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Physics learning and the application of multiple intelligences

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Abstract. The article looked at the learning problems in two different perspectives which are field area and sexism. Many studies indicate that the challenges to the students' academic performance globally in Physics are related to these two areas. Though, several solutions had been proffered to solve the problem with little improvement. Given this, the paper criticized many Physics teachers inability to see Physics classes as being of multiple intelligences. The author of the script, therefore, identified eight types of intelligence from Howard Gardner's *Frame of Minds*. The script believed that Physics learning problems could be solved if teachers apply five of the intelligence to the teaching and learning of Physics in schools. The paper has some implications for the teaching and learning of Physics at all levels.

Keywords: Intelligence; IQ; Academic performance; Teaching and learning; Constructivism.

Resumo. ***Aprendizagem de Física e aplicação de inteligências múltiplas***. O artigo analisou os problemas de aprendizagem em duas perspectivas diferentes, a área de campo e sexismo. Muitos estudos indicam que os desafios para o desempenho acadêmico global dos alunos de Física estão relacionados a essas duas áreas. Porém, várias soluções foram oferecidas para resolver o problema com pouca melhoria. Diante disso, o artigo critica a incapacidade de muitos professores de Física em ver as aulas de como de múltiplas inteligências. O autor do roteiro, portanto, identificou oito tipos de inteligência do *Quadro de Mentes* de Howard Gardner. O roteiro acreditava que os problemas de aprendizado de Física poderiam ser resolvidos se os professores aplicassem cinco das inteligências ao ensino e à aprendizagem de Física nas escolas. O artigo tem algumas implicações para o ensino e a aprendizagem de Física em todos os níveis.

Palavras-chave: Inteligência; QI; Performance acadêmica; Ensinando e aprendendo; Construtivismo.

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Introduction

There are several studies about the learning of Physics with documented literature that students performed poorly due to difficulty in learning. According to the UNESCO (1999), Physics teaching and learning is a global challenge that needs the attention of everybody. The starting point of this paper is to define the scope of the learning challenges. Firstly, to point out that students' learning problem varies according to the field of Physics. Secondly, the perspective of sexism is germane to the learning challenges in Physics. The problem students are facing in electromagnetism may not be the same as in Quantum Physics. Table 1 below shows students' academic performance and enrolment in electromagnetism achievement test in a College of Education in Nigeria.

Table 1. Students' academic performance and enrolment in electromagnetism achievement test in a College of Education in Nigeria.

	Male (%)	Female (%)
1	31	31
2	31	23
3	8	15
4	38	38
5	31	46
6	46	23
7	38	23
8	31	15
9	46	31
10	46	23
11	23	38
12	23	-
13	8	-
14	8	-
15	46	-

Source: Aina (2017).

The table indicates more male than female students and also poor performances: no student score above 46%. It is indeed bad performances.

A volume of literature reports that males are more in Physics than the female and that boys performed better than girls in the subject. The understanding that the Physics-learning environment preferentially favours male students over female students is one reason so few women may be pursuing Physics degrees (Nissen and Shemwell, 2016). In England, Wales and Northern Ireland, boys are more interested to know about physical science topics whereas girls' interests lay more in the biological and environmental sciences (Murphy and Whitelegg, 2006). The study shows that between 2000 and 2004 in the UK boys' entry rate to Physics is higher than boys' entry for chemistry and biology. Physics lags behind other sciences in enrolment and also have fewer women than the men in the USA (Robynne and Hazari, 2016). According to Wilson et al. (2016), there is a statistically significant gap in male and female overall Physics performance on the Australian Science Olympiad Exam (ASOE).

The University students faced lots of problem learning thermal Physics (Leinonen et al., 2013). According to Singh and Marshman (2015), learning quantum mechanics is considered to be primarily challenging for the university students. Several studies indicate that students had challenges in learning current electricity and electrostatics.

Teaching electrostatics is believed to be a challenging task due to its complexity and degree of abstraction (Chang, 2007). The study of Jaakkola and Nurmi (2004) reveals that electricity is an essential and challenging Physics topic at all school levels where students often have many difficulties in learning. McDermott and Shaffer (1992), much research studies conducted on the understanding of electricity revealed that students had difficulties in the conceptual understanding.

