Physics Teachers' Conception of a Supportive Learning Environment

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Abstract
The 2018 result of the Programme for International Students Assessment (PISA) shows below-average Filipino students' scientific literacy. Trends in International Mathematics and Science Studies (TIMSS) show the same result even after implementing the country's revised basic education curriculum. These findings from international assessments call for an analysis by researchers and policymakers to explore the possible interplay of curricular variables contributing to the Filipino students' challenged scientific literacy. This research article seeks to account for Filipino physics teachers' experiences and exposition of their patterns of thoughts regarding critical aspects of classroom instruction. Physics teachers from various provinces participated in a semi-structured interview, and their responses were subjected to thematic analysis. The results reveal several factors that contribute to deter the achievement of quality physics classroom instruction. Practitioners in the field cited critical factors that must be considered and subject to continual study to create educational policy support.

Keywords: Physics Education Challenges, Improving Physics Education, Physics Teacher's Experience, Successful Physics Classroom

Introduction

The low student achievement in Physics of Filipino students is not a new trend in Philippine education. Local studies have long documented this physics education dilemma (Orleans, 2007). International evaluations on the quality of science, mathematics, and reading of Filipino students enrolled in basic education, such as the International Association for the Evaluation of Educational Achievement in 2004, were reported below the international standards threshold. The latest 2018 Programme for International Student Assessment (PISA) result shows that Filipino Students' Mathematical and Scientific Literacy falls below the average standard set by the Organization for Economic Cooperation and Development (OECD). Department of Education (DepEd), as the countries' primary basic education institution, is very keen on recognizing the relevance of PISA and TIMSS's results. In its official statement, the institution (DepEd) has assured the public of its introspection into the gaps and issues hindering the acquisition of the country's quality basic education. These international assessment results provide a fertile ground for introspection by educational researchers, practitioners, and policymakers. It is important to note that a comparison between the international competencies measured by TIMSS and the local competencies as stipulated by the K-12 curriculum showed remarkable disparity (Balagtas, et.al., 2019). In the sciences, competencies included in the assessment done by TIMSS were not present in the curriculum for that grade level but are present for the next grade level. Hence, it comes with a minor surprise that the evaluation would yield poor results. Equally important is the research's context of secondary education curriculum and not on primary education curriculum. Only primary education participated in the latest TIMSS and not the high school.

A complete understanding of this phenomenon is inarguably not a straightforward task. It possibly involves complex factors and complex relationships among variables that consequently led to the country's below-average performance in mathematics and scientific literacy. It is noteworthy that the Philippines transitioned from its 10-year basic education to 12-year basic education in 2013. With the Department of Education's ardent hope, its participation in the 2019 TIMSS could gauge the effectiveness of this new enhanced 12-year basic education curriculum and its delivery system. Moreover, this descriptive research aims to provide an introspection to the dynamics inside the science classrooms and the teaching-learning process. The problem of curricular competencies disparity between international assessment and our local curriculum is not the focus of this study. However, we have set our research on how our teachers are doing concerning the acquisition of our local curriculum. Setting the lens of our analysis on the actual classrooms will provide us with a perspective on the actual dynamics of teaching and learning and rid ourselves of the preconceived conceptions explaining science and mathematics achievement's status quo. The analysis is centered not on the intended or written curriculum such as that of Balagtas, et.al. 2019 but will focus on less looked upon aspects of the curriculum. These curricular aspects may be unknown to the researcher and will be deducted from the qualitative data through thematic coding.

In gathering the qualitative data, the semi-structured interview is purposively utilized to allow a maximum degree of freedom for the teachers to express their patterns of thoughts over the open-ended questions. In this manner, the researchers can directly probe into implicit reasoning in their responses and allow a thorough exposition of the teachers' viewpoint, reasoning, and thought patterns over critical questions on their classroom experience. This research article will allow researchers and science educators a radical exposition of the lived experiences of the physics teachers and their viewpoint on critical issues affecting the Philippine basic education classroom.

