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Perceptions of a – level physics students and teachers on the effectiveness of online physics teaching and learning

Abstract

Compelling evidence why physics should be effectively taught at secondary school level, include its use in the universe to find solutions to daily life challenges. Physics education prepares secondary school graduates to proceed with the study and application of science to explore the universe, as well as being productive members of diverse socio – economic sectors of any nation. Understanding Physics and developing skills that allow students to be responsible citizens in promoting sustainable development depends on how physics education is taught. While interaction between classmates, and students and teachers is important, but with the advent of the COVID – 19 outbreak the learn from home policy which many countries adopted, suspended face – to – face learning, giving way to physics online learning as a combination of synchronous and asynchronous distance learning. This study sought to explore A – Level physics learners' and teachers' perceptions on the effectiveness of online physics teaching and learning. Semi – structured interviews with purposive sampled A – Level physics learners (PLs) and physics teachers (PTs) were used to collect data. Findings from the study show that if online physics learning is to be successfully, then it should be implemented blended with face – to – face learning. However, ways to support those learners disadvantaged financially to afford data to remain internet connected, should be put into place so that every learners benefits. The study has shown that not all physics concepts can be taught effectively through online strategy, therefore physics syllabi should clearly spell out areas which can be taught online and those which are mandatory to be taught face – to – face.

Keywords: Online learning, physics education, effectiveness of online physics learning

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Introduction

There is a lot of compelling evidence why physics should be effectively taught at secondary school level. As a field of science, physics is applied related to events that we use and observe in the universe enabling solutions to daily life challenges to be found. This essential role of physics has caused significant increase in physics courses taught and applied in schools.[1] Physics education is important for preparing secondary school graduates to proceed in the study and application of science to explore the universe, as well as being productive members of diverse socio – economic sectors of any nation. During learning physics, learners develop critical thinking skills consistent with pursuant of creating science knowledge, keeping track of technological changes, and understanding and interpreting events occurring in nature. Although online learning is being integrated in physics education, students attend physics classes under the impression of their previous knowledge, attitudes, beliefs and values. Opinions and prejudices involving scientifically inaccurate thoughts may develop from these previous learning experiences, as well as from the current teaching and learning process. Conceptual learning and teaching of physics is made challenging by these factors.[1]

However, due to its essential role in exploring and understanding the universe, physics education need to be implemented with the view to achieve sustainable development goal (SDG) number 4, which seeks to ensure effective learning and acquisition of relevant knowledge, skills and competencies. Educational objectives for strengthening learners' knowledge and skills required for sustainable development are outlined in sustainable development goals (SDGs) vision specifically SDG 4 agenda for inclusive and equitable quality education for all learners. In this regard Physics Education (PE) bears real great potential for opportunities to engender sustainable development.[2] In addition to fostering high – ending reasoning skills and students' scientific literacy competencies,[3] notes that PE produces technically literate, skilled workforce to support sustainable development.

Physics teachers have been observed in Malaysia to focus on provoking students' interest and curiosity in physics as means to boost enrolment in PE. In this vein physics teachers were observed to utilise various hands – on activities, inquiry – based experiments and simulation aiming promote more students participation by nurturing deep and meaningful learning.[4] While physics teachers are acknowledged to play significant roles towards meeting SGD 4 targets through quality PE,[5] teaching practices among physics teachers are greatly influenced by their perceptions. For instance teachers with positive sustainable development views reflect greater inclination and aptitude for sustainable physics education.[6] In addition, experienced physics teachers have been found through research to express more preparedness to integrate sustainable education in physics teaching than novice physics teachers.[3] However, some researchers have reported physics teachers' difficulties in implementing pedagogical and curriculum practices.