There had been many reasons Physics education scholars gave for these challenges without a concrete solution. For many decade articles on the challenges of Physics, learning pervaded the entire education sector globally, yet the improvement in the students' performance is tenuous. The particular area that many writers and Physics educations seem to ignore is the area of intelligence. The rational understanding of the Intelligence Quotient (IQ) exists among the students still hold sway in Physics classes. Thus, it stood on the idea that intelligence is a single, unchanged, inborn capacity. However, it was discovered that IQ measure very limited aspect of intelligence (Phaneuf, 2006) which most Physics teachers do not understand. The most significant mistake a teacher can make is to think that all learners are the same. Many studies in education have recognized that the students in a classroom have hugely different learning profiles (Arnold and Fonseca, 2004). Students have different learning styles which are the function of the teacher to identify these styles for appropriate instructional methods to produce best learning outcome (Akinbobola, 2015).

This was the reason Gardner (1983) came up to say it is wrong to measure learners' intelligence with IQ because as we have students with a different background in class, so we have multiple intelligences. This is the background of the multiple intelligences theory. The multiple intelligence theory is by the work of Gardner (1993) which identified nine types of intelligence. The theory believed people have different strengths and intelligence. It shows that human cognitive ability is more than a single entity (IQ) and that learners of any subject will do better and make greater progress if allowed to use their areas of strength to learn the necessary material (Arnold and Fonseca, 2004). According to Visser et al. (2006), Gardner (1993) described intelligence as a biopsychological potential that could be influenced by experience, culture, and motivational factors. The proponent of the theory believed that there is no hierarchy of ability. It thus implies that in the matter of real-life significance, none of the intelligence is greater than the others. According to Visser et al. (2006), it could be inferred that students learning of Physics depend on many factors of which the classroom experience, culture, and motivation are crucial. Students have different kinds of minds which make them learn, remember, perform, and understand in different ways (Fose, 2005).

Therefore, to ensure the learners possess these factors adequately for Physics understanding the teachers should have a change of teaching orientation. This stems from the fact that teachers are essential in any process of learning irrespective of the subject. Thus, the kernel of this article is applying the theory of multiple intelligences for improving students' Physics understanding.

Teaching and learning of Physics

Teaching and learning of Physics have been facing severe challenges globally: the challenges vary from one country to another. However, some challenges are general irrespective of the clime. To comprehend this paper correctly some of these challenges shall be review before looking at the types of intelligence.

Students' interest is crucial to learning, and that is why interest is the number one motivator in learning. Research studies indicate that factually students interest in learning Physics is decreasing everywhere in the world especially among the female students. Lavonen et al. (2005) in their paper "Pupil interest in Physics..." discovered challenges interest posed to the teaching and learning in Finland. According to Murphv and Whitelegg (2006), a report of the survey indicates a decline of students' interest in Physics in the US. Studies and literature indicate students' low interest in Physics learning everywhere in the world including Africa countries as observed by Aina (2016) and Wambugu (2013).

The paucity of qualified teachers had been a severe challenge to the learning of Physics in most countries of the world. The attempt to solve this problem leads to the evolvement of another serious problem of out-of-field teaching. Teaching out-of-field occurs when a teacher teaches a subject he or she did not qualify. Research data show that out-of-field teaching typically involves the qualified individuals to teach subjects that do not match their qualifications (Ingersoll, 2002). Teaching out-of-field means that teacher teaches subject or year levels without having the appropriate qualifications (Du Plessis et al., 2013). It happens both in developing and developed countries like Nigeria, South Africa, the U.S, and Australia. Du Plessis et al. (2014) cited that 16% and 30% of science teachers in Australia and South Africa respectively were unqualified while 31.4% of Physics teachers were unqualified in the United Kingdom.