Methodology

Data

Several teachers were sent letters of invitation to participate in the study along with the consent form explicitly stating the extent and nature of their involvement in the study and how their anonymity is secured. Among them, eight in-service physics teachers responded positively and undertook a semi-structured interview. The minimum inclusion criterion is that the teacher respondents must have taught physics in secondary schools for at least two (2) years. This ensures that they have an experiential grasp with which they will base their responses on the question. Moreover, this ensures that they have mandatorily undergone the Teacher Induction Program (TIP) by the Department of Education (DepEd). TIP is an institutionalized continuing professional development program designed to provide a comprehensive and systematic support system for teachers from 0-3 years of experience (DepEd). The teacher respondents' range of teaching experience ranges from 2 years to 11 years. Three (3) of which have master's degree in Science Education, four (4) are working with their master's degree, and one (1) bachelor's degree. They are scattered in three adjacent provinces in Mindanao, and the schools with which they are affiliated include rural and urban settings. Each of them is coded as follows [ISTI1,…, ISTI8], which means In-service teacher 1 and so on.

Instrument

The interview questions were carefully drafted and deliberated among the authors to ensure no leading question and the questions are as open-ended as possible. In the interest of probing into the implicit reasoning of the participants' responses to the questions, a semi-structured interview is fitting to exposit their patterns of thoughts to allow a more significant opportunity for expression.

Data Analysis

Recorded interviews were transcribed for qualitative analysis. The authors carefully read through individually transcribed interview responses, and anecdotes were taken. Individual anecdotes were further summarized in the second analysis cycle based on individual responses to the open-ended questions. In the third analysis cycle, patterns were deduced from their individual responses. When individual patterns were deduced from individual interviews, it is compared among the eight (8) responses to see which themes are interlinked and supported across the responses. This leads to the figures in this study that synthesize the themes from the quantitative analysis of data.

Findings and Discussion

This section deals with the discussion of the interview responses on the conducted semi-structured interview with in-service teachers. This will provide us with an overview of the challenges encountered in physics instruction, the skills they deemed essential to develop in the students, and how each of these constructs is related to each other. Although the sample cannot be taken as a complete representation of the population due to its small sample size, it can describe the in-service teachers' statuesque. This can serve as an essential piece of information that could help direct interventions and support that is aimed with their context.

1. Teachers' Conception of a Successful Physics Classroom

The teacher-respondents show a consensus that a successful physics classroom is tied with sufficient hands-on instrument. It is essential to point out that what they mean by an instrument is solely referring to "laboratory equipment" and less on other instruments such as computers, televisions, and projectors. It is also noteworthy that this is a typical response for both local and urban schools. This agrees with the belief that Physics is a discipline founded on a conceptual basis but is grounded on experimentation (Ince et.al., 2015). The emphasis is heavily stressed on the hands-on instrument and is evident in their responses, which could be evidence of its lack. Studies reveal that material insufficiency is one of the frequently experienced challenges in teaching Physics through hands-on methods. Consequently, teachers' rate of experimental application in class is meager (Onyesolu, 2009). To quote one of the verbatim responses of ISTI7, "It is very hard to let them understand if you will not use experiments. If you just keep on talk and talk, it is in vain, the students will not understand. You should be able to visualize and do hands-on. It is also documented that insufficient funding for equipment and supplies is the most severe concern for the secondary physics teachers (Tesfaye & White, 2007). This study is in the context of a U.S. classroom, a more affluent country in terms of financial resources. Suppose material and fund insufficiency persists on this country. In that case, it does not come as a surprise that it is also among the challenge grappled in developing countries, such as the Philippines.

Although the interviewed in-service teachers utilize alternatives such as simulations, videos, localized demonstrations, and materials, they use these to ameliorate the lack of a hands-on instrument. After analyzing the interview transcripts and how they respond to the questions, alternatives are their last resort. It could be avoided if hands-on equipment in Physics is available.

In addition to the necessity of instruments for a successful Physics classroom, the utilization of rich-activities in the classroom is another defining attribute of a successful Physics classroom. National Science Teacher Association (NSTA, 2007) highlighted the role of hands-on activities in improving students' acquisition of science skills and sustained interest. The respondents uphold the firm belief that interactive activities are indispensable for an ideal physics classroom. Moreover, in-service teachers argued that these activities must be anchored on real-life daily experiences of the learners. This allows students to easily relate to the learning material and be actively engaged since it is within their grasp of reality. They claimed that even abstract topics must be crafted with an activity that is relatable to the students, although they conceded that it is not always possible. The utilization of rich-activity such as laboratory experiments is one efficient means of comprehending complicated and abstract theories more straightforward with greater clarity (McDermott, 2001). The extent of real-life application is limited to the way activities are designed and the regular daily conversation of the students.

