**Analyzing Secondary School Students’ Preferences for Mathematics Learning Modalities**

 **ABSTRACT**

This study aims to analyze secondary school students' preferences from the three districts of Mati City Division, Davao Oriental, Philippines, for different mathematics learning modalities amid evolving educational environments. Specifically, it focuses on four key attributes: learning environment, learning materials, teaching methods, and evaluation methods. Using a conjoint analysis within an experimental design framework, 372 randomly selected high school students were asked to rate 11 hypothetical learning profiles constructed through orthogonal design. Each profile represented a unique combination of attribute levels. A structured survey questionnaire was used to collect demographic data and preference ratings. Results of the conjoint analysis revealed that students strongly preferred a face-to-face learning environment, digital learning materials, group work as a teaching method, and traditional tests as an evaluation method. Notably, the preference for traditional assessment methods and group-based instruction stood out, despite growing trends toward individualized and technology-driven approaches. These findings highlight the importance of maintaining personal interaction and familiar evaluation formats in mathematics education. The insights gained from this study may guide educators, curriculum developers, and policymakers in designing mathematics instruction that aligns with student preferences, ultimately enhancing engagement, comprehension, and overall learning outcomes in similar educational contexts.

***Keywords:*** *conjoint analysis, mathematics learning modalities, Mati City division, secondary school students, students’ preference,*

**INTRODUCTION**

 Among academic subjects, mathematics presents unique challenges, requiring instructional methods that not only convey complex concepts but also foster students’ problem-solving skills. Mathematics, as a discipline, often involves abstract reasoning and sequential learning, which may necessitate varied teaching approaches to accommodate different learners (Bautista & Valtoribio, 2024). Studies have shown that students tend to have distinct preferences regarding how they learn, and these preferences are influenced by factors such as personal characteristics, learning environments, and the availability of resources (Ferri et al., 2020). Additionally, Salimaco (2020) found that students’ study habits and mathematics anxiety significantly influence their achievement in the subject, highlighting the need for supportive and low-anxiety learning environments.

Recent developments in education, particularly during the COVID-19 pandemic, have led to transformative changes in how teaching and learning are delivered. This period saw a rapid shift from traditional face-to-face instruction to alternative modalities such as online, blended, and modular learning (Clemente-Suarez et al., 2024; Ali, 2020; Adedoyin & Soykan, 2020). Each learning modality presents distinct advantages and limitations, and their effectiveness often depends on variables such as the nature of the subject, the individual learning preferences of students, and the surrounding educational environment (Clemente-Suarez et al., 2024; Ali, 2020; Adedoyin & Soykan, 2020).

It is important to note that after the pandemic, the Philippine educational system experienced a significant shift in teaching and learning approaches. Research indicated that students have developed a preference for learning environments that combine both online and face-to-face interactions, emphasizing flexibility and engagement. For instance, Yandug et al. (2023) stated that students favored a blended mode of delivery, which includes synchronous online meetings and asynchronous activities, allowing for better time management. Some students have shown a stronger inclination towards online learning based on their experiences during the pandemic (Limbong & Simbolon, 2024). In addition, teachers adapted to online assessments, employing various methods such as quizzes and project-based evaluations to gauge student learning (Gerabon et al., 2024).

In the context of mathematics education, Salimaco (2023) highlighted the abrupt shift from physical to virtual classes during the pandemic, revealing significant challenges in teaching methodologies and student engagement. Teachers in higher education institutions, especially in mathematics, faced difficulties in presenting topics effectively due to limited board work and reduced student interaction. Issues such as slow internet connectivity, lack of digital infrastructure, and the need for increased flexibility and leniency were also prominent. Despite these challenges, teachers made various adjustments to ensure learning continuity, demonstrating resilience and commitment. Complementing this, Salimaco and Tan (2023) emphasized the importance of establishing clear standards for teaching mathematics through blended modalities. Their study identified key factors—such as teaching management, communication and feedback, student monitoring, and accessibility of materials—that contribute to effective blended learning environments. These findings echo the broader observations of Cahapay (2020) and Ferraras (2020), who noted that instructional practices in Philippine tertiary education were reshaped to address the crisis.

