzed their effects on student anxiety, reporting that higher anxiety levels lead to decreased persistence in students' majors; Ofiaz (2019) explored whether there are differences between men and women in language anxiety, shyness and language learning strategies, and based on correlation analyses, found that there is a significant moderate negative correlation between students' foreign language learning anxiety and academic achievement, and that foreign language anxiety negatively impacts students' oral skills and academic achievements; Alrabai (2022) classified instructional design strategies into anxiety regulation and motivation facilitation strategies, conducted three types of emotion regulation experiments and suggested that anxiety is a negative emotion that learners should minimize to avoid negative emotional experiences. It is not difficult to find that most studies exploring the effects of anxiety on student performance have only explored the effects of different active learning activities on anxiety and student performance in the same teaching and learning environment, or have only explored the relationship between anxiety and academic performance as a whole, thus directly drawing a negative correlation. However, some scholars argue that anxiety does not always have negative effects and that moderate levels of anxiety can even promote learning. For example, Sajedi (2016) explored the relationship between anxiety and language performance with a questionnaire of 20 subjects and reported that facilitative anxiety positively affects performance, whereas excessive anxiety can lead to poor performance, and anxiety can sometimes serve as necessary motivation for some individuals; Cooper et al. (2018) conducted exploratory interviews with 52 students and mentioned that although high levels of student anxiety have been shown to inhibit academic performance, moderate anxiety can enhance students' motivation and performance.

The Yerkes-Dodson law (Yerkes and Dodson, 1908) was previously mentioned, stating that performance increases with increased psychological arousal (stress and anxiety) up to a certain point, after which performance begins to decline. The relationship between anxiety and performance depends on task difficulty (Teigen, 1994). For example, if a task is simple, students may need anxiety as a motivating factor; otherwise, there is no drive to perform. If a task is difficult, lower levels of arousal (stress and anxiety) are needed for students to concentrate and work effectively.

## 1.3 Scale tool to measure anxiety

Anxiety is classified into different types depending on its source by scholars, and the types of anxiety produced by students in the classroom are test anxiety (Sarason, 1984), social anxiety (Morris and Maisto, 2005), performance anxiety (Zeidner, 1998), language anxiety (Horwitz et al., 1986), course content anxiety (Putwain et al., 2010), task anxiety (Elliot and McGregor, 1999), time management anxiety (Britton and Tesser, 1991), and academic

future anxiety (Honicke and Broadbent, 2016). For different types of anxiety will be measured with different scales. And the scale used in this paper mainly refers to FLCAS (Foreign Language Classroom Anxiety Scale), which was developed by Horwitz et al. (1986) and has been widely used in teaching classrooms and agreed upon. Although the scale is widely used in foreign language classrooms, this paper argues that it can also be applied to other subject classrooms, especially those with active instructional design. Some of its questions can measure students' communicative anxiety and test anxiety, and these emotions can also occur in other classrooms, so this scale has generality. Therefore, the anxiety scale in this paper was adapted from the FLCAS and modified to fit the specific context of this study. Regarding the modification of the scale, some of the questions in FLCAS were selected and rewritten in a very subtle way, for example, the words "in a foreign language class" and "in a language classroom" were changed to "in this classroom", the words "in the classroom" were changed to "in the classroom", and the words "in the classroom" were changed to "in the classroom". For example, the words "in the foreign language class" and "in the language classroom" in the original scale were changed to "in this classroom", and "when speaking English" was changed to "when practicing in the classroom", so that the anxiety scale was more suitable for the specific situation of this study. Other scales such as the Generalized Anxiety Disorder 7-item Scale (GAD-7) developed by Kroenke et al. (2007). are general in nature, whereas the FLCAS was chosen for this study to explore anxiety in a classroom context.

## 1.4 Student performance

The fifth factor is student performance. Students' performance is defined as students' ability to compare the desired benefit with the observed effect of a particular product or service (Budur et al., 2019). Therefore, student performance in this study is composed of grades assigned by teachers based on students' overall performance and students' self-assessments of their learning status. Comprehensive performance includes the student's performance in class and the results of tests and assignments, not just performance in class. Including teacher evaluations provides a more objective contrast to the evaluation system based solely on students' perspectives (Gopal et al., 2021). Regarding the relationship between anxiety and student performance, some scholars believe that anxiety only has negative effects, while others believe it can act as a facilitating factor. Despite various studies on the relationship between anxiety and student performance, there is limited literature on the specific scope of positive anxiety resulting from teaching practices. Additionally, research by Gopal et al. (2021). indicates that course design, student expectations, and teacher feedback are key factors in measuring and enhancing student. This study hypothesizes that anxiety's impact on student performance is not solely negative; rather, there exists an anxiety range that can provide motivation for most individuals and maintain a good learning or working state. This range of anxiety is termed positive anxiety (Budur et al., 2019).

## 1.5 The relationship between active learning, anxiety levels, and student performance

In this study, the authors examined instructional design as a factor influencing students' anxiety levels and its impact on their performance. Active learning classrooms lead to changes in students' classroom anxiety levels. Cooper et al. (2018) reported that active learning classrooms have more assessment situations and are more likely to trigger anxiety in students than traditional lecture courses.

England et al. (2017) proposed that clickers, cold calling, and group work in active learning all have an impact on students' anxiety levels and generally elevate them, with cold calling being more likely to increase students' anxiety levels. Cooper et al. (2018) suggested that active learning classrooms, including cold calling, clickers, and group work, can stimulate students' anxiety levels and evaluated specific activities that either enhance or mitigate student anxiety. They also concluded that cold calling is the only activity that increases student anxiety. Downing et al. (2020) suggested that active learning increases students' anxiety levels by amplifying their fear of negative evaluation, and they described situations where students experience fear, such as answering questions in the classroom or during group activities. The authors conjecture that there is a link between active learning, which has been found by others to not only increase student anxiety levels, but has also been empirically validated to improve student performance. However, there is a paucity of literature exploring the relationship between active teaching styles, student anxiety levels, and student performance. Therefore, in this paper, anxiety is used as a mediating variable to establish and validate a theoretical framework for the instructional design of active learning and student performance in a blended online and offline classroom model.

Therefore, this study will set up five classes with different instructional designs, all having the same learning content to limit the difficulty, resulting in different levels of anxiety and performance. The data obtained from this experiment will be used to establish a theoretical framework and determine the range of positive anxiety.

