

## RESEARCH ARTICLE

# Analyzing the level of interest of high school students in solving mathematical problems in the modular and face-to-face learning

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## ABSTRACT

As schools continue to adjust to changing circumstances, it is essential to use strategies that not only help students learn, but also interest and inspire them. More effective and engaging learning experiences can be created with the use of knowledge on how different strategies affect students' levels of interest. This quantitative study aimed to analyze the interest levels of students in solving mathematical problems as mediated by different teaching ideas/strategies i.e., with gamification, with graphic and visuals, and with digital resources. Likert-scale was used to code and assign weight for the questionnaire. Findings indicated that interest levels of students were high during distance learning because they can access online resources (e.g., search engines, YouTube, e-books) to be used for independent learning. In face-to-face classes, students reported high level of interest in solving mathematical problems if there are learning aids (e.g., graphs, pictures, charts) presented to them and access to online resources. As suggested, teaching strategies require teachers to focus more on visual and online-assisted learning to make students feel interested in solving mathematical problems and in learning mathematical concepts. The findings offered teachers an opportunity to integrate more on innovative teaching through adapting to resources which their students have access to. Such instructional direction required in-depth assessment to establish some novel instructional strategies that stimulate students to learn more.

**Keywords:** digital resources; face-to-face learning; gamification; graphic and visual learning; interest level; modular learning

## 1. Introduction

One of the predictors of academic success is the interest of students. Interest can be considered a complex concept that involve both cognitive and emotional factors. The cognitive aspects of interest involve the acquiring of knowledge and the processing of information related to objects or tasks, reflecting a form of intellectual concern. In contrast, the emotional aspects of interest include the affective experiences and subjective engagement that accompany one's involvement in a particular activity<sup>[1]</sup>. These emotional experiences can manifest as a sense of enjoyment, fun, or other positive feelings, which in turn contribute to a heightened motivation and desire to actively engage in an activity<sup>[2]</sup>.

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The goal of this study was to analyze the interest level of junior high school students in solving mathematical problems during modular and face-to-face classes. This study compared their interest levels as influenced by teaching ideas/strategies implemented i.e., with gamification, with graphic and visuals, and with digital resources. Such analysis shed light on how these teaching ideas/strategies could mediate the interest levels of students.

The presence of strengthened levels of interest in mathematics, as well as in other academic areas, has been found to be correlated with enhanced performance and learning outcomes within both K-12 and post-secondary educational settings<sup>[1-8]</sup>. Having higher interest levels has been observed to correspond with increased engagement in crucial cognitive processes such as attention, persistence, perceived competence, and utilization of effective learning strategies. These cognitive processes, in turn, have been identified as potential mediators and predictors of academic achievement<sup>[3,5,6,9-11]</sup>.

Cognitive engagement theories, in the context of student learning, suggest that a high level of commitment and perseverance is essential for understanding a given topic or concept. This psychological state involves considerable effort and dedicated study over an extended period<sup>[12-18]</sup>. Inquiry-based learning, for instance, encourage students to ask questions, explore topics independently, and draw their conclusions. This approach stimulates curiosity and critical thinking, leading to enhanced cognitive engagement. By providing opportunities for students to formulate their questions and explore areas of interest, this approach stimulates a sense of curiosity that propels students to delve deeper into the subject. The act of questioning becomes a gateway to intellectual exploration, sparking a natural desire to seek knowledge and understand the intricacies of a given topic. In this way, inquiry-based learning capitalizes on the innate human inclination to inquire, fostering a curiosity-driven engagement that transcends the boundaries of conventional instruction.

