INQUIRY-BASED LEARNING AS A MEDIATOR ON ACADEMIC ADAPTABILITY AND 21ST CENTURY SKILLS OF SENIOR HIGH SCHOOL STUDENTS IN SCIENCE

Inquiry-Based Learning as a Mediator on Academic Adaptability and 21st Century Skills of Senior High School Students in Science

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Abstract

Academic preparedness among senior high school students is hampered by their lack of 21st-century abilities, especially in science education. This study investigated how inquiry-based learning (IBL) mediated the relationship between academic adaptability and scientific 21st- century abilities. Using a non-experimental quantitative research design, the study surveyed 200 senior high school students selected through random convenience sampling; it was revealed that Inquiry-based learning partially mediates the link between adaptability and scientific 21st-century abilities of senior high school students, affirming the Social Cognitive Theory. It is recommended that educators integrate structured IBL strategies and provide teacher training to maximize its benefits in fostering critical thinking, collaboration, and creativity.

Keywords: *inquiry-based learning, academic adaptability, 21st century skills*

Introduction

Students' lack of 21st-century abilities, such as creativity, communication, teamwork, and critical thinking, posed a serious barrier in the rapidly changing area of scientific education. According to Lay and Osman (2020), students frequently have difficulty acquiring 21st-century abilities, including effective digital literacy, communication, and creative thinking. These shortcomings made adapting to the changing needs of professional and educational settings in the digital era more difficult. They emphasized the need for innovative instructional strategies, such as integrating inquiry-based and constructivist methods, to help students bridge these gaps effectively. Similarly, Hiong (2017) clarified the significant lack of 21st-century abilities that undergraduate students possess that are pertinent to science. Additionally, findings from a study by Tindowen et al. (2017) further corroborated these observations, revealing a significant deficit in learners' attainment of 21st-century skills, with particular emphasis on the context of science education.

Numerous assessments and reports highlighted concerns regarding the deficiency in 21st-century skills in the United States. The National Assessment of Educational Progress (NAEP) consistently indicated that many American students lacked proficiency in critical subjects such as reading, mathematics, and science (NCES, 2019). Similarly, the European Commission's Education and Training Monitor identified persistent gaps in developing essential skills across member states (European Commission, 2019).

Meanwhile, there was an ongoing struggle in the Philippines to integrate science education with the indispensable 21st-century skills necessary for students (DepEd Philippines, 2021). Research showed that Filipino graduates lacked 21st-century abilities in scientific classes, particularly communication, teamwork, and critical thinking (Gonzales, 2016). These results emphasized the worldwide difficulty of equipping pupils with the abilities required to prosper in the quickly changing 21st-century environment.

Poor 21st-century skills jeopardize students' active participation in inquiry and problem- solving. While inquiry-based learning (IBL) has been shown to foster key 21st-century skills in science education, a significant gap remains in understanding how adaptability, a critical skill, interacts within this context. Therefore, addressing this issue is urgent to prevent further student learning and engagement challenges.

Research Objectives

This study sought to ascertain how inquiry-based learning mediated the link between students' 21st-century scientific competence and academic flexibility. This research seeks to respond to the following queries.

1. To determine the levels of inquiry-based learning in terms of students' prior knowledge activation, students' class engagement, student-centered environment creation, cultivation of 21st-century skills, academic adaptability in terms of self-learning, information utilization, environmental choice, goal orientation coping with stress; and 21st-century skills in terms of Collaboration, critical thinking, creativity, and communication of senior high school students in science.
2. To determine the significance of the relationship between inquiry-based learning, academic adaptability, and the 21st-century skills of senior high school students in science.
3. To determine the significance of the mediating effect of inquiry-based learning on the relationship between adaptability and 21st-century skills in science among students.

Methodology

Research Design

Using a descriptive-correlational design and mediation analysis, this study used a non- experimental quantitative research approach to

investigate the interactions between important factors. The study employed descriptive quantitative research to gather and examine measurable data, ensuring objectivity through standardized instruments and protocols (Queiros et al., 2017). The non-experimental design was chosen because it addresses research questions that cannot be ethically or practically manipulated through controlled experiments. The correlational design helped identify patterns and relationships between the independent and dependent variables, as outlined by Kumar and Chong (2018). It provided insights into how these variables are related in the current context. As shown in studies by Haglund & Mooi-Recker (2010), Preacher et al. (2007), and Zhao et al. (2010), mediation analysis was also used to investigate the causal mechanisms between variables, adding a third mediator to explain how the independent variable affects the dependent variable. A greater comprehension of the relationships between the variables under investigation was made possible by this all-encompassing approach.

