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SCIENCE TEACHERS' PREPAREDNESS AND PRACTICES IN SMARTPHONE-BASED PHYSICS EXPERIMENTS

Abstract. The advancement of smartphone technology has reaped several benefits in many sectors. In education, teachers have yet to fully adopt in their classrooms, which calls for their preparedness. This mixed-methods study has examined the knowledge, skills, attitudes, and classroom practices of 58 randomly selected in-service science teachers from public high schools in the Eastern Visayas region of the Philippines regarding smartphone-based physics experiments. Using validated and reliable instruments, this paper uncovered a disconnect between teachers' positive attitude towards smartphone implementation and their practical and theoretical knowledge and skills. Most teachers have a low conceptual understanding (f = 23) of smartphone-based experimentation and struggle to apply skills in data collection, analysis, and interpretation. Even more profound was the lack of practical skills among surveyed teachers. The average teacher score was only 1.30 out of 15, placing them at an *absent* skill level. During the classroom observations, these findings were confirmed: the use of smartphones in science classes was *rarely* or *never* observed. Qualitative insights indicated that teachers were genuinely perplexed by fundamental concepts such as repeated data collection, unit representation, and graphing. These results imply that presumptions about teachers' baseline preparedness cannot be used to design effective continuing professional development programs. Rather, CPD must start with the basics, employing scaffolding techniques that develop competence and confidence from the ground up. Even the most passionate educators will find it difficult to turn their idealistic perspectives of technology into worthwhile educational opportunities for their pupils if these fundamental gaps are not filled. This needs assessment provides the evidence base for creating focused, useful professional development that meets teachers where they are.

Keywords: Smartphone-based experiments; Teacher preparedness; needs analysis; Continuing Professional Development; Data literacy; Inquiry-based learning

1. INTRODUCTION

Over the last decade, the use of smartphones in science education has gained significant attention due to their capacity to collect and analyze real-time data through built-in sensors. Through real experimentation and the visualization of abstract ideas, smartphone-based physics experiments offer teachers an affordable, effective way to incorporate inquiry-based learning while fostering student engagement. These new technologies offer fresh opportunities to raise the standard of physics education in nations like the Philippines, where access to fully equipped laboratory facilities is limited.

However, incorporating smartphone-based experiments into classroom practice introduces novel pedagogical and technical challenges for the teachers. The solution would require more than just a positive attitude toward technology; teachers also need to understand how smartphone sensors work, collect data, and analyze and interpret it with high precision and accuracy. Many science teachers may face both technical and knowledge-based difficulties as they integrate emerging technologies into their teaching practice. These issues are related to

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collecting data, graphing, estimating uncertainties, and correlating experimental data with physics concepts [1], [2]. This problem arises despite science teachers expressing readiness to utilize digital tools in their teaching practice [3]. To create a functional Continuing Professional Development (CPD) program in this area, it is first necessary to find out how ready teachers are and what areas they need help with [4].

Statement of the problem. The affordability and practicality of smartphones for classroom teaching and learning are the prime benefits that can alleviate poor science instruction in resource-constrained areas. However, the success of its implementation is reliant on the readiness and preparedness of the science teachers, who will facilitate its use [5]. Basically, science teachers need to be fully aware of these sensors in smartphones. They are envisioned to have technical skills to collect data, analyze it, and interpret the results. At the same time, they need the proper attitude to integrate these various skills in the teaching process that would cultivate learning among the students.

Another issue that needs to be known is whether science teachers in a particular school possess the knowledge, skills, and attitude (KSA) to enhance instruction through smartphone-based physics experiments. The literature is found to be limited in this field. Without a clear understanding of teachers' initial KSA and classroom practices, the design of a Continuing Professional Development (CPD) program might fail to address the most critical gaps and provide insufficient scaffolding.

Considering these concerns, it may not be possible to fully utilize the potential of smartphone-based physics experiments, and instruction may not improve. Consequently, prior to the implementation of a CPD program, it is imperative to assess the actual preparedness of in-service science teachers concerning smartphone-based experimentation.

Analysis of recent studies and publications. Several studies have shown that smartphone-based learning can enhance engagement, learning outcomes, and improve attitude among students [6],[7]. Recent trends in learning using mobile devices show that smartphones are becoming more common and cheaper [8]. In the Philippines, where many schools face a scarcity of laboratory tools, science teachers can benefit from the application of such technology in schools. At the same time, new technologies like 5G are making mobile learning more accessible in schools. Schools and individual students are buying smartphones for both group and individual lessons. They are also using different apps to help students learn in ways that are tailored to them and fit their needs [9]. These changes have made it more likely that technology-enhanced learning and the use of mobile tools in the classroom will become more common [10]. Mobile learning can help students become more engaged and improve their digital literacy.

