The Survey on High School Students' Attitudes and Equitable Feelings Toward Online Math Homework

by

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DISSERTATION ABSTRACT

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Title: The Survey on High School Students' Attitudes and Equitable Feelings Toward Online Math Homework

This study aimed to examine high school students' attitudes and equitable feelings toward online math homework (OHW). A total of 690 students from two high schools located in China completed an online survey. Data were analyzed using R programming language and revealed that students generally have a positive attitude toward OHW, with high-achieving students from well-resourced, higher-tier schools demonstrating significantly more favorable attitudes compared to low-achieving students from lower-tier schools with fewer resources. Human-centered features included in online homework systems, such as the ability to redo incorrect questions, and receive instant feedback and hints, were key predictors of positive attitudes. However, no significant differences were found between male and female students in their attitudes toward OHW. Students in high-tier schools and female students showed significantly more positive preferences for the help system in the digital environment. Math levels and family income did not significantly impact student preferences for the help system in online homework.

These findings highlight the importance of developing OHW platforms that are user-friendly and student-centered, offering diverse forms of academic support tailored to different learners' needs. The study suggests that the gradual transition from traditional physical homework to online platforms could enhance student engagement and learning outcomes, particularly when attention is given to the equitable distribution of educational resources.
Key Words: Attitudes, High School Student, Math, Online, Homework

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CHAPTER I

INTRODUCTION

Homework has been a significant focus of educational research for several decades, with a widely accepted definition emerging in the 1980s. It is generally understood as any task assigned by schoolteachers for students to complete outside of regular school hours (Cooper et al., 2006). As a fundamental component of the educational process, homework serves as a medium for educators to implement instructional objectives and promote student learning beyond the classroom. Gill and Schlossman (2003) examined the time spent on homework by K-12 students in the US over a 50-year span. Doing homework is a daily task for most K-12 students. The majority of students at all grade levels spent approximately one hour on homework on a school day, an amount of time that has not changed for at least 20 years.

In China, homework has recently become a social issue. Both the public and the government have noted the potential negative effects homework can have on students' physical and mental health. In July 2021, the General Office of the CPC Central Committee and the General Office of the State Council issued the "double reduction" policy, which regulates the total amount of homework assigned to students. Specifically, homework is prohibited for students in grades 1 and 2 of primary school. For grades 3–6, the average time for completing homework is limited to 60 minutes, while for junior high school students, it is limited to 90 minutes (CPC, 2021).

Although educators and researchers have conducted research on this social phenomenon for decades, published empirical articles on the topic are limited. When I searched the most common digital Chinese database "CNKI" using the key word "homework"[1] in the title, the search yielded only 2,791 articles published in over 100 years, from 1922 to 2025. The scope of these articles covers a few specific areas. Exploring the impact of homework on student mental health and the relationship between homework and achievement are two primary research interests (Chen, 2017; Li, 2011; Liu et al., 2013; Shao et al., 2024; Xu et al., 2015; Zhang et al., 2024; Zhao et al., 2024). Zhao et al. (2024) examined the relationship between homework time and students' mental health, considering teacher support and parental involvement as moderating factors. Their data came from the China Education Panel Survey (CEPS), a comprehensive and nationally representative survey of 21,942 students in grades 7 to 9, conducted from 2013 to 2015. The results of the fixed-effects regression model indicate that there is a significantly negative relationship between homework time and students' mental health when it exceeds approximately 1 hour and 15 minutes. However, this relationship is not linear. The results of the moderation models reveal that teacher support, particularly emotional support, improves students' mental health, while parental involvement does not have a significant positive effect.

Shao et al. (2024) explored the relationship between homework time and student performance in grades 4 and 8, using data from a large-scale testing database in China. They found that the optimal homework time is 1–1.2 hours for grade 4 students and 1.7–2 hours for grade 8 students. The relationship between time spent on homework and academic achievement is positive when homework time is below the cut-off; once it exceeds the cut-off, the relationship becomes negative.

[1] I used the Chinese word "家庭作业" in my search on this database. This word translates to "homework" in English.

To address the issues related to homework in China, more research and research with a greater diversity of focus is needed. Given the limited number of Chinese studies on the topic, I turn to research conducted elsewhere to inform my current work. In the United States, research on homework has a long history, spanning over 100 years since the early 20th century (Xu & Corno, 1998). Throughout this period, a vast body of research has accumulated, reflecting the significance of homework in academic settings. However, despite this extensive research, scholars have not reached a consensus on the effectiveness of homework as a teaching tool. Some studies emphasize its benefits, while others highlight its limitations and potential drawbacks. For instance, Cooper's (1989) comprehensive meta-analysis revealed that high school students who engage in homework tend to outperform their peers who do not. Specifically, students completing homework scored better than 75% of those who did not. However, the correlation between homework and academic achievement varied significantly across grade levels, with a near-zero correlation for students in grades 3 through 5, a modest .07 for students in grades 5 through 9, and a stronger .25 for high school students. Moreover, Cooper (1989) found no consistent pattern, suggesting that homework effectiveness might differ across subjects.

While substantial research has been conducted on homework as a general construct, there has been less attention to the impact of homework in specific subjects, such as math. Cooper et al. (2006) reported that subject matter could influence the effectiveness of homework. Despite this finding, few studies have explicitly examined the relationship between subject-specific homework and student achievement. A notable exception is Fan et al.'s (2016) meta-analysis that explored the link between homework and K-12 student performance in math and science from 1986 to 2015. Using the keyword "homework" to search in digital databases such as ERIC and

PsycINFO, Fan et al. analyzed approximately 8,300 empirical articles. After refining the search to focus on both “homework” and “achievement” or “performance,” the results narrowed to 2,328 articles. Further refining to focus on math, science, and related subjects reduced the number to 115 published studies. This research highlighted the need for more in-depth exploration of the relationship between math homework and student achievement.

In addition, public attitudes toward homework have shifted significantly over the past century in response to social and educational changes. In the early 20th century, homework was viewed as a tool to discipline children’s minds. By the 1940s, the focus shifted to problem-solving skills rather than the rote practice provided by homework. In the late 1950s, after the Soviet Union launched Sputnik, homework regained importance in the United States’ educational system as the U.S. sought to improve academic performance. However, in the mid-1960s, many educators and parents raised concerns that homework was placing excessive pressure on students. By the 1980s, the competitive global marketplace once again led to renewed support for homework (Cooper & Valentine, 2001).

Research suggests that attitudes play a critical role in shaping behavior (Kraus, 1995). Surprisingly, however, little attention has been paid to students’ attitudes toward homework, especially online homework (OHW), in the existing literature. Cooper (1989) found no studies examining whether attitudes of teachers, students, or parents could predict homework behavior or academic achievement. Homework has often been a source of tension between students, parents, and teachers, with pediatricians and family doctors noting that homework-related stress frequently arises as an area of concern during medical visits (Cooper, 1991). Therefore, understanding whether these key stakeholders share consistent attitudes toward homework is crucial.

With the rise of technology, online homework management systems (OHMS) have become widely used across various disciplines. These systems, typically built by major textbook publishers, automate the grading process and record student performance (Haverty, 2012). However, findings related to the effectiveness of online homework remain inconsistent in the literature. Some studies report that online homework boosts student achievement, while others find no measurable impact. The COVID-19 pandemic further complicated this issue, as education increasingly shifted to virtual platforms. Exploring student attitudes toward online homework, especially in specific subjects like math, has become a critical area of research in the 21st century.

Traditional physical homework is generally one-size-fits-all, making it inflexible for addressing students' diverse needs. Even though teachers can occasionally assign individualized homework, they usually spend a significant amount of time and effort. However, Online Homework (OHW) systems are built on technologies that allow teachers to easily create personalized assignments through simple settings. Digital homework can flexibly accommodate individual differences such as learning styles, abilities, and more. When students are treated fairly, they may develop a sense of equity. Although I have not found any research directly exploring the link between OHW and students’ sense of equity, I aim to test the hypothesis that students may feel a greater sense of fairness when completing OHW.

In my dissertation, I seek to explore high school students’ attitudes toward online math homework. By examining students’ perspectives, I hope to provide valuable insights into the effectiveness of online homework and how it intersects with subject-specific factors, specifically mathematics. This study will contribute to a deeper understanding of how students perceive online homework in a rapidly evolving educational landscape.

CHAPTER II

LITERATURE SYNTHESIS

Homework serves a range of educational objectives, both instructional and non-instructional. Cooper and Valentine (2001) identified several positive effects of homework, including improved study retention, enhanced study skills, better attitudes toward school, increased independence, and greater responsibility. Homework can also foster stronger parent-child communication regarding school-related activities (Van Voorhis, 2003). However, the negative effects of homework should not be overlooked. These include increased boredom, reduced leisure time, confusion stemming from parental involvement, and the potential for dishonest behaviors, such as cheating (Cooper & Valentine, 2001). In this chapter, I synthesize the literature on homework research to provide a context for my dissertation study.

Types of Homework Research

A variety of studies have been published on the topic of homework. One very useful type of research involves systematic reviews and meta-analyses that synthesize findings from previous studies. These reviews aim to draw general conclusions, identify research gaps, or develop theoretical models of homework (Cooper, 2001; Cooper et al., 2006; Fan et al., 2017; Magalhaes et al., 2020; Trautwein et al., 2006). One of the most comprehensive efforts in this category was conducted by Cooper et al. (2006), who employed a meta-analysis to investigate the homework-achievement relationship in studies conducted in the United States between 1987 and 2003. Their findings indicated a stronger positive correlation between homework and academic achievement in grades 7-12 than in grades K-6. Additionally, they found that homework had little to no relationship with academic achievement in specific subjects.

More recently, Magalhaes et al. (2020) conducted a systematic review that compared the benefits of online versus traditional homework. They selected 31 studies, all of which compared students' quantitative performance in these two homework formats. The studies varied significantly in terms of sample sizes, course domains, and the methods of online homework implementation. While half of the studies found no difference in performance between online and traditional homework, nine studies reported higher performance with online homework, and only one study favored traditional homework, six studies had mixed results. The review highlighted the need for further research, particularly regarding how different approaches to online homework affect student outcomes.

A second type of research directly explores the relationships between homework-related variables, such as homework time, frequency, effort, perceived quality, and academic achievement (Cooper, 2001; Cooper et al., 2006; Fan et al., 2017; Magalhaes et al., 2020; Trautwein et al., 2006). For instance, a study by Rosário et al. (2018) examined how various homework factors influenced math achievement among 6th-grade students in Portugal. The study found that students' perceptions of homework quality mediated the relationship between homework purposes and achievement. When students viewed homework as a tool for practice, they perceived it as more valuable, which in turn positively impacted their math performance.

Trautwein (2007) further explored these relationships in a series of studies involving both student- and class-level analyses. Study I showed a moderate positive relationship between homework time and achievement at the class level, but a negative relationship at the student level. Study II revealed that homework frequency was a significant predictor of achievement at the class level, whereas homework time was negatively related to student-level achievement. Study III found that homework effort, rather than time, positively impacted both grades and test scores. These findings suggest that while homework can be beneficial, the amount of time spent on it does not necessarily lead to improved academic outcomes. Instead, the quality of effort and frequency of homework assignments play more critical roles.

The third type of research investigates the effects of stakeholders' involvement and attitudes toward homework on student performance (Cooper, 2001; Cooper et al., 2006; Fan et al., 2017; Magalhaes et al., 2020; Trautwein et al., 2006). For example, Núñez et al. (2015) examined how students' perceptions of teachers' homework feedback influenced their homework-related behaviors and academic achievement. The study, which included 454 students in Grades 5-12, found that students who perceived higher levels of feedback from teachers were more likely to complete their homework and manage their time effectively. This, in turn, positively impacted their academic achievement. Additionally, the study found that as students progressed to higher grades, they perceived receiving less feedback on their homework, which could negatively affect their performance.

Similarly, a large-scale study conducted by Cooper et al. (1998) analyzed the attitudes toward homework among students, teachers, and parents due to the previous research results that homework has been a source of conflict among teachers, parents, and students. Pediatricians and family practitioners have reported that children's medical problems are often related to issues with homework (Cooper, 1989; Cooper, 1991). The study used the Homework Process Inventory (HPI) and gathered data from 709 students, 82 parents and teachers. The results indicated that students in lower grades (2^{nd} and 4^{th}) tended to have negative attitudes toward homework, while students in upper grades (6-12) and their teachers viewed homework more positively. Moreover, the amount of homework completed was more strongly correlated with academic achievement in the upper grades, highlighting the importance of homework completion rather than mere assignment.

Research Specific to Math Homework

Homework has long been a component of mathematics education, providing students with opportunities to practice and reinforce concepts learned in class. Xu (2015) observed that math is a core subject in Grades K-12, typically requiring more homework than other subjects. Students generally spend one-fifth to two-fifths of their total homework time on math assignments. However, the relationship between math homework and student achievement has generated mixed results, with various factors such as the type of homework, its frequency, and student characteristics influencing the outcomes.

Lunsford and Pendergrass (2016) conducted an 8-year review of college student performance in mathematics, particularly in lower-level courses such as statistics, precalculus, and calculus. They emphasized the benefits of online homework (OHW) as part of formative assessment, concluding that OHW contributes significantly to student learning. The formative nature of OHW, which includes frequent procedural practice and feedback, helps engage students and improve learning outcomes, especially in foundational courses.

A more specific examination of OHW's impact was conducted by Roschelle et al. (2016), who evaluated the ASSISTments online homework system's effect on 2,850 7^{th}-grade students from 46 schools in Maine. By pairing schools based on prior achievement and enrollment, and then randomly assigning them to treatment (with ASSISTments) or control (without ASSISTments), they were able to assess the system's impact. Hierarchical linear modeling (HLM) analysis revealed that students using ASSISTments showed significant improvements in math scores, an impact that differentially benefited those with lower prior math achievement.

This finding supports the hypothesis that OHW, when paired with teacher training, can enhance math achievement, particularly for students who start with lower achievement levels.

In a similar vein, Trautwein et al. (2002) analyzed repeated-measurement data from 1,976 German 7th-graders across 125 classes to explore the relationship between homework and math achievement. The study found that frequent homework assignments positively impacted math achievement, while lengthy assignments had a negative, though not statistically significant, effect. The study also found that longer homework assignments reduced achievement variability within classes, suggesting a standardizing effect for students with different achievement levels. However, the study did not find a significant impact of homework monitoring on achievement gains, highlighting the complexity of the homework-achievement relationship and the need for nuanced research on how different homework variables affect student outcomes.

A meta-analysis by Fan et al. (2017) examined the relationship between homework and academic achievement in math and science, synthesizing research from 1986 to 2015. The analysis found a slight but positive overall effect of homework on achievement, with the strongest effects observed in elementary and high school students, particularly in the U.S. Conversely, Asian students demonstrated the weakest correlation between homework and achievement. This finding highlights the importance of considering cultural contexts when examining the impact of homework on student outcomes.