A respondent stressed that it is a mark of success in Physics instruction when the taught concepts are seen in the learners' daily conversational dialogues. This means that the students recognized the mechanisms and physics principles at work as they observed their immediate surroundings and experiences.

Aside from these, respondents also expressed the need for innovative pedagogy. Innovative pedagogy is vital since the teacher who serves as a facilitator must be cautious in designing the learning environment. They argued that instruments and activities are rendered useless unless the teacher employs innovative pedagogy. Hence, it veers away from the traditional chalk-and-talk technique, which involves computer technology in instruction. As Edgar Dale pointed out in his second revision of the cone of experience in 1954, a teacher must consider carefully planning and using media in classroom instruction to create a rich learning experience. Dale describes a rich learning experience as a learning experience that revolves around more concrete level activities and considers the interplay of concrete and abstract levels depending on the classroom's need and the nature of the learning task (Garrett, 1997).

2. Skills Teachers' Deemed Most Important

Norris and Ennis in 1989, defined critical thinking as rational thinking that is focused on decision making what to do and what to believe (Garcia, 2015). In a psychological context, it is defined as "the mental process, strategies and representations people use to solve problems, make decisions, and learn new concepts" (Sternberg, 2000; Lai, 2011). Critical Thinking is the most commonly cited skills by the respondents. It is reported that this is one of the skills where Filipino students are having difficulty with (Marquez, 2017; Ramos, 2018). The Manila Times article in 2018 shows the decline of Filipino critical thinking from an already low base. Researchers attributed this to the rote memorization present on the schools' pedagogy. Teachers' challenge in the students' critical thinking spans students' logical understanding of solving word problems, following logical inferences in a word problem, and rational decision-making in solving students' problems. On a more modest scale, teachers documented that simple analysis of video and simulations poses challenges to some learners. Hence, these teachers practice modifying the questioning patterns in the activity and simplifying what is meant to facilitate the learners' analysis and comprehension. Although it was reported to provide promising results in the students, the teacher's instructional time is consumed.

Equally important is the skill of comprehension. In our context, respondents define comprehension as understanding the written texts, analyzing the given variables, and what is asked. Comprehension primarily needs the students' ability to read sentences and make sense of what they are reading. Although relatively few, students who have not fully mastered the reading skills have reached high school. One respondent admitted that the result of Phil-IRI (Revised Philippine Informal Reading Inventory) in their school revealed that they have high school students who are non-readers. Phil-IRI is an assessment tool utilized by the Department of Education (DepEd) in measuring and gauging students' reading performance. DepEd recognizes literacy improvement as a pressing concern for the country's education and has launched its flagship program, "Every Child A Reader Program" in 2017. Although these studies do not claim representation of the country's population, evidence from interviewed teachers that the unmastered reading skills are persisting even in high school. Logically, the development of comprehension skills is hampered and rendered impossible because of the students' very fundamental problem of reading readiness.

In addition, to aid in the achievement of comprehension is the need for hands-on manipulation. According to the physics teachers, this is one of the most stressed attributes of a successful Physics classroom. The hands-on manipulation anchored on real-life situation activities leads to an easier understanding and appreciation of a concept. This is similar to McDermott's statement in 2011. A rich-learning activity such as a laboratory experiment is one efficient means of making the comprehension of complex and abstract theories simpler and more straightforward. Moreover, the skill of hands-on manipulation can be supported by the use of technology and computers. Most of the high-end laboratory equipment today utilizes computers to manipulate, gather, store and analyze data. Hence, basic computer skills are an essential skill in this technology-driven age in our educational context. Physics teachers have utilized PhET simulations and localization whenever an actual physics instrument is non-existent in the school. The use of simulations is their means of providing a closer experience to the real thing.

Numeracy is also an essential skill that must be developed in the learners. It covers basic arithmetic operation, upgrading to algebraic manipulation, and its application in Physics contexts such as formula manipulation and problem-solving calculation. The majority of the respondents argued that the basic arithmetic skill is a fundamental skill that should have been developed before entering high school. However, this is not the case, and it further complicates the achievement of the curriculum's intended learning outcomes, especially on competencies that require mathematics skills.

Overarching the core skills such as critical thinking skills, comprehension skills, and numeracy skills is problem-solving. Problem-solving, which is reported as an essential part of teaching Physics by the respondents, needs the development of critical thinking, comprehension, and numeracy as prerequisite skills. Thus, it poses a significant challenge for a teacher employing problem-solving in Physics when either one or all of these prerequisite skills are unmastered or underdeveloped. This relationship can be illustrated in the figure below.

