THE EFFICACY OF COLLABORATIVE LEARNING STRATEGIES IN EDUCATION: EXAMINING COLLECTIVE INTELLIGENCE AS A CONTRIBUTOR TO ACADEMIC SUCCESS

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Abstract: This study constructed a core conceptual framework using collaborative strategy, collective intelligence, collaboration quality, and academic performance as variables by introducing the following demographic gender, age, grade, and parental education variables. Attempting to analyze the differences in the perceived means of the respondents' demographic variable groupings for each of the variables of collaborative strategies, collective intelligence, collaboration quality, and academic performance and the influence of the independent variables on the dependent variables, the study proposed the following research hypotheses: 1. Collaborative learning strategies have a significant positive impact on the academic performance of high school students. 2. There is a significant positive correlation between collective intelligence and the academic performance of high school students. 3. Collaboration quality mediates the relationship between cooperative learning strategies and academic performance of high school students. 4. Effective practices that enhance collaborative learning in high school education will positively contribute to the academic performance of students. And using students from four high schools in Province B as a case study, the sample size was calculated as 7456 using simple random sampling method in the study population, 410 questionnaires were distributed in this study, 395 questionnaires were returned using simple random sampling method and the recovery rate was 96.3%.

This study found that collaborative strategy plays an important role in academic performance; collective intelligence plays an important role in academic performance; there is a significant indirect relationship between collaborative strategy and academic performance through the collaboration quality; and there is a significant indirect relationship between collective intelligence and academic performance through the mediator collaboration quality. Specific manifestations of collaborative strategy, collective intelligence, collaboration quality, and academic performance in subsequent changes in real academic life. This study provides a reference point for subsequent scholars to explore the development of future students, as well as an outlook and suggestions for future related research.

Keywords: Collaborative Strategy, Collective Intelligence, Collaboration Quality, Academic Performance

Introduction

In recent years, the field of education has undergone significant changes characterized by a shift from traditional, teacher-centered teaching methods to more student-centered, collaborative learning environments. This shift reflects a broader recognition of the importance of active student participation and interaction in the learning process (Johnson & Johnson, 2018). Collaborative learning as a pedagogical approach has emerged as an important strategy for facilitating such engagement, with students working together in groups to achieve shared learning goals (Dillenbourg, 1999).

Against this backdrop, this study focuses on high school students and endeavors to contribute to the emerging field of collaborative learning by delving into the intricate and dynamic relationship between collaborative strategies, collective intelligence, and academic achievement. High school education is a pivotal moment in students' academic journeys, where they are expected to not only master subject-specific knowledge, but also develop essential skills such as critical thinking, communication, and collaboration. Therefore, it is critical to understand how collaborative learning strategies can impact academic performance at this critical stage.

Collaborative learning differs from the traditional teacher-centered paradigm by emphasizing active participation, peer interaction, and shared responsibility for learning outcomes. Collaborative learning is rooted in the principles of social constructivism, which recognizes that knowledge is co-constructed through social interaction and dialogue between learners (Vygotsky, 1978). In collaborative learning environments, students have the opportunity to engage in collaborative tasks, discussions, and projects where they can utilize collective knowledge and skills to solve problems, explore complex concepts, and achieve shared learning goals.

The efficacy of collaborative learning strategies in improving academic performance has received increasing attention from educators, researchers, and policymakers. This attention stems from the recognition of the potential of collaborative learning in developing students' critical thinking skills, problem-solving skills, and interpersonal skills (Slavin, 2014). By promoting collaboration, educators aim to create a learning environment that mirrors real-world environments in which individuals must collaborate effectively to achieve common goals. Therefore, it has become imperative to understand the impact of collaborative strategies on academic outcomes, especially in the high school setting.

High school education is a pivotal moment in a student's academic journey and serves as a foundational stage for them to acquire the necessary knowledge and skills for their future endeavors. In addition, upper secondary is often seen as a preparatory stage for higher education or entry into the world of work, which underscores the importance of academic achievement during this period. Given the critical role of high school education in shaping students' life trajectories, it becomes imperative to examine how collaborative learning strategies affect academic achievement in this context.