Even though the evidence is clear, there are still some problems that need to be solved, such as how to integrate it into the classroom effectively, the gap between what teachers know and what they do, and the lack of research on how mobile learning affects teachers' practices and professional identity [11]. Many studies are devoted to measuring and learning various students' constructs, while very little is known about the preparedness of the science teachers. This is exacerbated by a few studies exploring the skills in data collection, analysis, and interpretation of results using smartphone sensors. This can mean that few CPD programs are implemented within this field. According to Ivaniuk et al. [12], teachers need professional development in smartphone-based learning to acquire the necessary skills, access relevant support, and receive training that is relevant to their work so they can use mobile technologies effectively in the classroom. In support of this, the CPD program needs to be in line with the needs of science teachers so that the training is practical, focused, and able to help them build the specific skills they need to use smartphones to do physics experiments in the classroom [13].

The research goal and the research objectives. To address the identified gaps, this

study specifically evaluated the preparedness of in-service science teachers by analyzing their foundational KSAs and actual classroom practices concerning smartphone-based physics experiments. The data would be used for future CPD programs in this field. Doing this needs assessment was very important because it gave a clear picture of the teachers' basic skills and pointed out the exact areas where they needed help. Without this kind of proof, CPD programs might have been based on guesses and missed important misunderstandings or skill gaps.

Specifically, this research aimed to answer the following questions:

(1) What is the initial level of science teachers' knowledge and skills in data collection, analysis, and interpretation related to smartphone-based physics experiments?

(2) What are the science teachers' attitudes towards smartphone-based physics experiments in terms of the SAMR levels?

(3) What are the existing classroom practices of science teachers in using smartphone-based physics experiments?

2. RESEARCH METHODS

2.1 Research Design

The researchers utilized a sequential explanatory mixed methods design (Quan-Qual). Shrestha [14] set out that this approach began with the collection and analysis of quantitative data, followed by qualitative data to elucidate and contextualize the findings. This approach has enabled the researchers to explore teachers' rich competencies in the use of smartphone sensors for data collection, analysis, and interpretation. After gathering quantitative data, the researchers used qualitative insights to explain the underlying causes and processes of the patterns they saw.

During the quantitative phase, the researchers conducted surveys to evaluate teachers' KSAs and classroom practices in smartphone-based physics experiments. Descriptive statistical analysis was used to identify patterns, strengths, and weaknesses in the constructs of the teachers under study. This phase provided a general sense of the science teachers' readiness and identified areas where they might need additional training.

During the qualitative phase, the researcher conducted a case study of selected teachers to gain deeper insight into the patterns identified in the quantitative data. This process included interviews and classroom observations, which helped the researcher understand teachers' real-life experiences, teaching methods, and the problems they encountered when using smartphones in experiments. The qualitative findings elucidated the fundamental reasons for the quantitative results, such as the correlation between low skill scores and teachers' lack of confidence in using smartphone sensors, as well as challenges related to classroom logistics.

2.2. Research Participants

This research involved 58 science teachers working in eight public high schools in one of the provinces in the Philippines. The participants were selected by the school's division office based on the researchers' recommendations. Each participant has at least 5 years of teaching experience, including teaching physics from seventh to twelfth grade.

The sampling technique utilized is purposive sampling. This type of sampling technique has eliminated selection bias, meaning the researchers have avoided including teachers without the right background by selecting participants based on clear, pre-defined criteria, such as years of experience or subject specialization. This process kept people who were not relevant or qualified from changing the results.

2.3. Research Instruments

Two main instruments were used in this study. The first one is the KSA Questionnaire, and the second is the Classroom Observation Checklists. The knowledge section of the former is a standardized instrument adapted from Pacala [15], the attitude section is adapted from Pleskach et al. [16], and the skills section is adapted from Cambridge Assessment International Education (CAIE) Paper 5. These segments of the instrument were validated and reliable and were no longer subjected to further testing.

The Classroom Observation Checklists are researcher-made and require validation. To validate this instrument, three science teachers and two school heads acted as expert validators. These professionals were chosen because they had taught science before and knew how to observe a classroom effectively. This process ensured that their feedback was grounded in their subject knowledge and teaching experience. The Content Validity Index (CVI) was the primary method used to assess the instrument's content validity. During this process, each item on the checklist was given a score based on its relevance, clarity, and ease of testing the targeted skills [17]. The findings indicated that all three criteria achieved a CVI of 1.0, the maximum value attainable. This information showed that all the experts agreed that each standard was correct. Most experts gave scores of 4 or 5, which meant they thought the items were either relevant or very relevant, clear or very clear, and simple or very simple.

2.4. Data Treatment

The data on knowledge, skills, and attitudes were analyzed using descriptive statistics, including mean and standard deviation. For instance, the data knowledge was categorized into different interpretations based on the sum; if a teacher got 25 marks, they are considered to have a poor understanding. Additionally, graphs were plotted to visualize data on attitude and levels of conceptual understanding.

3. RESULTS AND DISCUSSION

3.1. Initial Knowledge in Smartphone-based Physics Experiments

The construct of knowledge in smartphone-based data-collection and analysis experiments included four components: Introduction to Smartphone-Based Physics Experiments (Component 1), Basics of Data Collection Using Smartphone Sensors (Component 2), Data Analysis and Interpretation Techniques (Component 3), and Classroom Integration of Smartphone-Based Physics Experiments (Component 4). The maximum score for this knowledge section is 64, consisting of 32 items.

