Transforming Science Teaching Environment for the 21st Century Primary School Pupils

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ABSTRACT

The transformation of technology in the 21st century has produced children who are technology savvy and exposed to the internet and social networking at a very young age. These children are already in our school system. Thus teachers too need to use technology and transform the learning environment to meet the requirements of these children. This article discusses the need for transforming the primary school science teaching environment so that school children could have meaningful learning using tools familiar to them. However, while some parts of Malaysia are developing very rapidly, others are not developing as rapidly. School children in some areas are just as contented to share a single desktop computer without the Internet for a lesson. Thus teachers need to be creative to transform and improvise the learning environment to meet the pupils' needs. This article discusses a case study on seven excellent teachers of primary school science from different parts of Malaysia. The findings of the study indicated that the excellent teachers have improvised their teachings and teaching environment to meet the needs of their pupils and the curriculum for 21st century learning.

Keywords: *21st century pupils; science teaching for primary school; pupils' needs; teaching and learning tools; teaching and learning environment*

INTRODUCTION

Learning as we know traditionally is a process that usually happens in a classroom where the pupils sit in rows at desks and teachers lecture in front of them. Thus a learning environment is usually perceived as a place and space where teaching and learning happens in places such as schools, classrooms or a library. However, today's learning environments need to embrace the variety of places, ideas, and people that the modern world demands. These reflect a flexibility of space, time, people, and technology (Machado, 2013).

In contrast to traditional learning, 21st century learning needs students to acquire skills that allow them to be involved in their own learning (Prensky, 2008). Although most 21st century learning takes place in physical locations such as schools, in today's globalized and technology-driven world, a learning environment can be virtual, online, remote; which in other words, it need not be conducted in a place at all. Thus a 21st century learning environment could be generalized as a system that organizes the conditions in which humans learn best. This system must accommodate the unique learning needs of every learner and support the positive human relationships needed for effective learning. These learning environments should be able to support and inspire students and educators to acquire the knowledge and skills needed in the 21st century.

The Malaysian government has a vision for Malaysia to be a developed country by 2020. This implies that the country needs a workforce equipped with skills enabling them to compete and be marketable globally. To achieve this, teaching for the 21st century needs to prepare pupils for a complex life and work environment in the 21st century (NEA, 2013; Partnership for 21st Century Skills, 2007). Learning and innovation skills relevant in preparing pupils for the 21st century skills are:

- Critical Thinking and Problem Solving (e.g., effectively analyze and evaluate evidence, arguments, claims and beliefs; solve different kinds of non-familiar problems in both conventional and innovative ways).

- Communication (e.g., articulate thoughts and ideas effectively using oral and written communication skills in a variety of forms and contexts).

- Collaboration (e.g., demonstrate ability to work effectively and respectfully with diverse teams).

- Creativity and Innovation (e.g., use a wide range of idea creation techniques to create new and worthwhile ideas).

This means that if our students are to compete globally today, they must be proficient critical thinkers, communicators, collaborators and creators. The traditional need to equip pupils with the 3R skills (reading, writing and arithmetic) is no longer adequate (NEA, 2013). Primary and secondary school teachers should be competent and able to teach effectively to promote these skills. These teachers need to change the way they teach as the 21st century pupils now come to school with very different sets of experiences and expectations than the 20th century pupils. These technology savvy people navigate their life far differently than many of their teachers. Thus to be able to connect, relate and motivate them, teachers need to be open to new ways of teaching that support the pupil's needs (Apple, 2008; Lemke, 2010; Rotherham & Willigham, 2009)

In adapting to these new ways of teaching, teachers may be surprised that their pupils have already acquired the skills needed for the 21st century learning from outside the classroom. These pupils live their lives digitally every day, in the form of Internet, text messaging, social networking, and multimedia in their lives outside the school so they expect their learning process to be interactive and engaging with application of technology. A disconnection between the way they live and the way they are taught when teachers continue to teach with 20th century teaching style will lead to demotivation and boredom in the classroom.