Furthermore, the concept of collective intelligence has become a compelling area of inquiry in

educational research. Collective intelligence refers to the phenomenon in which a group demonstrates an ability to perform tasks, solve problems, or make decisions that exceeds the abilities of individual group members (Woolley, et al., 2010). This concept emphasizes the notion that a group possesses a unique ability to leverage the diverse knowledge, perspectives, and skills of its members in order to achieve collective goals.

In educational settings, utilizing collective intelligence can be beneficial in improving learning outcomes and academic performance. By utilizing the collective intelligence of a group, educators can create learning environments that promote deep understanding, critical analysis, and innovative problem solving. Additionally, collaborative tasks that utilize collective intelligence provide students with opportunities to engage in meaningful peer interactions that promote social and cognitive development (Engelmann et al., 2019). Therefore, examining the relationship between collaborative strategies, collective intelligence, and academic achievement is critical to advancing our understanding of effective instructional practices.

In conclusion, the intersection between collaborative learning strategies, collective intelligence, and academic achievement is a rich and multifaceted area of research with important implications for educational theory, practice, and policy. This study seeks to contribute to the emerging field of collaborative learning by examining the role of collaborative strategies and collective intelligence in shaping the academic achievement of high school students. By exploring how the quality of collaboration mediates this relationship, this study aims to provide valuable insights to inform educational practice in order to maximize students' potential and prepare them for success in an increasingly interconnected world.

Research Problem Statement:

Improving students' academic performance is a common and important concern among educators in today's education field. In order to effectively improve students' academic performance, educators continue to explore a variety of instructional methods and strategies. In this context, cooperative learning strategies and collective intelligence have received much attention as potential means of educational improvement. However, our understanding of how these factors affect academic performance is still limited, and in particular, their interrelationships as well as the mechanisms mediating their effects have not been fully explored. Therefore, the relationship between collaborative strategies, collective intelligence, collaboration quality, and academic performance deserves to be explored in depth.

A research question is posed:

How do cooperative learning strategies affect academic performance in educational settings?

How does collective intelligence affect students' academic performance?

Is there an interaction between collaborative learning strategies and collective intelligence and

what is the impact on student academic success?

How does the quality of collaboration mediate the relationship between cooperative learning strategies and academic performance?

How does collaboration quality mediate the relationship between collective intelligence and academic performance?

How does collaboration quality in the schooling environment affect students' academic achievement?

How do students' perceptions of collaborative learning strategies, collective intelligence, and collaboration quality affect their academic achievement?

How should schooling policies and practices be adapted to maximize students' collaborative learning, use of collective intelligence, and academic performance?

By delving into the above questions, we will provide important insights into educational practices, guidance for school education policies and practices, and a theoretical foundation and methodological path for future research.

Research Objective (s)

Objective 1. To Assess the Impact of Collaborative Learning Strategies on Academic Performance

This objective focuses on evaluating how the implementation of collaborative learning strategies influences students' academic performance in high school settings. By examining various collaborative strategies such as group discussions, cooperative projects, and peer tutoring, the study aims to determine the extent to which these strategies contribute to improved academic achievement across different subjects and grade levels.

Objective 2. To Investigate the Relationship Between Collective Intelligence and Academic Success

This objective aims to explore the role of collective intelligence in shaping academic performance within collaborative learning environments. By analyzing the collective problem-solving abilities, knowledge integration processes, and decision-making skills of student groups, the study seeks to understand how collective intelligence influences students' academic outcomes and achievements.

Objective 3. To Examine the Mediating Effect of Collaboration Quality on Academic Performance

This objective focuses on examining the mediating role of collaboration quality in the relationship between collaborative learning strategies, collective intelligence, and academic performance. Collaboration quality encompasses factors such as effective communication, equitable participation, shared goal setting, and constructive conflict resolution within student groups. By investigating how collaboration quality impacts the effectiveness of collaborative learning strategies and the manifestation of collective intelligence, the study aims to provide insights into optimizing student learning experiences and academic outcomes.

