EQUIPPING THE SMART CLASSROOM TO HELP THE TEACHER OVERCOME CHALLENGES

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Abstract

Increasing students' engagement in the classroom and providing a valuable environment for students to practise 21st century skills could be some of the major challenges facing the teacher. The teacher can have a large role to play in terms of encouraging the students to be more actively engaged in the classroom and ensuring the classroom is suitable for pursuing 21st century skills, especially communicating, collaborating, creative and critical thinking skills (4Cs). The 4Cs are increasingly considered as potential requirements for future workplaces and society in general. As such, students should be more engaged in the classroom in pursuit of content knowledge and 21st century skills. The teacher can overcome these challenges by equipping the smart classroom with Multi-touch tables and 3D printers. The features of a Multi-touch tables and 3D printers provide opportunities for the teacher to design robust collaborative learning activities that can increase students' engagement and foster students' 4Cs.

Keywords: Equipping, Smart Classroom, Overcome Challenges.

تجهيز الفصل الدراسي الذكي لمساعدة المعلم على التغلب على التحديات

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المستخلص

تعد زيادة مشاركة الطلاب في الفصل الدراسي وتوفير بيئة تفاعلية للطلاب لممارسة مهارات القرن الحادي والعشرين من بين التحديات الرئيسية التي تواجه المعلم، ويلعب المعلم دور كبير في تشجيع الطلاب على المشاركة بشكل أكثر نشاطًا في الفصل الدراسي والتأكد من أن الفصل الدراسي لديه القدرة على اكتساب مهارات القرن الحادي والعشرين، وخاصة مهارات التواصل والتعاون والتفكير الإبداعي والنقدي (الساعات الأربعة، Cs4)، كما يرى الكثير أن تلك الساعات بشكل متزايد تعد بمثابة متطلبات محتملة لأماكن العمل المستقبلية والمجتمع بشكل عام، وعلى هذا النحو، يجب أن يكون الطلاب أكثر انخراطًا في الفصل الدراسي سعيًا وراء معرفة المحتوى ومهارات القرن الحادي والعشرين، ويمكن للمعلم التغلب على هذه التحديات من خلال تجهيز الفصول الدراسية الذكية بطاولات متعددة اللمس وطابعات ثلاثية الأبعاد، حيث يمكن أن توفر تلك الأدوات فرصًا للمعلم لتصميم أنشطة تعليمية تعاونية قوية يمكنها زيادة مشاركة الطلاب وتعزيز اكتسابهم لتلك الساعات.

الكلمات المفتاحية: التجهيز، الفصل الذكي، التغلب على التحديات.

1. Introduction

There exist a number of educational challenges that can seriously hinder the implementation of a successful education system in keeping with the demands of the 21st century. These challenges can vary and anyone related to the education process including teachers will have to deal with them at some point. However, this paper sheds light on two possible challenges that physics teachers may have to contend with future. It assumes that the physics teacher may have to face the challenging task of increasing his/her students' engagement in the classroom. As such, the physics teacher will need to identify ways to overcome this issue. According to Marks (2000), students who are more engaged in the classroom are more likely to learn and attain social development.

In addition, the paper considers a further challenge for the physics teacher in terms of providing an effective environment for students to practise 21st century skills, particularly communicating, collaborating, creative and critical thinking skills (4Cs), which are thought to be crucial for success in today's society and best instructed within educational content (Greenhill, 2013).

On the other hand, it is important for teachers to equip the classroom using new technologies that can help them overcome these challenges. In fact, some educators consider technology as one of the most significant factors to foster the learning process. More specifically, teachers who use technology confirm its positive effects on students' engagement and relevance to 21st century skills (Walden University, 2010). This paper also assumes that smart classrooms should be equipped with new and effective technologies that can help the physics teacher overcome any likely obstacles.

The most appropriate technologies to do so include Multi-touch table and 3D printers. They have the potential to be effective technologies and keep students engaged in the classroom, as well as allow them to practise 21st century skills, including the 4Cs. These technologies have recently been introduced and are increasingly considered as essential and effective in the education field. While the Multi-touch table is a valuable technology for classroom learning

(Higgins, 2012), 3D printer is seen to have a considerable impact on education (Johnson et al., 2015). Nevertheless, the teacher should aim to harness these technologies with the appropriate type of teaching/learning activities that can make the smart classroom environment more effective to overcome the challenges. The proposed type of teaching/learning activities that seems suitable for these challenges could be collaborative learning activities. The schools should develop collaborative learning activities to improve the student motivation and achievement (Fisher, 2009).

A number of points should be considered to help the teacher overcome the challenges of employing Multi-touch table and 3D printer in his/her classroom. First, when designing an activity, the teacher should be well knowledgeable about Multi-touch tables to avoid any problems during the application of the activity. In addition, the teacher can deal with the challenge of controlling the classroom by linking the Multi-touch table to his device. Furthermore, the school should train the teacher and students on how to use 3D printer and the design software to ensure they do not face any difficulties during 3D printer activity-based sessions.