Another problem is the pedagogy of teaching which may be and not limited to the issue of qualified teachers. The method of instruction most teachers employed to teach Physics has been a concern today. Research studies indicate that a student may develop an interest in Physics or not depend on how the teachers teach it. Riveros (2012) asserts that the way most teachers teaches Physics make students hate the subject. The pedagogical content knowledge (PCK) of many teachers is imperfect; they do not know how to impart relevant Physics knowledge to the students. Pedagogical content knowledge (PCK) is a characteristic of teacher knowledge of how subject matter should be taught (Koh, Chai, and Tsait, 2010). It is a unique body of knowledge of teacher required to successfully perform teaching within complex and varied context (Park and Oliver, 2007).

The misconception has been a blight on Physics teaching and learning in the recent time. A research study indicates that even Physics teachers have conceptual misconceptions in Physics (Eraikhuemen and Ogumogu, 2014). The teachers' misconception might not be unconnected with the inadequate PCK, which in turn affected students' learning. The situation in the Physics class is such that the teachers are zealous to give new information for the students' learning without considering their previous knowledge. This is how students enter into Physics class with preconception inimical to the learning of new information. The constructivist learning requires the prior experience as a springboard for the construction of new knowledge. Students are crucial in constructivist learning. Constructivism believes that learners play an active role in constructing meaning by themselves (Cornu and Peters, 2005). Constructivism emphasizes the importance of the knowledge, beliefs, and skills that an individual brings to the experience of learning (Garbett, 2011).

It is possible to obliterate the challenges highlighted above through the efforts of the students, parents, the government and the teacher. However, the consideration of Physics class as a cohort of students with multiple intelligences by the teacher is the hub of the paper.

Types of intelligence

Many scholars have identified different types of intelligence based on the individual perspectives, but the paper adopts the perspective of Howard Gardner's multiple intelligences proposed, 1983 in the *Frames of Mind* (Phillips, 2010) and discussed eight types of intelligence. These are Linguistic, Logical-mathematical, Musical, Spatial, Bodily-kinesthetic, Intrapersonal and Interpersonal. Given this, the paper honed the intelligence types as applicable to the teaching and learning in Physics. It implies the discussion of those directly applicable to Physics class is the next focus of the article.

Linguistic intelligence: this type of intelligence deals with the use of language. It is intelligence that is sensitive to the use of spoken and written language. This is the understanding of the ordering, meaning of words spoken, written and how to properly use the language. Linguistic learner dominantly relies upon reading, writing, and speaking as their intelligence.

Logical-mathematical intelligence: it deals with the ability to solve mathematical problems. According to Visser et al. (2006), Gardner described it as the ability to study problems, to carry out mathematical operations logically and analytically, and to conduct scientific investigations. It involves more of understanding through the manipulation of numbers. The logical-mathematical learners are systematic and very organized and have a logical rationale or argument for what they are doing.

Spatial intelligence: it is intelligence that sought for understanding by visual aids. It involves understanding the shapes, images, patterns, designs, and textures by the eyes. According to Herr (2007), this is learning by models, photograph, video, diagrams, maps, and charts. The learner here loves and prefers watching a demonstration showing them what to do, how to do it, and do it themselves.

Bodily-Kinesthetic intelligence: this intelligence has the potential of using the whole body or parts of the body to solve the problem. It processes knowledge through bodily sensations, movements, and manipulations (Herr, 2007). The learner learns best by doing, performs tasks much better after watching the teacher's demonstration and prefers to mimic the teacher's actions.

Intrapersonal intelligence: According to Gardner (1999), Intrapersonal intelligence is the ability to understand and to have an effective working model of oneself. It involves the awareness of individual desires, fears, and abilities; this includes the use of information to make sound life decisions. Fose (2005), the Intrapersonal Learner possesses the type of intelligence that appreciates self-reflection.

Interpersonal intelligence: it is when learning is through cooperative and collaborative experience, group laboratory work, peer argumentative learning, and dialogue. According to Gardner (1983), a learner here understands the intentions, motivations, needs, and desires of others, and is capable of working effectively with them. Learners who have this intelligence used interaction as a tool for learning.

The above-discussed types of intelligence are those directly related to the teaching and learning of Physics. Therefore, the application of this types of intelligence to the teaching and learning of Physics is the next discussion.