A national study by Cheema and Sheridan (2015) used data from the 2012 Program for International Student Assessment (PISA) to explore the relationship between math homework, math anxiety, and student achievement among 4,978 U.S. students. The researchers controlled for factors such as gender, grade, race, and socioeconomic status and found that math homework time positively correlated with math performance, while math anxiety was negatively related to performance. Their findings also demonstrated that student achievement varies across these individual factors, reinforcing the complex interplay between homework, anxiety, and student performance.

Fernández-Alonso et al. (2015) provided additional evidence of the relationship between homework and math achievement through their study of 7,451 Spanish adolescents. The researchers investigated the effects of various homework-related variables, such as time spent, effort, and the frequency and type of homework, on math performance. After controlling individual factors such as socioeconomic status, gender, and prior knowledge, the study found that homework frequency and the type of homework assigned by teachers significantly impacted student performance. Interestingly, neither the amount of time spent on homework nor student effort showed a significant effect on achievement. These findings underscore the importance of the nature and structure of homework assignments over sheer effort or time invested.

Despite the positive findings linking homework to improved math performance, studies also highlight several limitations. Cooper et al. (2006) argued that factors such as student motivation, grade level, and abilities play a significant role in determining the effectiveness of homework. More recent literature emphasizes the need for research on individualized homework, particularly in online formats (Cleynen et al., 2020; Ehrman et al., 2003; Haelermans & Ghysels, 2017; Magoulas et al., 2003; Xu, 2020). These researchers argue that personalized homework could better cater to student needs and enhance performance, yet the evidence on this front remains limited. Further studies are necessary to examine how individualized online homework can be optimized to improve student outcomes, particularly in math education.

In conclusion, math homework, particularly when structured as frequent, formative assignments, has the potential to positively influence student achievement. However, the effectiveness of homework depends on various factors, including the nature of the assignments, student characteristics, and the level of support provided by teachers. While studies generally support the notion that math homework can enhance learning, particularly for lower-achieving students (Lunsford & Pendergrass, 2016; Roschelle et al.,2016), future research should focus on the role of individualized online homework systems in addressing the diverse needs of students.

Online Homework (OHW)

Online homework (OHW) refers to assignments delivered, completed, and graded through digital platforms, typically providing automatic grading and instant feedback (Leong, 2014). Such systems are often built by major textbook publishers and applied across various disciplines, offering automated grading and score recording (Haverty, 2012). These systems became increasingly prevalent during the COVID-19 pandemic, as online and remote learning became the norm in education. Compared with traditional homework, OHW is interactive (Riffell & Sibley, 2005) and can meet student individual needs by helping teachers design assignments for each student or a group, not the whole class.

Common OHW Systems

OHW systems have evolved significantly in the last decade, with many capable of handling diverse question types, including multiple-choice, fill-in-the-blank, matching, and free-response formats. The most used systems include StatsPortal, MyMathLab, LaunchPad, WebAssign, WeBWork, ASSISTments, EducoSoft, and ALEKS (Allain & Williams, 2006; Boudreaux et al., 2022; Lunsford & Pendergrass, 2016; Richards-Babb et al., 2011). While some OHW systems are free and open-source (e.g., WeBWork), most are fee-based.

Advantages and Disadvantages of OHW

Limited previous studies have highlighted the advantages of OHW, particularly its capacity for meeting individual needs: timely feedback, individual tasks, and the positive impact on student attitudes and motivation. Lunsford and Pendergrass (2016) reported that students felt their online assignments aligned with their abilities and that teachers used individualized teaching strategies. Similarly, Corbett and Anderson (2001) emphasized the importance of timely feedback, which helps students make incremental progress and enhances their understanding of material. Albelbisi (2018) found that immediate feedback encourages students to make more attempts and master knowledge more cost-effectively. Kortemeyer, et al. (2015) emphasized that feedback is important to instructors to motivate students and tweak their teaching when they implement online learning. Feedback in this research includes academic feedback, motivation feedback, and instructor feedback. Academic feedback has typically entailed grades, the results of each exercise, and learning reports. Motivation feedback also has been used as an extrinsic reward, made by computer algorithms, to encourage students to learn. Ten extrinsic motivations (achievement, helping, rewards, immersion, identity presentation, social relations, playing, learning, uniqueness, and creativity) have been used to increase students' intrinsic motivation.

White (2002) reported that most students preferred using online systems to assist with their classroom studies because the digital discussion format provided them with an accessible communication method for their learning. Mojdehi and Bazargani (2018) randomly assigned 60 participants, aged 16-21, to either a treatment group with individualized tasks or a control group with uniform tasks. The treatment group exhibited significantly higher motivation, based on pretest and posttest data, suggesting that individualized tasks can boost student engagement and performance.

Other studies noted that homework can improve students' academic skills and their academic success when the assigned work is suitable for students' interests and needs and well-designed for students' life-long learning process skills (e.g., Bembenutty, 2011; Ramdass & Zimmerman, 2011). Xu (2010) indicated that one of the most important aspects of homework design is to create homework assignments that are interesting and engaging to students. When students are interested in the given task, they are more likely to understand it and learn from it.

Two studies also emphasize the importance of student-centered design in OHW systems. Boudreaux et al. (2020) evaluated three OHW systems—WeBWork (an open-source system), EducoSoft, and MyMathlab—across five classes with 145 students and four instructors. Students used each system for two weeks and then ranked them in terms of usability and help features. The results indicated that students preferred OHW systems with better user interfaces and help features, even if they were more expensive. Although this study offered valuable insights, the short exposure period (two weeks per system) may not have provided enough time for students to give deep feedback, and the attitudes of teachers toward these systems were not considered.

Another study by Alshare (2011), based on the IS Success Model created by Delone & McLean in 1992, surveyed 674 midwestern U.S. university students to investigate factors contributing to online learning success. The findings revealed that three human factors—comfort with online learning, self-management, and perceived web self-efficacy—significantly impacted learning outcomes, and both comfort with online learning and web self-efficacy were strong predictors of student satisfaction. These findings underscore the importance of enhancing these factors to improve students' online learning experiences.

Leong and Alexander (2014) conducted a qualitative survey to explore the advantages and disadvantages of OHW. These advantages include:

1. Easy Accessibility: Students can easily access homework without needing a physical textbook;

2. Convenience: Homework can be completed from any location with an internet connection, allowing students to work flexibly based on their personal schedules;

3. 24/7 Availability: OHW systems allow students to work on assignments at any time, accommodating diverse schedules and maximizing flexibility;

4. Instant Feedback: OHW provides immediate feedback on the correctness of solutions, helping students learn from their mistakes in real-time and fostering continuous improvement;

5. Step-by-Step Solutions: Some platforms offer detailed solutions, helping students understand their errors and improving learning outcomes;

6. Remote Access: OHW systems allow students to complete assignments from any computer with internet access, adding convenience and flexibility.

Despite the benefits, OHW systems have limitations, many of which can negatively impact students' learning experiences. Such limitations include:

1. Emphasis on Final Solutions: OHW platforms often focus on the final answer rather than the process of solving problems, leaving students uncertain about how to arrive at the correct solution;

2. Limited Feedback: For most questions, OHW systems provide only binary feedback (correct/incorrect) without detailed explanations, which can hinder deeper understanding;

3. Frustration with Error Marking: Students often express frustration with the simple correct/incorrect feedback, as it lacks the nuance typically provided by instructors;

4. Difficulty with Mathematical Input: Some students struggle to input mathematical symbols or answers into the system, which may lead to errors unrelated to their understanding of the material;

5. Lack of Detailed Feedback: OHW systems rarely identify which part of an answer is incorrect, limiting students' ability to learn from specific mistakes; and

6. Technology-Related Issues: Students often encounter difficulties with the platform itself, which can frustrate and detract from the learning process.

As OHW systems continue to grow in educational settings, designing student-centered systems is an emerging topic. Providing critical guidance on improving these systems can enhance both their effectiveness and the overall student learning experience.

Attitudes Toward OHW

Attitudes toward OHW have been studied, revealing mixed results depending on demographic factors, student proficiency, and the specific platform used. Several studies indicate positive student attitudes toward OHW. For example, Altun (2008) explored the attitudes of middle school students in Turkey toward online homework sites and found that 86.7% of students reported positive attitudes. Factors such as gender, age, and internet use frequency significantly impacted these attitudes. Males were found to use online homework sites more practically, while females were more attentive to ethical considerations. Similarly, Albelbisi et al. (2022) found that perceived usefulness and perceived ease of use were strong predictors of positive attitudes toward OHW among secondary school students, with a negative relationship observed between math anxiety and attitudes toward OHW. Students with more favorable views of OHW experienced lower levels of anxiety. The authors suggested that a possible explanation is that the OHW system provides students with more chance to be engaged in math-learning.

Leong and Alexander (2014) examined student attitudes toward WebAssign, an OHW platform, in remedial math courses. The study revealed that lower-achieving students had more positive attitudes toward the platform compared to higher-achieving students, which the authors hypothesized was likely due to the immediate feedback provided by the system. This finding highlights the role of OHW in supporting struggling students.

One study interviewed 25 students about their attitudes toward an online homework system "MyiMaths". Albelbisi (2018) reported that students were satisfied with this online system for four reasons: (a) timely feedback encouraged students to make attempts and master the knowledge cost-effectively, (b) the system provided students access to re-doing wrong items, which increased students' confidence in learning, (c) the platform included helpful resources, such as instructional examples, relevant videos, and other helpful materials, and (d) the platform helped students focus on homework. The different kinds of rewards also inspired students to learn more (Albelbisi, 2018). Despite these positive results, this research also had several limitations. First, the sample size was small. The researcher interviewed 25 students familiar with "MyiMaths", excluding students without online homework experience from their sample. Hence, to some extent, the results lack generalizability. Second, the researcher only examined one online system, the "MyiMaths" platform, which cannot represent a whole picture of students' attitudes toward OHW. Third, the researchers only employed a qualitative method. The inclusion of quantitative as well as qualitative approaches could add to the trustworthiness of the findings.

Despite the many studies that report favorable student attitudes toward homework, not all studies report uniformly positive attitudes. Cooper et al. (1998) examined attitudes toward traditional homework across various grade levels and found that younger students expressed negative attitudes, while older students and teachers held more positive views. This finding suggests that attitudes toward homework, including OHW, may shift over time and vary by age and grade level. Additionally, Haverty (2012) reported mixed results regarding attitudes toward OHW in non-accounting disciplines, with most studies showing positive reactions, while some university-wide evaluations indicated less favorable responses. These mixed outcomes reflect that while students appreciate the convenience and feedback of OHW, broader course evaluations may not align with discipline-specific attitudes.

OHW and Student Performance

Several studies have investigated the impact of OHW on student performance, particularly in math and science disciplines. For instance, Haelermans and Ghysels (2017) examined how individualized homework affects secondary students' numeracy achievement. The study used a pre and protest design, including a pre-experiment period and two experiment stages. The pre-experiment period was the time without intervention. The first experiment stage was a field experiment, where students completed personalized exercises (meeting each student's skill level and practice requests); the experiment stage II was the experimental intervention, where students practiced their learning through the one-size-to-all online homework assignment. The sample included 337 middle school students (aged 11-14). This study employed three numeracy tests to measure students' numeracy skills in different stages. The degree of homework individualization was the independent variable, and the outcomes from three tests were dependent variables, including the scores of the pretest stage and the experiment stage I, the absolute growth in scores between two consecutive stages, and a dummy indicator to display whether students' numeracy level increased or remained unchanged. The results showed a significant effect of individualized homework on the absolute growth in scores in the first stage, whereas there was no positive relationship between non-individualized online homework and the absolute growth in scores. This study provides evidence that individualized learning is beneficial to student performance.

Richards-Babb et al. (2011) examined the effect of OHW on college students' performance in chemistry courses and found that OHW improved student success rates and fostered positive study habits. The automatic grading and immediate feedback were particularly beneficial, with 85.7% of students recommending the continued use of OHW. Roschelle et al. (2016) conducted a large-scale study on the impact of the ASSISTments OHW system on middle school students in Maine, finding that students with lower prior math achievement benefited significantly from the system. The results suggest that OHW systems can be particularly effective for students in need of additional support, especially when combined with teacher training. Wooten and Dillard-Eggers (2013) also found that low-performing students benefited more from OHW compared to higher-achieving students in accounting courses, highlighting the motivational benefits of OHW for students who may struggle with traditional paper-and-pencil assignments.

Barrow et al. (2009) reported OHW has the potential to significantly enhance student math achievement in large classes at both the middle and high school levels. In a large-scale randomized experiment, they examined whether there was a significant difference in math achievement between students who completed online homework (treatment group) and those who completed traditional homework (control group). The study found no significant evidence that students in the treatment group had higher statewide test scores compared to the control group.

To summarize, the literature on OHW demonstrates both its potential and its limitations in modern education. While OHW systems offer significant advantages, including convenience, immediate feedback, and accessibility, they are not without drawbacks, such as limited process-focused feedback and technological frustrations. Attitudes toward OHW vary depending on factors such as student proficiency, age, and the specific system used. Nevertheless, OHW has been shown to positively impact student performance, particularly for lower-achieving students, and has become a valuable tool in today's increasingly digital educational landscape. This growing body of research underscores the importance of considering both the advantages and challenges of OHW when implementing digital learning tools in the classroom. It is worth noting that researchers have rarely focused on the human-centered design of OHW systems.

We know from prior studies that the association between homework and student performance is more positive and stronger at high-grade levels than in earlier grades (K -6), yet findings linking homework and achievement are mixed. In addition, the majority of researchers have investigated students' attitudes toward specific OHW systems, not toward OHW more generally. Finally, prior studies have various limitations, such as small sample size, subject bias, a lack of studies set outside of the US, and a scarcity of OHW systems designed with a student-centered approach. These limitations inform my research.

The Current Study

This study addresses four educational phenomena that have not been adequately explored by previous researchers. First, while some studies have examined students' attitudes toward online homework (OHW) systems, they have largely focused on whether OHW improves performance or is more effective than traditional homework. There is little research investigating student attitudes toward OHW as a potential moderator between OHW and student achievement.

Second, only a few studies have explored the design of human-centered online math homework platforms (Alshare, 2011; Barab, 2005; Boudreaux et al., 2020; Imtiaz, 2016; White, 2002), though platform design is a key element in the quality of OHW (Alshare, 2011; Boudreaux et al., 2020). Third, research linking math homework—particularly OHW—to math achievement is scarce. Finally, no studies, based on my review, have examined whether online homework may increase students' sense of equity, which is a component of students' attitudes toward OHW. Equitability involves understanding and meeting students' needs to help them become skilled, knowledgeable, and engaged learners. OHW may provide more equitable learning experiences due to its flexibility and ability to accommodate individual learning styles.