The participants had low conceptual understanding (f = 23) of the smartphone-based experiments, followed by poor understanding (f = 23) of its content, while 5 teachers had high conceptual understanding. The analysis of participant performance revealed distinct patterns across the knowledge core components. The module on Introduction to Smartphone-Based Physics Experiments recorded the highest average score (12.0), indicating that this foundational concept was most consistently understood by the group, with relatively low variability. Component 4 had the lowest average score (6.6), indicating it was the most difficult topic for participants to grasp overall. Consequently, the grand average (37.0) fell into the "Low understanding" band, a result primarily driven by pronounced struggles with the application and data collection modules, as reflected in the substantial standard deviation.

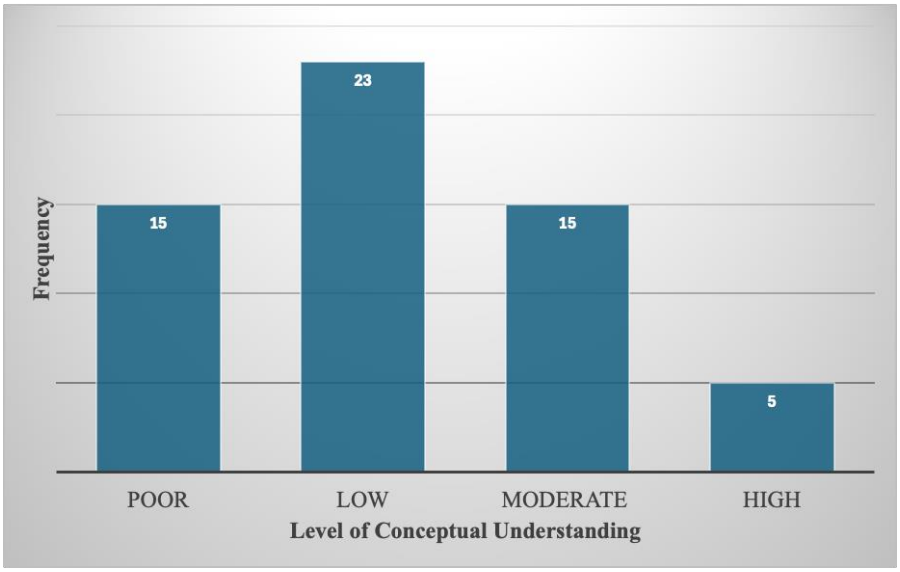


Figure 1. Participants' knowledge scores. The total maximum score of this test is 64.

Based on the item-by-item analysis, three main difficulties for the teachers were uncovered. These are connecting physics theory to practical experiments, limited understanding of the importance of repeated trials and their role in minimizing systematic and random errors, and common errors in data collection. Many teachers struggled to bridge the gap between theory and practice. The problem was not using Phyphox to get readings; it was figuring out why those specific measurements were important to the theory. A notable remark from Participant 7, *"I was confused at first about whether I should directly measure force. Rereading the paper, I realized the application only asked for pressure and area. That made me rethink the data collection process."* These statements suggest an issue with connecting the physics equation to the data collection process. The science teachers may know Phyphox, but they struggle with which variables to collect.

A second difficulty was the teachers' limited understanding of the importance of repeated trials and their role in minimizing systematic and random errors, as reflected in their low cumulative score on Item 11 *(What steps can be taken to ensure repeatable results when utilizing smartphone sensors?)*. This data indicated that teachers had yet to internalize fundamental experimental principles, including reliability, replication, and the distinction between systematic and random errors. In particular, they seemed unaware that repeating data primarily helps reduce random errors and improves the reliability of experimental results, while systematic errors require calibration or correction of the experimental setup.

Another difficulty is the common errors in data collection. Participants' accumulated score was only eight in Item 13, which asked, *"What is a common error in data collection using smartphone sensors?"* This data indicated that the in-service teachers had difficulty understanding how to collect data using the app. In corroboration with these findings, Participant 5 said, *"I was not sure about the error in the data collection using the smartphone app."* This data shows that, prior to the CPD program, participants had a limited understanding of common errors in data collection using smartphone sensors, as most participants, such as Participant 12, had attended such training for the first time.

These results align with the research conducted by Alexandros et al. [18]. They identified teachers' unfamiliarity with data collection using smartphone sensors as a significant barrier to implementing this strategy in the classroom. This framework helped to understand the low scores in the current study, not as mere ignorance, but as an indication of a larger systemic issue in the incorporation of digital tools into educational practices. They suggested that educators

initially perform the smartphone-based experiments themselves and verify the availability and functionality of the requisite sensors on students' devices. This suggestion directly addresses the themes of lack of prior exposure and technical anxiety that came up in the qualitative data. The findings revealed the importance of building greater familiarity and confidence among teachers before introducing technology into the classroom.