The relation between PE and sustainable development goals

Sustainable development in the social context as the capacity / ability of society or system to meet needs of all citizens, without compromising the ability of future generations to meet their own needs. Scientific and technological expansion has caused a lot of improvement in the quality of human life, but again the attendant detrimental effects of technology have adversely affected the global

environment. Education is recognised as crucial in most if not all the 17 sustainable development goals (SDGs). The critical role of education in achieving SDGs was affirmed at the United Nations World Summit in Johannesburg in 2002 by stressing the need to reorient current education system towards achieving SDG 4 through provision of quality education.[28] Promotion of sufficient knowledge mastery and skills among students to support sustainable development is one of the key targets of SDG 4.[7] The role of physics education in achieving SDGs is hinged on one hand in physics teachers' facilitation of learning, and on the other how students perceive the effectiveness of strategies used in physics teaching and learning. Understanding Physics and developing skills that allow students to be responsible citizens in promoting sustainable development depends on how physics education is taught.[2]

Physics teachers' perceptions of PE

Physics is perceived by students to be difficult,[8,9] which causes lack of motivation to learn physics. Therefore, when using new teaching and learning strategies like online learning, physics teachers should demonstrate good pedagogical content knowledge (PCK) so that learners are motivated. Effective use of new physics teaching and learning strategies depends on the physics teacher's preferred instructional design or PCK in relation to their perceptions on PE.[10] As posited by[11] PCK is crucial in connecting the teachers' knowledge of subject matter with teachers' understanding of teaching the content. There is a plethora of research reflecting the perception that physics is a difficult and demanding subject among students.[2,12,13] Also physics teachers' problematic teaching experiences have been reported,[14] as high workload, inadequate professional development training on physics pedagogy, insufficient equipment and laboratory facilities,[15] as well as limited internet access.[16-18] Teachers' low level competences in information and communication technology, have been noted to influence selection of instructional strategies, and contributing to low quality of learners' achievement in physical science.[19,20] Understanding specific physics concepts like electrostatics seems difficult due to their abstract nature.[21] Most physical science teachers are said to either underuse or do not learn innovative instructional strategies that can complement their teaching to improve learners' 21st century skills and knowledge.

Mobile learning transformation is not simply delivering content through mobile devices,[22] but a process of being able to operate learning platforms through mobiles devices in new and ever-changing contexts or learning spaces to deepen student learning.[23] Until recently teachers have been using technology like powerpoint for demonstration or presentation of information rather than as a pedagogical content tool,[13,24] which suggests that their competences in online teaching and learning may be low.

COVID – 19 pandemic outbreak and physics online learning

COVID – 19 outbreak negatively affected education at all levels. Based on European Union and UNESCO data, by February 2020, 191 countries had suspended face – to – face learning at all levels, affecting 1,5 billion learners.[25,26] Subsequently suspension of face – to – face learning gave way to online learning as a combination of synchronous and asynchronous distance learning. However, internet access, lack of infrastructure,[25-27] conditions that existed in students' and teachers' home environment, and inherent difficulties of courses that required a laboratory like physics, chemistry and biology, and lack of self – discipline and motivation among learners were challenges associated with this sudden total shift to online learning.[28,29]

An important component of any learning process is interaction between classmates, and students and teachers, hence there is concern about the effectiveness of interactive learning process in a distance (online) learning environment.[30,31] In physics education, the laboratory is an important environment for experimental interaction among students facilitated by the teacher to attain SDGs goals.[32] With the advent of the COVID – 19 outbreak, like any learning, implementation of physics learning underwent fundamental changes, with learning in the laboratory and school environment as an extension of the laboratory no longer possible due to self – isolation and social distancing COVID – 19 spreading control measures.[33] Through the learn from home policy which many countries adopted, Physics teachers like other teachers had to adapt delivery of lessons using various modes based on online teaching and learning,[34,35] which included mobile learning,[36] e – books[33] Moodle and virtual laboratory,[37] among others. Similarly students had to prepare to learn online. Challenges associated with COVID – 19 induced online learning included low technological mastery, limited computer hardware (smartphones, desktops, laptops, and tablets), poor internet infrastructure, and poor connectivity and high data costs.[30]