Given these gaps in the literature, the goal of my current study was to investigate the relation between attitudes toward online math homework, demographics, and math achievement guided by the following research questions:

(RQ1) What are students' overall attitudes toward online homework (OHW), and do they feel treated equitably when completing online math homework?

(RQ2) Which human-centered design features do students view positively, and which do they view negatively?

(RQ3) What are students' attitudes toward different homework help resources?

(RQ4) What are the effects of the higher order model in this research?

(RQ5) What regression relationships exist between latent variables and general variables, and between general variables and demographic factors?

Theoretical Perspectives

This research is grounded in two theoretical frameworks: Norman's (2013) *human-centered design (HCD)* theory and Cooper's (1989) homework process theory model, *A Model of*

Factors Influencing the Effects of Homework. HCD emphasizes designing systems that prioritize human needs, capabilities, and limitations (Norman, 2013) and is particularly relevant to OHW as it seeks to accommodate individual differences in students' abilities, needs, and learning styles. Cooper's homework process theory model identifies three key categories of factors that influence homework outcomes: exogenous factors/moderators, endogenous factors/mediators, and home-community factors. According to this model, student attitudes are exogenous factors that can moderate the effectiveness of homework (Cooper, 1989b), potentially contributing to positive outcomes such as increased feelings of equitability and satisfaction with OHW.

Table 1

A Model of Factors Influencing the Effects of Homework

	Factors			
Components	Exogenous factors/ moderators	Endogenous factors/ mediators	Home-community	Outcomes or effects
1	Economic status	Assignment amount	Competitors for student time	Assignment completion
2	Student ability	Assignment purpose	Home environment	Assignment performance
3	Student motivation	Degree of individualization	Others' involvement	Positive effects
4	Grade level	Completion deadlines		Negative effects
5	Sex	Feedback		
6	Subjects	……		

CHAPTER III

METHODS

Research Design

For this descriptive quantitative study, I gathered data using an online survey instrument that I created. I will provide additional details about the survey instrument in a later section.

Setting and Subjects

Initial data collection occurred in April of 2023 with a second round of data collection in December of 2024. This research includes students from two high schools in China for several reasons. First, previous systematic studies consistently reported that homework positively impacts high school student achievement (Albelbisi, 2018; Alshare, 2011; Altun, 2008; Cooper et al., 1998; Haverty, 2012). In a recent review of 31 studies comparing traditional homework with online homework (OHW) from 2002 to 2020, only two studies involved non-college students (Magalhães et al., 2020). Additionally, compared to middle school students in the same city, high school students have more access to computers for their studies. Students in both high schools where the study was set frequently use digital academic platforms for daily learning tasks and have experience with online homework, especially during the COVID-19 pandemic when they were in middle or high school.

The two high schools in which the current study was set represent different educational tiers in the educational system in China. Tongren Minzu High School in Guizhou province is a tier 3 school with low education resources and education performance, while Puning No. 2 High School in Guangdong province has high education resources and education performance at the tier 1 level in China. Tongren Minzu High School had 3882 students in grades 10 through 12, while Puning No. 2 High School had 4,478 students enrolled at the time of the study. All students in both schools were enrolled in mathematics courses for approximately 4.5 hours per week. Teachers reported that students were expected to spend about 3 hours per week completing homework assignments, all of which were in physical format. Teachers at both schools occasionally assigned supplementary digital learning materials to students. All 10th Grade students in both schools were invited to participate in the study. Ultimately, the study recruited a total of 690 students, with 373 from Tongren Minzu High School and 316 from Puning No. 2 High School. Class sizes in both schools are large, generally with at least 40 students per class.

Procedure

After obtaining approval from the University of Oregon Institutional Review Board and participating schools, I invited students to participate in an online survey and provided informed consent forms for the parents/guardians of students under 18 years old, and for the students themselves if they were over 18 years old.

Once the digital survey was ready, I sent an email to students with the survey link. The survey was published on the academic platform that students were familiar with and typically use for school-related tasks. Because the platform is regularly maintained by school staff, using it to collect data helps reduce potential barriers for students when answering the questions. The first page of the survey informed students about the purpose of the research, provided instructions on how to complete the survey, and asked for their consent to participate. By clicking the “NEXT” button at the bottom right corner of the first page, students could proceed to the questionnaire. They had four weeks to complete the survey.

Survey Instrument

Based on the existing literature, I designed a survey instrument that I called *The Survey about Attitudes Toward Online Homework in Math*. This instrument consists of three parts with 24 items in all. The first three items belong to the section "Individual Information." Cheema and Sheridan (2015) and Fernández-Alonso et al. (2015) explored the effect of individual factors on the relationship between homework and math achievement among adolescent students. These individual factors included gender, grade, race, socioeconomic status, amount of time spent, level of effort, type of homework, frequency of assignments, and the quantity of homework. Their findings revealed that when individual factors were controlled, the positive effect of homework on math achievement increased. Two additional studies examined how individual math achievement impacted the relationship between homework and math achievement, reporting that students with lower and average math achievement maintained positive attitudes toward web-based math homework (Leong, 2013; Leong & Alexander, 2014).

In this research, the subjects are high school students in China. Considering the students' background and the outcomes from previous empirical research, I included three questions to gather data on individual factors: gender, family income, and self-estimated math achievement. These factors are integral to my research for three reasons: (a) to examine how personal factors affect students' attitudes toward online homework (OHW), (b) to retest whether self-estimated math achievement predicts students' attitudes toward OHW, and (c) to contribute evidence to research on individual factors in OHW research.

Ten items (items 4 to 13) belong to the second section, "Features of a Human-Centered OHW System." These items were designed using a five-point Likert scale (1 – *Strongly Disagree* to 5 – *Strongly Agree*). They focused on the key characteristics of the OHW platform, such as individualization, adaptive practice items, immediate feedback, diverse help resources, and computer-mediated communication (CMC). These descriptions provided students with a general understanding of OHW, and their responses to these items were intended to help answer the research question: "What features should a human-centered OHW system have?" Q12 is not included in the calculation of student attitude scores because it is intended to collect ranking information about four specific help resources. The data from this section measured the degree of students' interest in human-centered homework systems.

The third part of the survey included 11 items (items 14 to 24) on a five-point Likert scale (1 – *Strongly Disagree* to 5 – *Strongly Agree*). Previous studies collected students' attitudes toward OHW based on their actual experiences, focusing on a particular system's effectiveness, convenience, stability, and overall assessment (Altun, 2008; Hill, 2019; Leong, 2013; Leong & Alexander, 2014; Smith et al., 2022; Wong, 2001). In these studies, features of different OHW systems have been associated with students' attitudes. Albelbisi et al., (2022) reported that perceived usefulness and ease of use are predictors of attitude toward the use of OHW. My study offered an innovative method to collect students' attitudes toward OHW by providing a description of the general features instead of using a specific OHW system. To solicit information about features of OHW systems, I provided a brief summary of what a human-centered OHW system might look like in the second section of the survey instrument. Then, I designed 11 items to collect students' overall positive or negative feelings toward the OHW system, including three items on equity (items 14 -16) and two items on general attitudes (items 22 and 24) by adapting the items from the *Delaware School Climate Survey* (Bear et al., 2011). Previous studies (Albelbisi, 2018; Lunsford & Pendergrass,2016; White, 2002) have reported that OHW can meet more individual needs; however, no previous studies have investigated whether students feel more equitably treated when they are asked to complete homework online.

Data Analysis

I analyzed my data using the R programming language to complete both descriptive analyses and structural equation modeling (SEM).

The descriptive analyses and Independent samples t-test addressed three research questions:

(1) What are students' overall attitudes toward online homework (OHW), and do they feel treated equitably when completing online math homework?

(2) Which human-centered design features do students view positively, and which do they view negatively?

(3) What are students' attitudes toward different online homework help resources?

The descriptive analyses and two-sample t-tests provided basic student information, such as gender, self-reported math achievement, and family income status. Additionally, the descriptive analyses offered insights into the degree to which students found homework help resources acceptable and their preferences in ranking these resources. The two-sample t-tests examined whether student preferences for the help system or the four different help resources differed significantly between the two levels of each demographic factor (School, Gender, Math Level, and Family Income).

The SEM analysis incorporated ANOVA, correlation, and regression analyses to answer the remaining research questions:

(4) What are the effects of the higher order model in this research?

(5) What regression relationships exist between latent variables and general variables, and between general variables and demographic factors?

Correlation analysis provided information about how student demographics moderate the relationship between attitudes and math achievement. Regression analysis identified the positive predictors of math achievement. ANOVA determined whether different attitudes toward online math homework exist among student groups with varying levels of math achievement.

CHAPTER IV

RESULTS

Descriptive Statistics about the Participants

A total of 690 grade 10 students from two different high schools in China participated in this research. Four demographic factors were collected: gender, math achievement, family income, and school. These factors were identified as potential influences on students' attitudes toward online math homework systems.

The gender distribution was nearly equal at Minzu High School, whereas, in Puning No. 2 High School, 53.16% of the participants were female, and 46.84% were male. Overall, with participants from both schools combined, 51.45% of the participants were female, and 48.55% were male.

In terms of family income, the majority of students in both schools came from families with middle or below-middle income levels: 92.51% at Minzu High School and 95.57% at Puning No. 2 High School. Across all participants, 93.92% of students reported coming from families with middle or below-middle income, while 6.08% came from upper-middle or upper-income families. Students were asked to select the descriptor of the income level they felt best described their families' situations. Possible answer options included *low income, below-middle income, middle income, upper middle income,* and *upper income*.

Regarding math achievement, 82.08% of students at Minzu High School reported having *average* or *low* math achievement, 9.9% reported *good* or *excellent* achievement, and 8.02% were *unsure*. At Puning No. 2 High School, 77.84% reported *average* or *low* achievement, 10.12% reported *good* or *excellent* achievement, and 12.03% were *unsure*. Overall, 80.14% of the participants reported that they had *average* or *low* math achievement, 10% had *good* or *excellent* achievement, and 9.86% were *unsure* of their math achievement level. Tables 2 and Figures 1-3 provide more detailed information.

Fig. 1
Gender Friquency in Two Schools

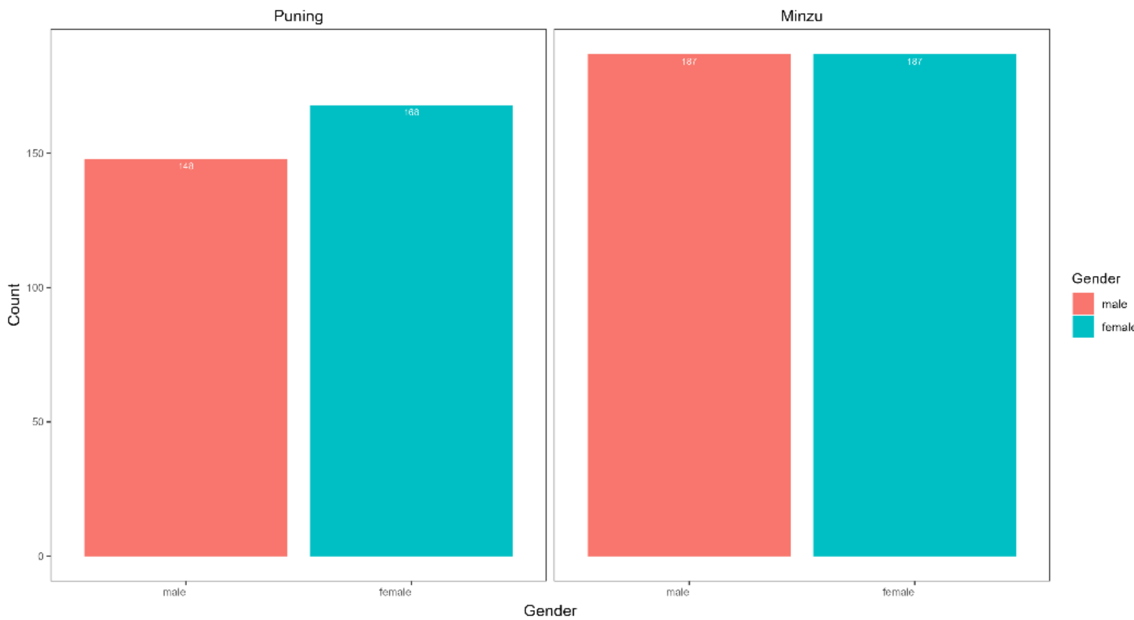


Fig. 2
MathLevel frequency in two schools

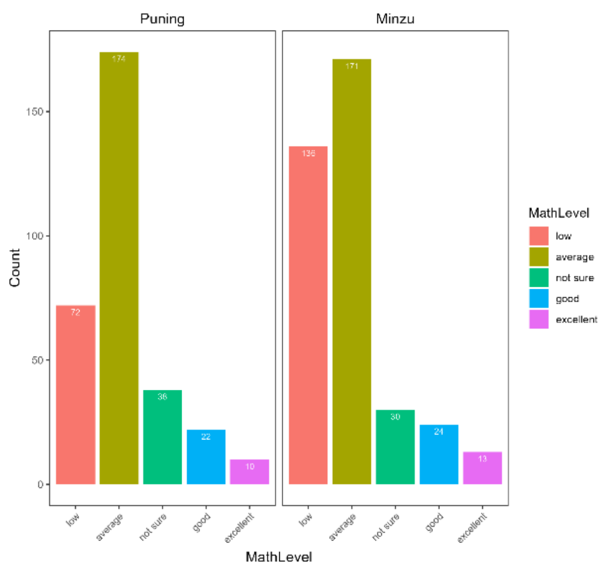
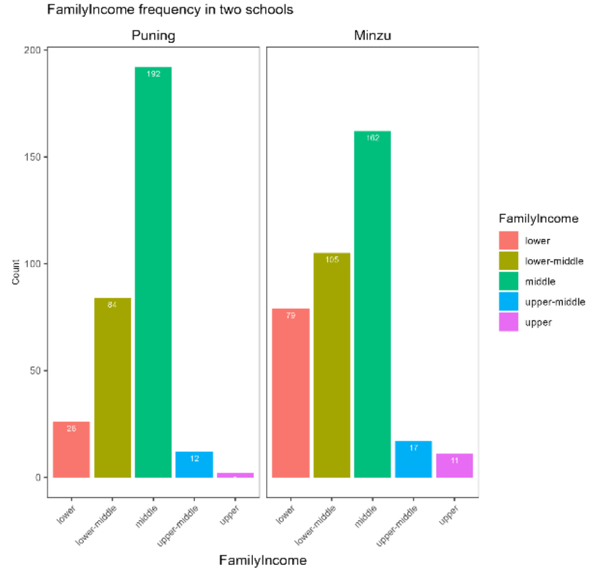


Fig. 3
FamilyIncome frequency in two schools



(RQ1) What are students' overall attitudes toward online homework (OHW), and do they feel treated equitably when completing online math homework?