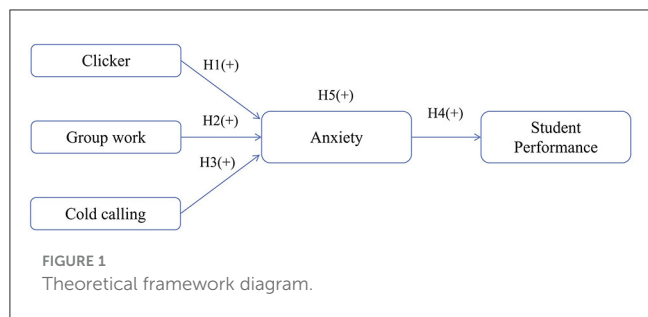
Therefore, in this study, we have set two main objectives:

1. To explore the relationship between active learning strategies and students' anxiety levels and performance.
2. To analyze the impact of active learning activities with different frequencies and intensities on students' anxiety levels and performance.

In order to further investigate these objectives, we will propose hypotheses: Regarding the relationship between active learning strategies and students' anxiety levels and performance, we have proposed a theoretical framework, as shown in Figure 1, which includes hypotheses:

H1: The use of clickers has a positive impact on students' overall anxiety levels.

H2: Group work has a positive impact on students' overall anxiety levels.



H3: Cold calling has a positive impact on students' overall anxiety levels.

H4: Anxiety has a negative impact on students' overall academic performance, but within a certain range of anxiety, it can also have a positive effect on improving student performance.

H5: Cold calling, group work, and clickers will influence students' performance through their anxiety levels.

H5a: Students' anxiety levels play a mediating role in the relationship between cold calling and student performance.

H5b: Students' anxiety levels play a mediating role in the relationship between group work and student performance.

H5c: Students' anxiety levels play a mediating role in the relationship between clickers and student performance.

The remaining structure of this paper is as follows: Part II presents the research experimental design. Part III analyzes the experimental results and conducts hypothesis testing. Finally, the paper concludes with a discussion and implications for future research.

## 2 Method

### 2.1 Participants

In this study, the total number of students in the 10 small classes in which classroom practice was carried out was 200, and after collecting all the data and removing the extreme data, the result was the successful incorporation of data from 186 students from various colleges of the Northeast Forestry University in China who took the design practice course. Prior to the survey, the students were informed about the class design of the study, only students who agreed to participate in the classroom design study were accepted for the practice, and random sampling method was used to assign students to different classes where each student had his/her own student number which consisted of the year of enrolment, the code of the faculty major and the initials of his/her name. The survey was conducted after previously asking the students whether they were willing to fill the scale questionnaire and being recruited for interview by random sampling method. Five students were randomly selected from each type of class to be interviewed and a total of 25 students participated in the interviews. Descriptive analysis revealed that 80.6% of the participants were undergraduate students, totaling 150 individuals, while the remaining were graduate students. The gender ratio was approximately 1:1 between male and female students. The students' ages ranged from 18 to 35 years, with the majority falling within

TABLE 1 Demographics of students who were adopted.

Year	<i>n</i>
Freshman	84
Sophomore	38
Junior	22
Senior	6
Super senior	36
Gender	<i>n</i>
Female	99
Male	87
Professional situation	<i>n</i>
Design profession	162
Non-design professional	24

the age group of 18 to 22 years. Details are shown in Table 1. The students who chose this research course were basically design-oriented, design students or design enthusiasts, all spoke Chinese as their first language, came from different provinces in China, and studied at the Northeast Forestry University. Therefore, the participants were close in terms of socio-cultural background, learning environment and age, which ensured the consistency of the collected data in terms of group homogeneity.

### 2.2 Materials

The measurement scales for the five variables, namely cold calling, group work, clickers, anxiety level, and student performance, were developed based on previous research. The cold calling scale was formulated with reference to Cooper et al. (2018) study and consists of four items. The group work scale was adapted from Cooper et al. (2018) research findings and comprises three items. The clickers scale was also derived from Cooper et al. (2018) study and includes four items. The anxiety scale was adapted from the Foreign Language Classroom Anxiety Scale (FLCAS) and modified to suit the specific classroom context of this study, with nine items in total. Student performance includes both teacher evaluations and students' self-assessments. The student questionnaire evaluation was developed based on the work of Gopal et al. (2021) and consists of three items. All these variables were measured using a five-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The teacher evaluation holds special significance, as it involved a five-point rating based on students' assignments, attendance, and classroom engagement, ranging from very poor (1) to excellent (5). A questionnaire survey was conducted among students from Northeast Forestry University in China, and the details of the questionnaire items are provided in Table 3. Students were interviewed after completing the scale questionnaire, which was semi-structured, with handout panels provided with the interview questions, which focused on asking students about their feelings of anxiety in different classroom situations and the reasons for their anxiety. In order for students

to understand the theoretical concepts involved in the interviews, terminology panels were provided to avoid any ambiguity about the content of the interviews, which lasted ~35 min each. The interviews were conducted with reference to the results of the =questionnaire completed by each student, and corresponding questions were asked in order to gain a more specific understanding of the students' situation.

In the classroom, the software used to facilitate active learning activities is Rain Class. Rain Class is an online education platform developed by Tsinghua University and widely used in China. The platform supports various teaching modes, including flipped classrooms, blended learning, etc., and has rich interactive features such as real-time Q&A, quizzes, polls, etc., to enhance classroom participation and learning experience.

The data analysis software used are SPSS and Amos. SPSS is a widely used statistical analysis tool suitable for complex data management and statistical analysis tasks. We chose SPSS for data preprocessing, descriptive statistical analysis, and correlation analysis. It is primarily used to organize data for easy import into Amos software, as well as to compute basic statistical descriptions, such as mean, standard deviation, etc.

Amos supports the construction of graphical models and path analysis, making model building and modification more intuitive and manageable. We chose Amos because it can effectively handle complex relationships between latent and observed variables in the model. In Amos, we first constructed a path diagram of the theoretical model, then input data exported from SPSS to fit the model. Through Amos, we can evaluate the overall fit of the model, the significance of path coefficients, and the direct and indirect effects between variables, thereby validating the research hypotheses.

## 2.3 Experimental section

This study is divided into two parts. The first part aims to establish a model with cold calling, group work, and clickers as independent variables, student anxiety level as the mediating variable, and student performance as the dependent variable. In this part, the researchers will analyze how the three teaching designs (cold calling, group work, and clickers) influence students' anxiety levels, which in turn affect their overall performance.