Purpose of the study

Like any teaching and learning activity, physics education involves two actors which are the teacher and student. According to[39] the teacher facilitates learning by creating learning conditions deliberately designed to promote teacher – learner and learner – learner interaction, in the context of teaching and learning media and technology. As[39] posit that perfect learning possesses five features which are interactions between: (1) teachers and students, (2) individual students and individual students, (3) students directly with media and sources; (4) individual learners and their groups, and (5) groups and other groups. How such interactions may effectively occur during online teaching and learning is an unclear issue. In the context of the COVID – 19 learn from home policy, physics education is viewed through the lens of online learning in the teaching and learning environment of information and communication technology, online teaching and learning preparedness, and attitudes towards online teaching and learning.[40,41] Therefore this study sought to explore A – Level physics learners' and teachers' perceptions on the effectiveness of online physics teaching and learning.

Methodology

Semi – structured interviews were used to allow A – Level physics learners (PLs) and physics teachers (PTs) to give and explain their perceptions on effectiveness of online physics teaching and learning. Purposively selected 20 PLs, and 8 PTs participated in the study. Purposive sampling was relevant since issues in the study required participants who had experience in online physics teaching and learning. To conceal identifiers each participant adopted a pseudo name from a cards picked from a box. Emergent codes were used to put data into themes which were subsequently used in thematic data analysis, consistent with the purpose of the study of exploring A Level physics learners' and teachers' perceptions on the effectiveness of online physics teaching and learning. Findings are in verbatim with interpretation to attach meaning.

Findings

The themes which emerged during data analysis are used in the presentation and analysis of data in the subsequent sections.

Difficult physics topics to learn online

In responding to what topics were challenging to learners in understanding through online teaching, physics Learner 4 (PL4) said:

Modern physics and topics which involve mathematical operations are difficult to understand online because they have many abstract concepts. The teacher is needed to clarify so that one does not develop misconceptions.

Similarly PL9 said:

Forces and motion are other topics which are challenging because their requirement of high conceptualisation skills, so that one can deal correctly with the resolution of forces. That is dealing with vectors.

Corroborating the views presented by learners PL4 and PL9, physics teacher 3 (PT3) stated:

Some students lack knowledge about derivatives and integrals in mathematics so they have challenges in understanding formula or handling concepts which involve mathematical operations. For instance vectors involved in electricity, and classical dynamics forces are challenging for learners to understand through online learning without support through face – face – to – face interaction.

PT6 responded to the question on the easy to understand concepts on waves saying:

Although videos are used to assist learners to understand wave phenomena, but still the physical presence of the teacher cannot be done away with totally. The teacher is important in elaborating certain issues so that concepts are understood without misconceptions arising. Also, the extent to which videos help learners to understand concepts depends on how appropriately they were developed. Developing good videos for teaching and learning for physics is challenging. The teachers need to be highly skilled in developing videos as teaching and learning materials.

Videos are good for illustrating how certain physics concepts apply in practice, but developing relevant videos for physics learning was said to demand expertise from teachers. Lacking such expertise by physics teachers implied some videos used were not the best, hence compromising the quality of online learning.

Teacher presence and concept clarification

Use of online line in physics was viewed as associated with many challenges by many learners involved in interviews. For instance PL10 concurring with PL1, PL15, PL12, PL19, PL21, and PL27 said:

Generally physics is a difficult subject because there are many abstract concepts involved, which require the teacher to explain in person. If the teacher is present the student can seek clarification on areas not understood, yet with online learning such clarification cannot be obtained. When learning online, once understanding of a concept is missed then there is nobody to ask for help because the teacher is physically not there. Therefore face – to – face is better.

In agreement with learners PL17 and PL30, PL6 raised a very important missing link in online learning, which is physical collaborative learning among learners during group work, saying:

When doing online learning students will be scattered in different places so they cannot make physical live discussions to share ideas. Physics is a subject which requires working both individually and in groups. Online learning does not allow learners to work in groups, which is a big disadvantage.