There is not much difference between the approach to teach the 21st century learners from the previous ones. We still want our pupils to be creative thinkers and problem solvers who have the necessary skills to function effectively in society and their workplace. The differences lie in how the skills are incorporated in the classroom and how technology is integrated into their teachings. To be able to do so will certainly change the way a teacher instructs (Beers, 2013). Beers suggested instruction that meets the needs of today's pupils incorporate:

- a variety of learning opportunities and activities

- the use of appropriate technology tools to accomplish learning goals

- project and problem based learning

- cross-curricular connections

- a focus on inquiry and student-led investigations

- collaborative learning environments, both within and beyond classroom

- high levels of visualization and the use of visuals to increase understanding

- frequent formative assessments including the use of self-assessment

Teachers could not claim that they have successfully taught for the 21st learners by simply using the tools needed. To teach successfully with the 21st century tools, teachers should be able to integrate the tools with various teaching strategies and approaches (Lieberman & Mace, 2010; Yost, Senther & Bailey, 2000). Using PowerPoint to deliver a lesson today is no longer adequate, but instead it has become out of date and a source of boredom when pupils have to sit and listen to the teacher talking and referring to the slides from the beginning to the end of a lesson. This approach is similar to using a whiteboard and transparencies which is teacher centered and does not allow the pupils to explore what they have learnt. IT-based teaching tools such as computers, projectors, interactive whiteboards and even simply a whiteboard could be utilized successfully if teachers are able to think creatively and involve pupils in the teaching and learning process. As mentioned by Beers (2013), they should provide lots of opportunities for learning,

project and problem based and let pupils inquire by doing investigations. Thus the 21st century teaching environment need not imprison the student in a classroom from the beginning to the end of the lesson, but instead transform it into an environment where students are free to move about, search for answers to the problems posed by the teacher and communicate freely with their peers.

The 21st century teacher should never restrict lessons to only a given space and time. For example, a teacher who has always taught a certain period a week will normally conduct the classes in the classroom, labs or computer labs. The teaching and learning process occurs in the given time and space where, for most pupils, once they leave the classroom, that will be the end of the topic. The only other time pupils will look back into the topic is when they need to revise it for exams. On the other hand, teachers adopting 21st century teaching will be able to attain the pupils' attention, keeping them focused on the topic by giving them tasks, to explore and search the internet, discuss with friends via emails, social networking or smart phones. Most of these networking sites are free, social in nature and promote self-expression, allowing multiple users to participate by editing, commenting and polishing a document collaboratively, rather than working alone (Apple, 2008; Lemke, 2010). This will keep the pupils focused on the topic, and the lesson continues even though pupils have already left the school. The teacher could simply monitor the pupils' work or facilitate them by keeping in touch with them through social networking, smartphones and so forth.

Teaching science should not limit teachers and pupils to classrooms or laboratories. A class could be conducted as successfully at the school field, garden, assembly area or even at the cafeteria depending on the topic being taught. The main idea is to engage pupils in their learning by giving them space to do so. It is such as waste that when abundant resources are outside the classroom for pupils to explore, they are made to listen to teachers and see pictures only from the textbooks. Pupils in the 21st century, also known as the digital natives live their lives digitally everyday (Pearlman, 2010; Tapscott, 1998). They use the Internet, text messaging, social networking and multimedia fluidly in their lives outside the school. Thus, providing them with parallel level of technology opportunity in their academic life could lead to interest, engagement and learning. It is the disconnection between the way the pupils live and the way they learn that is causing loss of interest and their engagement ultimately suffers (Blackmore, 2008)

Technology in science teaching and learning supports the teaching and learning process. Teachers still play the important role of conveying knowledge and facilitating the learning process. However, the 21st century learners need to think and solve problems, communicate, collaborate, create and innovate to prepare them for the 21st century workforce. Thus, peers play an important role in facilitating the learning process, as the pupils sit together and agree on ways to solve problems, and then select the most appropriate approach to do so. In the problem solving process, technology plays an important role for pupils to search, gain ideas, collect information, present ideas and communicate among themselves.

In Malaysia, information technology could easily be accessed by most schools and households. The Internet has become a crucial part of the people's lives and computer labs are available in most schools. Most urban pupils are computer literate and could at least use the Internet to communicate. In promoting learning for the 21st century skills, the new science curriculum, *Kurikulum Standard Sekolah Rendah* (Standard Curriculum for Primary School) called *Dunia Sains dan Teknologi* (The World of Science and Technology) trained pupils as early as in Year 1 to use the computer to search for information, use email or present their work (KPM, 2011). Most pupils in the urban areas are used to computers and gadgets. On the other hand, those in the remote areas are not as technology savvy as their urban counterparts and were introduced to computers and technological tools through formal education at school. These pupils are not as proficient in using computers.