The second part of the study investigates the relationship between different levels of student anxiety and their performance. In this part, student anxiety level is considered the independent variable, while student performance remains the dependent variable. The researchers will examine how varying levels of anxiety impact students' overall performance, thereby gaining insights into the potential effects of anxiety on academic outcomes.

By conducting both parts of the study, the researchers aim to explore the complex interactions between teaching designs, student anxiety levels, and academic performance. This two-fold approach provides a comprehensive understanding of the role of anxiety in the learning process and its potential implications for educational practices.

This study utilized a mixed-methods approach. For the quantitative part, an online survey was conducted to collect data

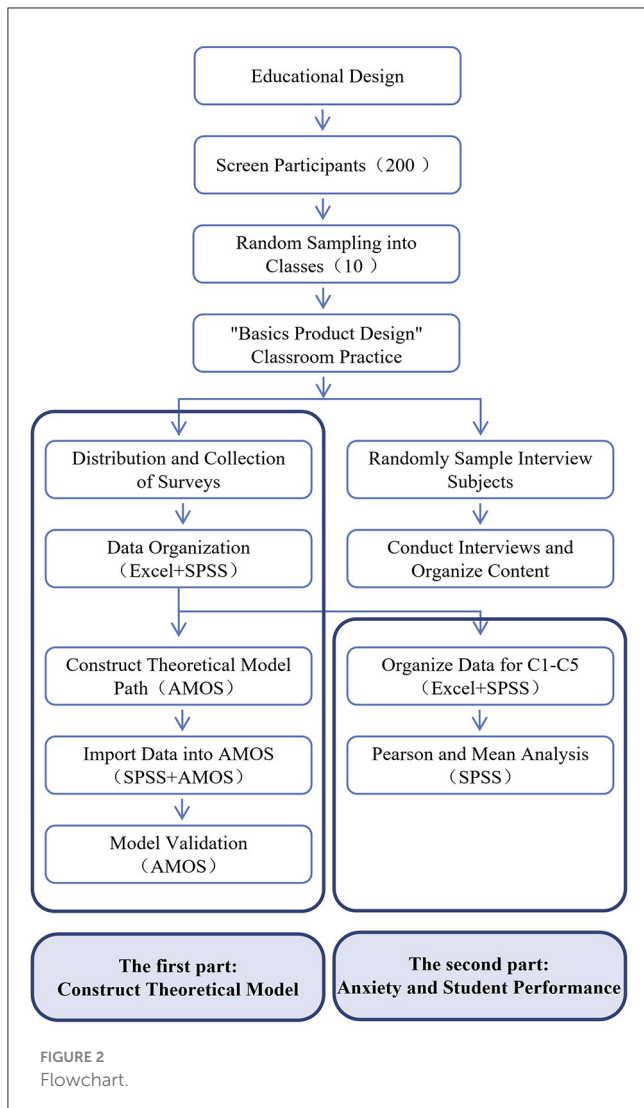
from 186 respondents at Northeast Forestry University, and the data were analyzed using Structural Equation Modeling (SEM). Additionally, data were organized in SPSS software, and structural model analysis was performed using AMOS software to validate the hypotheses. The data on student anxiety levels and performance from five different classes were also applied to study performance among varying levels of anxiety. The qualitative part involved selecting interview participants through random sampling and collecting feedback from 25 students. This qualitative data helps to deepen understanding of student perceptions and insights beyond the quantitative results.

## 2.4 Procedure

In this study, the curriculum experiment was conducted under real classroom conditions, and data were collected after the teaching experiment. The participants were selected through sampling, and they were informed about the purpose of the research and the data collection process. Confidentiality of the data was assured, and there were no incentives or rewards for participating in the study. After participants' confirmation, classes were divided through random sampling for the teaching practice of "Basics Product Design." In the classroom, cold calling using clickers in active learning activities implemented through the Rain Classroom software was conducted, and students were encouraged to use communication software to build online groups for easy communication. Questionnaires and interviews were conducted with participants after the practice. The information used in this research was collected through an online survey, which was created using Excel and distributed via QQ email. Students were asked to provide their college and major names. Two hundred questionnaires were retrieved. After excluding a few questionnaires with extreme values, 186 responses were included as the final research data. Then, interviewees were selected through random sampling, with five individuals from each class, totaling 25 people. Subsequently, text and data information were analyzed. To improve the clarity of the process, a flowchart was drawn as shown in [Figure 2](#).

## 2.5 Course design

The survey data and interview content were collected from students enrolled in the Introduction to Basics Product Design at Northeast Forestry University during the spring semester of 2022. Teaching is conducted in Chinese throughout. Teaching is conducted in the ordinary classrooms of the Chengdong Building at Northeast Forestry University. The instructional design consists of five different approaches, labeled as C1 to C5, ranging from traditional classroom teaching (C1) to active learning modes, with increasing emphasis on active learning content. Each class consists of 20 students, following a small-group teaching format, with the majority being undergraduate students and a small number of graduate students. The course is conducted over 4 weeks, with three classes per week, each lasting 45 min. Throughout the week, practical assignments are given, and in the fourth week, students



are required to submit a major assignment to assess their classroom engagement. After the course concludes, at the end of April 2022, students will be given questionnaires for data collection. Students were admitted to different classes through random sampling.

The course instructors all hold doctoral degrees and possess extensive experience in designing and teaching courses. They have adeptly adapted to the challenges posed by the pandemic and are well-versed in conducting online teaching using internet devices. Moreover, they demonstrate proficiency in implementing active learning methods during the course.

To test the generalizability and induce varying anxiety levels in the instructional conditions, five different classroom settings (C1–C5) were established. C1 served as the control group without active learning instructional design, while the remaining classrooms were designated as experimental groups with distinct active learning interventions.

In the C1 course, there is no active learning component in the instructional design. It follows a traditional classroom mode,

where the teacher delivers information to the students in a one-way manner, and the students passively listen to the lecture without engaging in activities such as cold calling, group work, or the use of clickers.

In the C2 course, the instructor occasionally uses clickers and cold calling, typically 1–2 times within a 45-min class. When clickers are employed, the instructor encourages individual discussions among the students. Moreover, clicker participation is integrated into the overall scoring. However, in the case of cold calling, the accuracy of responses is not factored into the grading process; mistakes made during cold calling are not penalized. It is important to note that throughout the entire course, no group activities are conducted.