PT16 expressed the inability to use certain teaching and learning strategies through online learning. The comment was:

Demonstrations, and practicals or experiments cannot be used in physics online learning because they are hands on activities. During the peak of COVID – 19 pandemic the practical aspect was negatively affected in a great way. Physics cannot be completely taught online effectively.

These responses express the limitations of physics online teaching and learning, which should be taken into consideration to fully achieve the learning objectives, consistent with sustainable development goals. Like any form of education, physics education should equip learners with practical aspects applicable in life for individual benefit and society in general. If learners are equipped with both critical thinking and practical skills to apply physics during their secondary school learning phase, they are most likely to pursue physics related carriers, or apply physics to find solutions to real life problems hence benefiting society.

Physics teachers' beliefs

An important factor which determines positive perception of a physics teacher in using a particular teaching and learning strategy are beliefs by the teacher on the use of the strategy. This was revealed by PT13, whose view was congruent with PT3 and PT18 saying:

I use particular strategies in teaching physics based on the belief that through those teaching and learning methods I am able develop students' conceptual understanding to the expected levels. My belief is based on curriculum goals as expressed in the national syllabus.

PT4 also said:

My belief in the appropriateness of any teaching approach builds confidence in using that strategy which benefits the learner. Of cause the strategies I choose are those which fall within the syllabus. If strategies not in the syllabus are used this may cause poor performance of learners in examinations, hence the need to stick to the syllabus.

These responses show that physics teachers implement teaching and learning strategies consistent with curriculum objectives. Therefore the nature of online learning in physics should not depend solemnly on the teacher's views and beliefs, but also as expressed in the syllabus. This will guide the teacher to meet the objectives of physics education as a subject. If not expressed as in the syllabus, then implementation will vary from teacher to teacher without standards or benchmarks that will be used as indicators for physics online teaching and learning assessment success.

Physics learning environment

Asked to comment on the appropriateness of the conditions or environment under which physics online learning is done, many teachers were concerned with lack of time because each topic has to be completed within certain duration. PT16 corroborating PT4's view said:

Each topic is supposed to be covered within a given time as schemed. The pace at which learning progresses is determined by response rate of learners to the teacher. The learners may take long to respond because they may be struggling with understanding concepts or getting funding for data to be connected. This was evident during the peak of COVID – 19 pandemic when social distancing was implemented to control the spread of the pandemic.

Related to PT16 and PT4's responses, PL8 in agreement with PL22 and PL26 indicated that online learning covers less content due to challenges of connectivity and lack of data to remain continuously connected:

Online learning is slow due to poor connectivity and lack of money for buying data to remain continuously connected. Although

this happens but one is expected to write examinations on the work not properly covered, which is not fare.

This shows that while online learning is topical currently, but it is associated with a host of challenges which should be dealt with, so that no learner is left behind, whether from rich or poor home background.

PL12, summarising PL3, PL10, PL17, PL20 and PL23's views indicated that remaining in touch with the teacher was challenging saying:

There are challenges which make constant connection with the teachers difficult. These include lack of data due to high cost, slow internet, poor connectivity and lack of laptops and smartphones.

These responses show that learners with poor financial backgrounds will be excluded from total involvement in learning if online learning is used in physics teaching and learning.

Physics as hands – on subject

Responding to the point that physics is a hands – on subject which requires one to be on the ground, PL 5 and PL16's views were summarised by PL 3 saying:

In learning physics real apparatus and materials need to be used, with no substitute material possible. This means such concepts cannot be learnt online, it is a must that one must be on the ground interacting with the teacher in the teaching and learning process. For instance during experiments the teacher needs to monitor and see whether apparatus have been assembled properly and give assistance where it is needed. This cannot be done online.

Responding to the question on alternatives that a physics teacher can apply to mitigate challenges associated with physics online learning, PT 11 said:

Using blended teaching strategies in physics is the solution, meaning using physics online teaching and learning on theoretical concepts which can be taught this way, and apply face – to – face on those concepts where practical activities are involved.