This research explored students' attitudes toward online math homework, divided into three categories: attitudes toward human-centered design, attitudes toward equitable treatment, and attitudes toward online math homework in general. These results are detailed in four descriptive tables (Tables 3-6).

Nine items using a five-point Likert scale (1 – *Strongly Disagree* to 5 – *Strongly Agree*) were used to assess attitudes toward human-centered design. The mean score was 30.98 out of 45 (68.80%), indicating that students generally had a positive perception of human-centered design in online math homework (see Table 3). Three items (Items 14-16) measured students' perceptions of equity in online math homework using the same five-point Likert scale. The mean and median scores were 10.04 and 10 out of 15, respectively, with the mean percentage at 66.93%. These results suggest that students felt positively about the equity of online math homework (see Table 4). Items 17-24 assessed attitudes toward online math homework, with a mean score of 24.84 out of 40 (62.10%) and a median score of 24 out of 40. Overall, students had positive attitudes toward online math homework (see Table 5).

Based on these three sub-attitudes, I created a descriptive table (Table 6) to show students' general attitudes toward online math homework. The mean score was 65.84 out of 100, and the median was 65 out of 100, with a positivity percentage of 65.84%.

(RQ2) Which human-centered design features do students view positively, and which do they view negatively?

Items 4-11 and Item 13 described six key human-centered design features of online math homework. Each item used a five-point scale (1 – *Strongly Disagree* to 5 – *Strongly Agree*). These features included:

1. Individualized homework aligned with students' abilities (Items 4 and 5).
2. Auto-adjustable and challenging math items (Items 6 and 7).
3. Timely feedback (Item 8).
4. The ability to redo incorrect questions (Items 9 and 10).
5. A help system (Item 11).
6. A virtual communication environment (Item 13).

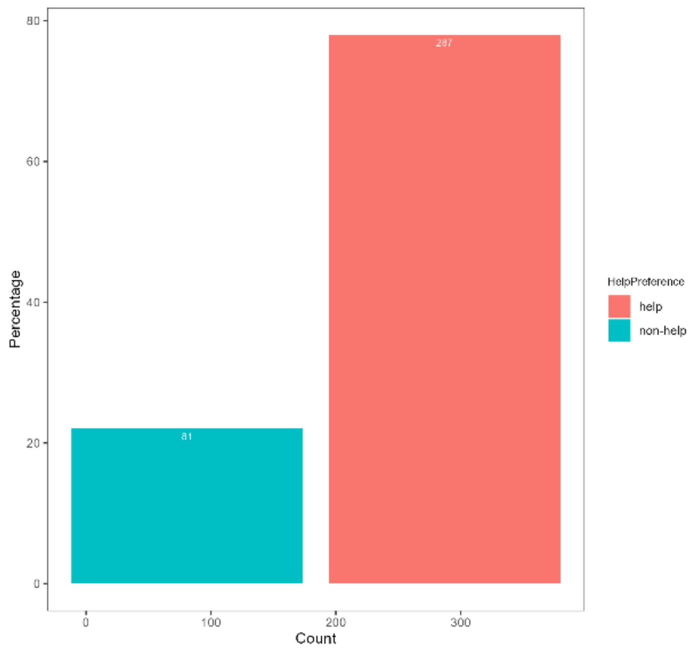
The most positively viewed feature was the ability to redo incorrect questions, with a mean score of 3.73. Timely feedback followed, with a mean of 3.58, and individualized homework ranked third with a mean of 3.56. Help resources were ranked fourth, with a mean score of 3.44, while auto-adjustable and challenging math items scored 3.14. The least popular feature was the virtual communication environment, with a mean of 3.09 (see Table 7).

(RQ3) What are students' attitudes toward different homework help resources?

Previous research (Boudreaux et al., 2020) has indicated that students prefer online math homework systems with help resources over those without. In this study, Item 11 was designed to assess student preferences for help resources in online math homework. The responses *Strongly Disagree* and *Disagree* were combined into a *Non-help* category; the other responses (*Agree*, and *Strongly Agree*) formed a *Help* category. The "not sure" response was excluded from the preference analysis. Of the participants, 322 (46.67%) selected "not sure", while 368 students clearly expressed either positive or negative attitudes toward online math homework systems with help resources. Among these participants, 287 (77.99%) prefer help resources (see Table 8 and Figure 4).

Fig. 4

Student Preference of Help Fuction



These findings suggest that a majority of students have a generally positive attitude toward help resources in online math homework. To explore these preferences in greater depth, descriptive statistics and independent samples t-tests were conducted across key demographic variables: School, Gender, Math Level, and Family Income. Prior to conducting the analyses, cases with missing data were removed, and the categorical levels of Math Level and Family Income were recoded. Specifically, Good and Excellent in Math Level were grouped as AboveAverage, while Low and Average were combined into AverageOrLow. In Family Income, Upper and Upper-Middle were grouped as AboveMiddle, and Middle, Lower-Middle, and Lower were combined into MiddleOrBelow. The final dataset included 331 cases after excluding 37 observations marked as Not Sure in Math Level.

The descriptive statistics further revealed that students from the high-tier school, No. 2 Puning High School, had a higher mean preference ($M = 1.88$) compared to those from the lower-tier Minzu High School ($M = 1.67$); female students reported a higher mean preference ($M = 1.85$) than male students ($M = 1.71$); students with higher math achievement showed greater preference ($M = 1.85$) than those with lower achievement ($M = 1.77$); and students from higher-income families reported a higher mean preference ($M = 1.86$) compared to those from middle or lower-income families ($M = 1.78$). Independent samples t-tests further indicated that the differences in mean preference were statistically significant for School ($p < .001$) and Gender ($p = .003$) (see Tables 9 and 10).

Although students who chose “not sure” were excluded from the preference analysis, they were included in the ranking of specific help resources with the rationale that they did, in fact, provide a ranking and the understanding that a larger sample size improves the validity of the ranking results.

A total of 609 students also ranked their preferences among four types of help resources: Instructions by Steps, Brief Hints, Videos or Animations, and Synchronous Volunteer Help (see Table 9 and Figure 5). The help resource *Videos/Animations* had the highest mean value of 3.94, followed by *Brief Hints* (mean = 3.89), *Volunteer Help* (mean = 3.79), and *Instructions by Steps* (mean = 3.77), which was the least preferred resource (see Tables 11).

Descriptive statistics across demographic factors showed that students from No. 2 Puning High School exhibited more positive attitudes toward all four help resources compared to those from Minzu High School; female students showed greater preference for all help resources except Brief Hints when compared to male students; students with higher math achievement preferred all help resources except Volunteer Help more than those with lower achievement; preferences among income groups were mixed across the four help resources.

Independent samples t-tests revealed that students from No. 2 Puning High School had significantly higher preferences for all four help resources than students from Minzu High School (all p-values $< .01$). In addition, female students significantly preferred Videos or Animations and Volunteer Help compared to male students (both p-values $< .01$) (see Tables 12 and 13).

(RQ4) What are the effects of the higher order model in this research?

The questionnaire used in this research contained a hierarchical structure. Apart from the three demographic items and one item exploring specific help resources, the remaining 20 items belonged to three latent variables: *attitudes toward human-centered design*, *equitable feelin*g, and *attitudes toward online math homework*. These latent variables collectively form the general attitudes toward online math homework.

The latent variable for *human-centered design* included nine items, *equitable feeling* included three items, and *attitudes toward online math homework* included eight items. This research met the just-identified requirements for higher-order modeling analysis. The effects of the model primarily focused on the overall goodness-of-fit and the variance explained by the latent variables.

However, the higher-order model only supports factor variables with two levels for regression analysis. Therefore, to address this limitation, some cases needed to be removed or merged. Excluding 68 cases where respondents indicated "not sure" in the MathLevel variable, reduced the total sample size to 622. Additionally, responses of *Good* and *Excellent* in

MathLevel were combined into an *AboveAverage* category, while *Low* and *Average* were grouped as *AverageOrLow*. Similarly, in the FamilyIncome variable, responses of *Upper* and *Upper-Middle* were combined into an *AboveMiddle* category, while Middle, Lower-Middle, and Lower were grouped into a *MiddleOrBelow* category.

Overall Goodness-of-Fit of the Higher Order Model

The X^2 statistic, TFI, and RMSEA were used to evaluate the overall goodness-of-fit of the model. The X^2 value was 1602.766 ($p = 0.0000$), the TFI value was 0.758 (below the desired threshold of 0.90), and the RMSEA was 0.095 (above the recommended threshold of 0.05). These results indicate that the goodness-of-fit of the higher-order model was less than ideal (see Table 15).

Latent Variables of the Higher Order Model

Table 16 presents the results for the latent variables. Of the nine indicators for the *human-centered design* (HCDesign) latent variable, item 9 did not have a significant effect. The latent variable for *attitudes toward math online homework* (MOHW) did not significantly impact item 22. After removing these two non-significant items and re-estimating the higher-order model, the overall model structure and results remained largely unchanged, particularly regarding the relationships between the higher-order latent variable and the first-order factors. Thus, I retained the two items because they were supported theoretically, and their retention was not discouraged empirically. The general attitudes factor (Gatt) significantly impacted HCDesign (effect = 0.839), Equity (effect = 0.984), and MOHW (effect = 0.850), all with p-values < 0.001.

(RQ5) What regression relationships exist between latent variables and general variables, and between general variables and demographic factors?

This model displays the correlations between 20 item indicators and three latent variables, and the relationships between the three latent variables and the general variable. It also shows the regressions between the latent variables and general variables, as well as between the general variables and demographic factors (gender, family income, math achievement, and school).

Variances of the Higher Order Model

Examining the variances allows us to determine, for each first-order dimension, what portion of its variance can be attributed to the second-order factor (Gatt). The results based on all 20 items and those based on 18 items (excluding the two non-significant items, Item 9 and Item 22) remained nearly identical. Table 17 shows that the variance of "HCdesign" is equal to 0.296. From this estimation, we know that the Gatt factor accounts for 1 - 0.296 = 0.704, which corresponds to the R^2 value. Additionally, the portion of the variance in the dimension "Equity" that can be attributed to the SDQ hierarchical factor is 96.70%, while for the dimension "MOHW" it is 72.30%. The variances of the variables “HCdesign” and “MOHW” caused by the “Gatt” are significant ($p = 0.000$), while Gatt does not significantly impact the variance of "Equity" (p-value = 0.463). Among the three latent variables, “Equity” is a nonsignificant predictor of student attitudes toward online math homework.

Attitudes Toward Online Homework across Demographic Factors

Before exploring the results of the higher-order modeling, we can develop a basic picture of students’ attitudes toward online math homework. Table 14 shows that male and female students had very similar attitude scores, with males scoring 65.60 and females 65.90. Puning No.2 High School had a higher average attitude score (68.50) compared to Minzu High School (63.55). Students from wealthier families exhibited a higher attitude score (67.84) than those from middle or lower-middle income families, whose average score was 65.63. Furthermore, students with higher math achievement expressed more positive attitudes toward online math homework (69.94) compared to students with average or lower math achievement (65.24). These factors will be further analyzed through regression in the higher-order model.

Regressions of the Higher Order Model

In the higher-order model, I examined the regressions between "Gatt" and four individual factors (gender, math level, school, and family income). The results show that *math level* and *school* significantly predicted the Gatt, with the corresponding *p*-values of 0.001 and 0.000, respectively (See table 18). After removing the non-significant demographic factors (Gender and FamilyIncome) and rerunning the higher order model, the results of the regression analysis changed. The correlation between MathLevel and the higher-order variable Gatt increased from 0.149 to 0.158 ($p = 0.001$), while the correlation between School and Gatt decreased slightly from 0.217 to 0.214 ($p < 0.001$) (See table 19). This indicates that students' math achievement and the tier of their school positively influenced their attitudes toward online math homework. Specifically, the mean attitude score (68.50) for Puning No.2 High School was significantly higher than that of Minzu High School, while students with good math achievement had a statistically significantly higher mean attitude score (69.94) compared to those with average or low math achievement (65.24). Tables 12 and 15 provide more detailed information, and Figure 6 and 7 visually represents all relevant information from this modeling analysis.

Fig.6

The Higher Order Model of High School Students Attitudes Toward Online Math Homework

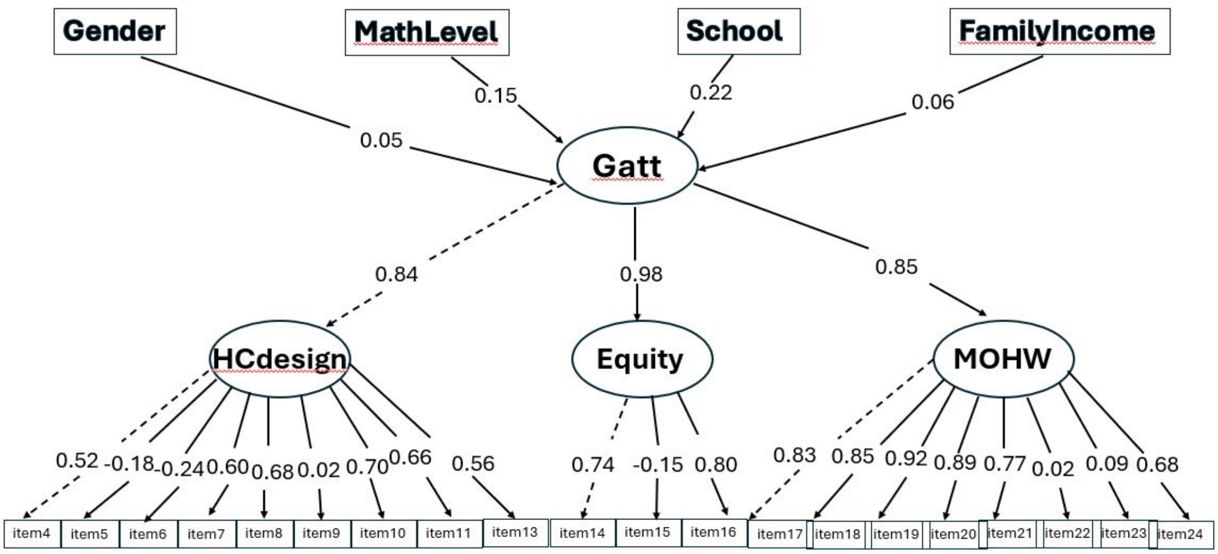
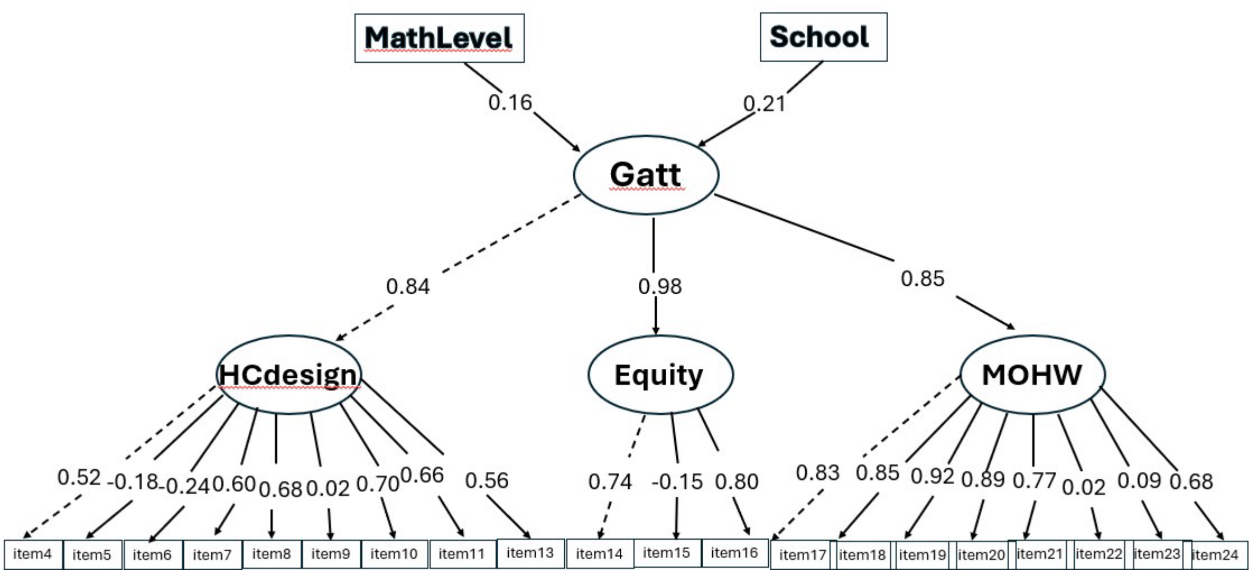