Respondents

This paragraph discusses the sample size selected for a study involving 200 senior high school students. While the minimum recommended sample size for correlational studies is often cited as 30 (Fraenkel & Wallen, 2009), the researchers opted for a larger group of 200 participants to enhance the accuracy and generalizability of their findings. The number of respondents, 200, was determined using tools such as Raosoft, ensuring that the sample size accurately aligns with the population size. This approach enhances the study's validity by reducing sampling errors (Smith & Johnson, 2021). Researchers can be more confident in their findings, and the margin of error is decreased with a bigger sample size.

Random sampling was used to choose the participants. Because it's feasible, random sampling is frequently used while collecting data, particularly when time, resources, and participant accessibility are limited. This method allows researchers to collect data quickly and cost-effectively by selecting readily available participants, making it suitable for exploration research or pilot studies.

The inclusion criteria for this study focus on students currently enrolled in grades 11 and 12 at the selected secondary public school within the Division of Panabo City. Eligible participants must have taken or currently be enrolled in at least one science-related course relevant to the study's objectives and demonstrate regular attendance based on school records. Only students who provided written informed consent (or parental consent if under 18) were included. The exclusion criteria exclude students who are not currently enrolled in grades 11 or 12, have inconsistent attendance (e.g., absences exceeding 20% of school days during the semester), or are enrolled in alternative education programs, such as special education with individualized learning plans or non-traditional learning modalities. Students who failed to consent or whose parents/legal guardians did not approve of their participation were also excluded.

Instrument

Yu and Zhang (2019) survey questionnaire. Cross-sectional research of twenty-four (19) declarative statements across five (5) domains was modified to examine the effects of academic adaptability on academic performance, immersion in learning, and academic burnout among Chinese medical students. When assessing the questionnaire, the respondents used the following criteria: 1 for very low, 2 for low, 3 for moderate, 4 for high, and 5 for very high. The outcome was analyzed using the Likert scale below. The research questionnaires underwent validity and reliability testing to ensure their effectiveness in capturing accurate and consistent data.

Conversely, the P21 framework defines 21st-century skills as being modified to assess students' proficiency in science for the twenty-first century. The twenty (20) items on the test were designed to gauge students' proficiency in science for the twenty-first century. The questionnaire has twenty-seven (20) declarative statements and four (4) indicators. The respondents rated the questionnaire using the following criteria: 1 for extremely low, 2 for low, 3 for moderate, 4 for high, and 5 for very high. The result was analyzed using the Likert scale.

Inquiry-based learning is also the mediating element that affects students' academic adaptability and 21st-century skills. The researcher modified Rohmah and Suriani's (2024) questionnaire. Implementing inquiry-based learning: Students' perceptions and preferences, comprising fifteen (14) declarative statements across four (4) domains. Respondents rated the questionnaire using the following criteria: 5 for very high, 4 for high, 3 for moderate, 2 for low, and 1 for very low, to assess their inquiry-based learning. The outcome was analyzed using the Likert scale.

Procedure

This study employed a systematic data collection method. The process began with a formal request submitted to the Holy Cross of Davao College Graduate School for permission to undertake the research. Following their approval, a request was sent to the Schools Division Superintendent (SDS) of the Department of Education Division of Panabo City, seeking authorization to conduct the study within their division. The SDS's endorsement was then included with a formal request to the principal of the selected school.

Upon receiving the principal's approval, data collection commenced. Participants were given consent and assent forms, ensuring adherence to ethical research practices, including informed consent. After obtaining consent, survey questionnaires were distributed to the student participants, who were asked to answer thoughtfully and honestly.

The collected questionnaires were then organized and prepared for analysis. This data was then submitted to a statistician for processing and statistical treatment. The resulting statistical output was subsequently analyzed and interpreted to formulate conclusions and

insights relevant to the research questions.