Application of the theory of multiple intelligences to physics learning

The starting point of the utilization of multiple intelligences is the teacher having the correct knowledge of his or her students. The teacher should see his or herself as a parent who must know everything about his or her child once he or she is still a teenager under the parent. For instance, it will not be correct for a mother to supply a few loaves of bread for her children breakfast because one or two of the children do not eat much in the morning. Those that can eat well in the morning may suffer and if it continues it may affect their health and education.

Given this, every Physics teacher should be versatile in his or her teaching pedagogy. A Physics teacher should consider the way he or she writes and speaks in Physics class. The teacher should avoid unconventional abbreviations and poor handwriting. This is to avoid confusing the linguistic learners among the students. Many teachers pronounced concepts in Physics wrongly; they shorten or abbreviates concept wrongly and sometimes do not write on the board. This is the reason some students fail because they are linguistic learners. Ho (1982), learning in science requires the abilities to read and understand scientific materials and also the ability to communicate science concepts. According to Bani-Salameh (2017), the language of instruction aid students to learn Physics concepts and as well correct any existing misconceptions about these concepts. A research study indicates that changing specific readability factors, such as sentence length, simplified vocabulary and the removal of obscure information, could improve students' achievement in science achievement (Prophet and Badede, 2009)

Students do have a problem in learning Physics because of the language of some unique terminology. According to Brookes (2006), these difficulties are mostly arising due to the misunderstanding of the specialized terminology. For example, if a teacher teaches *diode* and *transistor* for 40 min with wrong pronunciations, wrong spellings and abbreviations: the linguistic learners may have a poor understanding of these concepts. Subsequently, they may perform poorly on *diode* and *transistor* achievement test.

Logical-mathematical learners like to see everything a teacher teaches in numerical figure and data. These students in most time if not correctly put in control are not paying attention when a teacher is teaching any concept not involving numbers or data. They could cause a problem and distract the attention of others. A teacher should find ways of engaging these students during the teaching. The Physics teachers must be creative thinkers. During the lesson preparation, the teacher should be mindful of this cohort of students and know how to engage their interest. The teacher should be sure of the best strategies to engage the logical-mathematical learner because this is the aspect most Physics students do have difficulties. Physics students have difficulties in understanding concepts in Physics which demands adequate mathematical knowledge (Ibibo and Francis, 2017). Some students could perform mathematical operations correctly in the context of a mathematics problem but are unable to perform the same operations in the context of a Physics problem (Edward et al., 1996). The teacher must be aware that the understanding of the formula, equations, and symbol are not only enough for the students but the knowledge of its application. Sherin (2001), the students should be able to use the symbol with understanding.

There are Physics students who learned best when they see with their eyes. These students appreciate the use of charts, posters, and diagrams for learning. To ensure proper understanding of the concepts under discussion the teacher must carry them along during the lesson. According to Akinbobola (2015), the teaching strategies that employed Visual learning style are more useful for the students' understanding of electricity.

There are different types of the poster that a Physics teacher can use to enhance students' learning. Charts and diagrams well prepared are also vital to teach students in Physics class. For example, the teaching of complex topics like the *flux density, dynamo,* and *electric motor* require good diagrams and posters to explain how they operate. The conventional explanation may be enough for some students but for the spatial learners they need to see the diagrams of the different parts of the dynamo or motor.

Additionally, the teacher could present a video how these works. Personal experience as a Physics lecturer shows that most students do not understand the operation of the *dynamo* and *electric motor* until they watch the video or animation of how they work. Karlsson and Ivarsson (2008), animations provide exciting educational opportunities, with some pedagogical potential. Animations can enhance scientific curiosity, the acquisition of scientific language, and fostering scientific thinking (Barak and Dori, 2011). A teacher must be proactive and prepare for these types of students as he or she prepares for the Physics lesson.