This paper will seek to provide an overview of the context, along with a discussion of the significant challenges and the type of teaching/learning activities. In addition, the paper will explain how Multi-touch tables and 3D printer can help the teacher to overcome these challenges, and an example of how each technology can be used in the classroom.

2. Contextual framework; the challenges, the types of teaching/learning activities and proposed technologies

A major challenge for the physics teacher in the elementary stage is the students' low level of engagement in the classroom, which can have an effect on their learning. Also, the teacher has a further challenge to equip the classroom for students to gain hands-on 21st century skills. These two challenges, which have actually been re-emerging for a long time, have acquired such an importance due to the worrisome educational outcomes which might affect development in the 21st century. In addition, Stott (2014) suggested that the low level of students' engagement can pose risks for students' learning and themselves. Clearly, if the students do not actively engage in any classroom activities, they will not acquire neither the knowledge of the physics subject nor 21st century skills.

The students' engagement in the classroom is a challenge for many teachers in the different interdisciplinary subjects, but it can be a serious concern for science teachers. Hazari et al. (2015) argued that the most difficult challenge faced by science teachers is the lack of students' engagement in classroom. In addition, many students reported that engagement in the physics classrooms is far more difficult compared to other subjects (ibid). Therefore, the teacher should try to overcome this challenge, simply as he/she is responsible for creating the right learning environment that will foster engagement and learning in classroom (Robinson and Hullinger, 2008).

Another challenge faced the teacher is how to instil in his/her students the relevant 21st century skills "4Cs" and explain their importance for the future generations. Nowadays, students should be able to communicate and collaborate with others, as well being critical and creative in their thinking (Trilling and Fadel, 2009). In addition, society demands that everyone should seek to acquire "4C skills"; namely communicating, collaborating, critical thinking and creativity thinking skills in order to develop on a professional level (Eisenkarft, 2009 cited in Pacific Policy Research Center, 2010). Moreover, there is an agreement that students need to learn 21st century skills through discipline not as a separate subject (Cynthia, 2015). Therefore, it is important that the teacher of physics as is the case for any other teacher to provide the appropriate material for the students and create an environment that allows them to gain 21st century skills, particularly the 4Cs skills. It should however be borne in mind that 21st century skills are complex and challenging to teach (Cynthia, 2015).

The teaching method and the type of learning activities can play a significant role in order to overcome these challenges. The predominant teaching method in most of the educational institutions all over the world has for long been the lecture method (Saavedra and Opfer, 2012). However, Cynthia (2015) reported that there is a widespread agreement on the ineffectiveness of the lecture method in terms of teaching 21st century skills. As such, the physics teacher should think about the type of teaching/learning activities and the appropriate instruments to use to contribute to better learning outcomes and encourage the students to acquire valuable 21st century skills.

In this respect, collaborative learning activities could be considered suitable for the physics teacher to incentivise his/her students and provide a rich experience for students to practise the “4Cs”. According to Webb and Palincsar (1996), collaborative learning activities are valuable tools used to accomplish students’ learning and development. Indeed, students in collaborative learning activities have to think, communicate with peers, assess the task, be creative and make a decision as a team (Laal et al., 2013). In addition, this type of teaching/learning activities seems appropriate to the nature of teaching physics as it requires some kind of collaboration between students and discussion. In fact, students in the elementary stage should be informed about physics laws and principles and trained appropriately into practices of careful doing, close reflection, accurate thinking and precise expression, which is at the core of physics teaching (Newman, 1905).

As defined by Laal et al. (2013), collaboration learning refers to an educational teaching and learning method designed to encourage and support students to work collectively for the purpose of solving a problem, achieving a task or producing an artefact. The students will better master the skills of communicating, collaborating and critical thinking when their type of learning activities is collaborative (Cynthia, 2015). In addition, students who are involved in group activities will be able to learn the important skills of the 21st century much quicker (ibid). Furthermore, Cisco (2008) confirmed that collaborative learning activities allow the teacher more scope and leeway to engage the students in a problem-solving process within a group, deepen their understanding of concepts and enhance their understanding, which will in turn help them gain valuable skills for years to come. In other words, the students who are engaged in collaborative learning activities will practise the “4Cs” by communicating the idea, collaborating with their peers to solve any likely problems, and engaging in rich discussions to come up with a solution. However, the physics teacher has a responsibility in terms of designing the collaborative learning activities and employing good tools to ensure the students engage with the content of physics in the classroom and gain hands-on “4Cs” skills. The teacher may consider technology as a fundamental tool to carry out the required collaborative learning activities and provide a rich physics classroom experience for students willing to polish existing skills and acquire new ones.