Even though students became accustomed to online teaching methods, many teachers struggled to readapt their pedagogical strategies to face-to-face modalities (Saga, 2023; Kulsum & Amelia, 2024). Moreover, some students continue to express a preference for traditional face-to-face learning, citing the challenges of online modalities, such as technological issues and the lack of direct interaction, which can hinder academic performance and satisfaction (Yandug et al., 2023; Cabuquin, 2022). As face-to-face classes gradually resume, it is recommended that educators refine their strategies to support learners' physical and psychological well-being while still integrating technology to enhance engagement and learning outcomes.

 While many studies have examined learning modalities and students’ preferences during and after the pandemic, much of this research focuses on higher education. For instance, research on engineering students’ preferences for online learning delivery type during pandemic (Yandug et al.,2023), workstation design preferences for online classes among undergraduate students during COVID-19 pandemic (Gumasing et al., 2022). There were studies focuses on high school students like senior high school students’ preferences for online learning attributes during the COVID-19 pandemic (Consing, 2023), printed self-learning modules distribution and completion preferences of Grade 7-12 students (Dapa & Valdez, 2021), and the evaluation of the media platforms, devices and challenges associated with online teaching and learning of Mathematics (Salifu & Owusu-Boateng, 2022). Much of these researches did not address students’ preferences in the learning modalities in mathematics. There were limited studies that explored the relative importance of specific attributes in shaping students’ overall preferences for learning modalities in mathematics classes. This lack of data highlights a gap in the literature on how learning modalities impact the mathematics performance and engagement of high school students in this area. Since understanding the specific attributes that influence students’ preferences for learning modalities remain underexplored, this research aims to address these gaps by investigating the preferences of high school students in Mati City Division regarding learning modalities in mathematics.

 Therefore, the purpose of this study was to determine the preferences of high school students in Mati City Division for various learning modalities in their mathematics classes, using conjoint analysis. This method allows for a detailed exploration of the relative importance of different modality attributes, offering insights that could lead to more effective instructional strategies and improved learning experiences in mathematics education. By identifying the most and least preferred attributes, the study seeks to inform educators and policymakers about how to design and implement more effective, student-centered learning environments in mathematics education.

**Research Objectives**

 The main objective of this study was to determine the students’ preferences for different learning modalities in Mathematics using conjoint analysis in terms of learning environment, learning materials, teaching methods, and evaluation methods. Specifically, it aimed to:

1. Determine the demographic characteristics of high school students in terms of age, sex, grade level, and academic performance.
2. Determine students’ preference on the learning modalities in Mathematics class among high school students in Mati City Division.

**METHODOLOGY**

**Research Design**

This study utilized a quantitative approach, specifically employed conjoint analysis. Conjoint analysis is a widely used survey experimental design. It is used to measure consumer preferences and simulate reactions to product changes. and it allows researchers to estimate average marginal effects of factors while considering their interactions (Ham et al., 2024). It is an experimental design because it combines attributes and levels to create product concepts for evaluation, allowing researchers to measure preferences effectively (Huertas-Garcia et al., 2016). In this case, it was used to identify the preferences of high school students in Mati City Division for the different attributes on the learning modalities in Mathematics class.

**Sampling**

The respondents of this study were the officially enrolled high school students of Mati City Division, for schoolyear 2024 – 2025. Respondents were selected randomly through stratified random sampling. The sample was obtained using the formula provided by Dillman (2007). The formula resulted into a sample size of 372 respondents.