Problem-based learning (PBL) is an instructional approach that places the student at the center of the learning experience, with the primary goal of achieving specific learning objectives. This pedagogical method involves engaging students in the analysis, resolution, and discussion of real-world issues that are presented to them<sup>[2,19]</sup>. By immersing students in these authentic problem-solving scenarios, PBL aims to foster critical thinking skills, promote collaborative learning, and enhance students' understanding of the subject matter. PBL is an instructional approach rooted in the principles of student-centered constructivism. Educators play a pivotal role in facilitating students' cognitive engagement with real-world problem-solving endeavors<sup>[20,21]</sup>. Not only that problem-based learning is essential in mathematics, but it could also impact students' future career directions.

The effective use of manipulative materials has been found to be beneficial in aiding students in their comprehension of abstract mathematical concepts. Through the inclusion of teaching strategies that can be handled and interacted with, students are afforded the opportunity to actively engage in the exploration and validation of diverse mathematical concepts.

The use of a practical approach to mathematics education not only amplifies student involvement but also adds an aspect of enthusiasm and complexity to the educational experience. As a result, students are inclined to engage actively in their mathematics studies, so enhancing their general confidence and proficiency in the subject area<sup>[22,23]</sup>.

Educational systems have had to adapt rapidly, shifting between different modes of instruction, including modular learning and traditional face-to-face classes. Understanding how the interest levels of junior high school students are influenced by these diverse teaching strategies is of paramount importance. This research endeavors to provide valuable insights into the effectiveness of various teaching approaches,

particularly gamification, visual aids, and digital resources, in maintaining and enhancing students' interest in mathematics.

The purpose of this study is to address a notable gap in the existing literature by conducting a comparative analysis of teaching strategies and their mediating impact on the interest levels of high school students in both distance learning and face-to-face classes. The current research seeks to delve deeper into the comparative effectiveness of three specific strategies—gamification, graphical and visual representations, and online access—when implemented in both distance learning and face-to-face classes. Most previous research has focused on a singular teaching strategy, limiting the ability to draw meaningful comparisons. In contrast, this study takes a more holistic approach by concurrently examining three distinct strategies, providing a nuanced and comprehensive perspective on their impact on student interest in solving mathematical problems.

## **2. Literature review**

### **2.1. The concept of interest**

The emergence of interest is seen in the student's reaction, as they demonstrate awareness and a desire to actively engage in a particular item or activity. This prompts them to seek more information or get actively interested in it<sup>[24]</sup>. The display of students' interest in studying mathematics may be seen by their inclination to dedicate attention, exhibit genuine curiosity, and actively engage in the process of learning mathematics<sup>[25–27]</sup>.

Experiences in the traditional classroom setting, which possess relevance, significance, personal resonance, or novelty, have the potential to serve as influence an individual's interest in mathematics or a specific professional field<sup>[12,13,28,29]</sup>. This has the potential to induce affective changes specifically an increase in engagement levels that can be attributed to the stimulation of situational interest<sup>[30]</sup>. When an external stimulus elicits or captivates the attention of a student, it has been empirically observed to enhance concentration and foster perseverance in an educational endeavor, thus leading to enhanced learning<sup>[3,4]</sup>.

The ongoing stimulation of situational interest leads to the sustained presence of situational interest, which is characterized by prolonged focus and determination, as well as the emergence of positive emotional, cognitive, and evaluative reactions<sup>[12,13,31–33]</sup>. Students' attitudes may change as situational attention is maintained and knowledge and value are established; they may show a growing interest in a particular subject area and desire to pursue further education<sup>[3]</sup>.

However, although several studies<sup>[34,35]</sup> were conducted mainly about how interest levels could influence students' performance, there is a need to analyze some extrinsic factors that could also mediate the interest levels of students. Studies were more focused on how students feel (like how motivated they are) about something. Most researchers interpret interest as a psycho-emotional aspect that drives the action of an individual to engage in learning. This study further looked onto some extrinsic factors like the learning environment that the students are exposed to. Notably, environment also has influence on how students perceive themselves<sup>[36–38]</sup>. Hence, such research direction will shed light on how teaching strategies could influence the learning experience of students thereby reflecting their interest level.