In recent years, the development of technology has shaped many types of teaching/learning activities, including collaborative learning activities. As such, the teacher should invest in this development for the sake of enhancing the education process. In addition, technology enables users to explore new ways to communicate, collaborate and innovate, as well as to think critically and solve problems (Vockley, 2007). Furthermore, by providing access to technology in the classroom, the teacher can increase students’ engagement; however, while so doing, he/she is also required to identify a new approach of learning using technology to foster prospective skills (ibid). According to Cynthia (2015), using technology can stimulate students to construct a new knowledge in collaboration with peers. It seems therefore that the teacher should design classroom activities while utilising the potential of new technologies, which can be used as a significant tool to promote learning using collaborative activities. Therefore, the teacher of physics has plenty of new technologies that may help him/her to design the most appropriate collaborative learning activities that can instigate students’ engagement and help them acquire valuable “4Cs” skills to support their learning for the future ahead. This paper proposes equipping the smart classroom using two technologies that can be appropriate for the nature of the physics subject and can also help the teacher to overcome his/her challenges. The technologies proposed are Multi-touch tables and 3D printer (see Figure 1). However, the paper stresses that it is not only important to have technology in the classroom, but knowledge of how to use these technologies is also equally a prerequisite to ensure the right mix of learning activities are provided in the classroom.

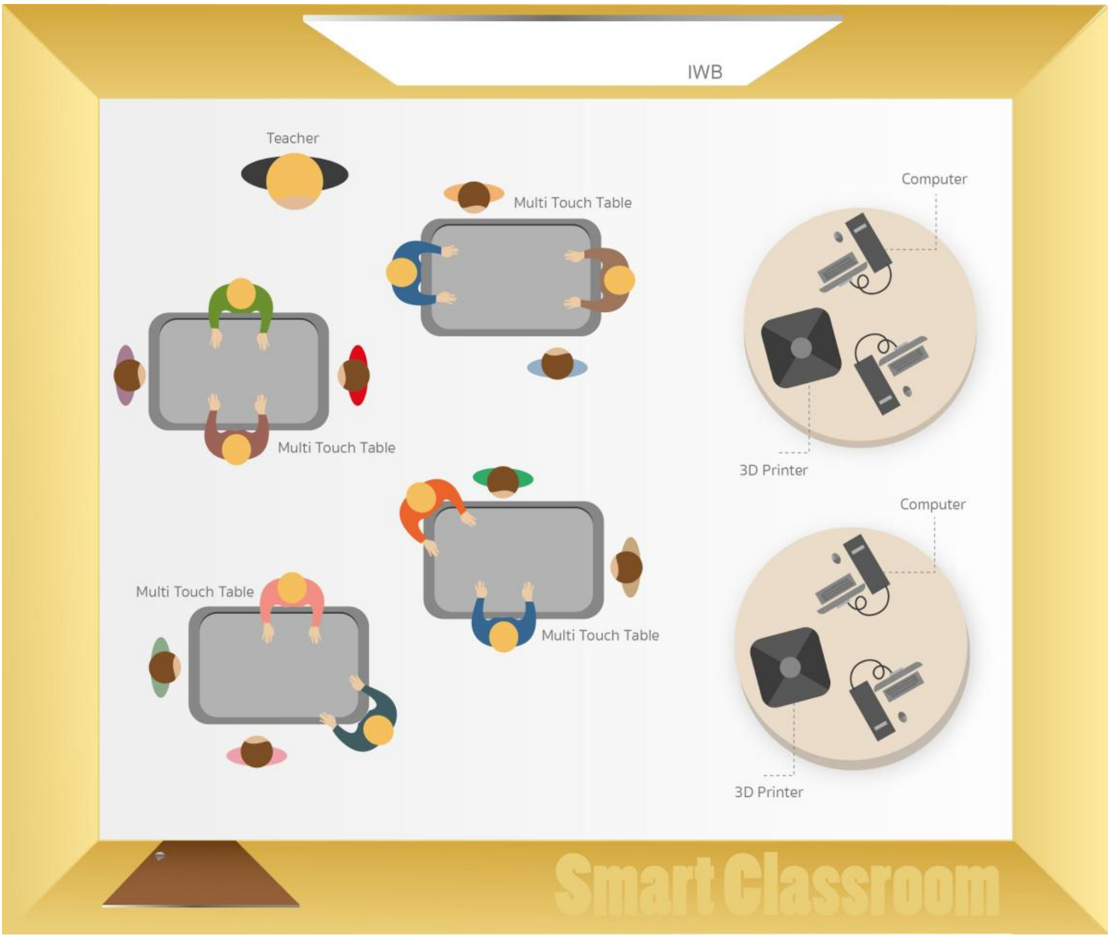

Figure 1: The smart classroom model.