**Data Collection**

Prior to the dissemination of the printed questionnaires, the researcher prepared a letter of permission to conduct the study recommended from Graduate School Head of Davao Oriental State University and was sent to the Schools Division Superintendent, Office of the SDS of Mati City Division. The approved permission letter was sent to the Public Schools District Supervisors, School Heads, and relevant educational authorities of the identified target schools. A letter of consent was provided to both the students and their parents, upholding ethical standards. Upon approval of the conduct of the study, printed survey – questionnaires were distributed to the randomly selected respondents. Before that, the researcher distributed a printed copies of the informed consent and assent forms to both the parents and the respondents. Since the respondents were minors, it is necessary for parents and respondents to sign the forms. The researcher thoroughly explained the forms through personal meetings or phone calls to provide further clarifications or concerns and to ensure clear understanding of the research purpose. Strict confidentiality of all participant information was maintained, with data securely stored.

The survey questionnaire was administered physically, with the researcher or enumerator distributing the paper-based questionnaires to the respondents in their respective schools. This was conducted within the designated private rooms of the participating schools to ensure privacy and safety of the respondents. These rooms were secured to prevent unauthorized access and to create a comfortable environment, particularly for vulnerable participants. Only authorized personnel, such as the researcher and designated school representatives, were allowed to enter these rooms during data collection. Respondents answered the questionnaire for a maximum of 10 minutes. The completed questionnaires were collected by the researcher or enumerator at an agreed time. Health protocols, if any, was observed throughout the data collection process. Gathered data from the questionnaires were tallied, tabulated, and subjected to the appropriate statistical analysis and treatment. All data collected was securely stored on a flash drive, which remains under the sole custody of the researcher. To maintain confidentiality, no one else is granted access. The data were retained for three years or until the research paper is fully published, which ever occur first. After this period, all data will be permanently deleted and disposed of in accordance with ethical data disposal practices.

**Research Instruments**

First essential step in conducting a conjoint analysis is to identify relevant attributes and their corresponding levels that define the product or service. In this study regarding mathematics learning modalities, there were four key attributes with three levels each. Given these attribute levels, the total number of possible combinations (profiles) using a full factorial design is calculated as: 3x3x3x3 = 81 total combinations (profiles). Presenting all 81 combinations (profiles) to the respondents would be cognitively demanding, time-consuming, and could potentially lead to response fatigue, thereby compromising the quality of the data. To address this issue, the study employed a fractional factorial approach using orthogonal arrays to reduce the total number of profiles into a manageable and statistically efficient subset.

 The selection of a reduced number of profiles was carried out using the ORTHOPLAN procedure in IBM SPSS Statistics. This tool generates an orthogonal array, which is a subset of combinations that are statistically independent and balanced across all attribute levels. Orthogonal arrays guarantee that each factor is tested independently, so the effect of one factor doesn’t affect the results of another, and ensure that the results are fair and not biased (Notz, n.d.). The orthogonal design produced 11 distinct profiles. These profiles represent combinations of the various levels of the four attributes in such a way that each level of every attribute appears an equal number of times across the set. This allows the researcher to capture students’ preferences effectively while reducing the cognitive load on respondents.

Thus, this study used a survey questionnaire divided into two parts. The first part was the demographic attributes which ask the demographic profile of students including age, gender, grade level, and academic performance. The second part of the questionnaire covered the generated eleven (11) hypothetical profiles inclusive of the two hold out cases of learning modalities in mathematics class consisting of the combination of one level per attribute. Respondents rated these combinations based on their preferences.

To ensure valid and reliable data in experimental designs, orthogonality and balance are essential. Orthogonality ensures that the effect of different factors can be estimated independently, preventing the estimation of one effect from influencing another, leading to unbiased results (Minitab, n.d.). Balance requires that each level of every attribute appears equally across profiles, ensuring that all factor levels are equally represented (Arbour et al., 2022). Creating orthogonal and balanced profiles are more feasible when attributes have an equal number of levels, leading to an optimal design. In this study, an orthogonal design was generated using statistical software, ensuring both orthogonality and balance. Therefore, the data collected from respondents were valid and reliable.

**Data Analyses**

The following statistical methods were employed:

For objective number 1, descriptive statistics was utilized to summarize the demographic profile of the respondents. The researcher consolidated the data gathered from the answers of the respondents in the first part of the survey questionnaire. Frequency distribution was used in the presentation of age, gender, grade level, and academic performance. Arithmetic Mean was also used to get the average academic performance of the students.