The third component evaluated the participants' prior knowledge of data analysis and interpretation techniques. The lowest score was in item 17 (Which type of graph is most appropriate for comparing discrete categories such as sensor types used in different experiments?). This score indicated that misconceptions were present in this area. In this section, three initial barriers to data analysis and interpretation techniques were observed. These barriers include the correct use of graphs, the detection of data errors, and the verification of data reliability.

If observed difficulties were noted in using graphs, scores were also low on item 20 (Which technique should be used to detect errors in smartphone sensor data?), with 21 accumulated marks, suggesting a low understanding or partial misconceptions. The result was echoed in Participant 19's (Individual Interview Transcript, Page 14, Line 280-281) admission that, *"Sa axes pa lang ng graph, hindi ko na napansin na walang units." (Even on the axes of the graph, I did not notice that there were no units.)* This finding suggested that teachers lacked the necessary analytical habits and procedural awareness to ensure data integrity, including checking for measurement consistency and calibration accuracy.

The last barrier in the third section, discussed in Item 22, concerned "*What to do when analyzing smartphone data: what should be done if data points are inconsistent?*" The participants only accumulated 21 marks, further reflecting a limited understanding of data reliability and error analysis. The participants struggled to recognize that inconsistent data might stem from systematic or random errors and that such errors might require statistical or procedural intervention, such as repeating measurements or identifying outliers. Participant 9 (Individual Interview Transcript, Page 18, Line 349-351) admitted, *"Na-confuse ako paano magkakaroon ng reliable data. Akala ko pag okay ang instrument, okay din ang data." ("I was confused about how to obtain reliable data. I thought that if the instrument was fine, the data would also be fine.").* These responses revealed a surface-level understanding of reliability, in which accuracy was primarily associated with the instrument rather than the experimental procedure.

3.2. Initial Skills in Data Collection, Analysis, and Interpretation in Physics

The skills part assessed how well in-service teachers can conduct physics experiments using smartphones, focusing on collecting, analyzing, interpreting, and presenting data. In the pre-test, teachers conducted a theory-based experiment using raw data from CAIE 9702 Paper 5. This involved (a) finding the gradient or slope from an equation, (b) filling out a data table and guessing how uncertain it is, (c) making a graph with error bars, (d) drawing a line of best fit, and (e) interpreting the graph.

The data presented in Figure 2 revealed a profound and widespread lack of preparedness among participants to conduct smartphone-based physics experiments. Most teachers have limited skills in conducting smartphone-based experiments. The overwhelmingly low performance was starkly summarized by the grand average score of 1.30 out of a possible 15, which fell squarely within the "Absent" skill level. This deficiency was particularly acute in the core analytical skills; the average score for "Finding Slope" was nearly zero (0.10 ± 0.31), and "Graphing" skills were similarly underdeveloped (0.20 ± 0.41), indicating that the foundational competencies required for data analysis were virtually non-existent for the majority of the

cohort.

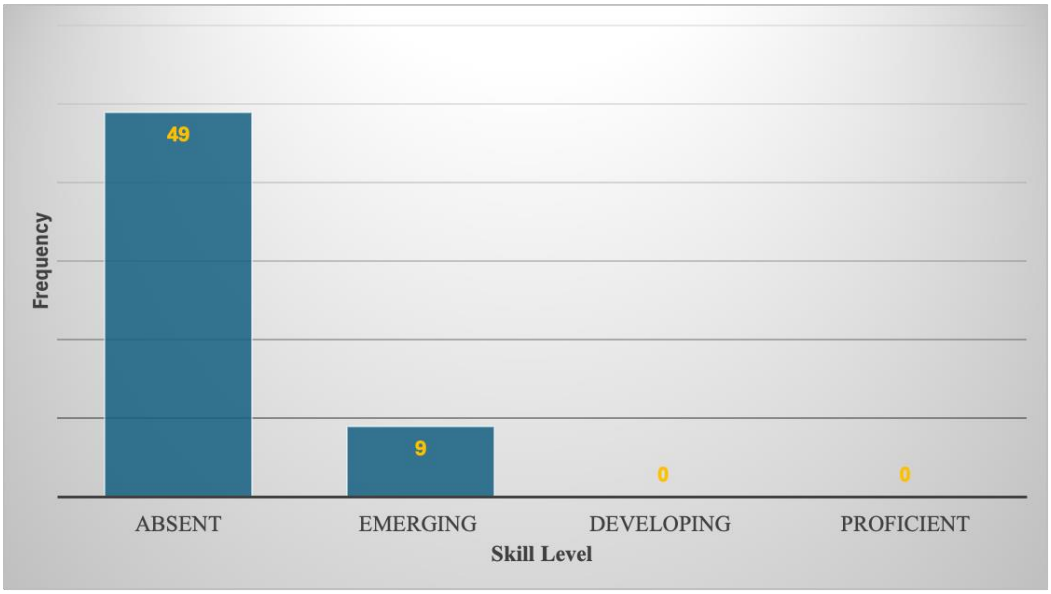


Figure 2. Distribution of participants' skill scores.