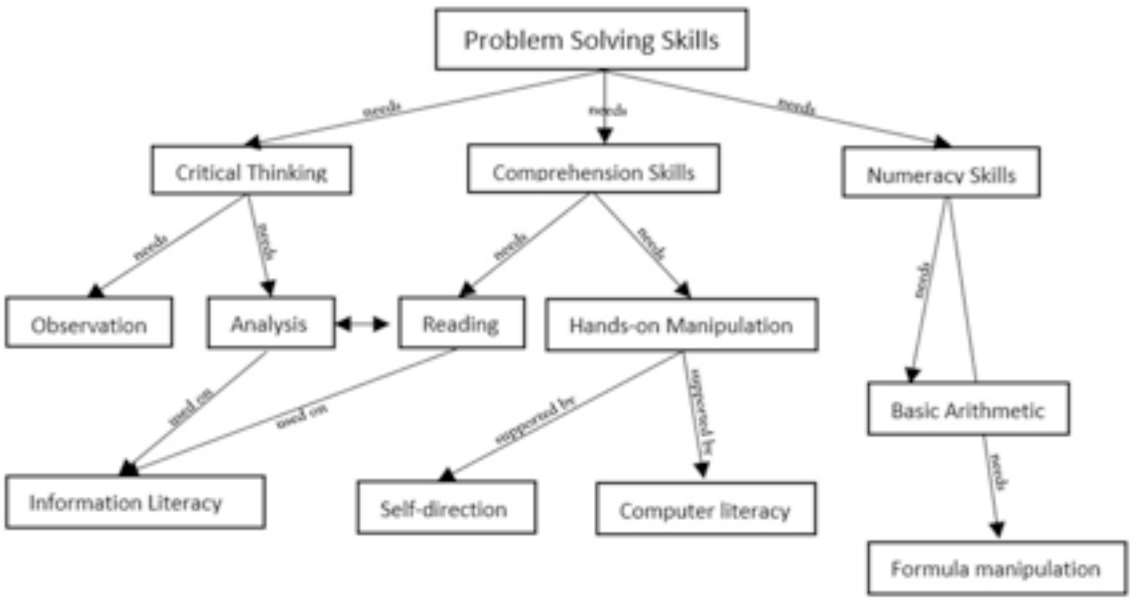

Figure 1: Necessary Skills To Be Developed

Challenges Encountered in Teaching Physics

The challenges met by the respondents can be summarized into four (4) broad categories. These are literacy, numeracy, facilities, and real-life application. This is reflected in the figure below.