Fig.7

The Higher Order Model of High School Students Attitudes Toward Online Math Homework with Significant Predictors



CHAPTER V

DISCUSSION

The literature highlights several aspects of homework that require deeper investigation, including attitudes toward homework, online homework (OHW), math homework, and the creation of human-centered homework systems. This research explores students' attitudes toward online math homework that incorporates human-centered features and seeks to understand how demographic factors influence these attitudes. In this section, I will compare the results of this research with prior studies and offer further reflections.

In general, there are two common methods for collecting students' attitudes toward OHW. A few prior studies (Albelbisi et al., 2022) use surveys with different items representing various features of OHW. The advantage of this approach, used in my dissertation study, is that the data are not tied to any specific OHW system, making the results applicable across a variety of systems. However, a limitation of this method is that it may not provide in-depth information. Most prior studies, on the other hand, collect attitudes using a survey focused on a specific OHW system. While such an approach provides system-specific insights, the findings may not be generalizable. The goal of my research was to obtain generalizable results about online math homework systems, so the first method was employed.

Students' Attitudes toward Online Math Homework and Students' Equitable Feeling

The findings related to RQ1 show that students have a positive attitude toward online math homework, which aligns with previous studies (Albelbisi, 2018; Alshare, 2011; Altun, 2008; Cooper et al., 1998; Haverty, 2012) that report students' positive attitudes toward OHW. However, my study only investigated student attitudes; future research could expand the scope to include parents and educators. Comprehensive studies involving multiple perspectives could provide more effective guidance for the development of OHW systems in education.

Based on the literature reviewed, this research may be the first to examine whether OHW affects students' sense of equity. Descriptive results indicate that students feel equitable when using OHW. However, further studies are needed to validate these findings. Additionally, the validity of the three survey items used to measure equity could be a potential concern, suggesting that the inclusion of more items may enhance the validity of the measurement.

Student Attitudes toward Human-Centered Design

The human-centered design features were ranked in descending order based on their mean values: redoing incorrect questions (3.73), timely feedback (3.58), individualized homework (3.56), help system (3.44), adaptive challenging questions (3.14), and the virtual communication environment (3.09). Student attitudes toward each feature were positive. All these features have been investigated previously (Albelbisi, 2018; Alshare, 2011; Boudreaux et al., 2020; Cleynen et al., 2020; Haelermans & Ghysels, 2017; Haverty, 2012; Leong & Alexander, 2014; Lucas, 2012; Lunsford & Pendergrass, 2016; Magoulas et al., 2003 Richards-Babb et al., 2011; Roschelle et al., 2016; Núñez et al., 2014; White, 2002). The previous studies consistently support that students preferred immediate feedback and redoing incorrect questions, which likely contributed to students' positive attitudes.

Leong and Alexander (2014) conducted a study to explore benefits of OHW from college students and identified six advantages, two of them are related to human-centered design (help system and instant feedback). In the Boudreaux et al. (2020) study, students preferred OHW systems with better user interfaces and help features, even if they were more expensive. White (2002) reported that most students preferred using online systems to assist with their classroom studies because the digital discussion format provided them with an accessible communication method for their learning.

While prior research has not comprehensively ranked human-centered design features, this study fills that gap by examining how students perceive and rank each feature. The discrepancies in research focus across studies provide reasonable evidence for the ranking results. Of the studies collected for this analysis, nine focus on feedback: four specifically examine how timely feedback affects student performance or attitudes (Leong & Alexander, 2014; Haverty, 2012; Núñez et al., 2014; Richards-Babb et al., 2011), four other studies explored both feedback and redoing incorrect problems (Albelbisi, 2018; Boudreaux et al., 2020; Lucas, 2012; Roschelle et al., 2016), and one focused on feedback and the help system (Alshare, 2011). Four prior studies addressed individualized homework (Cleynen et al., 2020; Haelermans & Ghysels, 2017; Lunsford & Pendergrass, 2016; Roschelle et al., 2016). Two examined help features. One looked at virtual communication (White, 2002), and two focused on adaptive items (Magoulas et al., 2003; Nabulsi & Odeleye, 2021). Overall, feedback, redoing incorrect questions, and individualized homework are more widely studied than adaptive items and virtual communication.

The ranking of the four different help resources in my dissertation study may be influenced by how directly each feature impacts student performance. Immediate feedback and the opportunity to redo problems are closely tied to learning outcomes, as they motivate students and help them work effectively. Individualized homework addresses student learning styles, abilities, and needs, making homework more efficient and enhancing its supportive function. Consequently, it is not too surprising that redoing, feedback, and individualized homework ranked the highest. The help system makes support more accessible, especially for students who may have difficulty attending office hours or seeking help on campus. In contrast, adaptive items and virtual communication may have a less direct impact on learning outcomes, which could explain their lower rankings.

This study underscores the importance of incorporating human-centered design elements into online homework systems (OHW), ensuring they align with student needs and contribute to student achievement. However, few prior studies have comprehensively examined all of the human-centered design features proposed in this research or ranked them. Future studies could focus further on this aspect and provide additional insights. For example, studies that include field observations of students using these OHW features and interviews with students about why they used certain features and not others, as well as what aspects of the human-centered design features they liked, and why, could provide a more nuanced and in-depth understanding of the value of these different features.

Student Attitudes toward Help Resources

Previous studies have primarily examined whether help resources are necessary for online homework (OHW) without delving into the ranking of popular help resources. In my dissertation study, participants were asked not only to express whether they found help resources necessary but also to rank their preferences for different types of help resources. The results indicate that 88.26% of students desire help resources, which aligns with the findings of previous studies (Albelbisi, 2018; Boudreaux et al., 2020; Goehle & Wagaman, 2016; Leong & Alexander, 2014). Female students and students from the high-tier school showed a stronger preference for the help system compared to male students and those from the low-tier school. Hupp-Wilds (2014) found that females are more likely to receive help than males in both dangerous and emotional situations, which may explain the higher tendency among female students to prefer help resources. However, no suitable prior research was found to explain why students from the high-tier school preferred the help system. A possible explanation is that the high-tier school has greater access to various resources, including help resources, allowing students to fully experience how such support tools can enhance their learning.

Four types of help resources were identified from prior research, and student preferences for these resources were ranked based on their mean scores. The ranking, from highest to lowest, was as follows: *Video/Animations* (3.94), *Brief Hints* (3.89), *Volunteers* (3.79), and *Step-by-Step Instructions* (3.77).

The results show that all four help resources are popular among high school students, with only slight differences in preference between them. Video/Animations ranked the highest. This resource is generally concise and engaging, combining visual and auditory information. Psychological research suggests that humans prefer processing visual and auditory stimuli, which may explain why students favored this type of help resource. Additionally, students can control the pace of the videos according to their needs, adding flexibility.

The second-ranked resource, Brief Hints, is also concise and highlights key information, allowing students to find solutions quickly. Chinese high school students often juggle multiple tasks, so efficiency is a priority for them. Brief Hints enable students to access the necessary information without spending too much time.

In contrast, Volunteers and Step-by-Step Instructions, while helpful, require more time for communication or involve reading longer content to find key information. As a result, students who are particularly concerned about time management may rank these two resources lower than Video/Animations and Brief Hints.

The results from the descriptive analysis and independent samples t-test indicated that students from the high-tier school had significantly stronger preferences for all four types of help resources compared to students from the low-tier school. This finding aligns with earlier results in this research showing that high-tier school students had a greater overall preference for help systems in online math homework platforms. Additionally, female students demonstrated significantly more positive attitudes toward two types of help resources—Video/Animations and Volunteer—than male students. These resources involve higher levels of interaction and can offer not only academic support but also emotional assistance. As Hupp-Wilds (2014) suggested, females tend to require more support than males in emotionally challenging or high-stress situations.

Assistance is a crucial element in student learning, and the findings in this study demonstrate the importance of considering student backgrounds and psychological research when designing help systems in OHW platforms.

Regressions between Latent Variables and General Variables, and between General Variables and Demographic Factors

The results of the regression analysis between attitudes and demographic factors indicate that math achievement level and school are significant predictors of attitudes toward online math homework (p = 0.001). Students with higher math achievement levels exhibit more positive attitudes toward OHW compared to students with average or lower math achievement levels. This finding contradicts previous research, which found that lower-achieving students had more positive attitudes toward OHW than higher-achieving students. One possible explanation for this discrepancy is that previous studies typically collected attitudes after students used one or two specific OHW systems over a period of time (Lucas, 2012; Lunsford & Pendergrass, 2016;

Roschelle et al., 2016; Leong & Alexander, 2014; Wooten & Dillard-Eggers, 2013). The increase in learning performance directly improved the lower-achieving students' attitudes toward OHW in those cases. In contrast, the current study did not focus on a specific OHW system. The survey incorporated six popular human-centered design features, which emphasized individualized learning, as well as four common help resources. In contrast, the current study did not focus on a specific OHW system and did not collect information about changes in student performance. The survey incorporated six popular human-centered design features, which emphasized individualized learning, as well as four common help resources. These elements were likely better suited to address a variety of student needs, leading to more positive attitudes across achievement levels.

Additionally, all relevant studies reviewed were conducted before the COVID-19 pandemic, at a time when digital homework was one option among many and not mandatory, and when OHW systems were developing more slowly. During the pandemic, however, remote learning became the primary mode of education, which significantly increased the demand for student-centered OHW systems to meet various student needs. Students also became more aware of how human-centered OHW designs could benefit their learning. High-achieving students may have been better able to utilize the advantages of OHW systems, which could explain why they reported more positive attitudes compared to their peers with lower academic performance.

Students from Puning No. 2 High School demonstrated more positive attitudes toward online math homework than those from Minzu High School. The primary distinction between these two schools is that Puning No. 2 High School has more educational resources and higher overall performance than Minzu High School. Students at Puning No. 2 High School may have had better experiences with digital devices, internet access, and online resources, contributing to their confidence in utilizing OHW systems, advanced skills in managing OHW, and a focus on the efficiency of digital resources. This deep understanding of human-centered OHW systems might be associated with the more positive attitudes reported by students from Puning No. 2 High School as compared to students in Minzu High School. This explanation aligns with previous research. Alshare (2011) suggested that positive attitudes toward OHW systems were significantly predicted by two human factors: comfort with online learning and perceived web self-efficacy.

Prior studies (Altun, 2008; Cheema & Sheridan,2015; Fernández-Alonso et al., 2015) have presented mixed results on whether gender or socioeconomic status significantly predicts student attitudes. In the current study, no evidence supports the idea that family income or gender are statistically significant predictors of student attitudes toward OHW.

The regression results between attitudes and the three latent variables (human-centered design, equity, and online math homework) provide evidence that human-centered design and online math homework are significant predictors of attitudes toward online math homework. Previous studies (Alshare, 2011; Boudreaux et al., 2020) investigating the impact of human-centered design on attitudes consistently report positive effects, and the findings of this research align with those results. Although past research (Fan et al., 2016; Haverty, 2012; Leong & Alexander, 2014; Lunsford & Pendergrass, 2016) has yielded mixed results regarding subject-specific effects on attitudes, the current study provides evidence that the math subject positively impacts attitudes toward OHW.

Study Limitations

While the thorough introduction, analysis, and discussion in this study provide valuable insights, several limitations should be acknowledged. This study followed a typical quantitative approach, which, although contributing to objective data collection, does not capture in-depth, varied insights from participants. This may have impacted the richness of the findings.

The use of self-reported data through a 5-point Likert scale to measure individual factors such as Family Income and Math Level present some challenges in terms of validity and reliability. Moreover, the use of five levels for each individual variable was not effective, as the results did not show significant differences among the levels. After reassigning the five levels into two, some significant results emerged. Therefore, using two or three levels for individual factors may be more effective in future studies.

Additionally, all participants were 10th-grade students in China, which limits the diversity of the sample in terms of both grade level and cultural context. As a result, the findings may not generalize to students in other grades or cultural settings.

This study also employed only descriptive statistics to explore the ranking human-centered design features. These results were descriptive and do not support inferential conclusions.

Lastly, the survey measured students' sense of equity through three items. Among the three latent variables examined (human-centered design, equity, and online math homework), equity was not a significant predictor of attitudes toward online math homework. This result may reflect the limitations of using only a small number of items to measure equitable feelings. To put it simply, the scale might have been too constrained for results to be statistically significant.

Areas for Future Research

Based on the limitations discussed, several areas for future research are proposed. A mixed-method approach, incorporating both quantitative and qualitative methods, should be employed. Specifically, using focus groups or interviews to collect qualitative data could provide deeper insights into help resources and human-centered features that contribute to a student-centered online homework (OHW) system.