Furthermore, the high standard deviations, especially in "Completing Table" (0.65 ± 0.88) and "Analysis" (0.30 ± 0.80), indicated that while the group's knowledge was generally poor, there was notable variation. A small subset of participants (e.g., Participants 3, 8, 10, 18, and 19) demonstrated "Emerging" skills, scoring points on specific tasks. However, the fact that 75% of participants (15 out of 20) were classified at the "Absent" level confirmed that these emerging skills were the exception, painting a clear picture of a group of teachers that largely entered the CPD program without the necessary baseline skills in data handling and interpretation.

The consequences of this skills deficiency were significant. It indicated that participants might begin a CPD program lacking the fundamental skills required for data analysis and interpretation, which were crucial for the effective implementation of smartphone-based physics experiments. To follow up on this needs assessment, the program had to start with the basics and use a scaffolding approach by gradually helping participants improve at tasks from simple to more complex. Assuming that participants already possessed the necessary skills would have put them at risk of being left out and hindered the CPD programs' goals. These results indicate that teachers performed poorly overall in applying experimental skills, including computing gradients, estimating uncertainty, graphing data with error bars, and interpreting physics data.

The pedagogical implications of these deficiencies are profound. Without average or above-average experimental skills from teachers, students are at a disadvantage because they may not receive the necessary help to meaningfully interpret experimental results, which could limit their capacity to foster higher-order thinking in science classrooms [19]. For instance, without the skills to construct graphs, either in MS Excel or graphing paper, teachers cannot model how scientific knowledge is built through approximation, variability, and refinement. This skill is essential for developing students' understanding of the nature of science [20]. Instead, physics labs risk becoming confirmation-based activities, which could be said as a treasure hunt for the correct answer, rather than authentic inquiry-based learning experiences [21]. This event creates an implementation gap. Although teachers may value inquiry-based pedagogy, they are unable to enact it in practice due to limited experimental skills. Such gaps

diminish students' opportunities to experience science as an iterative and interpretive process, which is critical for cultivating scientific literacy and preparing learners to engage with real-world problems [22].

According to the participants, they were confused about how the table headings were presented. For instance, in CAIE, the presentation is in the form of quantity/unit, whereas in Philippine books, where it is also expressed as quantity (unit), such as time (s). Moreover, several teachers reported that deriving the slope from the physics equation was new to them. The qualitative data uncovered profound conceptual barriers that explained the quantitative skills deficit. For example, Participant 3 (Individual Interview Transcript, Page 26, Line 519-520) admitted, *"Nagloading anay ak hadtu pagkita kun paano answeran" ("I paused for a moment back then, figuring out how to answer it").* This statement showed that even in basic data tasks, science teachers can experience cognitive hesitation when answering. Similarly, Participant 10 (Individual Interview Transcript, Page 27, Line 543-545) reflected, *"Ang nakikita ko kasi sa books ay like time (s). So, nalito ako doon sa t/s. Akala ko edivide and time" ("What I usually see in books is just time (s). So, I got confused with t/s. I thought it meant to divide time"),* which highlighted a misinterpretation of t/s as an instruction rather than a unit label for seconds. These accounts revealed that the problem was not just procedural but also conceptual, traceable to a lack of understanding of how mathematics formalizes physical phenomena. The science teachers' misunderstanding of symbols and units showed how mathematical abstraction became separate from physical reality.

3.3. Initial Attitude in Smartphone-based Physics Experiments

Smartphone-based physics experiments are innovative methods that require science teachers to have a positive attitude toward incorporating mobile technology into instruction, as well as technical knowledge. Teaching data analysis and interpretation using smartphone applications requires that teachers feel confident and open to incorporating digital tools into the classroom.

The data in Figure 3 show that, at higher levels of the SAMR model, scores tend to be higher. For example, modifications and redefinitions have been achieved with a very positive attitude (VPA), scoring 16.7 and 17.1, respectively. The other lower levels have been scored with a positive attitude (PA), with substitution scoring 13.3 and augmentation scoring 16.7. This apparent gap suggested that teachers held an aspirational view of technology: they were enthusiastic about its transformative potential in redefining classroom practice but lacked the confidence and practical skills to implement even its simplest uses. When these findings were synthesized with the skills results, a clearer picture emerged. Teachers' struggles with plotting graphs, calculating uncertainty, and interpreting data indicated that their positive attitude toward a theoretical concept, such as redefinition, was not enough to overcome the practical and psychological barriers posed by a lack of fundamental skills. In other words, enthusiasm for higher-level integration does not translate into classroom practice when the basics remain a challenge. This implementation gap highlighted the need for a comprehensive CPD program that builds teachers' confidence and competence from the ground up, ensuring that their aspirational attitudes can be supported by the necessary foundational skills [23; 24].