Objective 4. To Identify Effective Practices for Enhancing Collaborative Learning in High School Education

This objective aims to identify effective teaching and learning practices that promote student engagement, critical thinking, and academic success within high school classrooms. By synthesizing findings from empirical analysis and qualitative inquiry, the study seeks to uncover strategies and approaches that maximize the benefits of collaborative learning. These practices may include instructional methods, classroom management techniques, and professional development initiatives tailored to support collaborative learning environments and facilitate positive student outcomes.

Literature Review

Collaborative learning is an activity in which participants interact with other members of a group to learn something new (Johnson, Johnson, & Smith, 20l4, Johnson, Maruyama, Johnson, Nelson, & Skon, 1981), and it is an integral part of the "student-centeredness" of educational psychology (Blasco-Arcas, Buil, Hernández-Ortega, & Sese, 20l3; McDonough & Foote, 20l3; McDonough & Foote, 20l4; McDonough, 20l5). It is a research component that cannot be ignored in educational psychology's "advocacy of student-centeredness" (Blasco-Arcas, Buil, Hernández-Ortega, & Sese, 20l3; McDonough & Foote, 2015). Around this research, researchers have focused on the positive effects that collaborative learning may have on students' academic performance and motivation. Among others, Retnowati, Ayres and Sweller (2017) found that collaborative learning can enhance students' academic performance compared to individual learning; Jones and Issrof (2005) found that collaborative learning enhances students' motivation compared to individual learning; Mevarech and Kramarski (2003) found that collaborative learning can enhance students' ability to use metacognitive strategies compared to individual learning. Based on this foundation, researchers further explored what factors make collaborative learning an effective learning method. Studies have found that students' cognitive engagement, level of motivation, and level of prior knowledge affect learners' performance in collaborative learning (Johnson et al., 2014; Johnson et al, 198l; Laal & Ghodsi, 2012). However, these studies have not examined the mechanisms by which the positive effects of collaborative learning occur at the group level, treating the group members in collaborative learning as a whole.

A large body of empirical research supports the efficacy of collaborative learning strategies to improve academic performance across educational contexts. Meta-analytic reviews consistently show that students involved in collaborative learning outperform students in traditional instructional settings (Springer et al., 1999; Lou et al., 2001). For example, a meta-analysis by Springer, Stanne, and Donovan (1999) found that undergraduate students in science, mathematics, engineering, and technical disciplines demonstrated higher achievement when engaged in small group learning activities compared to lecture-based instruction.

In addition, collaborative learning improves critical thinking skills, problem-solving skills, and interpersonal skills. Through active participation in collaborative tasks and discussions with peers, students have the opportunity to exchange ideas, debate different points of view, and collaborate in the construction of new knowledge (Rosário et al., 2013). This process of social negotiation and knowledge co-construction promotes deeper understanding, higher-order thinking, and metacognitive awareness, which in turn promotes academic performance.

The concept of collective intelligence comes from different theoretical perspectives, including social psychology, cognitive science, and organizational behavior. Social psychologists have long recognized the phenomenon of group intelligence, whereby groups exhibit greater problem-solving abilities and decision-making outcomes compared to individual members (Woolley, et al., 2015). According to social identity theory, group members derive a sense of belonging and identity from their group membership, which motivates them to work together effectively and contribute to collective goals (Tajfel & Turner, 1986).

The cognitive view of collective intelligence emphasizes the fundamental processes of group cognition and information processing. Distributed cognition theory suggests that cognition is not confined to an individual's mind, but is distributed across individuals, artifacts, and the environment (Hutchins, 1995). In collaborative problem-solving tasks, group members collectively generate, share, and integrate knowledge and expertise to arrive at solutions that exceed the capabilities of any single individual.

Empirical research provides compelling evidence for the existence and effectiveness of collective intelligence in a variety of situations. Experimental studies have shown that diverse groups with different perspectives, backgrounds, and expertise consistently outperform homogeneous groups in problem-solving tasks (Hong and Page, 2004). Diversity of information and perspectives in diverse groups promotes cognitive conflict, which stimulates critical thinking and innovation (Nemeth & Wachtler, 1983).