### **2.2. Interest in problem solving and students' learning**

Prior to embarking on the process of problem-solving, students engaging in PBL could understand the given situation. In the given situation, students often encounter a notable difficulty in the process of transforming their theoretical ideas into concrete explanations that facilitate their learning by providing

intuitive solutions<sup>[2]</sup>. Manipulative materials are employed in mathematics education with the purpose of facilitating students' comprehension of abstract concepts or the introduction of novel mathematical ideas<sup>[39]</sup>. Manipulative materials are physical entities that afford students the opportunity to engage in hands-on exploration, manipulation, arrangement, movement, grouping, sorting, and utilization for the purpose of enhancing their comprehension and application of mathematical concepts and problem-solving<sup>[40-42]</sup>.

A low level of interest among students can potentially result in challenges when it comes to the successful completion of mathematics tasks<sup>[43,44]</sup>. Students who are challenged in understanding a particular idea are more likely to encounter difficulties at the next levels, hence diminishing their motivation and engagement in mathematical learning endeavors. Utilizing real-world scenarios as pedagogical tools inside the mathematics classroom is a potential strategy to enhance students' engagement and motivation in the process of mathematical learning<sup>[2]</sup>. In addition, the implementation of small group activities within the classroom setting, along with the incorporation of supplemental educational resources such as puzzles and manipulative materials, serves to stimulate children's interest and learning<sup>[45,46]</sup>.

The process of aligning manipulatives with mathematical concepts is a crucial step for teachers in their lesson planning. To effectively utilize manipulative materials in mathematics education, it is essential to understand the correlation between the physical object and the mathematical concepts it represents. Mathematics is a discipline characterized by its abstract nature, wherein it establishes connections with the tangible world through the utilization of physical representations, thereby embodying the approach of abstract concepts.

### **2.3. Teaching and instructional strategies**

Gamification emerges as a viable learning paradigm that may be effectively employed, owing to its inherent creativity and innovation<sup>[47,48]</sup>. Gamification is an educational idea that seeks to enhance the appeal of a non-game context by integrating elements of game thinking and game mechanics<sup>[49,50]</sup>.

The adoption of Quizz-based gamification is employed to enhance the enjoyment, self-assurance, and competitive spirit within educational endeavors, specifically through leveraging mobile phones as the primary medium for learning activities<sup>[48]</sup>. Gamification can potentially serve as a catalyst in providing students with external motivation to have short-term benefits in learning<sup>[51,52]</sup>. Consequently, by leveraging extrinsic incentives, the use of gamification has the potential to reignite intrinsic motivation by arousing curiosity and generating interest in an enjoyable manner<sup>[53,54]</sup>.

Visual aids are instructional tools employed in educational settings to enhance the learning experience of students, fostering their engagement, and facilitating comprehension. Visual aids are often regarded as a highly effective technique for enhancing the efficacy of teaching and facilitating the optimal distribution of knowledge<sup>[55-57]</sup>. The use of visual aids in educational instruction serves to augment lesson plans and help students in learning the subject matter<sup>[58,59]</sup>. The inclusion of visual aids in instruction and teaching can be highly advantageous in enhancing the learning of students. Furthermore, the integration of both visual and auditory cues seems to be extremely efficacious, as it engages the two most crucial sensory modalities<sup>[60-62]</sup>.

Some teachers also use digital resources to aid students' learning process<sup>[63]</sup>. Reitz<sup>[64]</sup> defines electronic resources as formats that require data for operation, encoding, and reading on a peripheral device, such as visiting websites on the Internet<sup>[65]</sup>. Popular electronic resources encompass a variety of digital media, such as e-journals, e-books, e-magazines, e-newspapers, databases, and similar mediums<sup>[65,66]</sup>.

Engaging in deliberate and reflective reading experiences reinforced with multimedia resources has the potential to foster intrinsic motivation among children between the ages of three and eight, which facilitates

their learning of language skills and information. For instance, several studies have demonstrated that e-books have efficiently facilitated the advancement of literacy and linguistic skills<sup>[67-70]</sup>. However, it was also evident that students feel worried about accessing digital resources because of their economic situation<sup>[71,72]</sup>.