For objective 2, conjoint analysis was utilized. Conjoint analysis is a commonly used method in research that helps understand how people make choices by showing which features or aspects of a product or service they prefer. It works by asking individuals to compare different options and make trade-offs, allowing researchers to see what factors are most important in their decision-making (Sood et al., 2022).

It used to estimate part-worth utility for each attribute’s level calculate the relative importance values of attributes (Sung et al., 2023). Using the ratings from the respondents on the 11 different profiles of mathematics learning modalities, a computer optimized algorithm provided the results of part-worth utility estimate of each level per attribute. Having greater part-worth utility value within the attribute shows greater preferences.

**RESULTS AND DISCUSSIONS**

Table 1. Demographic profile of respondents.

|  |  |  |
| --- | --- | --- |
| **Profiles** | **Frequency** | **Percent** |
| Grade Level | Grade 7 | 75 | 20.2 |
| Grade 8 | 56 | 15.1 |
| Grade 9 | 61 | 16.4 |
| Grade 10 | 65 | 17.5 |
| Grade 11 | 62 | 16.7 |
| Grade 12 | 53 | 14.2 |
| Sex | Male | 151 | 40.6 |
| Female | 221 | 59.4 |
| Age | 12 years old | 12 | 3.2 |
| 13 years old | 68 | 18.3 |
| 14 years old | 88 | 23.7 |
| 15 years old | 66 | 17.7 |
| 16 years old | 70 | 18.8 |
| 17 years old | 61 | 16.4 |
| 18 years old | 7 | 1.9 |
| Grades | 75 – 79 | 39 | 10.48 |
| 80 – 84 | 77 | 20.7 |
| 85 – 89 | 117 | 31.45 |
| 90 – 94 | 104 | 27.96 |
| 95 – 99 | 35 | 9.41 |
| Mean Grade | 87.17 |

Table 1 presented the demographic characteristics of the high school students who participated in this study, specifically in terms of grade level, sex, age, and the academic performance in mathematics in grades. As shown in Table 1, the respondents were distributed across different grade levels from Grade 7 to Grade 12. Grade 7 level had the highest number of respondents, comprising of 75 students (20.2%). This was followed by Grade 10 level with 65 students (17.5%), Grade 11 level with 62 students (16.7%), Grade 9 level with 61 students (16.4%), and Grade 8 level with 53 students (15.1%). However, Grade 12 level had the smallest proportion with 53 students (14.2%). The distribution was based on the proportion across all grade levels. The table also shows that majority of the respondents were 221 females (59.4%) and only 151 students (40.6% were males. This result indicates a female-dominated sample. In terms of age, Table 1 showed that the most common age group was 14 years old (n=88, 23.7%), followed by 16 years old students (n=70, 18.8%), 13 years old students (n=68, 18.3%), 15 years old students (n=66, 17.7%), and 17 years old students (n=61, 16.4%). The lower number age groups included 12 years old students with 3.2%(n=12) and 18 years old students with 1.9%(n=7). The age distribution is consistent with the expected age ranges of students in Grade 7 to Grade 12 in the Philippine K-12 educational system. As seen in the results, most students were within the 13 to 17 age range, which is typical grade placement without having a significant number of overage or underage learners. Moreover, as revealed in Table 1, the majority of the students’ achieved grades in Mathematics within the 85 – 89 range (n=117, 31.45%). This was followed by those with grades between 90 – 94 (n=104, 27.96%) and 80 – 84 (n=77, 20.7%). A smaller portion of students reported grades between 75 – 79 (n=39, 10.48%) and 95 – 99 (n=35, 9.41%). The overall mean grade of the respondents was 87.17, which indicates a very satisfactory academic standing based on the Philippine grading system.