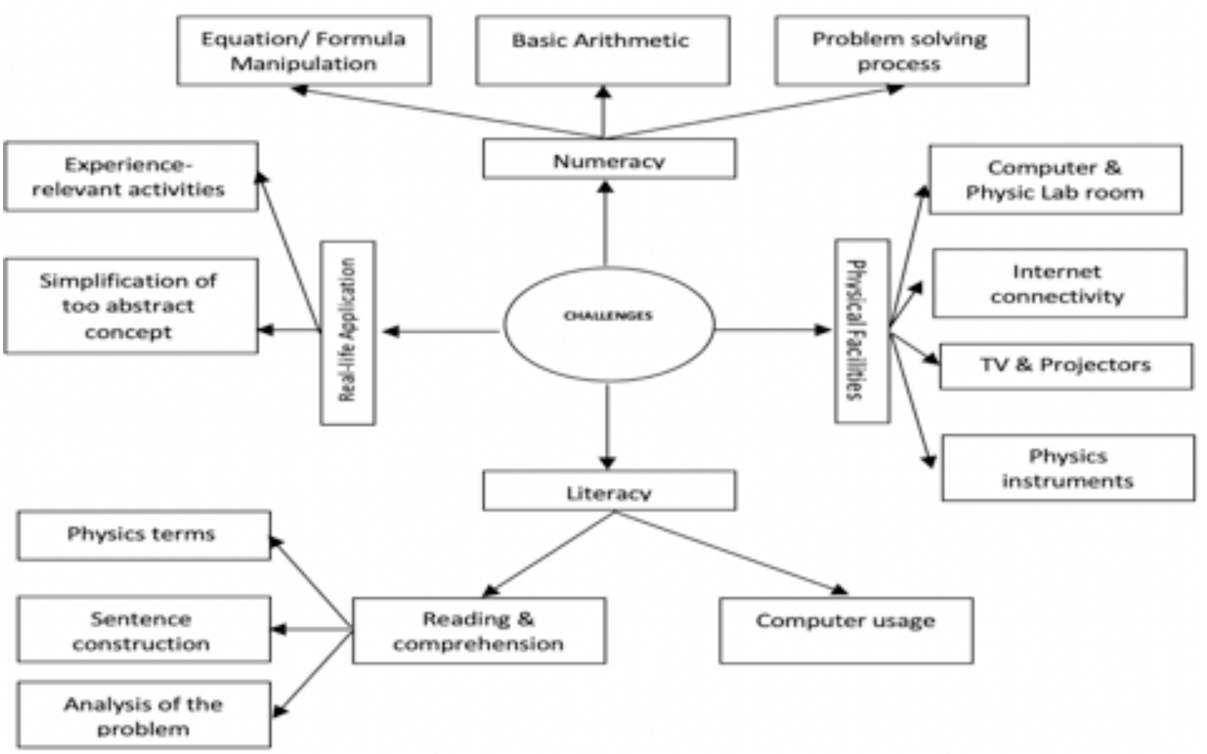

Figure 2: Challenges Met in Physics Instruction

All of the respondents experience the challenge of unmastered numeracy skills. The numeracy challenge covers basic arithmetic, manipulation of formulas or equations, and the standard process of solution generation. One extreme example is reported for a Grade 12 student who cannot perform basic division [ISTI7]. It is also documented that students cannot add simple fractions even in Grade 10 [ISTI5]. Although a generalization should not be made, most of these cases are isolated to hinterland schools. Urban school communities experience the problem but relatively mild compared to the hinterland school community. This means that this problem persists for Grade 7, but as grade level progresses, it becomes less and less of a problem. On the justification of hinterland school communities, a possible reason for very low numeracy is cited by one respondent [ISTI3] who said that her students' priority is on farming and providing for their basic needs. Hence, education is regarded as a less priority.

On equation and formula manipulation, it is reported that students find it challenging to manipulate the arrangement of variables in an equation to get the desired arrangement depending on what is asked in a problem. It is also related to a documented case, where students know the equations to be utilized but are clueless on how to proceed or where to start. Even identifying variables such as initial pressure and final volume is still a challenge for some high school students. Consequently, the process of solution generation in arriving at an answer is a challenge for the learners.

In literacy, it is divided into two: reading comprehension and computer literacy. Although it is reported to be very few in a classroom population, students who cannot read are present in every sampled school community. As reflected by a Philippine-classroom context study, “students exhibit struggles in understanding the concepts of science as well as exercising the skills needed to be a proficient reader” (Imam et.al., 2014). The respondents report that the reading comprehension challenge's nature is on understanding the sentence and the technical terms involved in physics. Consequently, teachers allocate extra time, which could have been used for other purposes, just to refine and simplify their way of delivering questions, simplify the instruction, and even to the point of vernacular translation.

Surprisingly, it is reported that when a vernacular translation is used, the students can arrive at the solution. This means that the problem is really comprehending the word problem in the English language and not the word problem itself, as is claimed by [ISTI7, ISTI6, ISTI2]. Problem-solving of Filipino-English bilingual students suggested that the difficulties that the students experienced in understanding arithmetic word problems are possibly magnified for students who have to solve the word problem written in their second language (Bernardo, 2002). This leads to the teachers to simplify the problem whenever possible and avoid the use of unfamiliar terms. Also, visualization of the problems or concept through sketches is a useful tool to understand better. This is also done to avoid misconceptions generated through an individual's own imagination of the concept.

Computer illiteracy is also reported for the majority of the respondents. Even the operation of turning on a computer and basic encoding is already a challenge for many students. This is supported by the data gathered by South East Asian Ministers of Education Organization-Innovation and Technology (SEAMEO INNOTECH) Philippines in 2001 where among the 45, 811 schools, only 14.28% or 5, 217 schools have computers, 18.24 % of the schools have proficient staff in terms of computer use and a minute 13.13% have schools' heads with ICT training in the last five (5) years (Bonifacio, 2013). These challenges faced by the teacher can be attributed to the lack of computers at home, and their use in school is deprived due to the absence of computer labs, or if there is, it is allocated for the use of a specialized strand or subject. However, it is reported that even in the hinterland school community that uses solar panels as an energy source, the wide use of android phones. The respondent estimates that 80% of his class has a mobile phone supported by the android operating system.