Scholars have explored to some extent how team members interact with each other and what effects they produce during collaboration, i.e., what is the quality of team collaboration. Hackman (1987) argued that efficient team collaboration is one in which team members are highly aligned with the team's goals and common interests, in which the team's competence for the job grows over time, and in which members' competencies are consistently developed and O' Neil et al. (2017) inherited and carried forward Hackman's viewpoints from work across boundaries, build effective team processes and states, manage team development issues, and human resource utilization. development issues) and human resources utilization (average human capital) four perspectives for the theoretical connotation and practical application of the extension. From the team process, factors such as coordination, mutual assistance, and communication are important factors for team collaboration quality, and teams with

good team collaboration tend to perform better in these aspects. Zhao, et al. (2010) conducted a study on the evaluation of the quality of industry-university-research cooperation, pointing out that the quality of industry-university-research cooperation not only includes the contribution of each innovation subject, but also should take into account the quality of the whole project cooperation process, such as the satisfaction of the distribution of benefits, the cooperation and the approximate cost, and the effect of communication.

Empirical studies continue to demonstrate the positive impact of collaborative learning strategies on academic performance. Meta-analytic reviews have found that students engaged in collaborative learning activities outperform their peers in traditional instructional settings (Springer et al., 1999; Lou et al., 2001). By fostering active participation, critical thinking, and knowledge construction in a group setting, collaborative learning strategies contribute to deeper learning and higher academic achievement.

In summary, collaborative learning strategies, collective intelligence, and collaboration quality are important factors that influence academic performance. They interact with each other to contribute to students' academic performance. Future research can further explore the dynamic relationship between these variables and find more effective teaching strategies and methods to improve students' academic performance.

Methodology

With probability-based sampling methods, the sample size can be determined through the population collection process. For example, the sample size used in this study was determined based on Taro Yamane's sample size formula (1973), and the sample size was determined based on a 95% confidence level and a permissible value. The sampling error is 5% or 0.05. The overall sample size is 7456. When n = number of samples used in the study. n = total number of people, e = random sampling error set at 0.05.

The sample size and formula are as follows

$$n = \frac{N}{1 + Ne^2}$$

$$n = \frac{7456}{1 + 7456 \text{ X } 0.05^2}$$

$$n = 379.13$$

The minimum sample size was calculated to be 379.13, rounded to the nearest whole number to ensure an adequate sample size. Therefore, approximately 379 participants were needed for the study, and actual and potential attrition rates had to be considered when determining the final sample size.

Data collection for this study was all conducted online. Participants received an email invitation to access the survey as well as instructions for completing the survey. Online survey administration

allowed for secure and efficient data collection while ensuring participant anonymity. Due to the different school hours, it was difficult to conduct offline surveys in the field, so the "Questionnaire Star Online Platform" (www.wjx.cn) was chosen for this study to distribute, measure, and collect the questionnaires. In this study, questionnaires were administered to students in four high schools in Province B. A total of 410 questionnaires were distributed and returned. A total of 410 questionnaires were distributed and 395 valid questionnaires were returned, with a validity rate of 96.3%.

Results

In the regression ANOVA for collaborative strategies, academic performance, the adjusted R-square was .415, indicating that collaborative strategies (independent variable) explained 41.5% of the variance in academic performance (dependent variable). In the ANOVA test, the F-value is 280.863 and the significance P-value is 0.000b less than 0.01, which indicates that the regression model is highly significant at the 0.01 level and the model is usable and meaningful. As can be seen, after analyzing the coefficient a coefficient, we found that the unstandardized coefficient of collaborative strategies, academic performance is 0.482, and the results of the regression analysis indicate that collaborative strategies have a significant predictive effect on academic performance ($P < 0.001$). The model explained 41.5% of the variance in academic performance, suggesting that collaborative strategies play a significant role in academic success.

In the regression ANOVA analysis of collective intelligence, academic performance, it can be seen that the adjusted R-square was .822, indicating that collective intelligence (independent variable) explained 82.2% of the variance in academic success (dependent variable). In the ANOVA test, the F-value is 1819.968 and the significance P-value is 0.000b less than 0.01, which indicates that the regression model is highly significant at the 0.01 level and the model is usable and meaningful. As can be seen, after analyzing the coefficient a coefficient, we found that the unstandardized coefficient of collective intelligence, academic performance is 1.005, and the results of the regression analysis indicate that collective intelligence is a significant predictor of academic performance ($P < 0.001$). The model explained 82.2% of the variance in academic performance, indicating that collective intelligence plays a significant role in academic success.