Limited studies were conducted comparing the teaching strategies and how they mediate the interest levels of high school students in distance learning and face-to-face classes. Although studies from Meşe and Dursun<sup>[73]</sup>, Sailer et al.<sup>[74]</sup> and Aldalur and Perez<sup>[75]</sup> about interest levels and gamification, Agni and Zainal<sup>[76]</sup>, Ho et al.<sup>[77]</sup> and González-Beltrán et al.<sup>[78]</sup> about interest level and visual learning, indicated similar results, the researchers seek to discuss more about which of these strategies work better during distance and face-to-face classes. Most studies only focused on one teaching strategy while the current study analyzed three strategies independently as implemented in distance and face-to-face classes.

### **3. Research questions**

Previous studies noted that gamification, use of graphical representations, and online access can influence the interest levels of students in learning. The purpose of this study was to expand their results by comparing the interest levels of students in solving mathematical problems based on the modality of learning. The present study analyzed the interest levels of high school Students from Zamboanga City in solving mathematical problems, where their teachers utilized digital resources, graphical and visual representations and gamification as teaching strategies.

1) What is the level of interest of students in solving mathematical problems in the distance modular learning and face-to-face learning:

- a. With gamification.
- b. With graphic and visuals.
- c. With digital resources.

2) Is there any significant difference between the interest of students in solving mathematical problems during distance modular learning and face-to-face learning?

## **4. Methods**

### **4.1. Research design**

The study was a small-scale study conducted in a high school at Zamboanga City, Philippines. This study used survey method to collect data regarding the interest of junior high school students in solving mathematical problems from face-to-face and distance learning. This study was a comparative study that compares the interest levels of students based on different learning approaches i.e., with gamification, with graphic and visuals, and with digital resources. This study compared these categories of learning mathematics using hypothesis testing methods.

This study compared the interest levels of students based on several learning approaches they were exposed to during distance learning and face-to-face learning. The survey was conducted after the implementation of face-to-face classes for academic year 2022–2023 when health restrictions were lifted. Every participating student experienced these teaching approaches set by their teachers for distance learning and face-to-face learning.

Gamification involved some learning games like rolling a die, puzzles, math-wordle. Graphic and visuals focused more on graphical representations like pie charts, illustrations, pictures etc., to explain real-life mathematical concepts. Digital resources as an instructional approach that make use of online accessible platforms/resource like YouTube, e-books, research papers. The researchers identified local teachers from

Zamboanga who used all these approaches and selected samples from their class and sampled participants from their class. The selected students were then surveyed using a validated research instrument.

The selection of schools to be part in survey was randomized. A total of 122 high school students from Zamboanga City participated in the survey. **Table 1** shows that these participants were divided into two groups—the 60 (50%) participants from grade levels 7–8 and another 60 (50%) participants from grade levels 9–10. These participants were consisted of 60 (50%) individuals who had >86% in mathematics from school year 2021–2022; while 60 individuals had < 85% grade in mathematics from that same school year. The researchers used the theoretical mean for these intervals to evenly distribute the participants’ demographic profiles.

**Table 1.** Demographic profile of the respondents.

Demographics		<i>n</i>
Students’ grade level	Grade 7–8	60
	Grade 9–10	60
Year-end grade	86 and above	60
	85 below	60

#### 4.2. Research instrument

This study used a validated Likert-scale questionnaire to collect data from high school students. The instrument was composed of three parts. Part I seek for student’s demographic profiles, Part II collected data for interest in solving math problems during distance learning mode, and Part III was for interest during face-to-face classes. **Table 2** presents the summary for Cronbach’s alpha.