3. Multi-Touch Table

Multi-touch table technology is an emerging technology that provides an electronic surface through which one or more users are allowed multiple touches. This process enables students to interact with each other with multiple points of control, which is a far cry compared to other existing technologies (Hatch et al., 2011). In addition, Multi-touch table can be used as a technology affordance to support collaborative learning activities by changing the nature of students' interaction (Dillenbourg and Evans, 2011 cited in Mercier et al., 2015). The unique advantage of Multi-touch table lies in its high potential to support and enhance face-to-face collaborative learning (Jamil and Subramanian, 2012). In addition, Multi-touch tables can reshape the classroom to be more adaptable to collaborative learning activities. According to Greenhill (2010), the classroom should be thoroughly invested in as a physical space to facilitate collaboration, interaction, and information sharing, which can all contribute to maximising the attainment of skills needed for futuer learning. Therefore, providing Multi-touch tables in the physics classroom can allow the teacher to set up effective collaborative activities as a result of the possible collaboration between students through new means of technology, which can also enhance students' engagement.

Mercier et al. (2015) found that student-student interaction in Multi-touch table activities far exceeds interaction during paper and pen activities. They argued that interaction facilitated by Multi-touch table improves students' engagement in the various activities and increases their teamworking efforts. In addition, leading technologies, of which Multi-touch table could be used as an example, will help students achieve higher levels of engagement (Cisco, 2008). Collaborative learning activities based on Multi-touch tables are not regarded as a traditional activity, which is typically based on pen and paper. In fact, the teacher can provide the content of the lesson and task in Multi-touch tables and then ask the students to work together using the options provided on the table screen. The roles of students vary, such as having a discussion with peers about the content, working on the task and touching the table to complete the task. As for the role of the teacher, it is simply focused on orchestrating and assisting the groups while working instead of only delivering information. The students in this kind of activity seem more engaged due to diverse ways of interaction with content and peers, which can potentially meet their learning expectations. Also, the process offers a fresh perspective on collaboration allowing the student to communicate with his/her peers and stimulate deep thinking before making a decision on the table.

As pointed out in a research study, the Multi-touch tables can alter the instrument of collaborative learning activities that group members use for interaction with each other, as well as the content of the learning activity (Mercier et al., 2015). In addition, in their study, Harris et al. (2009) examined the use of Multi-touch tables in the classroom and concluded students discuss and communicate more about the task when they use Multi-touch tables. In this respect, it seems that the use of Multi-touch tables does not just improve the students' engagement, but it can also they help them gain potential skills, particularly communication and collaboration with others.

Furthermore, Multi-touch tables can be networked and students can pass the content around the tables. These tables can also be linked to the teacher's device and the teacher can then move the content from the Multi-touch tables to IWB (as example see video). Thus, employing the affordances of Multi-touch tables can provide valuable collaborative learning activities in the physics classroom, which may reflect on the students' learning outcomes and their gaining of potential skills. In a study done by Mercier et al. about using Multi-touch tables in mathematics classroom (2015), students were found to show higher levels of collaborative engagement in the task when using Multi-touch tables. Furthermore, the students were able to solve the task using pre-existing strategies or by creating new strategies through observation and collaboration with their peers (ibid). Therefore, using Multi-touch tables in the physics classroom does not only improve students' engagement, communication and collaboration, but it also stimulates their critical and creative thinking abilities whilst on the activity, as well as utilising features of the Multi-touch table to represent their thoughts or solutions.

It is equally important for the teacher to think creatively by seeking to employ various strategies once the Multi-touch table is introduced into the classroom and by also carefully considering the design of the activity, as well as providing the relevant content in keeping with the affordances availed by the Multi-touch table. As argued by Mercier et al. (2015), the content and how it is presented on one table and between tables can have an effect on the educational use of Multi-touch tables in a learning setting. For example, there are Multi-touch tables that do not have text entry features. As such, the teacher should design the activity based on the specifications and advantages of Multi-touch tables as this differs from one company to another.

In addition, there is another issue regarding the use of Multi-touch tables, which relates to the role of the instructor and his/her interaction with the groups (Higgin et al., 2011). In other words, applying collaborative learning activities through Multi-touch tables might limit the role of the teacher. According to Kennewell (2001), the role of the teacher should be geared towards orchestrating and monitoring students during classroom activities to achieve the task outcomes. Therefore, the teacher should always be aware of technical solutions in order to employ the Multi-touch table to its full potential and be ready for any technical glitches. For example, the teacher can use an iPad as an "orchestration tool", as was the case in the SynergyNet Project (Evens et al., 2012). In this project, the teacher used the iPad to access the web interface then have it controlled on the Multi-touch tables, which allowed him to start, pause or end the activity (ibid). Using this kind of tools might help the teacher to overcome the challenges of interacting with groups and effectively managing the classroom activity. In this practice, the teacher can also monitor students' contributions during the activity and encourage the students to be more involved.