Ethical Considerations

Although the research poses minimal psychological or emotional risks, it's crucial to acknowledge the possibility of students experiencing stress, confusion, or anxiety, especially when their 21st-century skills, adaptability, and inquiry-based learning are evaluated. Several precautions were implemented to address these potential issues. All participants (and their parents, when necessary) provided informed consent, demonstrating their understanding of the study's purpose and their right to withdraw without consequence. The research design focused on establishing a supportive atmosphere through explicit instructions and ensuring a comfortable data collection process. Participants were also guaranteed that their responses would be kept confidential and used exclusively for research, thereby reducing any stress associated with personal disclosure. These measures foster a secure and encouraging environment, minimizing potential participant discomfort.

Results and Discussion

Descriptive Analysis

Table 1. *Descriptive Table*

Variables	SD	Mean	Descriptive Level
Academic Adaptability	0.406	3.84	High
Self-Learning	0.533	3.67	High
Information Utilization	0.493	3.86	High
Environmental Choice	0.505	3.79	High
Goal Orientation	0.614	3.90	High
Coping with stress	0.613	3.99	High
Inquiry-Based Learning	0.477	3.92	High
Students' prior knowledge activation	0.623	3.95	High
Students' class engagement	0.904	3.86	High
Student-centered environment creation	0.541	3.96	High
Cultivation of the 21st century skills	0.617	3.92	High
21st Century Skills	0.467	4.05	High
Critical Thinking	0.521	3.86	High
Collaboration	0.590	4.26	Very High
Communication	0.634	4.00	High
Creativity	0.584	4.09	High

The results indicate that senior high school students exhibit high academic adaptability, inquiry-based learning (IBL), and proficiency in 21st-century skills in science, with consistent performance across most areas. Academic adaptability, with an overall mean of 3.84 (SD = 0.406), reflects students' ability to effectively manage academic demands. Among its indicators, Coping with Stress scored the highest (M = 3.99, SD = 0.613), demonstrating students' resilience in handling academic pressures despite some variations. Goal Orientation (M = 3.90, SD = 0.614) suggests that most students are focused on setting and achieving their academic goals, though some exhibit variability in maintaining this focus. Additionally, Information Utilization (M = 3.86, SD = 0.493) highlights students' ability to find and apply relevant information effectively. While students showed a strong ability to make environmental choices (M = 3.79, SD = 0.505) and engage in self-learning (M = 3.67, SD = 0.533), some may benefit from additional support to further enhance their independent learning skills.

Inquiry-based learning (IBL) also proved effective, with a high overall mean score of 3.92 (SD = 0.477), indicating successful engagement in inquiry-focused activities. The Student-Centered Environment Creation indicator scored the highest (M = 3.96, SD = 0.541), suggesting that classrooms effectively foster student-driven learning experiences. Prior Knowledge Activation (M = 3.95, SD = 0.623) was also a strength, though it exhibited greater variability. Furthermore, students developed essential competencies through the cultivation of 21st-century skills (M = 3.92, SD = 0.617) and classroom activities (Class Engagement, M = 3.86, SD = 0.904). However, the high variability in engagement levels suggests that while many students actively participate in class, some may require additional motivation and support.

Regarding 21st-century skills, students demonstrated high proficiency, with an overall mean of 4.05 (SD = 0.467). Among the key competencies, Collaboration scored the highest (M = 4.26, SD = 0.590), rated as "very high," indicating strong teamwork abilities. Creativity (M = 4.09, SD = 0.584) highlights students' capacity for innovation, while Communication (M = 4.00, SD = 0.634) reflects their ability to effectively express ideas, despite some variability. Critical Thinking (M = 3.86, SD = 0.521) suggests that most students can analyze and evaluate information effectively, though there is room for improvement. These findings confirm that students are well-equipped with the essential competencies required for inquiry-driven learning and for overcoming academic challenges. However, areas such as self-learning and class engagement require further reinforcement to ensure more consistent performance.

This research underscores the interconnectedness of academic adaptability, IBL, and proficiency in 21st-century skills, particularly in science education. The high level of academic adaptability (M = 3.84, SD = 0.406) aligns with studies emphasizing the importance of adaptability in overcoming academic challenges (Usán Supervía & Salavera Bordás, 2020). Moreover, research by She, Liang, and Jiang (2023) suggests that adaptability is most effective when paired with motivation and strong organizational skills. The strong engagement with inquiry-driven learning practices (M = 3.92, SD = 0.477) highlights IBL's positive impact on problem-solving, collaboration, and critical thinking—findings consistent with those of Hwang and Chang (2011) and Pedaste et al. (2015). However, this study also confirmed concerns regarding the limitations of IBL, particularly for students with insufficient prior knowledge or self-regulation skills (Cheng, 2023). These findings suggest that while adaptability and IBL are key drivers of academic success, their effectiveness is maximized when structured support systems address students' diverse learning needs.