In the substitution level, the mean score is 13.3 and is categorized as PA. This finding suggested that a significant number of educators initially held the view that smartphones could serve as alternatives to more conventional instruments, such as motion sensors or stopwatches. Nevertheless, several participants (such as Participants 5 and 11) received low scores in this domain, suggesting hesitancy or a lack of confidence in performing even the most basic smartphone functions. Without an extensive CPD program and practical application, encouraging and advantageous attitudes toward technology integration are often insufficient [25; 26]. Despite their belief in smartphones' potential, educators may still lack the skills to use

them effectively in the classroom.

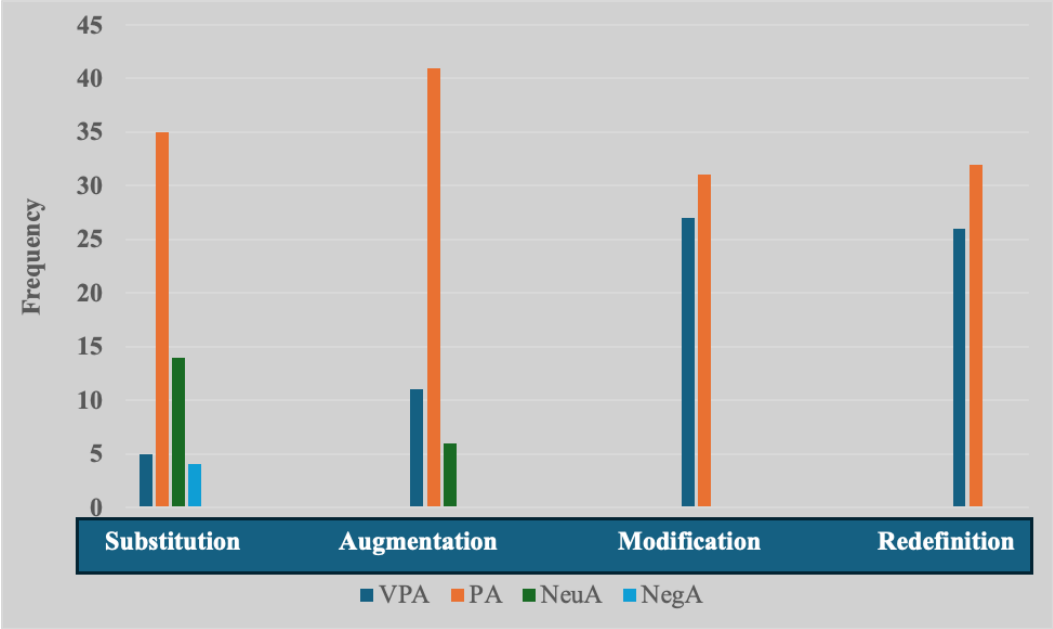


Figure 3. Distribution of participants' attitude scores. Scoring: 17–20 = Very Positive Attitude (VPA), 13–16 = Positive Attitude (PA), 9–12 = Neutral Attitude (NeuA), and 4–8 = Negative Attitude (NegA).

With an average score of 16, the augmentation level indicated a positive attitude among teacher participants even before the implementation of the CPD program. It suggested that educators were already aware of how smartphones could improve physics instruction, especially in data visualization, student engagement, and fundamental data analysis. This view aligns with that of Lazos et al. [27], who highlighted how the visualization features of smartphone applications aid students in better understanding abstract concepts.

The pre-intervention attitude was even more positive at the Modification level, with an average score of 16.7, indicating a Very Positive Attitude. This result suggested that many educators were already open to modifying their lesson plans to accommodate smartphone-based learning before receiving training. Even in the absence of official professional development, this openness shows a fundamental readiness for instructional innovation. Participants 2, 6, and 9 were among those who demonstrated an early willingness to change classroom procedures, reflecting a shift in their pedagogical perspectives. For instance, Participant 6 emphasized the transformative potential of technology by stating, *"The application of smartphone-based physics teaching will change my classroom."* Participant 9 extended this perspective by reframing the concept of experimentation itself, noting, *"Before, I thought experiments had to be done only inside the laboratory. Now, I see that the world outside is also a laboratory, and smartphones help bridge that gap."* A critical factor in the successful integration of technology in science education is a teacher's willingness to modify the instructional design, as noted by Fadilla et al. [28].

With the highest initial mean score of 17.1, the Redefinition level was also classified as having a VPA. It implied that educators were most hopeful about the revolutionary possibilities of physics experiments conducted on smartphones, viewing them as both improvements and resources to support entirely new educational opportunities. These might include opportunities for individualized learning, real-time experimentation, and genuine scientific research. Notably, some participants (for example, Participants 5 and 11) expressed high expectations for the transformative role of technology despite having lower basic substitution scores. Participant 11 said, *"It is very exciting because we all know that students today are constantly on their*

smartphones. Using smartphones during classes or experiments can capture their interest and prevent boredom, especially since it involves something important and familiar to them, the use of their own devices to manipulate and analyze data." Even before receiving comprehensive training, teachers with a positive attitude towards emerging technologies, such as smartphones, are more likely to adopt these technologies in their classes [29].