Participant recruitment plans should be carefully designed to improve sample diversity in terms of both grade level and cultural context. As online learning becomes a global research topic, a more diverse sample would yield more generalizable and convincing results. In addition, applying additional statistical methods to analyze help resources and human-centered design features could lead to broader conclusions on how to build an effective student-centered OHW system.

Lastly, future research should further examine how factors such as the math subject, online learning, high school students, human-centered design, and individual factors influence student attitudes toward online math homework. Research in these areas is currently limited, even though math is a crucial subject for high school students, and online homework is becoming increasingly common.

Implications for Practice

The findings of this study provide several critical insights that can significantly impact teaching practices, administrative strategies, and the development of online homework (OHW) platforms, particularly for use in high school. High school students' attitudes toward online math homework are generally positive, with preferences for helpful resources and human-centered features. These features, along with the online format of homework, significantly predicted student attitudes toward OHW. This finding indicates that incorporating a student-centered approach with accessible support features, such as tutorial videos, hints, volunteers, or step-by-step instructions, could be beneficial for enhancing student engagement and success.

Another key takeaway from this study is that high-achieving students in high-tier schools with more educational funds and resources tend to have more positive attitudes toward online math homework than low-achieving students in low-tier schools. This disparity suggests that access to resources, both educational support and technological infrastructure, plays a crucial role in shaping students' perceptions and success in using OHW platforms. Therefore, educators and administrators should consider how to address these inequalities by ensuring that students from lower-resourced schools have access to reliable devices, high-speed internet, and adequate learning support.

For teachers, administrators, and developers of online homework platforms, these findings suggest several practical strategies. First, it is essential to develop OHW platforms that are not only user-friendly but also student-centered, providing multiple forms of support (e.g., instant feedback, hints, and tutorial resources). Teachers should be trained to use these platforms effectively, leveraging their features to support diverse learning needs. Administrators should ensure that schools have the necessary infrastructure, including reliable hardware and internet access, to facilitate effective use of OHW. Furthermore, developers should prioritize human-centered features, such as redoing incorrect items, timely feedback, and adaptive learning systems, to meet the varied student needs, thus enhancing engagement and learning outcomes.

The positive response from students toward the use of digital math homework suggests that the gradual shift from traditional physical homework to online platforms could be beneficial. Teachers and administrators should explore integrating digital homework into their curricula while ensuring that the systems used are equitable and accessible to all students, regardless of their socioeconomic background. This approach will support the development of more individualized learning experiences that can be tailored to meet the diverse needs of students, ultimately promoting greater equity in education.

This study also highlights the importance of continuous research to explore how digital math homework can more effectively support student achievement. Advanced research methodologies, including diverse statistical techniques and larger, more varied samples, will be essential for refining conclusions about how OHW impacts student learning. Future studies should also examine how different types of help resources and human-centered features rank in terms of their effectiveness, and how these elements contribute to fostering a sense of equity in students' attitudes toward online math homework.

From this research process, I have learned that revisiting previous research topics can be incredibly valuable, especially when testing how individual factors, human-centered design elements, and academic subjects influence student attitudes toward online homework. Also, it is important to fill gaps in the literature, such as ranking different types of help resources or exploring the role of equity in shaping students' perceptions. Some of the results from this study aligned with prior research, while others contradicted or expanded upon existing findings. These insights have encouraged me to reflect deeply on my own research process and conclusions and have led to new questions I aim to explore in future studies. In the future work, I will continue focusing on developing a platform that is accessible to students from varying socioeconomic backgrounds, with particular attention to providing adequate resources for those from lower-resourced schools.

APPENDIX A

Table 1
A Model of Factors Influencing the Effects of Homework

Components	Factors			Outcomes or effects
	Exogenous factors/ moderators	Endogenous factors/ mediators	Home-community	
1	Economic status	Assignment amount	Competitors for student time	Assignment completion
2	Student ability	Assignment purpose	Home environment	Assignment performance
3	Student motivation	Degree of individualization	Others' involvement	Positive effects
4	Grade level	Completion deadlines		Negative effects
5	Sex	Feedback		
6	Subjects	……		

APPENDIX B

Table 2

Subject Demographic Information

	School		
	Minzu High School	Puning No. 2 High School	Total
Gender			
female	187(50.00%)	168(53.16%)	355(51.45%)
male	187(50.00%)	148(46.84%)	335(48.55%)
Income			
lower	79(21.12%)	26(8.23%)	105(15.22%)
lower-middle	105(28.07%)	84(26.58%)	189(27.39%)
middle	162(43.32%)	192(60.76%)	354(51.30%)
upper-middle	17(4.55%)	12(3.80%)	29(4.20%)
upper	11(2.94%)	2(0.63%)	13(1.88%)
MA			
low	136(36.36%)	72(22.78%)	208(30.14%)
average	171(45.72%)	174(55.06%)	345(50.00%)
not sure	30(8.02%)	38(12.03%)	68(9.86%)
good	24(6.42%)	22(6.96%)	46(6.67%)
excellent	13(3.48%)	10(3.16%)	23(3.33%)

Notes: MA=math achievement. Percentage = group number/316*100 or Percentage = group number/374*100, total = group number/690*100

APPENDIX C

Table 3

Subject Attitudes toward the Human-Centered Design

	Mean	Median	SD
Item 4	3.57	3.00	1.10
Item 5	3.55	3.00	1.05
Item 6	3.03	3.00	1.00
Item 7	3.25	3.00	1.10
Item 8	3.58	4.00	1.12
Item 9	3.72	4.00	1.12
Item 10	3.74	4.00	1.03
Item 11	3.44	3.00	1.05
Item 13	3.09	3.00	0.99
Sum	30.96(68.80%)	31.00	4.67

Notes: These items were designed using a five-point Likert scale (1 – *Strongly Disagree* to 5 – *Strongly Agree*). Percentage = group number/45*100

APPENDIX D

Table 4

Subject Attitudes toward Equity

	Mean	Median	SD
Item 14	3.26	3.00	0.90
Item 15	3.53	3.00	1.03
Item 16	3.25	3.00	0.90
Sum	10.04(66.93%)	10.00	1.82

Notes: These items were designed using a five-point Likert scale (1 – *Strongly Disagree* to 5 – *Strongly Agree*). Percentage = group number/15*100

APPENDIX E

Table 5

Subject Attitudes toward the Math OHW System

	Mean	Median	SD
Item17	3.24	3.00	0.88
Item18	3.06	3.00	0.87
Item19	3.13	3.00	0.87
Item20	3.18	3.00	0.84
Item21	3.06	3.00	0.89
Item22	3.10	3.00	0.89
Item23	3.00	3.00	0.86
Item24	3.07	3.00	0.92
Sum	24.84(62.10%)	24.00	4.68

Notes: These items were designed using a five-point Likert scale (1 – *Strongly Disagree* to 5 – *Strongly Agree*). Percentage = group number/40*100

APPENDIX F

Table 6

Subject General Attitudes

	Mean	Median	SD
General Attitudes	65.84(65.84%)	65.00	9.29
Attitudes toward the Human-Centered Design	30.96	31.00	4.67
Attitudes toward Equity	10.04	10.00	1.82
Attitudes toward the Math OHW System	24.84	24.00	4.68

Notes: *General Attitudes include* Attitudes toward the Human-Centered Design, Attitudes toward Equity, and Attitudes toward the Math OHW System. Percentage = group number/100*100

APPENDIX G

Table 7

The Rank of Human-Centered Design Features

	Mean	Median	SD
Item 9 & 10	3.73	4.00	1.08
Item 8	3.58	4.00	1.12
Item 4 & 5	3.56	3.00	1.08
Item 11	3.44	3.00	1.05
Item 7 & 6	3.14	3.00	1.05
Item 13	3.09	3.00	0.99

Note: Items are shown in descending order based on their mean values.

APPENDIX H

Table 8

Help System Preference

	Count	Percentage
Non-help	81	22.01%
Help	287	77.99%

Note: The table contains 368 cases after removing cases with 'not sure' in 'HelpPreference'.

APPENDIX I

Table 9

Descriptive Statistics of HelpPreference across Demographic Variables

	Mean	SD
School		
Minzu	1.67	0.47
Puning	1.88	0.32
Gender		
Female	1.85	0.36
Male	1.71	0.45
MathLevel		
AverageorBelow	1.77	0.42
AboveAverage	1.85	0.36
FamilyIncome		
AverageorBelow	1.78	0.42
AboveAverage	1.86	0.35

Note: The table contains 331 cases after removing cases with 'not sure' in 'HelpPreference' and 'MathLevel'.

APPENDIX J

Table 10

Two Sample t-test between HelpPreference and each demographic variable

	df	t-value	p
School	329	-4.79	< 0.01***
Gender	329	-2.98	0.003**
MathLevel	329	-1.18	0.239
FamilyIncome	329	-0.95	0.341

Note: The table contains 331 cases after removing cases with 'not sure' in 'HelpPreference' and 'MathLevel'. * = p < .05, ** = p < .01, *** = p <.001

APPENDIX K

Table 11

The Rank of Four Help Resources

	Mean	Median	SD
Videos/Animations	3.94	4.00	0.90
Brief Hints	3.89	4.00	0.89
Volunteer	3.79	4.00	0.93
Instructions by Steps	3.77	4.00	0.93

Note: Help Resources shown in descending order based on their mean values.

APPENDIX L

Table 12

Descriptive Statistics of Four Help Resources across Demographic Variables

	Instructions		BriefHints		VideoAnimation		Volunteer	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
School								
Minzu	3.66	0.93	3.71	0.90	3.80	0.91	3.66	0.94
Puning	3.91	0.90	4.10	0.84	4.15	0.80	4.00	0.85
Gender								
Male	3.76	0.96	3.91	0.86	3.84	0.91	3.69	0.96
Female	3.80	0.90	3.88	0.92	4.07	0.85	3.92	0.87
MathLevel								
AverageorBelow	3.78	0.90	3.87	0.88	3.96	0.87	3.82	0.91
AboveAverage	3.81	1.15	4.08	0.97	4.02	0.94	3.76	0.98
FamilyIncome								
AverageorBelow	3.78	0.91	3.90	0.88	3.97	0.86	3.81	0.90
AboveAverage	3.80	1.21	3.86	1.12	3.91	1.15	3.86	1.12

Note: The table contains 550 cases after removing cases with 'Strongly Disagree' or 'Disagree' in 'HelpPreference' and 'Not sure' in MathLevel.

APPENDIX M

Table 13

Two Sample t-test Between Each Help Resource and Each Demographic Variable

		t-value	df	p
School	Instructions	-3.19	548	0.002**
	BriefHints	-5.25	548	<0.001***
	VideoAnimation	-4.73	548	<0.001***
	Volunteer	-4.46	548	<0.001***
Gender	Instructions	-0.46	548	0.645
	BriefHints	0.46	548	0.644
	VideoAnimation	-3.07	548	0.002**
	Volunteer	-3.02	548	0.003**
MathLevel	Instructions	-0.27	548	0.789
	BriefHints	-1.77	548	0.078
	VideoAnimation	-0.48	548	0.630
	Volunteer	0.50	548	0.616
FamilyIncome	Instructions	-0.13	548	0.895
	BriefHints	0.243	548	0.808
	VideoAnimation	0.35	548	0.723
	Volunteer	-0.27	548	0.786

Note: The table contains 550 cases after removing cases with 'not sure' in 'HelpPreference'. * = p < .05, ** = p < .01, *** = p <.001

APPENDIX N

Table 14

The Attitudes toward Online Math Homework among Four Demographic Factors

	Mean	Median	SD
Gender			
Male	65.60	65.00	10.55
Female	65.90	65.00	7.94
School			
Puning	68.50	68.00	9.42
Minzu	63.55	63.00	8.53
Family Income			
Middle or below	65.63	65.00	9.15
Above middle	67.84	66.00	10.84
Math Achievement			
Average or below	65.24	65.00	9.06
Above average	69.94	69.00	9.92

Notes: The table contains 622 cases after resetting the 'FamilyIncome' and 'MathLevel' variables and removing cases with 'not sure' in 'MathLevel'.

APPENDIX O

Table 15

Overall Goodness-of-Fit Indices of the Higher Order Model

X^2	TLI	RMSEA
1602.766***	0.758*	0.095*

Notes: * = p < .05, ** = p < .01, *** = p <.001; A TLI value less than 0.90, and an RMSEA value greater than 0.05, indicate a significant result.

APPENDIX P

Table 16

Higher Order Model: Latent Variables

	Estimate	Std.Err	Z-value	P (>|z|)	Std.lv	Std.all
HCdesign =~						
Item 4	1.000				0.572	0.522
Item 5	-0.329	0.083	-3.971	< .001	-0.188	-0.178**
Item 6	-0.418	0.080	-5.246	< .001	-0.239	-0.239**
Item 7	1.152	0.107	10.807	< .001	0.659	0.596**
Item 8	1.344	0.116	11.629	< .001	0.768	0.684**
Item 9	-0.003	0.085	-0.037	0.970	-0.002	-0.002
Item 10	1.254	0.107	11.669	< .001	0.717	0.696**
Item 11	1.224	0.110	11.119	< .001	0.700	0.665**
Item 13	0.971	0.099	9.849	< .001	0.555	0.560**
Equity =~						
Item 14	1.000				0.661	0.737
Item 15	-0.223	0.067	-3.333	0.001	-0.148	-0.145**
Item 16	1.085	0.060	18.221	< .001	0.717	0.800**
MOHW =~						
Item 17	1.000				0.719	0.831
Item 18	1.033	0.039	26.566	< .001	0.742	0.853**
Item 19	1.113	0.037	29.969	< .001	0.800	0.921**
Item 20	1.056	0.037	28.270	< .001	0.760	0.891**
Item 21	0.959	0.043	22.392	< .001	0.690	0.769**
Item 22	0.023	0.051	0.455	0.649	0.017	0.019
Item 23	0.110	0.050	2.219	0.026	0.079	0.091*
Item 24	0.871	0.046	19.116	< .001	0.626	0.683**
Gatt =~						
HCdesign	1.000				0.839	0.839
Equity	1.356	0.123	10.984	< .001	0.984	0.984**
MOHW	1.275	0.116	11.015	< .001	0.850	0.850**

Notes: * = p < .05, ** = p < .01.