3.1 An example of using Multi-touch table in physics classroom

There are multiple uses for Multi-touch tables in the physics classroom. The following is an example on how the affordances of Multi-touch table can be taken advantage of to support collaborative learning activities in a physics classroom environment. The teacher can set up a task about Newton's laws using Multi-touch tables. In the task, the students are asked to match the pictures to the right laws (See Figure 2). In this activity, the students have to collaborate to solve the task. They also have to discuss and think and each member has to express his thoughts about which picture belongs to the correct law. In addition, students need to be actively engaged with the content displayed on the table and collaborate with other peers around the table to achieve the task. This practice may encourage low performing students to participate more and to try to explain their thoughts by communicating and working as a team with their peers to accomplish the tasks given to them.

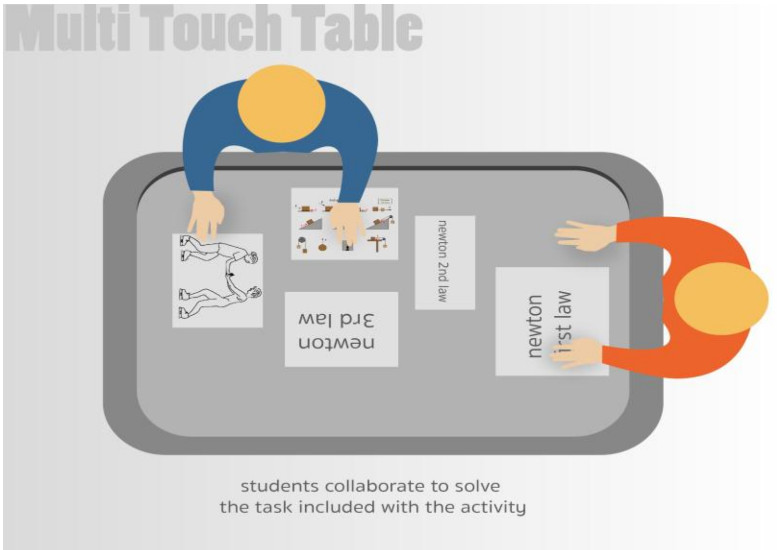

Figure 2: The use of Multi-touch table.

Similarly, each group can pass their answers to the other table to discuss and think critically about the answer they deem correct. In a way, the content of the activity and the potential affordances of the tables might stimulate students to think critically. The teacher can use an "orchestration tool" to ensure control over the tables. He/she can also monitor the contribution of each student either through a device (e.g. iPad) or visual observations, which may encourage the low-level students to participate more. The teacher can then display the work done on the tables on IWB and discuss each group's contribution with the whole classroom, which can add to the variety of the educational material provided for learners. However, this is an example which may differ from one context to another, but it still shows how Multi-touch tables can prompt students' engagement and optimise collaborative learning activity, which in turn can lead to a rich environment to practise the skills needed for this century and beyond, in particular communication, collaboration and critical thinking.

4. 3D printers

Making the learning experience as authentic as possible can be used as a means to improve the students' engagement in the classroom, given that it may appeal to their desires (Cisco, 2008). In addition, the physics teacher can make the lesson more authentic for students by providing 3D printers in the classroom. In fact, 3D printing has the advantage of being a very inexpensive tool for the creation of physical objects (Segerman, 2012). Furthermore, using 3D printers in the classroom can be a potentially significant teaching resource and can have a positive impact on students' engagement (Department for Education (DfE), 2013). 3D printers allow users to design a prototype model of an idea in a computer and convert it into a physical object (Segerman, 2012). The potential of 3D printers lies in the fact that it can transfer a design in a computer software into a physical object, which can reshape physics classroom activities, and allow students to see the realistic configuration of a physics concept. According to Johnson et al. (2013), 3D printer allows for more authentic exploration of objects that may not be available to schools. In addition, allowing students to use 3D printers in the classroom can develop a sense of creativity in them because they have to consider and go through several stages during the activity itself (e.g. planning, designing, printing and evaluation). In addition, the opportunities to convert a concept or idea into a 3D object seems to be a robust teaching tool, which can help students to reach a new level of thinking.

Providing 3D printers in the classroom can positively change the physics classroom environment to be more appropriate for creativity and innovation. Triling & Fadel (2009) argued that the learning environment can enhance students' creativity and encourage them to raise questions, create to new ideas, and learn from mistakes and failures. Moreover, the students using the 3D printing model have to experience a number of stages, such as planning, designing and evaluation, which requires questioning and thinking of new ideas and then criticising and correcting their own mistakes in the design until the final model is printed out. Indeed, 3D printers provide a host of new innovative ideas by permitting users to generate physical models (EDUCAUSE, 2012).