In the C3 course, the instructor occasionally utilizes clickers and cold calling. However, when clickers are employed, students are not permitted to discuss their answers and must respond individually to the questions. It is explicitly communicated to the students that the accuracy of clicker responses will be taken into account for grading, and incorrect answers will result in point deductions. Similarly, the accuracy of responses during cold calling will also be considered for grading, and incorrect answers will lead to point deductions. Furthermore, the C3 course incorporates group activities, and the major assignment for the course will be presented in a group format. Students are granted autonomy in selecting their group members for the assignment.

In the C4 course, the instructor frequently uses clickers ( $\geq 3$  times within one class session) and occasionally employs cold calling. Prior to responding to clicker questions, students are not permitted to engage in group or individual discussions. The accuracy and level of participation in clicker responses are considered in the grading, and the accuracy of cold calling responses is also taken into account for grades. Additionally, the C4 course incorporates group classroom activities, and the major assignment will be presented in a group format. However, students do not have the option to choose their group members, as the instructor will assign them to groups. Students are informed that the group major assignment accounts for 30% of the overall course grade.

In the C5 course, the instructor frequently utilizes clickers and cold calling ( $\geq 3$  times within one class session). Students are not permitted to discuss the clicker questions before responding. The accuracy and level of participation in clicker responses, as well as the accuracy of cold calling responses, are taken into account for grading. Additionally, the C5 course incorporates group activities, and students are randomly assigned to groups. The students are informed that the clicker and cold calling components contribute to 10% of the overall course grade, while the group major assignment accounts for 30% of the total course grade.

The research is divided into two parts. In the first part, a theoretical framework model is established, considering five factors. To ensure the generalizability of the experiment, three teaching methods (C3, C4, and C5) are chosen for investigation. Eight classes are selected as the data source, comprising a total of 160 students. After excluding extreme data, the sample size is reduced to 150 students. In the second part, the relationship between anxiety levels and student performance is explored. Five classes, each representing one teaching method, are selected for the investigation. Each class consists of 20 students, resulting in a total

TABLE 2 Study of specific adoption data.

Class Number	Number of students attending classes	Number of adopted data	Adopted research components
C1	20	18	The second part
C2	20	18	The second part
C3-1	20	19	The first part the second part
C3-2	20	18	The first part
C4-1	20	19	The first part the second part
C4-2	20	18	The first part
C4-3	20	19	The first part
C5-1	20	19	The first part the second part
C5-2	20	19	The first part
C5-3	20	19	The first part

of 100 students. After excluding seven extreme samples, the final sample size is 93 students. The specific adoption of data for these two parts of the study is detailed in Table 2. The first part of the table refers to the theoretical framework model, while the second part refers to an in-depth exploration of the relationship between anxiety levels and student performance.

## 3 Results

### 3.1 Validation of the model

#### 3.1.1 Exploratory factor analysis

To analyze the data, we utilized SPSS and AMOS software. Initially, exploratory factor analysis (EFA) with VARIMAX rotation was conducted on the 150 samples to extract different factors. The results of the exploratory factor analysis revealed five distinct factors.

Factor 1 was labeled “Group Work,” encompassing questionnaire items such as “I feel less informed in the group,” “Group work puts pressure on me,” and “I find it difficult to communicate with group members.”

Factor 2 was termed “Clicker,” incorporating items such as “The design of the clicker causes me stress,” “The content of clicker questions is ambiguous,” and “There is not enough time to answer the questions,” and “The frequency with which the clicker is used makes me feel uncomfortable.”

Factor 3 was denoted as “Cold Calling,” encompassing items such as “The passive response setting in cold calling makes me uncomfortable,” “Cold calling happens too frequently,” “I am afraid of performing poorly in cold calling activities,” and “Cold calls make the classroom atmosphere more tense.”

Factor 4 was identified as “Anxiety Value,” which included items like “I worry about making mistakes in class,” “I lack confidence in class exercises,” and “I tremble when the teacher calls my name in class.”

Factor 5 was labeled “Student Performance,” which included items such as “Overall performance rating given by the teacher” and Self-rating of learning status in this course. Together, these five factors accounted for 73.795% of the total variance.

To validate the factors extracted through exploratory factor analysis (EFA), the authors conducted confirmatory factor analysis (CFA) using AMOS. Finally, the authors applied structural equation modeling (SEM) to test the hypothesized relationships.

#### 3.1.2 Reliability and validity analysis of sample data

To determine the reliability and stability of the questionnaire scales, a reliability analysis was conducted on the data obtained from 150 participants, considering both the overall scale and individual factors. Cronbach’s  $\alpha$  coefficient was used to assess internal consistency, with values above 0.60 deemed acceptable for each subscale, and values above 0.80 considered acceptable for the entire scale, indicating high internal consistency, reliability, and stability of the questionnaire. The results of the reliability analysis were as follows: Group Work: Cronbach’s  $\alpha = 0.79$ , Clicker: Cronbach’s  $\alpha = 0.79$ , Cold Calling: Cronbach’s  $\alpha = 0.92$ , Anxiety Value: Cronbach’s  $\alpha = 0.95$ , and Student Performance: Cronbach’s  $\alpha = 0.88$ . Moreover, the overall Cronbach’s  $\alpha$  coefficient for the entire questionnaire was found to be 0.92, affirming the high internal consistency of the overall scale. These results confirm that the data meets the standard requirements for reliability and stability, thus ensuring the validity of the questionnaire.

#### 3.1.3 Measurement model

Table 3 summarizes the results of the reliability and validity analysis, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA). The EFA yielded six distinct factors, which were subsequently validated through CFA. As presented in Table 4, the measurement model demonstrated good convergence (Arpaci and Baloglu, 2016; Arun et al., 2018). The results of the confirmatory factor analysis indicated that the standardized factor loadings were statistically significant, with values above 0.05. Furthermore, the measurement model displayed acceptable model fit indices, including CMIN/df = 1.481, Incremental Fit Index (IFI) = 0.990, Tucker-Lewis Index (TLI) = 0.988, Goodness of Fit Index (GFI) = 0.879, and Root Mean Square Error of Approximation (RMSEA) = 0.028, suggesting a good fit for the model, demonstrating its ideal characteristics.

According to acceptable criteria, the Average Variance Extracted (AVE) should be higher than the squared correlation between latent variables and all other variables. In this study, the square root of the AVE values is greater than the inter-construct correlation coefficients, confirming the discriminant validity (Table 4) (Hair et al., 2006). The results in Table 2 demonstrate that the measurement model has achieved good discriminant validity.

#### 3.1.4 Structural model

To test the hypotheses proposed earlier, this study employed Structural Equation Modeling (SEM) techniques, a multivariate statistical analysis method that combines factor analysis



TABLE 3 Factor analysis.