**Table 2.** Test for reliability of instrument.

Scale	Modular ( <i>N</i> = 50)	Face-to-face class ( <i>N</i> = 50)
<b>With gamification</b>		
I enjoy solving math problems more when gamified elements are incorporated.	0.78	0.83
Learning math through gamification makes the subject more engaging for me.	0.72	0.82
Gamified approaches make me more motivated to participate in math activities.	0.76	0.79
I find that gamification helps me understand and remember math concepts better.	0.80	0.78
I am more likely to spend extra time on math problems if they involve gamified elements.	0.81	0.80
<b>With graphics and visuals</b>		
Visual representations of math problems help me comprehend the concepts better.	0.75	0.81
I find math problems more interesting when accompanied by visual aids.	0.74	0.76
Graphics and visuals make it easier for me to remember math-related information.	0.79	0.83
Visual elements make math lessons more enjoyable than text-only approaches.	0.80	0.74
I feel more confident in my math abilities when supported by visual materials.	0.76	0.86
<b>With digital resources</b>		
I prefer using digital tools to solve math problems over traditional methods.	0.84	0.83
Digital resources make learning math more convenient for me.	0.83	0.80
I find math lessons with interactive digital elements more enjoyable.	0.80	0.79
The use of digital resources enhances my understanding of complex math concepts.	0.79	0.78
I am more motivated to participate in math activities when digital tools are involved.	0.88	0.89

#### 4.3. Data gathering procedure

Upon approval from the Research Ethics Clearance for research implementation the researcher gathered data from the students. The processes and procedures in this study were closely monitored to uphold the

research standard, ethics, and mandates of the affiliation.

Permission for the conduct of the study was sought from the principals of selected high schools through a formal letter. Once permission was granted, the approved letter was presented to the school advisers of junior high school to facilitate the administration of the questionnaire.

The research designed two letters of consent, one for the high school students and one for the parents. The first letter seek permission from the students while second one seeks permission from their parents. Highlighted in these letters were the confidentiality, data use, publication, and terms covered in data gathering. The participants and their parents should affix their signature in the letter.

Once the permission was granted, the researchers administered the questionnaire to the participants. They were given one hour to respond to the questionnaire. The data gathering was done only by face-to-face.

#### 4.4. Data analysis

This study used both descriptive and inferential statistics to analyze the data. Data processing software (i.e., SPSS, Microsoft Excel) was used to numerically analyze the data. Below were the tests used in this study.

Weighted mean: This was used to analyze the interest levels of the students and interpret the mean using value intervals. Likert-scale is weighted to assign values in a response and the mean ( $\bar{x}$ ) of responses can be interpreted descriptively.

$$\bar{x}_w = \frac{\sum_{i=1}^n (w_i x_i)}{\sum_{i=1}^n w_i}$$

where,  $\bar{x}_w$  is the weighted mean;  $w_i$  is the allocated weighted value;  $x_i$  is the observed values.

The resulting mean was interpreted using these descriptive values. These values were used to interpret the interest levels of students in solving mathematical problems. **Table 3** below presents the equivalent interpretation of the mean values in terms of interest levels.

**Table 3.** Equivalent descriptive values.

$\bar{x}$	Description (Interest level)
1.0–1.60	Very low
1.61–2.20	Low
2.21–2.80	Moderate
2.81–3.40	High
3.41–4.00	Very high

Paired *t*-test: This test was used to compare the level of interests of students i.e., interest during face-to-face and interest in distance learning. The comparison was done independently in three learning ideas. Before using this test, the researchers performed normality test of the data to adhere to the conditions necessary in this test.

$$t = \frac{\sum d}{\sqrt{\frac{n(\sum d^2) - (\sum d)^2}{n - 1}}}$$

where, *d* is the difference per paired value; *n* is the number of samples.