3.4 Initial Classroom Practices of Science Teachers towards Smartphone-Based Physics Experiments

The practices focused on topics such as the use of smartphone sensors in data collection (Component 1), data analysis methods (Component 2), student engagement (Component 3), and the application of experimental data in teaching physics concepts (Component 4), and were documented using a researcher-created classroom observation tool. A four-point scale rated each criterion, with 1 indicating "*Never*" and 4 indicating "*Often."* Overall, the mean rating was 1.9, suggesting that before the CPD, teachers had not yet fully integrated smartphone-based physics experiments into their classroom practices.

Table 1

Initial Classroom Practices of Science Teachers towards Smartphone-Based Physics Experiments

	Component					
Participant #	1	2	3	4	Average	Interpretation
1	2.6	2.4	2.6	2.4	2.5	Rarely
10	2.0	2.0	1.6	1.8	1.9	Never
15	1.0	1.6	2.0	1.4	1.5	Never
2	1.6	1.8	1.8	1.8	1.8	Never
9	1.0	1.6	2.4	2.0	1.8	Never
14	1.0	1.6	2.0	2.0	1.7	Never
6	2.0	1.6	1.6	1.2	1.6	Never
7	1.0	1.0	2.2	1.8	1.5	Never
17	1.2	1.8	2.0	1.4	1.6	Never
19	2.6	2.0	2.6	3.0	2.6	Rarely
20	1.2	2.8	2.8	2.0	2.2	Rarely
Average	1.6	1.8	2.1	1.9	1.9	Never

Scoring: 1-Never, 2 – Rarely, 3 – Sometimes, 4 – Often

Eleven of the 58 teacher-participants were selected for classroom observation. These teachers were selected through random sampling of the eight schools to ensure representation across different school types and teaching contexts, including public, science, and agricultural high schools.

To analyze each criterion, the average score for data collection using smartphone sensors was 1.6, indicating that few smartphone features were observed. The average score for data analysis and interpretation techniques was 1.8, indicating that these methods were not frequently used. Student engagement and interaction received a score of 2.1, a slightly higher score, which suggested that some teachers occasionally tried to engage their students. Additionally, classroom integration received an average score of 1.9, indicating limited use of these tools in lesson delivery. Moreover, only three science teachers, participants number 1, 19,

and 20, had average scores that fell within the "*Rarely"* category, with Participant 19 showing the highest overall score of 2.6. The remaining participants had average ratings below 2.0, indicating that they had "Never" practiced the targeted strategies prior to the CPD.

The pre-CPD classroom observation data were used to triangulate the findings on teachers' knowledge, skills, and attitudes (KSAs) toward smartphone-based physics experiments. This triangulation aimed to validate how the teachers' conceptual understanding, practical competencies, and attitudes were reflected in their actual classroom practices before the implementation of the CPD program.

Firstly, regarding Data Collection Using Smartphone Sensors, this was the most underdeveloped practice, with an observation mean of 1.6 (Never). This minimal application directly reflected critical gaps in both knowledge and skills. Specifically, the knowledge assessment revealed a low average score (8.4) in the Basics of Data Collection, indicating a poor conceptual understanding of how sensors work. Furthermore, this was compounded by an "Absent" skill level in practical data handling, particularly in Completing Tables (Average = 0.65 out of 5 marks). Consequently, despite a positive attitude toward Augmentation (Mean=16.0, PA), teachers' profound deficiencies in procedural knowledge and technical competency prevented them from confidently facilitating sensor-based data collection in the classroom.

Transitioning to the practice of Data Analysis and Interpretation Techniques, classroom observation showed it was also rarely observed (Mean = 1.8, Never). This was a direct consequence of severely underdeveloped analytical skills and conceptual knowledge. For instance, the skills test showed near-zero proficiency in Finding Slope (0.10 out of 1 mark) and Graphing (0.20 out of 4 marks), meaning teachers could not transform raw data into graphs or perform basic quantitative analysis. Similarly, the knowledge test confirmed a weak understanding of Data Analysis Techniques (Average = 10.5). As a result, even when teachers held very positive attitudes toward transformative activities (Modification and Redefinition), they lacked the fundamental ability to guide students in interpreting data or linking results to physics concepts, making such activities impossible to implement.

In terms of Student Engagement and Interaction, the observed level was low (Mean = 2.1, Rarely), primarily hindered by teachers' lack of practical skills. Although teachers held positive-to-very positive attitudes across all SAMR levels, indicating a strong philosophical belief in student-centered learning, they could not act on it. Specifically, their inability to reliably collect data or interpret results led them to default to teacher-centered demonstrations. Therefore, the gap between their aspirational attitude and their minimal classroom practice underscores that positive beliefs are insufficient without the foundational skills to create engaging, hands-on learning experiences [30].

4. CONCLUSION AND PROSPECT OF FURTHER RESEARCH

When we began this research, we wondered whether teachers in a resource-constrained context like the Philippines would be ready to embrace smartphone-based experimentation. The answer, we discovered, is both encouraging and sobering. Our teachers want to innovate. Teachers' attitudes towards the future use of smartphones in their lessons and experiments were positive, particularly at higher levels of the SAMR model. They can envision a classroom where students use their own devices to collect real-time data, where experiments extend beyond laboratory walls, and where abstract physics concepts become tangible through hands-on exploration. This aspirational mindset is a gift, one that any professional development program should cherish and nurture.