Observation variables	Items	Mean	Std.	Unstd.	S.E.	t-value	P	SMC	CR	AVE
Group work	I find it difficult to communicate with group members	2.35	0.725	1.011	0.136	7.428	***	0.526	0.798	0.570
	Group work puts pressure on me	2.35	0.686	1				0.471		
	I feel less informed in the group	2.33	0.845	1.09	0.136	8.027	***	0.714		
Clicker	The frequency with which the clicker is used makes me feel uncomfortable	3.13	0.737	1.043	0.132	7.895	***	0.543	0.798	0.498
	There is not enough time to answer the questions	3.05	0.663	0.936	0.129	7.237	***	0.440		
	The content of clicker questions is ambiguous	3.25	0.689	0.889	0.114	7.799	***	0.475		
	The design of the clicker causes me stress	3.23	0.731	1				0.534		
Cold calling	Cold calls make the classroom atmosphere more tense	3.23	0.86	1.036	0.073	14.244	***	0.740	0.924	0.753
	I am afraid of performing poorly in cold calling activities	3.16	0.894	1.029	0.067	15.249	***	0.799		
	Cold calling happens too frequently	3.32	0.843	0.909	0.067	13.65	***	0.711		
	The passive response setting in cold calling makes me uncomfortable	3.23	0.874	1				0.764		
Anxiety value	I worry about making mistakes in class	3.45	0.819	0.989	0.084	11.701	***	0.671	0.949	0.673
	I lack confidence in class exercises	3.35	0.829	0.966	0.081	11.987	***	0.687		
	I tremble when the teacher calls my name in class	3.43	0.801	0.929	0.082	11.341	***	0.642		
	My heart beats rapidly when I'm about to be called to answer a question	3.42	0.838	0.994	0.082	12.127	***	0.702		
	I feel that other classmates have stronger professional abilities than me	3.40	0.808	1				0.653		
	I feel very nervous about some of the practical tests in class	3.51	0.804	0.897	0.079	11.389	***	0.646		
	I feel fearful when making unprepared remarks in class.	3.38	0.82	0.975	0.083	11.746	***	0.672		
	Even when fully prepared, I still feel anxious	3.43	0.832	0.965	0.08	12.047	***	0.692		
	I feel very afraid when the teacher corrects my mistakes	3.52	0.829	0.987	0.082	12.018	***	0.687		
Student performance	Overall performance rating given by the teacher	3.78	0.698	1				0.487	0.893	0.739
	I believe that my attitude toward learning is positive	3.58	0.917	1.149	0.11	10.457	***	0.841		
	This class has improved my professional competence	3.63	0.943	1.221	0.119	10.29	***	0.889		

\*\*\*indicates that the *p*-value < 0.001.

and multiple regression analysis. It is used to analyze the structural relationships between observed variables and latent variables. Table 5 presents the fit indices for the structural model, and all model fit values are within the specified ranges. This indicates that the model has achieved good fit. Additionally, indices such as Goodness of Fit Index (GFI) = 0.879 are supported, further confirming the adequacy of the model fit.

Indeed, the model successfully fit the data, and all covariates between variables and regression weights were statistically significant ( $P < 0.001$ ). This indicates that the relationships between the variables and their regression weights were found to be significant and reliable in explaining the observed data.

Table 6 presents the relationships between the exogenous, mediator, and endogenous variables, namely, small group work, clicker, cold calling, anxiety level, and student performance. The

TABLE 4 Validity analysis of measurement model.

	CR	AVE	Cold calling	Clicker	Group work	Anxiety value	Student performance
Cold calling	0.924	0.753	<b>0.868</b>				
Clicker	0.798	0.498	0.677	<b>0.706</b>			
Group work	0.798	0.57	0.538	0.634	<b>0.755</b>		
Anxiety value	0.949	0.673	0.845	0.713	0.633	<b>0.820</b>	
Student performance	0.893	0.739	-0.307	-0.386	-0.307	-0.386	<b>0.860</b>

AVE (Average Variance Extracted) is the extracted average variance, and CR (Composite Reliability) is the composite reliability. The bold values on the diagonal represent the square root of AVE.

TABLE 5 Criterion for model fit.

Criterion for goodness of fit measure	Recommended values	Model fit value
GFI	>0.8	0.879
AGFI	>0.8	0.849
IFI	>0.9	0.99
RMR	≤0.08	0.039
RMSEA	≤0.08	0.028

first three factors showed a positive relationship with anxiety level, leading to a slight decrease in overall student performance. The results indicated that the clicker had a positive relationship with anxiety level, but with  $p > 0.05$ , H1 was not supported. The second factor, small group work, showed a positive correlation with student satisfaction ( $SE = 0.166$ ,  $t$ -value = 2.369;  $p < 0.05$ ). Thus, H2 was supported. The third factor, cold calling, showed that feedback was positively correlated with student satisfaction ( $SE = 0.067$ ,  $t$ -value = 7.172;  $p < 0.05$ ). Thus, H3 was supported. The results demonstrated that among small group work, clicker, and cold calling, cold calling had the greatest impact on students' anxiety level ( $SE = 0.632$ ), followed by the clicker ( $SE = 0.188$ ), and small group work ( $SE = 0.166$ ). Small group work had the smallest impact on students' anxiety level.

Table 7 indicates that students' anxiety level partially mediated the relationship between cold calling and student performance. Thus, H5(a) was supported. Additionally, the analysis results showed that anxiety level fully mediated the positive relationship between clicker and student performance. Hence, H5(b) was supported. However, the mediation analysis results demonstrated that anxiety level partially mediated the positive relationship between small group work and student performance. Therefore, H5(c) was supported.

## 3.2 Positive anxiety

### 3.2.1 Reliability analysis

Reliability analyses for each construct for classes C3, C4, and C5 were calculated and validated in 4.1.2, so specific reliability analyses were conducted for C1 and C2. The Cronbach's alpha coefficients for the anxiety factor questionnaire in C1 were 0.806, and for the

student performance factor was 0.906. The clicker questionnaire factor Cronbach's alpha coefficients were 0.807, and the cold call factor coefficient is 0.855, anxiety factor questionnaire coefficient is 0.863 and student performance factor coefficient is 0.946. Therefore, the results show that the data passed the standardized.

### 3.2.2 Mean comparison

In order to explore the relationship between anxiety levels and student performance in the five classes with different teaching methods, the mean anxiety levels and student performance of the five classes were compared. The results are presented in Figure 3 and Table 8.