## 5. Results and discussion

### 5.1. Interest level of students

**Table 4** presents the interest levels of students in solving mathematical problems in the modular distance learning. When applying gamification, the students feel highly interested ( $\bar{x} = 3.20$ ) in solving mathematical problems. Students were also highly interested in solving mathematical problems using graphics and visuals ( $\bar{x} = 3.20$ ). Notably, high school students from were interested more on solving mathematical problems with help from digital resources ( $\bar{x} = 3.26$ ).

**Table 4.** Interest level of students during modular distance learning.

Category	$\bar{x}$	Remarks
With gamification	3.20	High
With graphic and visuals	3.22	High
With digital resources	3.26	High
Range: 1.0–1.60 very low, 1.61–2.20 low, 2.21–2.80 moderate, 2.81–3.40 high, 3.41–4.00 very high.		

**Table 5** presents the interest levels of students in solving mathematical problems during face-to-face classes. The students feel very interested in solving problems with the help of graphical and visuals ( $\bar{x} = 3.68$ ). Students also feel highly interested in solving mathematical problems with the use of digital resources ( $\bar{x} = 3.40$ ). In contrast, students were also interested in solving while having games ( $\bar{x} = 3.20$ ).

**Table 5.** Interest level of students during face-to-face classes.

Teaching ideas	$\bar{x}$	Remarks
With gamification	3.20	High
With graphic and visuals	3.68	Very high
With digital resources	3.40	High
Range: 1.0–1.60 very low, 1.61–2.20 low, 2.21–2.80 moderate, 2.81–3.40 high, 3.41–4.00 very high.		

### 5.2. Inferential analysis on students' interest levels

This study compared the interest levels of students using paired *t*-test. Shown in **Table 6**, the test indicated that the high school students were significantly interested in solving mathematical problems while at school than of having modular, most especially when teaching ideas focused on graphics and visuals ( $p = 0.023$ ) and having access to digital resources ( $p = 0.046$ ).

**Table 6.** Inferential test for interest levels.

Teaching Ideas	Modality	$\bar{x}$	Sig.
With gamification	Face-to-face	3.2031	0.089
	Modular	3.2046	
With graphic and visuals	Face-to-face	3.6825	0.023*
	Modular	3.2234	
With digital resources	Face-to-face	3.4042	0.046*
	Modular	3.2634	

\*Significant at  $p < 0.05$ .

Interest levels of students in solving mathematical problems showed promising application in teaching



and education. The high school students feel interested in solving mathematical problems when they are at school, probably because of some organizational factors such as access to learning materials and peer interaction.

The high school students also feel interested in solving math problems when they have access to digital resources. Because of the distance learning modality, the students learned to use online contents such as videos, e-books, pictures, to assist them in learning. This is an essential part of learning, especially the self-assisted one, because students learned to be resourceful in accessing digital contents.

Students are active participants in the learning process, contributing their own thoughts, experiences, and challenges<sup>[79-81]</sup>. This study suggested that students in face-to-face modality feel more interested in solving math problems with graphical representation and access to online resources because it simulates their learning engagement. Active cognitive engagement is crucial for learners as it involves the mobilization of cognitive, motivational, and emotional aspects during the learning process<sup>[82-84]</sup>. This active engagement has been shown to result in improved academic performance and better overall outcomes<sup>[85,86]</sup>.

Cognitive engagement suggests that students exhibit a high level of commitment and perseverance in understanding a topic<sup>[12-14]</sup>. This psychological state involves putting in significant effort and studying diligently for an extended period<sup>[15-18]</sup>. When a student feels engaged in a learning environment (like solving math problems with games), it also influences their interest in the subject. In this study, the instructional strategies effectively mediate the interest levels of students because of its capacity to engage them in cognitive learning. Similarly, among engineering students, to foster the development of engineering skills, it is essential to engage instructors and students from many academic fields, thereby stimulating learners to analyze real-life problems and design solutions<sup>[33]</sup>.