In the collaboration quality model, both the constant and collaborative strategies variables were statistically significant in predicting collaboration quality with p-values less than 0.05.

In the academic performance model, all variables (constants, collaborative strategies, and collaboration quality) were statistically significant in predicting academic performance with p-values less than 0.05.

The total effect of collaborative strategies on academic performance (academic success) was the sum of the direct and indirect effects. The total effect was statistically significant ($p < 0.05$),

indicating a significant relationship between collaborative strategies (collaborative strategies) and academic performance (academic success).

The direct effect of collaborative strategies on academic performance was also statistically significant ($p < 0.05$), indicating a significant direct relationship between collaborative strategies (collaborative strategies) and academic success (academic performance).

The indirect effect of collaborative strategies on academic performance, mediated by collaboration quality, was also statistically significant ($p < 0.05$), indicating a significant indirect relationship between collaborative strategies (collaborative strategies) and academic success (academic success) through the mediator collaboration quality.

In the collaboration quality model, both the constant and collective intelligence variables were statistically significant in predicting collaboration quality, with p-values less than 0.05.

In the academic performance model, all variables (constant, collective intelligence, and collaboration quality) were statistically significant in predicting academic performance with p-values less than 0.05.

The total effect of collective intelligence on academic performance was the sum of the direct and indirect effects. The total effect was statistically significant ($p < 0.05$), indicating a significant relationship between collective intelligence and Y (academic performance).

The direct effect of collective intelligence on Y was also statistically significant ($p < 0.05$), indicating a significant direct relationship between collective intelligence and Y (academic performance).

The indirect effect of collective intelligence on Y, mediated by collaboration quality, was also statistically significant ($p < 0.05$), indicating a significant indirect relationship between collective intelligence and Y (academic performance) through the mediator collaboration quality.

Discussion

The findings of this study emphasize the importance of collaborative learning strategies and collective intelligence in predicting student academic performance, while also highlighting the mediating role of collaboration quality in these relationships. By delving deeper into these constructs, this study provides valuable insights into the dynamics of collaborative learning environments and their implications for educational practice and policy.

Our findings profoundly validate the importance of collaborative learning strategies in enhancing academic performance. We observed a significant positive correlation between collaborative strategies and academic achievement, which is in line with previous findings on the benefits of collaborative learning approaches (Johnson & Johnson, 2019). This further emphasizes the importance of incorporating collaborative approaches such as group discussions, collaborative projects, and peer

learning activities into educational practices, as these strategies can promote student engagement and improve their academic achievement.

In our study, we also identified the critical role of collective intelligence in predicting academic performance, highlighting the importance of utilizing group intelligence and group insights. Our findings show that groups with multiple perspectives and collaborative problem-solving skills exhibit better academic performance (Woolley et al., 2010). Therefore, educators should actively encourage students to engage in a variety of collaborative activities that help promote knowledge sharing, develop critical thinking skills, and spark innovation, thereby realizing the full potential of collective intelligence in improving academic achievement.

In addition, our study reveals the mediating role that collaboration quality plays between collaborative strategies and academic achievement. Through effective communication, fair participation, and constructive conflict resolution, collaboration quality had a significant impact on academic achievement. This demonstrates the importance of fostering collaboration quality as a key factor in maximizing the benefits of collaborative learning strategies. Therefore, educators should focus on creating a positive collaborative learning atmosphere that promotes good interactions and cooperation among students, thereby effectively enhancing academic achievement.

In summary, our study not only confirmed the importance of collaborative learning strategies and collective intelligence for academic performance, but also provided insight into the mediating role of collaboration quality in these relationships. These findings provide important insights into educational practice, emphasizing the need to create positive collaborative learning environments and foster collaboration quality. Our study provides guidance for educators to better design instructional activities and curricula to promote student achievement and holistic development.