When anxiety levels are relatively low, such as in the C1, C2, and C3 classes, student performance also improves as anxiety increases. However, when anxiety levels exceed a certain limit, higher anxiety levels are associated with lower student performance.

Based on the comprehensive results, H4 is supported.

### 3.2.3 Pearson correlation analysis

A Pearson correlation analysis was conducted to examine the relationship between overall student performance and anxiety levels across the five classes. The results showed a significant negative correlation ( $p < 0.05$ ) between anxiety levels and student performance. This indicates that, on the whole, student performance is negatively correlated with anxiety levels. The results are presented in Table 9. However, it is important to note that the relationship between student performance and anxiety levels may vary under different circumstances, and it is not an absolute negative correlation.

## 3.3 Analysis of interview results

In this study, five students were randomly selected to be interviewed in each type of class, for a total of 25 interviews. By interviewing the students, we were able to understand how they felt in different teaching classes, and we collected feedback accordingly. In the C1 traditional classroom, the lecturer outputs knowledge more in a lecture style, and the main investigation is based on the final assignment, the students' feedback is that they are more calm in the classroom, and they think that the classroom is less interesting, and only one of the five interviewed

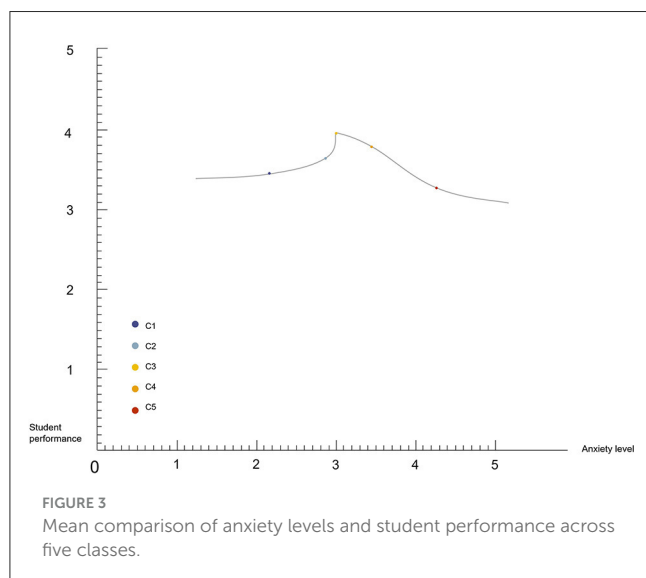
TABLE 6 Structural analysis.

Hypothesis	Relationship			Estimate(SE)	C.R.	P value	Decision
H1(+)	Anxiety value	<-	Clicker	0.188	1.759	0.078	Not supported
H2(+)	Anxiety value	<-	Group work	0.166	2.369	0.018	Supported
H3(+)	Anxiety value	<-	Cold calling	0.632	7.173	***	Supported
H4(+)	Student performance	<-	Anxiety value	-0.306	-1.53	0.126	Not supported

\*\*\*p < 0.059.

TABLE 7 Mediation analysis.

Hypothesis	Relationship	Estimate	p value	Mediation
H5(a)	Student performance ← anxiety value ← cold calling	-0.134	0.139	Part
H5(b)	Student performance ← anxiety value ← clicker	-0.062	0.05	Full
H5(c)	Student performance ← anxiety value ← group work	-0.062	0.068	Part



students with good grades responded that they can rely on their own internal drive to immerse themselves in the classroom, while the other students have an obvious sense of urgency only near the end of the semester. In the C2 classroom, students responded that they felt a sense of crisis due to clickers and cold calling, which motivated them to participate in the class to some extent, but the majority of students appeared to be active and participated actively in the classroom question and answer session because the instructor informed them that the activity was graded on participation rather than accuracy. In the C3 classroom, students experienced anxiety and stress due to being told that the activity was scored according to accuracy. Students reported feeling pressure and stress from time to time in the classroom, but were also reminded to immerse themselves in the classroom because of this stress. For the group format of the big final assignment, some students gave feedback that they would feel anxious because they could not find a suitable group member, but for those who found a preferred group member,

the collaborative group format allowed them to feel safe and emotionally stable, which would soothe the anxiety that comes with the end of the semester. In the C4 classroom, the use of clickers increased in frequency and discussion was not allowed while answering questions. This was a point that caused anxiety for most students. The fact that group groupings were randomly assigned by the teacher relieved anxiety for some students with social anxiety, but increased anxiety for students with preferred candidates. The practical group activities in the classroom would be interesting for the students, and more frequent group activities would make the students feel conflicted or happy to cooperate with their partners, and this activity is higher for the students to deal with interpersonal skills. At the same time, the teacher informed students of the value of the group assignment, which made some students anxious and worried about the uncertainty of working with classmates, one of them showed obvious dissatisfaction with his teammates, while some students indicated that they attached more importance and seriousness to the assignment because of its larger value, which was a motivating effect. In the C5 course, the frequency of cold calling was increased compared to C4, and students were informed of the percentage of marks for all activities. From the feedback of the students interviewed in C5, we can find that most of the students experience significant anxiety in the classroom and say that frequent cold calling makes them feel uncomfortable, while the whole classroom environment can often cause stress to the students, and most of the students say that the activities are too frequent, and only one high-achieving student out of the five interviewed says that he likes the activities and the information in the classroom, which is compact, and it immerses him in it and creates a flow of emotions. in it and create a mind stream.

## 4 Discussion

The rapid development of the internet and the unprecedented impact of the pandemic have led to the widespread adoption of blended learning in higher education classrooms. Blended learning, an instructional approach that integrates both online and

TABLE 8 Mean of anxiety levels and student performance across five classes.

Class identification number	C1	C2	C3	C4	C5
Anxiety value	2.17	2.86	3	3.44	4.27
Student performance	3.46	3.63	3.95	3.78	3.78

TABLE 9 Pearson correlation analysis of student anxiety levels and student performance.