Elastika et al.<sup>[87]</sup> explained that the environment and setting could influence the learning of students in mathematics. Interest in mathematics is driven by the students' attitude towards the subject<sup>[55,88]</sup>. Furthermore, game-based learning, collaborative learning, and other techniques could also encourage students to learn mathematics. In this study, it was indicated that some teaching ideas e.g., gamification, graphics and visuals, and digital resources, can be linked to students' increasing interest in solving math problems.

Notably, student-teacher interaction in face-to-face classes could also influence students' interest in solving mathematics problems. This study revealed that students feel more interested in solving mathematics problems in face-to-face than in distance learning. Similarly, face-to-face classes seem to be more effective in increasing the interest levels of students because it strongly advocates for active learning<sup>[89,90]</sup>. Classroom instruction allows for direct and synchronous contact, as well as discussion and interaction between students and teachers<sup>[91,92]</sup>. For instance, teachers include the usage of digital resources in a face-to-face environment into their lesson plans; as a result, students benefit from the usefulness of digital resources especially when certain tasks need the use of internet.

The findings provided insights on the possible influence of common teaching ideas implemented by their teachers shedding light on integrating the teaching strategies applied in the school. The students were interested in solving mathematical problems with the use of graphics and visuals. The utilization of graphic and visual representation held in-favor of students' interest as the self-learning modules printed pictures and visuals that aided students' grasp of understanding mathematical concepts. This finding calls for the teachers to integrate into more problem visualizations and creative presentations of mathematical problems to encourage students to learn math.

## **6. Limitations**

The relatively small sample size is one noticeable limitation, which may jeopardize the study's capacity to adequately capture the range of student experiences and involvement levels. The findings may not be typical of the larger population, reducing the results' external validity. Samples might lack diversity in terms of demographic factors, academic backgrounds, or other relevant variables. This homogeneity may limit the generalizability to a more varied student population. Furthermore, the setting, particularly if limited to a single institution or geographic location, may restrict the findings' generalizability. Educational contexts vary greatly, and results obtained in one setting may not be applicable in another. The findings may not be easily transferable to different educational systems, especially if the methods and instructional strategies employed are specific to a particular context. Although this study provided valuable information about the interest levels of students in modular and face-to-face classes, further studies shall be made with large-scale data.

## **7. Conclusion**

High school students, when situated within the school environment, manifest heightened interest, ostensibly attributable to the accessibility of learning materials and the dynamics of environmental stimulation. Within face-to-face modalities, students demonstrate a high interest level when engaged to graphical representations and online resources, simulating an environment conducive to their academic endeavor. The preference for face-to-face interactions, grounded in its efficacy in promoting active learning and synchronous engagement, resonates with established pedagogical concepts. Cognitive engagement and PBL are highly related because PBL encourages students to have active participation and processing of new information or skills, leading to a deeper understanding and meaningful learning experiences.

In PBL, students engage with real-world problems and challenges. This approach requires active cognitive processes as students work collaboratively to understand, analyze, and solve complex problems, promoting a higher level of engagement. Solving mathematical problems with gamification and access to online resources were highly effective methods in face-to-face modality because it stimulates students to think critically and innovatively. Developing instruction to meet the different needs of students promotes cognitive engagement. By adapting content, process, and products to accommodate varying learning styles and abilities, instructors can capture the interest and involvement of a broader range of students.

## **Author contributions**

Conceptualization, KPDC and RTDP; methodology, KPDC and RTDP; software, KPDC and RTDP; validation, KPDC and RTDP; formal analysis, KPDC, RTDP and MME; investigation, KPDC, RTDP and MME; resources, KPDC, RTDP and MME; data curation, KPDC and RTDP; writing—original draft preparation, KPDC, RTDP and MME; writing—review and editing, KPDC, RTDP and MME; visualization, KPDC and RTDP; supervision, KPDC and RTDP; project administration, KPDC and RTDP; funding acquisition, KPDC and RTDP. All authors have read and agreed to the published version of the manuscript.

## **Conflict of interest**

The authors declare no conflict of interest.

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