However, our findings also revealed a difficult truth. When we assessed teachers' actual knowledge and skills, we found profound gaps in the fundamentals. This meant that enthusiasm,

however genuine, cannot bridge the gap between aspiration and implementation. Most of the teachers had difficulty connecting physics theories to their real-world applications. For example, the use of repeated trials, the recognition of common errors in data collection, and the interpretation of graphs. The skills assessment painted an even starker picture: most teachers entered this study unable to calculate a slope from experimental data, construct a graph with error bars, or draw meaningful conclusions from the numbers their smartphones might generate. These are not minor gaps; they are the very foundation of authentic inquiry-based learning.

What we saw in classrooms was the most illuminating. Teachers were not incorporating smartphone-based experiments into their practice, despite their positive attitudes toward them. The "never" ratings across almost every observation component revealed something crucial: even the most ardent beliefs about technology's potential cannot be put into practice when teachers lack procedural knowledge and technical confidence. Our documentation of the implementation gap indicates a lack of preparation rather than a lack of will.

This study clearly shows that teachers require more than support or philosophical alignment with technologies, such as smartphones. They require methodical, scaffolded assistance that starts with the fundamentals and purposefully advances toward the transformative practices they hope to attain. A CPD program based on these findings cannot presume prior knowledge of data collection methods, ignore the distinction between random and systematic error, or skip the fundamental skill of helping teachers build confidence in their ability to interpret their own experimental results before asking them to help students do the same.

Therefore, the way forward is simple, but it calls for intentionality and humility. Our educators have demonstrated their current situation and their needs. They lack a roadmap, but they have a vision. That roadmap can be provided by a carefully planned CPD program that addresses the particular gaps identified by this study. It can respect educators' goals while providing them with the practical skills those goals require. It can make smartphone-based physics experiments commonplace, allowing Filipino science teachers to provide their students with real, interesting, and meaningful physics experiences even in schools with limited laboratory resources.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors used Grammarly to enhance the grammar and syntax of this article. Other than that, we declare that we did not use any form of artificial intelligence to generate or improve the results and discussion.

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CONFLICT OF INTEREST

The authors declare that there is no financial or non-financial conflict that could intervene in the results of this paper.

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ГОТОВНІСТЬ І ПРАКТИКИ ВЧИТЕЛІВ ПРИРОДНИЧИХ ДИСЦИПЛІН У ВИКОРИСТАННІ СМАРТФОНІВ ДЛЯ ФІЗИЧНИХ ЕКСПЕРИМЕНТІВ

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Анотація. Розвиток технологій смартфонів приніс чимало переваг у багатьох галузях. У сфері освіти вчителі ще не в повній мірі впровадили їх у свою навчальну діяльність, що вимагає від них відповідної підготовки. У цьому дослідженні, проведеному з використанням змішаних методів, було проаналізовано знання, навички, ставлення та педагогічну практику 58 випадково відібраних діючих вчителів природничих дисциплін з державних середніх шкіл регіону Східні Вісаї на Філіппінах, які проводять фізичні експерименти з використанням смартфонів. За допомогою валідованих та надійних інструментів у цій статті було виявлено розбіжність між позитивним ставленням учителів до впровадження смартфонів та їхніми практичними й теоретичними знаннями та навичками. Більшість учителів мають низький рівень концептуального розуміння (f = 23) експериментів з використанням смартфонів і зазнають труднощів із застосуванням навичок збору, аналізу та інтерпретації даних. Ще більш гострою проблемою виявився брак практичних навичок серед опитаних учителів. Середній бал учителів становив лише 1,30 з 15, що відповідає рівню «відсутність навичок». Під час спостережень за уроками ці висновки підтвердились: використання смартфонів на уроках природничих дисциплін спостерігалось рідко або взагалі не спостерігалось. Якісні дані свідчили про те, що вчителі були справді збентежені такими фундаментальними поняттями, як повторний збір даних, представлення одиниць виміру та побудова графіків. Ці результати свідчать про те, що припущення щодо початкового рівня підготовленості вчителів не можуть слугувати основою для розробки ефективних програм безперервного професійного розвитку. Натомість безперервний професійний розвиток повинен починатися з основ, із застосуванням методів «скелетоутворення», які розвивають компетентності та впевненість у собі з самого початку. Навіть найзахопленішим педагогам буде важко перетворити свої ідеалістичні уявлення про технології на корисні освітні можливості для своїх учнів, якщо ці фундаментальні прогалини не будуть усунені. Ця оцінка потреб забезпечує доказову базу для створення цілеспрямованого, корисного професійного розвитку, що відповідає поточній підготовці вчителів.

Ключові слова: експерименти зі смартфонами; підготовленість учителів; аналіз потреб; безперервний професійний розвиток; грамотність у роботі з даними; дослідницьке навчання.



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