Table 2. Part-worth utility estimates of mathematics learning modality preferences.

|  |  |  |
| --- | --- | --- |
| **Mathematics Learning Modality Attributes** | **Attribute Levels** | **Average Part-worth Utility Estimate** |
| Learning Environment | Face-to-face | 0.750 |
| Online | -.518 |
| Blended | -.231 |
|  Learning Material | Textbooks and Modules | .044 |
| Digital Resources | .208 |
| Video Tutorials | -.251 |
|  Teaching Method | Lecture-based | .039 |
| Class Interactions | -.086 |
| Group works | .047 |
|  Evaluation Method | Traditional Tests | .278 |
| Project-based | -.093 |
| Digital Assessment | -.185 |
| Constant |  | 6.943 |

In determining the students’ preference, estimated preference rating on the learning modalities in mathematics class using the part-worth utility estimate was utilized in this study. Table 2 presents the part-worth utility estimates for each level within the different attributes of learning modality in mathematics class. These values represent the average preferences indicated by the respondents. As mention earlier in this study, a higher utility score within attribute suggests a stronger preference for that specific level. The part-worth utilities are measured on an interval scale, meaning comparisons can only be made among levels within the same attribute. They are based on an arbitrary additive constant, so the values cannot be interpreted as ratios. However, because all utilities use the same unit of measurement, the values can be summed to determine the overall utility of a particular product profile.

 As shown in Table 2, among the levels under learning environment, face-to-face had the highest average part-worth utility estimate of 0.750 in comparison from the other levels. For learning material, digital resources gained the greatest average part-worth utility estimate of 0.208. In the attribute teaching method, the highest average part-worth utility estimate was 0.047 which correspond to group works but it had only a slight difference with lecture – based having an average part-worth utility estimate of 0.039. On the other hand, traditional tests had the highest average utility estimate of 0.278 for the evaluation method attribute.

**Figure 1. Part-worth Utility Levels for Learning Environment.**

Figure 1 illustrates the part-worth utility levels with the corresponding average part-worth utility estimate of the attribute learning environment. In the figure, face-to-face learning had the highest part-worth utility estimate of 0.750, indicating that the respondents strongly preferred this type of learning environment over others. In contrast, online learning (-0.518) and blended learning (-0.231) modalities were less favored. With this result, students perceive face-to-face instruction as the most effective and engaging modality for learning mathematics. This preference may be attributed to the nature of mathematics as a subject that often requires immediate feedback, guided practice, and direct teacher-students interaction. Ahmad et al. (2024) states that students felt more enjoyable and alive in face-to-face learning environment compared to other learning environment. Further, the familiarity and structure provided by traditional classroom settings may offer a sense of academic normalcy and security, especially in rural or resource-limited contexts.

 **Figure 2. Part-worth Utility Levels for Learning Material.**

Figure 2 shows the part-worth utility levels with the corresponding average part-worth utility estimate of the attribute learning material. As shown in the figure, digital resources were the most preferred level with an average part-worth utility estimate of 0.208, followed by textbooks and modules with an average part-worth utility estimate of 0.044). Interestingly, video tutorials were the least favored level with an average part-worth utility estimate of -0.251. The preference for digital resources according to Cuban (2020) may be due to interactivity, accessibility, and ability to support diverse learning styles through animations, simulations, and practice exercises. Dhakal (2023) stated that digital resources help students develop essential 21st-century skills and gives them the freedom to learn anytime and anywhere, depending on their needs. In addition, with a wide range of digital materials available through an e-resource repository, students can learn at their own pace and in ways that suit their individual learning styles-making it easier for them to succeed in higher mathematics (Dhakal, 2023)

**Figure 3. Part-worth Utility Levels for Teaching Method.**

Figure 3 shows the part-worth utility levels with the corresponding average part-worth utility estimate of the attribute teaching method. As presented in the figure, students showed a slight preference for group works (0.047) and lecture – based instruction (0.039). However, class interactions (-0.086) received a negative average part-worth utility estimate. The findings showed that there was a slight favorability toward lecture and group work. This imply that in teaching mathematics subjects, students prefer to have a balance between guided instruction and collaborative learning. The lower estimate for class interaction does not mean that it is unattractive. Class interactions might be appealing to the students in teaching math lessons but students prefer more on lecture and group activities. This pattern highlights the importance of well-designated collaborative activities and structured lectures in math classes to sustain student engagement and performance (Slavin, 2018). According to Acharya (2023), group works enhance students learning and promotes deeper understanding, higher achievement, and improved attitudes towards mathematics. In addition, Meehan and Howard (2023) stated that students value both lecture and group interactions for their learning.