In addition, Kostakis et al. (2015) reported that 3D printer can encourage creative capacity of students. Similarly, the students can use 3D printers to meet their needs, which can enhance their creativity skills. For example, the students can design and produce objects they were not allowed to handle, such as fragile objects (Johnson et al., 2013). Also, the physics teacher usually brings 2D objects to use as a tool to explain the concept of the lesson, which the students might sometimes find difficult and thus fail to engage and grasp the concept; however, by providing 3D printers in the classroom, the students will collaborate more to create their 3D objects that are relevant to the lesson, which can make the concept easy to grasp. Using this kind of practice, the teacher may encourage students to engage more actively in classroom activities and collaborate to solve the task, as well as communicate, and critically evaluate the model and ultimately produce a creative model. In other words, practising 21st century skills; i.e. “4Cs” can lead students to grasp the concept and understand processes.

3D printing-based activities can provide valuable opportunities for students to think creatively and critically collaborate with peers and construct their thoughts to be tangible objects, which allows them to apply 21st century skills “4Cs”. It is possible for the teacher and his/her students to create a 3D model of concepts in physics, engineering and maths, which are frequently interpreted only via formulas, which can simplify new methods of grasping these concepts (EDUCAUSE, 2012). Furthermore, this usage of 3D printers can increase students’ engagement. A good example of the benefits of 3D printers in the classroom can be seen in a 3D printer project which was carried out by the Department for Education about the potential benefits of 3D printers (2013). They found that students with poor engagement were able to see tangible objects, and as a result, they were more actively engaged in the lesson. In addition, they found that students can explore more complex designs using 3D printers. The physics teachers in this project used the 3D printer to promote thinking, reasoning and understanding of the subject. Therefore, it seems that using 3D printers in the classroom can offer a valuable experience for students and can keep them engaged with the acquisition and practice of 21st century skills “4Cs” through collaboration to carry out the design and produce 3D objects.

However, teachers and students might still face a number of challenges when attempting to implement the 3D printer procedures. According to The DfE (2013), teachers claimed that they would need months to be familiar with the printer and other associated software.

Using a 3D printer in the classroom requires that teachers are self-confident. Thus, in order to overcome this challenge, schools should give the appropriate self-development training for teachers, including software knowledge and maintenance training to enable them to use the software confidently. In addition, the student might face similar challenges when using new software, such as TinkerCAD. Thus, they should also be given the right training by IT experts to ensure they do not face any obstacles during their activities as this might have a negative effect on their enthusiasm.

Other challenges include the time spent to print 3D objects, as it takes hours to carry out the planning and design stages, which might not be suitable to a classroom situation where time is limited. Thus, the teacher should seek to better manage the time of his/her class project to ensure maximum benefit from applying 3D printing-based activities and to avoid any delay in the project, which may impact negatively on the students' engagement. As a solution for this challenge, the teacher may think of breaking the intended project into different levels. The first class session could be reserved for the project planning and design, the second session could be dedicated to printing and evaluation. It should also be pointed out that the 3D printer cannot cover all aspects of the curriculum. Therefore, the teacher should use it only when it is deemed appropriate for the content of the lesson, and the use of 3D representation is the most appropriate modality for understanding lesson content.

The cost of materials/filament of 3D printers can also hinder the application of 3D printer in the classroom because of the cost involved to repair and maintain such equipment, which will be overused by students. However, the new 3D printer technology can use different materials now compared to the past; it can use paper to print 3D objects through a specific technique (Cawley, 2015). The 3D objects can be made using paper, which means they are recyclable and environmentally friendly (ibid). Thus, there is an option to reduce the cost of materials by providing 3D printers that can operate using A4 papers as materials to print, such as Matrix 300+.

- **4.1 An example of using 3D printer in the physics classroom**

Supposing the lesson is focused on the nature of solid and liquid and the aim is to explain the physicist concept, which is water molecules. The latter do not change when the state of water is solid or liquid, but the interaction between molecules changes. The teacher can set up a project that requires the students to imagine what sort of interaction there is between different molecules in solid and liquid environments and how it looks like under different circumstances. The students will again work in groups to discuss and come up with a plan for this project. The students will have to communicate and exchange their thoughts about the concept. Next, they will have to sketch what the water molecules look like in each state. Afterwards, that they can work on the computer to design the water molecules. In the design stage, the students will engage in some critical thinking by discussing their shape and trying to modify it until they arrive at the final shape and then print it out. Each group will have to create two 3D models for water molecules in both states (solid and liquid). The teacher can ask each group to explain their version of the 3D printed model of water molecules to the classroom and give each student the opportunity to evaluate the group innovation, which can make the concept of water molecules easily comprehensible for them. It is clear in this example that the students will be actively involved in their project. Such positive engagement will ensure that they will get to experience collaboration, communication and critical and creative thinking skills.