On the same issue PT18 stated that:

Experiments need hands – on for learners and face – to – face interaction with the teacher to get assistance on unclear practical and theoretical aspects of physics learning.

These responses show that physics teachers view blending online learning with face – to – face learning as the best alternative, so that the strategies complement each other, hence improving effectiveness of online physics teaching and learning.

Time for physics teaching and learning

Asked whether time allocated was important to facilitate physics online learning PT6 said:

Yes, time is allocated to do any activity in physics education is important. If time is given is short then teaching will be fast, implying rushing through, which compromises conceptualisation of concepts hence poor understanding. In my view time allocated to online learning was not enough during the COVID – 19 lockdown.

Also PT19 said:

There should be enough time to cater for both fast and slow learners. Taking into account that physics is a challenging subject, then enough time should be made available on the timetable so that needs of all learners are adequately catered for.

In agreement with PT6 and PT19, learner PL5 noted:

If time given for learning physics is not enough the teachers will rush because of the need to cover the syllabus. The pace of covering the syllabus will be bad if learning is online because the teacher will be rushing while the learner cannot raise the concern because the teacher will not be physically accessible.

Another learner PL7 said, in relation to the availability of time:

Online learning needs a lot of time to download learning materials. The access of learning materials depend on the speed of the internet which is in most cases slow, and sometimes internet not available at all.

The point that these responses reveal is that physics online learning needs time for the teacher to cover the syllabus on one hand and for the learners to access material, read them and understand concepts. However, the amount of time needed is not available, hence both online teaching and learning strategies and face – to – face strategies need to be used. What needs to be worked out are proportions of content that can be covered through online learning, and that which can be covered through face – to – face teaching and learning. Research[2] shows that teachers who cover all the content supposed to be taught, teach very fast, raising concern about the quality of learning.

Feedback from the teacher

The feedback given by the teachers in any learning situation is important to guide the learner on what areas to work on in order to improve performance. Responding to the question on how the nature of feedback physics learners get from the teacher, physics learner PL7 said:

The feedback from the teachers helps to give me direction on the concepts I should focus on to improve. However, getting the feedback quickly depends on my ability to constantly be on internet to check on what the teacher may have sent, but high cost of data limits the time I can be on internet.

Another Learner PL15 noted:

Sometimes the teacher gives feedback late citing lack of data due insufficient funding.

In relation to giving feedback to learners timeously PT 13 noted:

Work overload gives pressure because in addition to teaching A – Level physics classes I teach lower classes which are very large. Ensuring that every learner gets feedback quickly is a great challenge although I try my best.

Also PT11 said:

There need to give comprehensive feedback to learners to guide them on areas of improvement. However, due to the fact that it is expensive to remain connected on internet for a long time, I am forced to give summarised comments which do not fully assist learners as I would want to happen.

It is clear from the responses that learners and teachers concur that feedback given online does not fully assist learners because it is not comprehensive, and not given quickly, citing high cost of data as an obstacle. This indicates the need to use face – to – face learning, which allows comprehensive feedback to be given.

Conclusion

Online teaching and learning threatens the achievement of MDGs, especially SDG 4 due to exclusion of learners who are financially

disadvantaged. If online learning in physics is to be successfully implemented, then it should be implemented blended with face – to – face learning. However, ways to support those learners disadvantaged financially should be put into place, so that every learners benefits. In terms of competences to use online teaching and learning approach, both physics learners and teachers revealed the need to be supported in communicating effectively, so that on one hand physics teachers give instruction without developing misconceptions, and on the other learners explain clearly where they need assistance from the teachers.

The study has shown that not all physics concepts can be taught effectively through online strategies, therefore physics syllabi should clearly spell out areas which can be taught online and those which are mandatory to be taught face – to – face. This implies blending of face – to – face and online physics teaching and learning strategies should be used.

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Conflicts of interest

None.

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