	Anxiety level	Student performance
Anxiety level	1	-0.391**
Student performance	-0.391**	1

\*\*Significantly correlated at the 0.01 level (two-tailed).

offline elements, has gained prominence due to its flexibility and adaptability to different learning environments. Simultaneously, the educational community has recognized the significant benefits of active learning approaches in enhancing teaching quality and student engagement. Against this backdrop, the researchers undertook a study that leveraged blended learning and active learning techniques to investigate specific scientific hypotheses. The primary aim was to establish a theoretical framework model to explore the intricate relationship between anxiety levels and student performance. This study sought to shed light on how anxiety, as a cognitive and emotional factor, could influence students' academic outcomes in the context of these innovative teaching methodologies. By implementing a rigorous experimental design and gathering comprehensive data, the study yielded valuable insights into the connections between anxiety levels and student performance. The findings of this research have the potential to inform and guide educators in designing more effective teaching strategies. Armed with this knowledge, educators can create conducive and supportive learning environments that address students' anxiety concerns and, consequently, enhance overall student performance. The implications of this study extend beyond a mere examination of instructional methods. The results have the potential to impact educational policies and practices by encouraging the integration of active learning strategies in blended learning settings. The application of these evidence-based approaches could lead to improved educational outcomes and student satisfaction.

This study aims to explore the effects of different active teaching designs on student anxiety levels and academic performance. It also aims to validate the appropriate anxiety levels that promote motivation for the majority of people. According to the theory of emotional cognition, emotion is a subjective feeling that requires the evaluation of stimuli by the cerebral cortex before the emergence of emotions (Qiao, 2008). The cognitive evaluation of environmental stimuli by individuals is a key factor in the generation of emotions (Fu, 2015). In the teaching environment, active learning strategies such as clickers, group work, and cold calling are considered to act as environmental stimuli, influencing students' perceptions and performances (Ames and Archer, 1988). Therefore, this study proposes hypotheses H1, H2, and H3, indicating that clickers, group work, and cold calling as teaching

designs can increase students' anxiety levels. It constructs a theoretical framework based on previous research.

The rationale for hypothesizing the association between clickers, group work, and cold calling with anxiety in this study is as follows. Clickers require students to answer questions immediately, possessing moderate social and evaluative aspects, demanding students to promptly search for correct information and adopt corresponding emotion regulation strategies (Brigati et al., 2020). This can lead students to feel pressure, and under conditions where scoring is based on accuracy and time is insufficient, it can further increase student anxiety (Cooper et al., 2018), corresponding to H1. In group work, students fear negative evaluations from peers, and even in the mere anticipation of participating in group work, they exhibit fear of negative evaluations (Elicker and McConnell, 2011). However, collaborating with group members with whom communication is comfortable may alleviate anxiety (Cooper and Brownell, 2016; Cooper et al., 2018), corresponding to H2. Cold calling can evoke students' fear of negative evaluations (Zhang, 2001), thereby exacerbating students' anxiety and classroom pressure (Broeckelman-Post et al., 2016; Cooper et al., 2018), corresponding to H3.

Previous research has shown that anxiety can motivate students to concentrate on their work to some extent (Yerkes and Dodson, 1908). This is also consistent with the findings of Rashtchi and Keyvanfar (2002), who suggest that anxiety or stress, if at an optimal level, can be a facilitator of language learning. The relationship between anxiety levels and academic performance is not linear. Hypothesis H4 proposes that although high levels of anxiety have a negative impact on overall student performance (Teigen, 1994; Suheir et al., 2020), moderate levels of anxiety can enhance student performance within a certain range (Yerkes and Dodson, 1908; Teigen, 1994; Sajedi, 2016). Furthermore, this study explores the role of anxiety as a mediator variable (Hypothesis H5). Meta-analyses by Freeman et al. (2014) support the view that active learning methods can improve exam scores. Classroom activities such as clickers, cold calling, and group work in this study significantly influence student performance by increasing their anxiety levels. Additionally, the study by Li et al. (2022) provides theoretical support, suggesting that changes in class competition levels can trigger changes in student anxiety levels, thus altering academic performance. Relative deprivation theory (Li et al., 2022) suggests that students tend to evaluate their academic performance by comparing themselves with other students in the same class (Davis, 1966). The active learning teaching methods in this study undoubtedly promote competition, prompting the proposal of Hypothesis H5.

Compared to previous research that primarily focused on exploring overall student anxiety and performance in a single classroom, often in theoretical courses (Gopal et al., 2021), the current study incorporates practical activities in the classroom. It aims to identify significant factors influencing student anxiety levels in instructional design and investigates the relationship between anxiety levels and student performance in diverse teaching environments, making the findings more applicable. Moreover, teacher evaluations are included in the assessment of student performance to enhance the comprehensiveness of the results. The findings of this study suggest that cold calling is the most influential factor affecting student anxiety levels, consistent with

the studies of Cooper et al. (2018) and England et al. (2017), emphasizing the importance of teachers using cold calling with caution to avoid excessive anxiety among students. By fostering a pleasant and harmonious classroom atmosphere, teachers can help alleviate the fear and anxiety associated with cold calling. Group work also increases student anxiety, but to a much lesser extent than cold calling, consistent with previous studies (England et al., 2017; Cooper et al., 2018). Overall, group work tends to increase anxiety levels, but whether it raises anxiety depends on the specific situation. If communication within the group is harmonious and members can collaborate in discussions, group work can actually reduce anxiety levels. Conversely, if group members struggle to cooperate, anxiety increases (England et al., 2017). Clickers do not significantly increase student anxiety, but their impact is greater than that of group work, consistent with the findings of England et al. (2017). In their study, the level of anxiety caused by clickers was higher than that caused by group work. It has been found in teaching practice that clickers do not necessarily increase anxiety when given sufficient time, appropriate frequency, or when facilitating peer discussions. The results of the structural equation model show a negative correlation between anxiety levels and student performance, although not significant. This may be because different students react differently to the same stimuli (Fu, 2015). For some, anxiety provides necessary motivation that can actually enhance progress (Sajedi, 2016), while highly anxious individuals tend to interpret stimuli negatively, thus affecting their performance (Bishop, 2007). Mediation effect testing shows that anxiety levels only fully mediate the relationship between clickers and student performance. This finding, combined with the insignificant relationship between clickers and anxiety levels, challenges our initial assumptions. The reasons may include the multidimensionality of anxiety-causing factors, differences in how clickers affect individuals, and the varying effects of clickers on student performance. More research methods and a larger, more diverse sample should be explored in the future.

Furthermore, the study reveals that moderate levels of anxiety may have a positive impact on student performance. In traditional classrooms, where students passively receive knowledge, they may lack a sense of participation and motivation. Conversely, active learning activities in practical contexts encourage students to take initiative, thereby enhancing their performance. The curriculum developed in this study will be offered to students for selection on an annual basis, and maintaining the current teaching plan may reinforce the data results obtained. The study's findings provide valuable insights for educators in designing effective teaching strategies to enhance student performance while taking into account and managing student anxiety levels in the classroom.