Facilities in schools is one of the highlighted problems by the respondents. This includes the insufficiency of physics laboratory instruments, physics laboratory rooms, computer laboratory, computer and internet access, T.V. and projector. Insufficiency of physics laboratory instrument is the primary concern of the respondents. They reported an insufficiency of available resources that they can use in teaching specific concepts in Physics. A similar observation in a Philippine classroom is documented.

"The lack of advanced laboratory materials and equipment also exacerbate the poor condition of teaching-learning process and the insufficient resources of a teaching tool, techniques, and strategies in science aggravate the difficulty to achieve the desired skills and competencies". (Linog et.al., 2013, p.47)

Moreover, the lack of hands-on approach deprives the students of collaboration, which may facilitate peer-learning (Scheckler, 2003). As a resolution, they resort to the use of simulation and videos instead. It is clear from their manner of answering that they prefer the actual tangible physics instrument over the "sensually-limited" simulations and video. This is reflected in their view of a successful Physics classroom as highly facilitative of hands-on learning. The use of simulation and video is also far from ideal because of the lack of computers to cater to individual students. Although Dep-Ed has provided tablets in the two hinterland schools where our teacher respondents are currently teaching, it is not readily available for the former school; the latter school has an issue of 9 tablets allocated for 23 students. As a result, very few of the students can readily participate in the actual manipulation of the simulation. Moreover, a worst-case scenario was reported where the teacher [ISTI3] just showed a video or simulation on her laptop towards 37 students. According to her, that set-up was not ideal for students, but it is the best they can do with the state of their resources.

The final challenge cited is on real-life application. The respondents find it challenging to create an activity relatable for the students who have experienced it first hand. They also noted that some aspect of the concept is too abstract and contains too much idealization or assumption which is not the case in an actual situation. Laboratory experiment utilization is a viable suggestion for practice (McDermott, 2001). However, lack of instruments is a problem that is currently experienced in almost every interviewed respondent. One teacher's [ISTI1] initiative in letting them experience projectile motion in the real-life application allows her students to play volleyball. She noted that it is a very crude experience compared to the theoretical aspect of projectile, where one can easily manipulate the projection angle. In real life, that is simply too complex to do. In terms of too complicated and too abstract Physics concepts, they reported having the most significant challenge in simplifying the activity and crafting it so that students have an experiential grasp of the concept presented in an activity.

Conclusions

The study results reveal that the challenges faced by Physics teachers can be broadly categorized into literacy, numeracy, physical facilities, and real-life application. Among others, the availability of instruments in teaching Physics is one of the most stressed defining attributes of a successful Physics classroom. However, it is also where the teachers find most challenging to acquire in their school localities. Classroom instruction in Physics is significantly deterred and affected because of this persisting problem in public schools. In addition, literacy and numeracy challenges and the lack of physical facilities further amplify the current dilemma. If unaddressed, it will continue to impact the quality of science education in the country negatively. It is also important to point out that the ideal classroom that the teachers defined is also the same thing that they find challenging in their practice given the current state of educational support from the government. In technological resources, laboratory materials, learning spaces, and teaching aids, a supported curriculum is a determining factor in impeding instruction's successful delivery. The study's result also showed that the skills deemed necessary by the teachers in a science classroom are the same set of skills that they are having difficulty developing. This is interesting because it reveals that the teachers in their classroom instruction are deeply aware of the set of skills needed by their students, such as critical thinking, numeracy, and comprehension, yet have a hard time developing these skills. Future quantitative studies are suggested to look for correlation, if there is, between the level of supported curriculum and these skills' achievement. Also, cross-analysis on how these cited challenges mediate the result of skill acquisition is promising for research exploration.

Suppose the Philippines basic education sector envisions the improvement of science literacy. Focused attention must be addressed to the teachers' challenges, such as literacy and numeracy problems of high school students, which should have been developed in early elementary education. Government support on providing laboratory equipment in every classroom should be of prime importance since this is one of the hallmarks of a successful physics classroom as defined by the teachers. Relevant training and ongoing professional development should also be implemented to allow teachers to apply promising innovative pedagogy such as STEM education that is timely and relevant. Consideration should be in mind such that they are provided support and training towards developing those necessary skills that they find challenging to develop in their students.

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