**Figure 4. Part-worth Utility Levels for Evaluation Method.**

Figure 4 shows the part-worth utility levels with the corresponding average part-worth utility estimate of the attribute evaluation method. As depicted in the figure, respondents expressed the strongest preference for traditional tests (0.278), while project-based assessments (-0.093) and digital assessment (-0.185) were less preferred. This result indicates that students value the conventional testing formats in evaluating the students understanding about the lesson discussed. Iannone and Simpson (2019) stated students prefer traditional tests because they believe these are fairer and better at measuring their math skills. However, digital assessment had the low preference even though technology is widely used today. According to Nguyen & Nyugen (2022), the low preference for digital assessment could stem from technological limitations, lack of exposure, or test anxiety associated with online testing platforms. There are still concerns about whether digital or online assessments can effectively measure critical thinking, and about possible technical problems during tests (Juma et al., 2024)

**CONCLUSIONS AND RECOMMENDATIONS**

Students in Mati City Division preferred face-to-face learning environments, digital learning resources, group works, and traditional form of evaluation as learning modalities in Mathematics class. This implies that despite the shift to online and blended modalities caused by the pandemic, students still find in-person classes more effective and it has highly value digital learning resources which complement learners’ experience beyond textbooks and printed modules. While alternative assessment methods are gaining attention, traditional tests still hold the favorite preference by the students in mathematics education. Interestingly, the teaching method was perceived as the least influential attribute in shaping student preferences which may imply that students are generally more adaptable to different instructional strategies as long as the learning environment and resources are supportive and engaging.

These insights can serve as valuable inputs for stakeholders of education in designing and implementing Mathematics learning modalities. It is recommended that schools and educators may revisit current instructional practices in mathematics to align them with students’ expressed preferences. Specifically, integrating group-oriented activities, curated digital content, and maintaining face-to-face delivery may better address students’ learning need and expectations. Further studies may be conducted considering other attributes or factors that may affect students’ preferences on the learning modalities in mathematics class.

**Ethical Approval and Consent:**

The researcher is fully committed to ensuring that respondents are not exploited under any circumstances. Respondents must be provided with sufficient information to make informed choices, their perspectives must be respected, and they must have the freedom to act on their decision. The researcher was dedicated to safeguarding respondents’ rights, particularly their freedom of opinion and choice regarding participation in this study. In maintain ethical standards, necessary approvals were obtained, including endorsements from the Dean of the graduate school, the Schools Division Superintendent, Public Schools District Supervisors, and the School Principal. Additionally, informed consent from parents and informed assent from student – respondents were secured to ensure participants fully understand their rights, especially regarding voluntary participation. Respondents were informed of their right to withdraw without any repercussions. The researcher ensured that no personal information was collected from the respondents. Access to the data were exclusively limited to the researcher. Both hard and soft copies of the data will be securely disposed after successfully published.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. The name, version, model, and source of the generative AI technology used by the author is the Copilot, developed by Microsoft. Source: https://m365.cloud.microsoft/chat

2. The AI tool was employed to refine grammatical accuracy, construct effective transitions, identify pertinent literature, synthesize key findings, and ensure proper citation formatting in accordance with APA 7th edition guidelines.

3. The prompts used were the following:

\* “Please review the following academic text for grammatical accuracy.”

\* “Suggest effective transitions to enhance coherence.”

\* Please help identify recent and relevant scholarly literature to support this idea. Provide full citations formatted in APA 7th edition style.

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