## 5 Limitations and future scope of the study

This study has several limitations that should be taken into consideration when interpreting the results. Firstly, the data were collected solely from the teaching practices of only one course at Northeast Forestry University, which limits the generalizability of the findings to different categories of courses. Future research could expand the sample to include courses from different universities

and categories to enhance the external validity of the results and the generalizability of the theory. Additionally, the data were collected only from Chinese students, and including students from different countries or international students in future studies would allow for better comparisons across cultural backgrounds.

The overall curriculum for this study was opted into by the students, and random sampling was used to divide the classes and select the interviewers. Since the researcher had no control over which students chose to participate, demographic parity between classes could not be achieved. Also, this paper was taught in small class sizes with only 20 students per class. In the future we could attempt classroom practice with larger sample sizes, with each class being at least >30 students rather than the 20 student size of the class in this study.

Furthermore, this study focused on three specific types of active learning activities that may affect anxiety levels. There might be other active learning activities that could also influence anxiety levels, which were not explored in this study. Future research could undertake a more comprehensive investigation of various active learning activities and their impact on anxiety levels. Another limitation is that the study did not systematically analyze the effects of teaching designs on anxiety levels among students with different levels of anxiety (mild, moderate, and severe). The analysis was conducted on the overall data from different class settings. Future research could consider examining anxiety levels and performance among specific student groups based on their anxiety levels.

Moreover, the study did not differentiate between students of different grades and types of courses. The course in this study was a combination of practice and theory, but the performance of students in purely practical or theoretical courses could be explored separately. Future research could investigate the influence of teaching designs on students' anxiety levels and performance in different types of courses.

Although this study focused on anxiety, there are other emotional factors that have an impact in a complex and changing classroom environment. Future studies may consider incorporating other emotional variables to obtain a more comprehensive analysis of emotional impact.

This study is potentially biased. For example, one of the questionnaire questions on students' performance was self-administered, which is subjective. Additionally, an interview tool was utilized, involving human understanding and communication. Although multiple authors were invited to analyze the interview transcripts and triangulation methods were applied to verify the reliability of the interview results with the questionnaire results, there still remains a certain degree of subjectivity. Therefore, future research should strive to employ standardized scoring systems and interview guides. Moreover, due to the pandemic's impact, students' mobility was confined to campus, potentially exacerbating their anxiety. Consequently, the overall anxiety level in this study may have been elevated. Lastly, further research could explore student anxiety induced by active learning in curriculum and subject design. This could include investigating how varying levels and frequencies of active learning activities influence learning through anxiety, as well as exploring theoretical frameworks that incorporate various factors of anxiety affecting learning.

These points present opportunities for future research to address and improve upon the limitations of this study, thereby enhancing the comprehensiveness and applicability of the findings.

## 6 Conclusion

The aim of this study was to investigate the relationship between active learning activities and students' anxiety levels and students' performance, and applied the structural equation modeling approach to construct a relational model linking the factors for the first time to investigate students' anxiety and performance in different teaching and learning environments. The active learning practices adopted in this study were cold calling, clickers and group work. This study was designed around five classes that implemented active learning activities at varying frequencies, involving only students who agreed to participate in the classroom practices. After these practices, data were collected using online surveys and interviews, and were analyzed and organized using SPSS and AMOS. The study successfully achieved its research objectives and validated the hypotheses. At the same time, the trial in this study occurred within the context of an epidemic pandemic, which inherently can trigger stress and anxiety in students. Consequently, students may be more sensitive to changes in classroom design, and overall anxiety levels may be higher compared to non-epidemic situations. The current research findings suggest that cold calling significantly influences students' anxiety levels in the teaching design, highlighting the need for caution when employing this approach. Establishing a classroom atmosphere that fosters appropriate anxiety levels may have a positive impact on students' performance. Therefore, incorporating active learning activities into the instructional design may help to prevent students from losing interest in learning and becoming less motivated to learn. However, in high-anxiety environments, the study shows that active learning may have a negative impact on student performance. Additionally, anxiety levels only served as a complete mediator between clicker use and student performance, but the relationship between clickers and anxiety levels was not significant. This finding challenges our initial assumptions and suggests a reevaluation of the relationship between clicker use and student anxiety. The insignificance might suggest several potential explanations. Firstly, it could be due to characteristics of the sample or measurement errors. Our sample might not fully represent the entire student population, thus there is a need to expand the sample size and scope. Secondly, anxiety levels could be influenced by various factors including individual learning styles, classroom atmosphere, and teaching methods, which might obscure the impact of clicker use, suggesting the exploration of potential moderating variables. Furthermore, the relationship between anxiety and learning performance might be more complex than anticipated, involving nonlinear or threshold effects not fully explored in this study. In summary, although this study did not establish a significant correlation between the use of clickers and anxiety levels, our results emphasize the importance of further researching student anxiety in active learning environments. Educators should continue to explore and assess

the impact of different teaching tools and methods on student anxiety and performance, to create a more inclusive and effective learning environment.

The study set up five instructional classrooms with varying frequencies and percentages of active learning activities and, as a result, elicited different levels of student anxiety and student performance. The results can be shown to some extent that students' performance increased in active learning classrooms within the appropriate frequency and percentage of active learning activities compared to traditional classrooms. Therefore, active learning instruction is not the only way to promote student environments, and pushing students to participate in too many activities can be counterproductive. These findings emphasize the importance of balancing and customizing teaching designs according to students' anxiety levels. While incorporating active learning can, to some extent, be beneficial for enhancing student performance in a low-anxiety environment, it is crucial to be mindful of its potential negative effects in high-anxiety situations, for example, the overstimulation and overstress reported by students in interviews can lead to an inability to immerse themselves in the practical project. In such cases, teachers should carefully control the frequency of active learning activities and consider the proportion of active learning components within the overall curriculum. In addition, teachers should be attentive to students' emotional responses and create a supportive learning environment that considers individual differences in anxiety levels. By doing so, teachers can optimize the learning experience and promote positive outcomes for students in different classroom settings.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

BL: Conceptualization, Formal analysis, Funding acquisition, Resources, Supervision, Writing – original draft, Writing – review and editing. JY: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Writing – original draft. LS: Writing – review and editing. HY: Conceptualization, Investigation, Methodology, Resources, Supervision, Visualization, Writing – original draft, Writing – review and editing.

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between learners positive anxiety and teaching design in mixed teaching mode.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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