5. Conclusion

This paper predicted the challenges that could be facing the physics teacher and how teachers can respond to such challenges. The first challenge relates to the students' low level of engagement in the classroom, while the second refers to providing valuable environment for students to practise 21st century skills. The paper assumes that the challenges are important because they can have an effect on the outcomes of education and might reflect negatively on students' ability to join the workforce. Basically, when students do not engage in the classroom, they will not be able to acquire the required knowledge of subjects and the 21st century skills contributing to the acquisition of such knowledge. The 21st century skills that were discussed in this paper are "4C"; i.e.

collaboration, communication, critical and creative thinking. These skills are prerequisites for society in general and the workplaces in particular for to secure a successful career for the students.

In addition, this paper claimed that the teacher should consider carefully the type of teaching and learning activities that can positively impact on the students' engagement in the classroom. For such activities, the collaborative learning activity was suggested as an effective approach. Collaborative learning activities can also provide a worthwhile opportunity for students to practise the skills pertinent to the coming decades. However, the paper advises that the teacher should equip the smart classroom using leading technologies. Applying the collaborative learning activities based on new technologies can help the teacher overcome any arising challenges. The proposed technologies include Multi-touch tables and 3D printers, which the paper suggests as prominent tools to equip the smart classroom. The availability of these two technologies can help the teacher design valuable classroom activities that can increase the students' engagement and allow them to practise the 21st century skills (4Cs).

The first technology is the Multi-touch table whose potentials made it an appropriate option for the teacher to deal with the aforementioned challenges. Previous studies argued for the benefits of the Multi-touch table in terms of encouraging students to engage in the classroom more often and instilling the "4C" skills from an early age, as well as supporting the students to work in groups to solve any problems using the Multi-touch table. However, it is the teacher's responsibility to design and provide an effective learning activity, which should achieve the intended goal; i.e. ensuring the students will engage with content and practise 21st century skills.

The second technology is the 3D printer, which can make the learning in classroom more authentic by allowing teachers and students to convert the concepts of physics into concrete 3D models. The students seem to be more enthusiastic about using 3D printers in the smart classroom, which can positively reflect on their engagement. The teacher can give the students a project based on the 3D printer, which should provide a rich environment contribute to the enhancement of students' creative, critical thinking and encouraging them to work collaboratively. However, for the optimal implementation of a 3D printer in a classroom, the teacher should be trained on how to use it and any other related software in order to overcome any technical glitches that may occur to the printer. The students should also be trained, especially on how to use computer software to design and modify the 3D model.

In conclusion, this paper recommended the provision of a Multi-touch table and 3D printer for a future smart classroom. These two technologies can overcome two serious challenges that might face physics teachers in the forthcoming decade. This paper also stressed that the presence of both technologies alone cannot be effective unless the teacher employs technology with the appropriate type of learning activities, which in this case seems to be collaborative learning activities.

References

Cawley, David (2015). *3D printer in the classroom.* [Online]. [Accessed 6 Jun 2016]. Available from: https://www.youtube.com/watch?v=Uom3P1JZMN8.

Cisco, (2008). "Equipping Every Learner for the 21st century" white paper. [Online]. [Accessed 3 Jun 2016]. Available from: http://www.cisco.com/c/dam/en_us/about/citizenship/socio-economic/docs/GlobalEdWP.pdf.

Hazari, Z., Cass, C. and Beattie, C. (2015). Obscuring power structures in the physics classroom: Linking teacher positioning, student engagement, and physics identity development. *Journal of Research in Science Teaching*, *52*(6), pp.735-762.

Cynthia Luna Scott. THE FUTURES of LEARNING 3: What kind of pedagogies for the 21st century? UNESCO Education Research and Foresight, Paris. [ERF Working Papers Series, No. 15]. Available from:http://unesdoc.unesco.org/images/0024/002431/243126e.pdf

Department for Education (2013). *3D printers in schools: uses in the curriculum.* [Online]. Report number: 00219-2013. Available from: https://www.gov.uk/government/publications/3d-printers-in-schools-uses-in-the-curriculum [Accessed 29 May 2016].

Dillenbourg, P. and Evans, M. (2011). Interactive tabletops in education. *International Journal of Computer-Supported Collaborative Learning*, *6*(4), pp.491-514.

EDUCAUSE (2012). "7 things you should know about 3D printer". EDUCAUSE Learning Initiative. Available from: https://library.educause.edu/resources/2012/7/7-things-you-should-know-about-3d-printing [Accessed 27 May 2016].

Evans, M. A.; Rick, J.; Horn, M. S.; Shen, C.; Mercier, E.; McNaughton, J.; Higgins, S.; Tissenbaum, M.; Lui, M.; and Slotta, J. D. (2012). Interactive surfaces and spaces: A learning sciences agenda. In *Symposium presented at the International Conference of the Learning Sciences*.