APPENDIX Q

Table 17

Higher Order Model: Variances

	Estimate	Std.Err	Z-value	P (>|z|)	Std.lv	Std.all
Item 4	0.872	0.053	16.322	< .001	0.872	0.727**
Item 5	1.079	0.062	17.523	< .001	1.079	0.968**
Item 6	0.939	0.054	17.433	< .001	0.939	0.943**
Item 7	0.786	0.050	15.591	< .001	0.786	0.644**
Item 8	0.671	0.047	14.410	< .001	0.671	0.532**
Item 9	1.214	0.069	17.635	< .001	1.214	1.000**
Item 10	0.547	0.038	14.229	< .001	0.547	0.516**
Item 11	0.619	0.041	14.973	< .001	0.619	0.558**
Item 13	0.677	0.043	15.725	< .001	0.677	0.687**
Item 14	0.368	0.027	13.607	< .001	0.368	0.457**
Item 15	1.010	0.058	17.567	< .001	1.010	0.979**
Item 16	0.289	0.026	11.171	< .001	0.289	0.359**
Item 17	0.231	0.015	15.191	< .001	0.231	0.309**
Item 18	0.206	0.014	14.908	< .001	0.206	0.272**
Item 19	0.115	0.010	11.986	< .001	0.115	0.152**
Item 20	0.149	0.011	13.698	< .001	0.149	0.206**
Item 21	0.329	0.020	16.150	< .001	0.329	0.409**
Item 22	0.800	0.045	17.635	< .001	0.800	1.000**
Item 23	0.749	0.043	17.627	< .001	0.749	0.992**
Item 24	0.449	0.027	16.744	< .001	0.449	0.534**
HCdesign	0.097	0.020	4.810	< .001	0.296	0.296**
Equity	0.014	0.020	0.732	0.464	0.033	0.033
MOHW	0.143	0.018	8.069	< .001	0.277	0.277**
Gatt	0.212	0.035	5.985	< .001	0.922	0.922**

Notes: * = p < .05, ** = p < .01.

APPENDIX R

Table 18

Higher Order Model: Regressions

	Estimate	Std.Err	Z-value	P (>|z|)	Std.lv	Std.all
Gatt~						
Gender	0.049	0.041	1.190	0.234	0.102	0.051
MathLevel	0.228	0.071	3.196	0.001	0.476	0.149**
School	0.209	0.044	4.721	< .001	0.436	0.217**
FamilyIncom	0.121	0.089	1.360	0.174	0.252	0.060

Notes: * = p < .05, ** = p < .01.

APPENDIX S

Table 19

Higher Order Model: Regressions with significant demographic variables

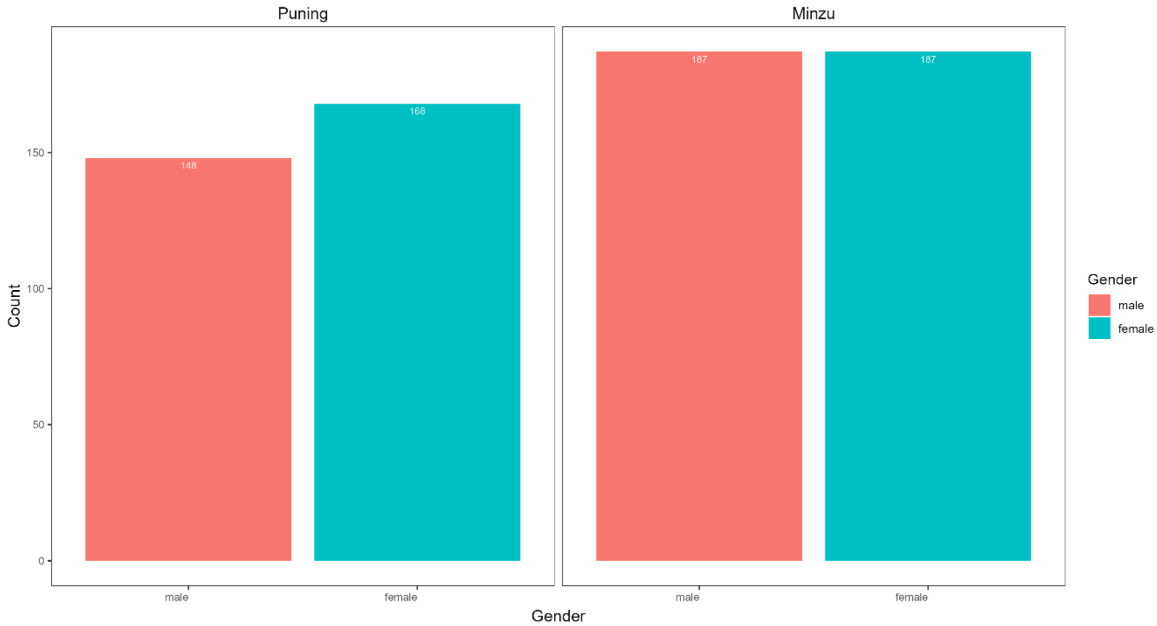
	Estimate	Std.Err	Z-value	P (>|z|)	Std.lv	Std.all
Gatt~						
MathLevel	0.241	0.067	3.604	0.001	0.504	0.158**
School	0.206	0.044	4.671	< .001	0.431	0.214**

Notes: * = p < .05, ** = p < .01.