Furthermore, this research highlights the strong presence of 21st-century skills, particularly collaboration, creativity, communication, and critical thinking. The high overall mean score (M = 4.05, SD = 0.467) reinforces the value of effective teaching strategies in fostering these skills. Prior studies by Saavedra and Opfer (2021) and Hmelo-Silver et al. (2020) have also emphasized the crucial role of these competencies in curriculum development. However, the observed variability in skill development, particularly in creativity and communication, underscores the need for explicit guidance and structured opportunities to nurture these competencies (Nguyen & Zhang, 2023; Miller & Chen, 2021). These results highlight the importance of balancing autonomy with instructional guidance in inquiry-based and student-centered learning approaches. Ultimately, the success of these pedagogies depends on flexible yet supportive instructional strategies that foster individual adaptability while addressing diverse student readiness levels. This ensures that all students, regardless of background, have equitable access to the skills necessary for academic and professional success.

Correlation Analysis

Table 2. *Correlation Table*

Variables	r	p-value	Decision on Ho
Academic Adaptability	0.610	0.000	Reject Ho
Inquiry-Based Learning	0.682	0.000	Reject Ho
21st Century Skills	0.618	0.000	Reject Ho

The analysis reveals significant positive relationships among academic adaptability, inquiry-based learning (IBL), and 21st-century skills in science students. A correlation coefficient of 0.610 ($p < 0.05$) indicates that students who adapt well academically tend to be more engaged in IBL practices. Similarly, a coefficient of 0.682 ($p < 0.05$) suggests that higher engagement in IBL is strongly associated with the development of essential 21st-century skills, including critical thinking, communication, collaboration, and creativity. Additionally, the correlation between academic adaptability and 21st-century skills (0.618, $p < 0.05$) implies that students who demonstrate adaptability are more proficient in these essential modern competencies. These results confirm that adaptability, inquiry-driven learning, and key skills development are interconnected and crucial for academic success and career readiness in today's evolving educational and professional landscape.

Moreover, the study highlights the strong link between academic adaptability and IBL, emphasizing the importance of flexibility in navigating the dynamic and open-ended nature of inquiry-based learning. Students who can adapt well are better equipped to absorb new information, tackle challenges, and thrive in student-driven learning environments—a finding that aligns with research by Taylor and Roberts (2022) and Kaçar et al. (2021). However, the effectiveness of IBL depends on appropriate support and guidance from educators, particularly for students with limited background knowledge or lower adaptability. This aligns with the conclusions of Schneider et al. (2020) and Darling-Hammond et al. (2020), which emphasize the necessity of well-structured IBL frameworks that leverage students' adaptability while ensuring sufficient scaffolding. By designing instructional approaches that account for students' diverse learning needs and readiness levels, educators can provide equitable opportunities for academic success across different learner profiles.

The study also reinforces the critical role of adaptability in fostering 21st-century skills, particularly critical thinking, creativity, and collaboration. This finding aligns with Bandura's Social Cognitive Theory (1986) and the research of Nguyen and Tan (2021), which highlight that adaptable students are better positioned to navigate complex academic environments. However, as Smith and Li (2023) note, adaptability alone is insufficient for skill development without motivation, prior knowledge, and external support systems. Similarly, research suggests that while IBL effectively enhances 21st-century skills, its impact varies depending on students' learning needs and must be adapted to support diverse student populations (Lukáč et al., 2022; Vongkulluksn et al., 2020). These findings underscore the importance of balanced educational interventions that integrate adaptability, scaffolded instruction, and inquiry-based learning to maximize student engagement and competent development. By implementing well-structured, student-centered pedagogies, educators can ensure that students are well-prepared to meet the demands of modern academic and professional challenges.

Mediation Analysis

The data analysis revealed key insights into the relationships among Academic Adaptability, Inquiry-Based Learning (IBL), and 21st-Century Skills. A significant indirect effect was observed between Academic Adaptability and 21st-Century Skills, mediated by IBL (estimate = 0.346, $p < 0.001$). This indicates that IBL plays a crucial role in linking adaptability to the development of essential skills.