Fisher, D. (2009, April). The use of instructional time in the typical high school classroom. In *The Educational Forum* (Vol. 73, No. 2, pp. 168-176). Taylor & Francis Group.

Greenhill, V. (2010). 21st century Knowledge and Skills in Educator Preparation. Partnership for 21st century Skills.

Harris, A.; Rick, J.; Bonnett, V.; Yuill, N.; Fleck, R.; Marshall, P.; and Rogers, Y. (2009, June). Around the table: are multiple-touch surfaces better than single-touch for children's collaborative interactions? In *Proceedings of the 9th international conference on Computer supported collaborative learning-Volume 1* (pp. 335-344). International Society of the Learning Sciences.

Hatch, A., Higgins, S., Joyce-Gibbons, A. and Mercier, E. (2011). NumberNet: Using multi-touch technology to support within and between group mathematics learning. In *Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL2011 Conference Proceedings* (Vol. 1, pp. 176-183).

Higgins, S., Mercier, E., Burd, L. and Joyce- Gibbons, A. (2012). Multi- touch tables and collaborative learning. *British Journal of Educational Technology*, *43*(6), pp.1041-1054.

Higgins, S. E.; Mercier, E.; Burd, E.; and Hatch, A. (2011). Multi-touch tables and the relationship with collaborative classroom pedagogies: A synthetic review. *International Journal of Computer-Supported Collaborative Learning*, *6*(4), pp.515-538.

Jamil, I. and Subramanian, S. (2012). The Impact of Interactive Tables and Multiple Surfaces Technologies towards Communication and Learning.

Johnson, L., Adams Becker, S., Estrada, V. and Martín, S. (2013). Technology Outlook for STEM+ Education 2013-2018: An NMC Horizon Project Sector Analysis. *New Media Consortium*.

Johnson, L., Adams Becker, S., Estrada, V., and Freeman, A. (2015). NMC Horizon Report: 2015 K-12 Edition. Austin, Texas: The New Media Consortium.

Kennewell, S., 2001. Using affordances and constraints to evaluate the use of information and communications technology in teaching and learning. *Journal of Information Technology for Teacher Education*, *10*(1-2), pp.101-116.

Kostakis, V., Niaros, V. and Giotitsas, C. (2015). Open source 3D printing as a means of learning: An educational experiment in two high schools in Greece. *Telematics and informatics*, *32*(1), pp.118-128.

Laal, M., Naseri, A. S., Laal, M. and Khattami-Kermanshahi, Z. (2013). What do we Achieve from Learning in Collaboration? *Procedia-Social and Behavioral Sciences*, *93*, pp.1427-1432.

Marks, H.M. (2000). Student engagement in instructional activity: Patterns in the elementary, middle, and high school years. *American educational research journal*, *37*(1), pp.153-184.

Mercier, E.; Vourloumi, G.; and Higgins, S. (2015). Student interactions and the development of ideas in multi- touch and paper- based collaborative mathematical problem solving. *British Journal of Educational Technology*.

Newman, H. (1905). Science Teaching in Elementary Schools. *The Elementary School Teacher*, *6*(4), pp.192-202. http://www.jstor.org/stable/992784.

Pacific Policy Research Center. (2010). 21st century skills for students and teachers. Honolulu: Kamehameha Schools, Research & Evaluation Division.

Robinson, C. C. and Hullinger, H. (2008). New benchmarks in higher education: Student engagement in online learning. *Journal of Education for Business*, *84*(2), pp.101-109.

Saavedra, A. and Opfer, V. (2012). Teaching and Learning 21st century Skills: Lessons from the Learning Sciences. A Global Cities Education Network Report. New York, Asia Society. http://asiasociety.org/files/rand-0512report.pdf [Accessed 8 Jun 2016].

Segerman, H. (2012). 3D printing for mathematical visualisation. *The Mathematical Intelligencer*, pp.1-7.

Stott, P. (2014). The perils of a lack of student engagement: Reflections of a "lonely, brave, and rather exposed" online instructor. *British Journal of Educational Technology*.

Trilling, B. and Fadel, C. (2009). *21st century skills: Learning for life in our times*. John Wiley & Sons.pp.56-60.

Vockley, M. (2007). Maximizing the Impact: The Pivotal Role of Technology in a 21st century Education System. *Partnership for 21st century Skills*.

Walden University, (2010). Educators, technology and 21st century skills: Dispelling five myths. A study on the connection between K–12 technology use and 21st century skills. Richard W. Riley College of Education and Leadership, Walden University, Minneapolis, MN: Author.

Webb, N. M. and Palincsar, A. S. (1996). *Group processes in the classroom*. Prentice Hall International.