APPENDIX T

Fig. 1

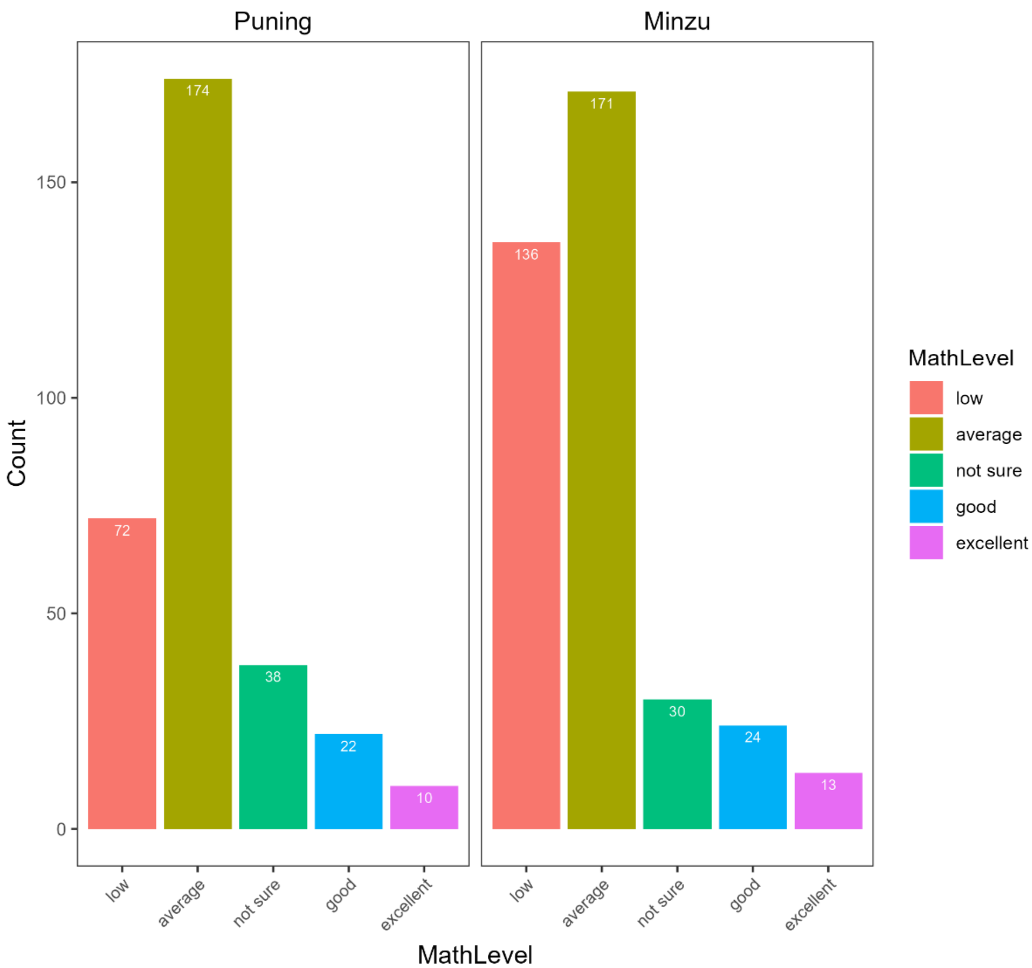
Gender Friquency in Two Schools



APPENDIX U

Fig. 2

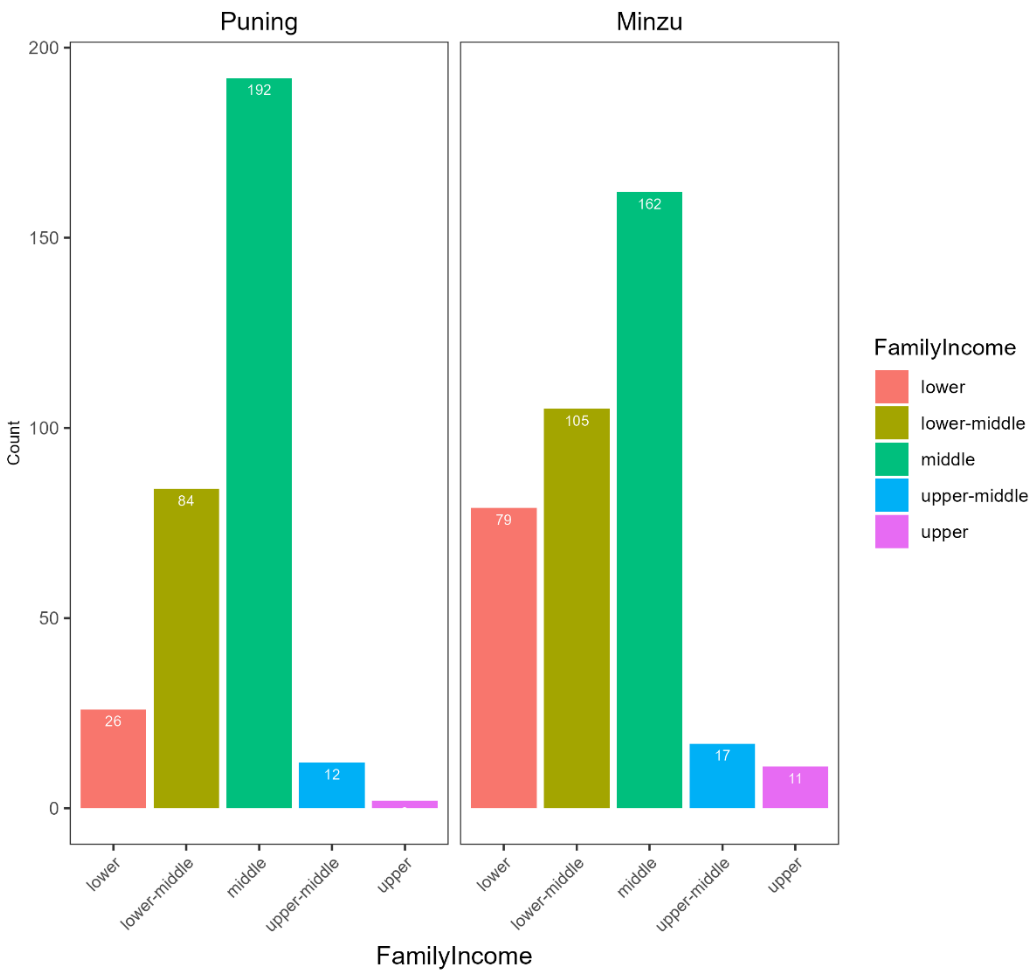
MathLevel Frequency in Two Schools



APPENDIXV

Fig. 3

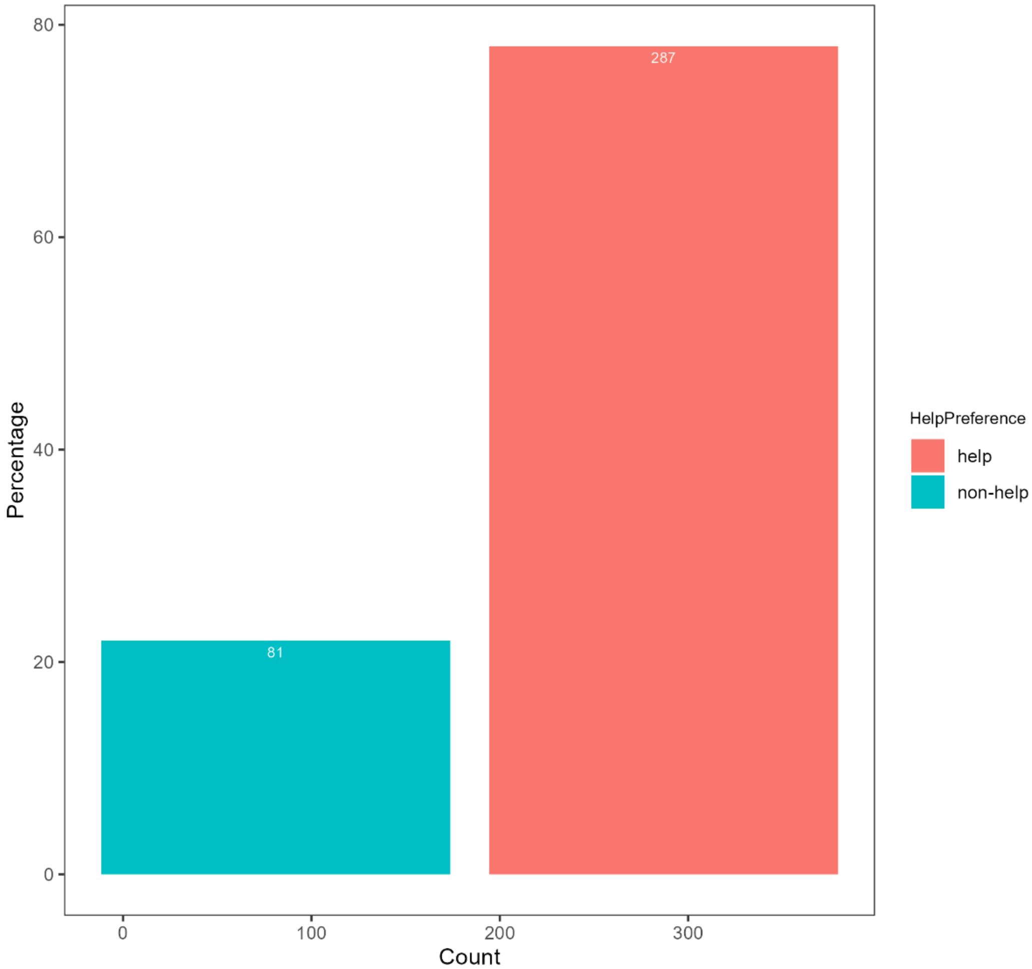
FamilyIncome Frequency in Two Schools



APPENDIX W

Fig. 4

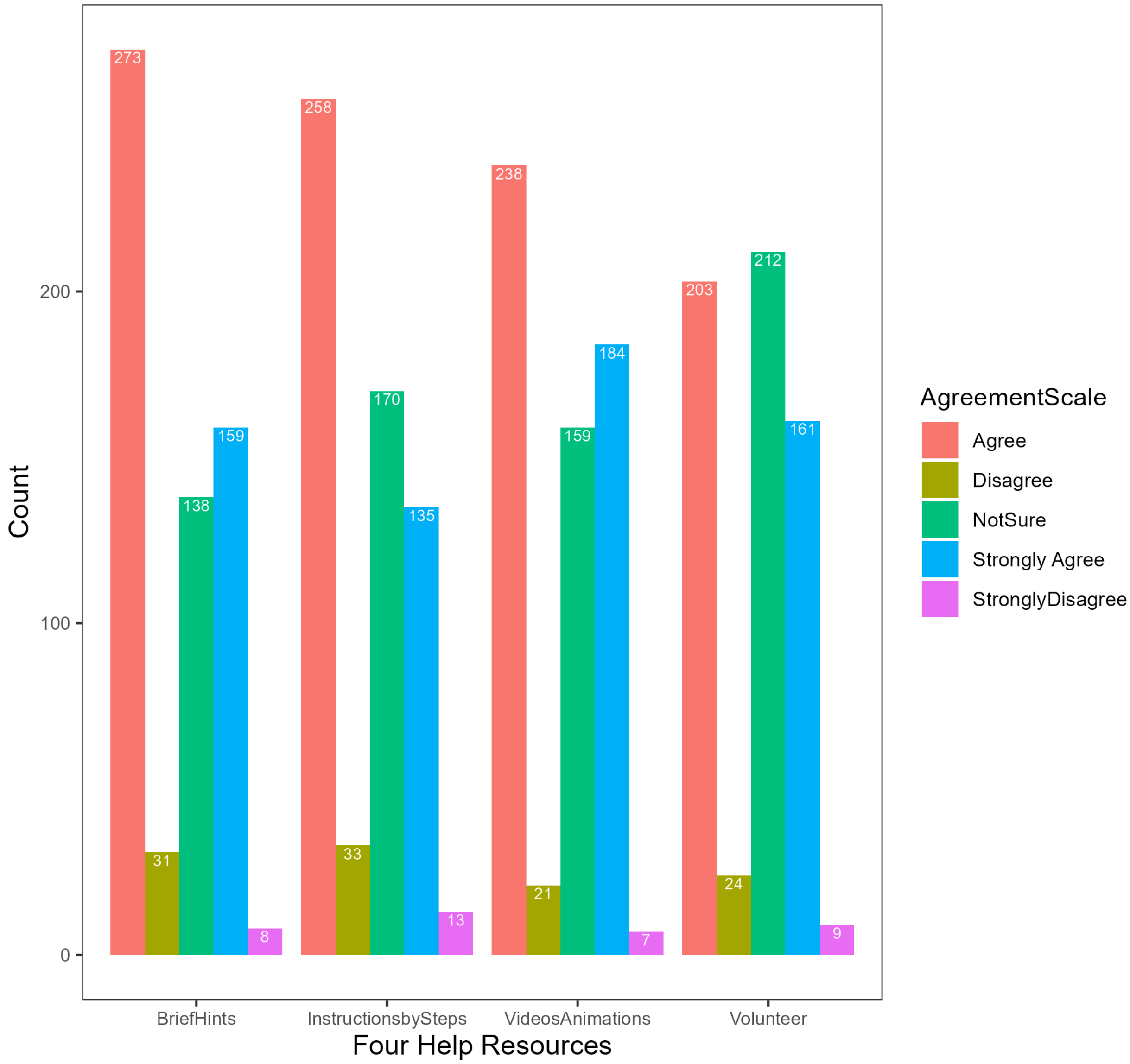
Student Preference of Help Fuction



APPENDIX X

Fig. 5

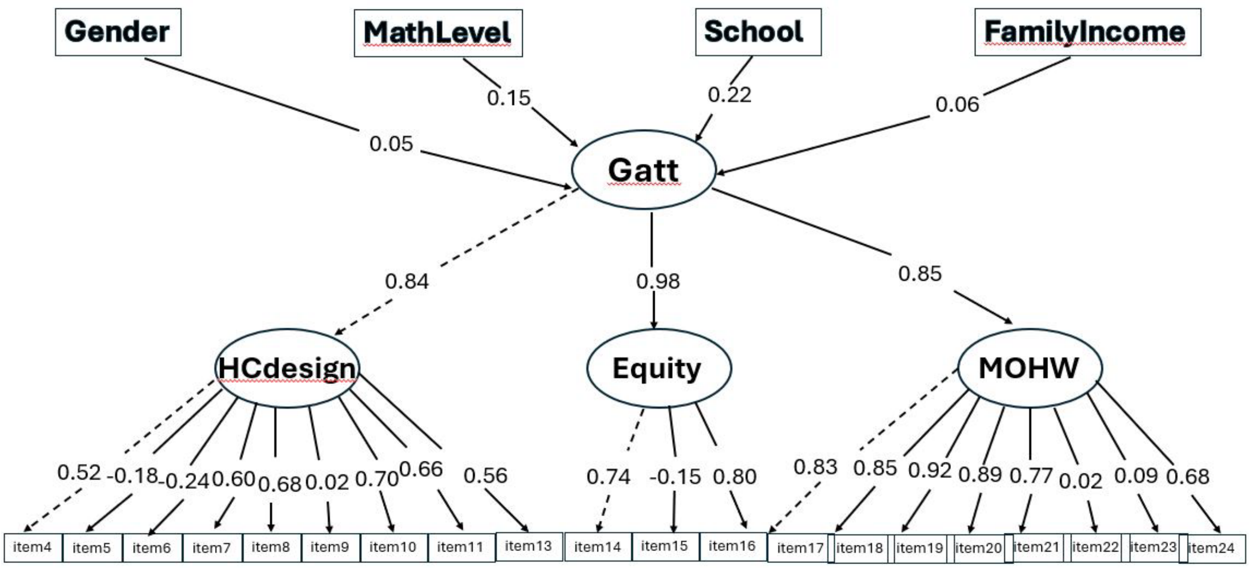
The Frequency Number for Each Group in Four Types of Help Resources



APPENDIX Y

Fig.6

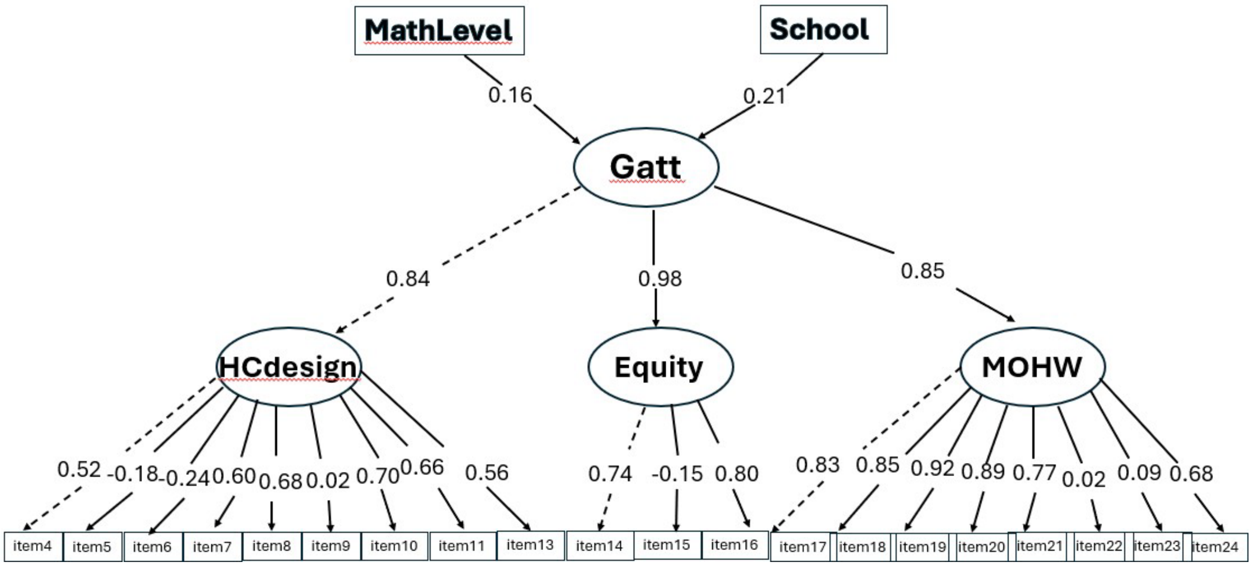
The Higher Order Model of High School Students Attitudes Toward Online Math Homework



APPENDIX Z

Fig.7

The Higher Order Model of High School Students Attitudes Toward Online Math Homework with Significant Predictors



The Survey about Attitudes Toward Online Math Homework (OHW)

INTRODUCTION

I am conducting research on Online Math Homework (OHW) systems, and your participation will provide valuable insights. This survey consists of two parts: Part 1 gathers demographic information, while Part 2 contains 21 questions exploring specific features of Math OHW and your opinions on using Online Math Homework. Each question includes five response options. Please answer each one based on your personal experience.

An example is provided for practice.

This book is interesting.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

Please click the green button to continue this study or close the browser to exit.

1.Gender: ○ Female ○ Male

2.Family Income: ○ Low ○ Below-Middle ○ Middle ○ Upper-Middle ○ Upper

3. Math achievement level: ○ Low ○ Not Sure ○ Average ○ Good ○ Excellent

4. I prefer doing math homework that matches my learning level.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

5. I dislike doing math homework that is the same for all students.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

6. I feel uncomfortable when math homework difficulty adjusts based on my previous answers.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

7. I enjoy solving challenging math homework questions within my math ability.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

8. I like receiving immediate feedback on whether my solutions are correct.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

9. It is NOT a good idea to redo the incorrect math homework questions online.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

10. Redoing incorrect math homework online helps me perform better.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

11. I prefer math homework that provides synchronous or asynchronous help resources.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

If you Strongly Disagree or Disagree with Q11, please skip to Q13

12. Please rate EACH following help resource:

(a) Step-by-step instructions ○ Terrible ○ Bad ○ Not Sure ○ Good ○ Excellent

(b) Brief hints ○ Terrible ○ Bad ○ Not Sure ○ Good ○ Excellent

(c) Teaching videos/animations ○ Terrible ○ Bad ○ Not Sure ○ Good ○ Excellent

(d) Online volunteers ○ Terrible ○ Bad ○ Not Sure ○ Good ○ Excellent

13. I feel more comfortable discussing math homework with peers in a virtual environment.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

14. Math OHW treats students fairly.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

15. It is unfair to have individualized math homework tailed to each student's learning level.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

16. Math OHW helps create an equitable school climate.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

17. OHW is helpful for learning Math.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

18. OHW enables me learning Math easily.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

19. OHW increases my productivity in Mathematics.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

20. OHW improves my chances to get a good grade in Math.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

21. Math OHW is convenient.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

22. I do not like math OHW.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

23. Math OHW is time-consuming.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

24. Math OHW is interesting.

○ Strongly Disagree ○ Disagree ○ Not Sure ○ Agree ○ Strongly Agree

高中学生对网络数学家庭作业的态度调查

指导语：

你好！这项研究的目的是了解高中学生对网络数学家庭作业的看法, 您的参与将有助于网络数学家庭作业的设计和质量提升。问卷包括两部分：第一部分 4 个问题，用于收集基本信息；第二部分包含 21 个问题，主要是陈述网络数学家庭作业的特点以及使用时的看法。每题都有信息陈述和备选选项，请根据您的个人实际情况回答（忽略网络和电子设备方面对网络家庭作业可能造成的障碍）。

答题示例如下：

今天是个好天气。（2） 1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

如果你已了解了本项研究，请开始答题

基本信息

1. 性别: 1. 女 2. 男 ( )

2. 家庭经济状况: 1. 低收入 2. 中等偏下收入 3.中等收入 4.中等偏上收入 5. 高收入 ( )

3. 数学水平: 1. 差 2. 一般 3. 不知道 4. 好 5. 优异 ( )

网络数学家庭作业

4. 我喜欢做适合我数学能力水平的家庭作业。( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

5. 我不喜欢做与班里同学一样的数学家庭作业。 ( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

6.网络数学家庭作业中，未做题目的难度随已做题目的正确度动态变化，这会让我感到不适应。( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

7. 我喜欢做与我数学能力相当的有挑战性的家庭作业。 ( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

8. 我喜欢做完数学家庭作业后，很快知道我的作业结果。 ( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

9. 重做错题不是一个好的数学学习方法。( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

10. 重做错题可以帮助我更好地学数学。 ( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

11. 我喜欢数学家庭作业提供实时的真人做题辅导或非实时的答题指导。( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

如果 11 题你选择了十分不同意或不同意，请跳到 13 题。

12. 请评价下列每种帮助资源：

(a) 详细的文字答题步骤　1. 十分糟糕　2. 糟糕　3. 不确定　4. 好　5.极好 ( )

(b) 要点提示　1. 十分糟糕　2. 糟糕　3. 不确定　4. 好　5. 极好( )

(c) 教学视屏/动画　1. 十分糟糕　2. 糟糕　3. 不确定　4. 好　5. 极好( )

(d) 在线提供帮助的志愿者　1. 十分糟糕　2. 糟糕　3. 不确定　4. 好　5. 极好( )

13.在网络环境中与同学讨论数学作业，我感觉更舒服。( )

1.十分不同意　2. 不同意　3.不确定　4.同意　5.十分同意

14. 网络数学家庭作业能满足个性化作业需求，公正的对待学生。( )

1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

15. 根据每个学生数学水平布置个性化数学作业是不公平的。( )

1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

16. 网络数学家庭作业能够营造因材施教的公正的校园文化。( )

1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

17. 网络数学家庭作业对我的数学学习有帮助。( )

1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

18. 网络数学家庭作业让我的数学学习变得轻松。 ( )

1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

19. 网络数学家庭作业能够提高我的数学学习效果。( )

1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

20. 网络数学家庭作业能增加我获得好的数学成绩的可能性。 ( )

1.十分不同意 2. 不同意 3.不确定 4.同意 5.十分同意

21. 网络数学家庭作业做起来很方便。 ( )

1.十分不同意　　2. 不同意　　3.不确定　　4.同意　　5.十分同意

22.我不喜欢做网络数学家庭作业。 ( )

1.十分不同意　　2. 不同意　　3.不确定　　4.同意　　5.十分同意

23. 做网络数学家庭作业很花时间。( )

1.十分不同意　　2. 不同意　　3.不确定　　4.同意　　5.十分同意

24. 做网络数学家庭作业很有趣。 ( )

1.十分不同意　　2. 不同意　　3.不确定　　4.同意　　5.十分同意

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