Our findings reveal an important finding that collaboration quality plays a mediating role between collaborative strategies and academic performance. This implies that the impact of collaborative strategies on academic performance is not direct, but rather indirect through influencing collaboration quality. This finding further emphasizes the importance of fostering collaboration quality such as effective communication, equitable participation, and constructive conflict resolution in educational settings (Huang & Lin, 2020).

In educational practice, this finding provides important insights for educators. Educators need to focus not only on the collaborative strategies themselves, but also on the quality of the collaborative process. To ensure that students can fully benefit from the potential of collaborative learning, they should aim to create a supportive and inclusive learning atmosphere. In such an environment, students are free to share ideas, exchange insights, and work together to solve problems in order to maximize the potential of their collective intelligence and improve academic performance.

To achieve this goal, educators can take a number of steps. First, they can design and implement

a series of collaborative learning activities aimed at fostering teamwork and cooperative skills among students. These activities could include group discussions, common projects and collaborative problem-solving tasks designed to stimulate student participation and provide opportunities for collaborative learning and support for each other.

Secondly, educators should emphasize communication and interaction in the teaching and learning process and encourage positive interaction and cooperation among students. By organizing regular group discussions, collaborative projects and peer assessment activities, educators can promote effective communication and cooperation among students, thereby improving collaboration quality.

In addition, educators can provide relevant training and support through educational training and professional development programs to help teachers better understand and apply collaborative learning strategies. Such trainings can include collaborative learning theories and practices, team building skills, and collaborative problem solving methods with the aim of improving teachers' professionalism and quality of teaching.

Finally, educators can also promote collaborative learning among students by providing appropriate instructional resources and support. This can include providing technical support such as online collaboration tools, virtual team projects, and collaborative learning platforms so that students can more easily engage in collaborative learning and achieve academic performance.

In summary, by focusing on collaboration quality and taking appropriate measures, educators can better utilize the potential of collaborative learning to improve student academic achievement. This contributes not only to the development of individual students, but also to the continuous improvement and development of the education system as a whole. By integrating insights and empirical evidence from relevant literature, this section provides valuable guidance for theory development, and practice in the field of education.

Conclusions

In our study, we worked to explore the efficacy of collaborative learning strategies in education, with a particular focus on the impact of collective intelligence on academic performance. We provide an in-depth analysis and summary of our findings and offer recommendations based on these findings so that educators, policymakers, and researchers can better utilize these results to optimize educational practices.

First, our study found a strong association between collaborative learning strategies and academic achievement. This means that students who are actively engaged in collaborative learning activities typically exhibit higher academic achievement. This finding has important implications for educational practice because it emphasizes the importance of creating a positive collaborative learning climate for student learning and success. Based on this finding, we recommend that educators actively

promote and implement collaborative learning strategies, such as group discussions, collaborative projects, and team assignments, in their classrooms to inspire and motivate students to learn.

Second, our study reveals the mediating role of collaboration quality between collaborative strategies and academic achievement. We found that effective communication, fair participation, and constructive conflict resolution within cooperative groups had a significant effect on academic achievement. Thus, fostering and promoting collaboration quality is one of the key factors in maximizing the benefits of collaborative learning strategies. In this regard, we recommend that educators focus on the development and training of students' teamwork skills, encouraging them to respect and listen to others' perspectives, as well as conflict resolution skills.

Third, our findings show the important role of collective intelligence in academic performance. We found that groups with higher levels of collective intelligence typically exhibited superior academic performance. This demonstrates the importance of utilizing collective wisdom and diverse perspectives in educational settings. Based on this finding, we recommend that educators encourage students to share and discuss their ideas and perspectives, and promote open learning environments to facilitate the sharing and exchange of knowledge and insights.

In summary, our study provides important theoretical support and empirical evidence for the application of collaborative learning strategies in education. These findings not only deepen our understanding of the impact of collaborative learning approaches on student achievement, but also provide useful insights for educational practice. In future educational practices, emphasis should be placed on developing students' collaborative skills, optimizing collaboration quality, and harnessing the potential of collective intelligence to further promote student achievement and development.

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