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Additionally, a direct effect was also found between Academic Adaptability and 21st-Century Skills (estimate = 0.371, β = 0.317, p < 0.001). The significance of both direct and indirect effects suggests the presence of partial mediation—meaning that while IBL explains part of the relationship, Academic Adaptability also has an independent impact on 21st-century skill development.

Table 3. *Mediation Table*

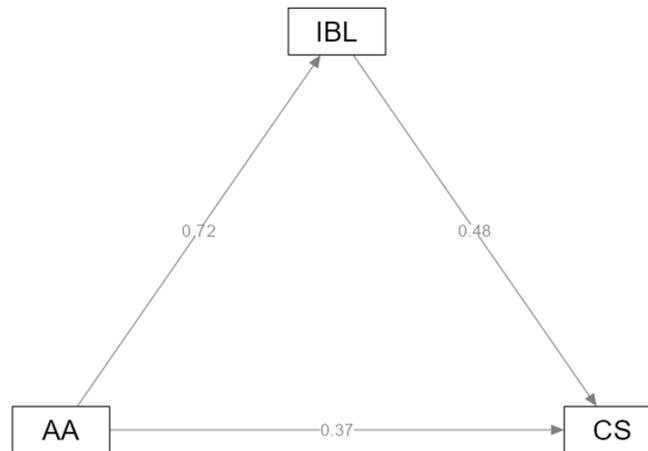| Type	Effect	Estimate	SE	β	z	p
Indirect	AA ⇒ IBL ⇒ CS	0.346	0.0542	0.296	6.38	< .001
Component	AA ⇒ IBL	0.718	0.0659	0.61	10.9	< .001
	IBL ⇒ CS	0.482	0.0613	0.485	7.87	< .001
Direct	AA ⇒ CS	0.371	0.072	0.317	5.14	< .001
Total	AA ⇒ CS	0.716	0.0655	0.613	10.94	< .001
Percent of Mediation = 48.3%						

Figure 1. *Path Model Illustrating the Mediation of Inquiry-based (IBL) Learning in the Relationship Between Academic Adaptability (AA) and 21st Century Skills (CS)*

The percent mediation analysis further clarifies the distribution of these effects. Specifically, 48.3% of the total effect of Academic Adaptability on 21st-Century Skills is mediated through IBL, while the remaining 51.7% is attributed to the direct effect of Academic Adaptability. This highlights the complex interplay between direct and mediated pathways, reinforcing the significance of both factors in shaping students' learning experiences.

Examining the mediation model further, the relationship between Academic Adaptability and IBL is notably strong (coefficient = 0.72), indicating that as students become more adaptable, their engagement with IBL significantly increases. Similarly, the relationship between IBL and 21st-Century Skills is moderately strong (coefficient = 0.48), confirming that IBL substantially contributes to the development of these competencies. Despite this, the direct path from Academic Adaptability to 21st-Century Skills remains significant (coefficient = 0.37), demonstrating that adaptability alone has a positive impact on skill development, even when accounting for IBL's mediating role. Taken together, these findings confirm the partial mediation effect, where IBL acts as a bridge between adaptability and essential skill development, yet a direct influence of adaptability persists.

Conclusions

Based on the findings, Inquiry-based learning partially mediates the link between adaptability and 21st-century skills of senior high school students in science. Based on this conclusion, the Social Cognitive Theory affirms the pivotal roles of vicarious and symbolic processes in facilitating inquiry-based strategies, where learners gain insights through observation and symbolic representation.

Educational policymakers can use the findings to reform science curricula by integrating inquiry-based learning (IBL) frameworks that enhance students' academic adaptability and 21st-century skills. Inquiry-based learning (IBL) methods cultivate critical thinking, problem-solving, teamwork, and self-direction skills. These skills are crucial for success in today's schools and workplaces. This research emphasizes the need for teachers to create interactive and cooperative classrooms, drawing on Bandura's Social Cognitive Theory, to boost student drive, involvement, and the growth of their abilities. Researchers can expand on this study by exploring factors like student motivation and resilience or applying them in different educational contexts to evaluate the broader impact of IBL on adaptability and skill-building. Finally, the findings can support initiatives aligned with Sustainable Development Goal (SDG) 4 by providing evidence to track and improve educational reforms that develop essential skills and ensure fair access to quality science education globally.

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