Reflection is one of the elements of authentic learning. The teacher should provide an enabling environment for the students to reflect on their learning. Some students have intrapersonal intelligence. These students learn through self–reflection. Reflection is those intellectual and affective activities in which individuals engage to explore their experiences to lead to new understandings and appreciations (Boud et al., 1985). According to these authors, reflection has three features which are, returning to the experience, attending to feelings and re-evaluating the experience. Herrington and Kelvin (2007) believed that the students could miss learning opportunities in school when they are not allowed to reflect upon and consolidate their learning. To think about their learning, the students should frequently return to the experience, recollecting the critical considerations and relating them to their partners (Herrington and Oliver, 2000). Reflection is an opportunity to think about, reflect and discuss choices. There are reflections *in* and *on* learning. Reflection *in* learning is when choices are made during the learning while reflection *on* learning is choices made after the learning (Herrington et al., 2010).

The teacher should carry these students along during the lesson. Many a time these students asked the teacher to teach a concept or a topic more than once before clear understanding. Some of them are very good at putting down every word pronounced by the teacher to enable them to reflect on it after the class. The teacher should be conscientious not to insist that all students must listen without writing. The intrapersonal learners depend much on what the students write done during the class.

The Physics teachers should also understand that there are students who prefer to learn in the company of other students through interaction. These need to socially, interact before they could have a proper understanding of the topic of discussion. The teacher should only keep pouring information upon the students but allow the students to have a moment of collaboration. These are students who have interpersonal intelligence.

Interaction is very crucial to students' learning. Learning is a process of interaction through which the learners develop their understanding by assembling facts, experiences, and practices. Powell and Kalina (2010) posit that collaboration and social interaction are integrated into social constructivism. The social constructivism believes in the social interaction of students in the classroom along with the critical thinking process. To create a deeper understanding of the learning needs cooperative learning among the students. The social learning is a part of building a social constructivist classroom. Thus, the theory of constructivism believes that students have lots to offer one another by not only working one-on-one with the teacher but also with other students.

The multiple intelligences underscore the importance of the Universal Design Learning (UDL) approach. The objective of the UDL is to anticipate different abilities of students in a class and adequately prepare ahead to meet the need of each through the teacher's strategies of teaching (McCoy and Mathur, 2017). The UDL is a proactive approach that enables the teacher prepare for the students' learning problem before it arises. The approach allows the teacher to meet the need of all categories of learners in the class. It is a belief that the problem of students' learning in Physics class could be reduced if the teacher is aware of the multiple intelligences and employ the UDL model.

Conclusion

The article reviewed different challenges students encountered while learning Physics and attributed the problems to the teacher inability to understand and apply the theory of multiple intelligences. The paper identified five types of intelligence that could apply to the teaching and learning of Physics. Nonetheless, there are eight bits of intelligence proposed by Howard Gardner, but five are directly applied to Physics teaching and learning in this script. The crux of the paper is that Physics teachers should adopt multiple intelligences theory to enable all categories of student benefit in the teaching. The teacher depending only on particular teaching strategies may not be appropriate for the multiple intelligences contexts.

The application of the multiple intelligences for effective Physics learning has some implications for both the teachers and the government. The discussion of implications is in this section of the article.

The present Physics teacher education curriculum of many countries may not be able to accommodate the infusion of the multiple intelligences. It, therefore, implies that the starting point is to incorporate the multiple intelligences into the pre-service teacher education curriculum. It should be part of the pedagogical study of the pre-service Physics teachers. Additionally, we should understand that the issue of intelligence is about the cognitive ability of students. Thus, it implies every Physics teacher should have a correct understanding of his or her students' cognitive abilities. This is like a parent having the understanding of the peculiarity of each child in a family. To achieve this demands, the adequate knowledge of the constructivist learning paradigm: every Physics teacher is expected to be a constructivist.

Another implication is the teacher-student ratio in Physics class. The teacher implementing multiple intelligences will be practically impossible in a large class. Therefore, the number of students to a teacher must be tiny for effective implementation. For instance, it will be difficult in a class where more than four types of intelligence are identified to pattern the teaching instruction accordingly within the instructional time. This implies a teacher should divide a large class into a stream of smaller students with a teacher each, and this will require more fund for infrastructure and personnel.

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