Because of these differences, teachers need to be able choose and adapt their lessons so that no pupils are left behind in 21st century learning. The main aim is to promote thinking and solve problems through various strategies and approaches that allow pupil to communicate and collaborate to solve them. Teachers need to be creative and able to adopt and adapt strategies for maximum outcomes. This article discusses a case study on seven excellent teachers in different parts of Malaysia. Since most parts of the country have already had access to information technology, the study sought to reveal if teachers teach to meet the needs of the 21st century learners. The objective of the study was to observe primary school excellent science teachers' style of teaching and investigate whether the teachers are able to conduct lessons to promote

thinking skills and problem solving using the 21st century environments.

The Study

Most excellent teachers are awarded with the title as they were able to teach effectively and innovatively. Most are involved in various academic activities and contributed to the education system as module writers, presenters and teacher coaches. This study hoped to find out how selected science excellent teachers perform in the classroom, the approaches they used to teach different topics in science, the teaching and learning environment chosen for the lesson, and their utilization of technology or teaching tools for 21st century learning. A total of seven science teachers who have won excellent teacher (ET) awards were chosen from a list of excellent teachers in primary schools in Malaysia. The teachers were chosen conveniently from a list of excellent science teachers from Selangor, Putrajaya, Perak, Kedah, Terengganu, Sabah and Sarawak so as to cover all parts of Malaysia. The teachers were given pseudo names ETS (Selangor), ETPj (Putrajaya), ETP (Perak), ETK (Kedah), ETT(Terengganu), ETS (Sabah) and ETSw (Sarawak) based on their home state. These teachers are degree holders and have teaching experience of two to eight years.

This was a qualitative study where the main data collection method involved classroom observations, interviews, and analysis of pupils' work and administrative documents. Thus findings of the study cannot be generalized to the science ET population in Malaysia. During classroom observations, the researcher made records by video recording the lesson and taking field notes. The video recordings were then transcribed for analysis. Interviews were then conducted on the excellent teachers, their pupils, school administers and peers. The observations and interviews were transcribed and coded and then categorized into themes for discussion (Table 1).

FINDINGS AND DISCUSSIONS

To be able to teach effectively for the 21st century, teachers need to be receptive of the changes rapidly occurring around them. As pupils nowadays are mostly born into the digital era, the curriculum has also changed to be able to equip them with the 21st century skills. Pupils as young as in the primary school must be equipped with the appropriate thinking and problem solving skills, communication and collaborative skills and think creatively and innovate. Although teaching should now be pupil centered, a teacher still plays the main role to teach and facilitate the pupils and keep them focused on the subject matter. The analysis of the study on the seven excellent teachers shows the teaching and learning trends among the excellent teachers' classes (Table 1).

Table 1 Teaching and Learning of an Effective Teacher

	Teaching activities
Set induction	promotes thinking, singing, question and answer, revision of previous lessons, relate to the things around them
Strategies	constructivist, inquiry, contextual, mastery
Assessment	formative assessment; question and answer, activity books
Motivation	interesting activities, pupils visualize, positive reinforcement, facilitate pupil with tasks
Communication	simple and brief explanation, pupils work in mixed ability groups, use simple sentences that pupils understand, keep pupils focused on the tasks given
Resources	ICT, things available in the classroom, places around the school, any easily available items

The seven excellent teachers interviewed agreed that set induction is a crucial part of the lesson as it keeps the pupils focused on the topic and content taught. One teacher responded that '*Set induction is important part of a lesson as it prepares pupils to be focused on the topic that a teacher intends to teach. It make them interested in learning'(ETS)*. The teacher believed that set induction triggers pupils to think about

an issue and motivates them to learn. An observation of ETPj showed the teacher using multiple approaches to begin his lesson on teeth. He initially played a song *Chan Mali Chan* with the lyrics changed according to the topic and sang along with the pupils. The pupils sang loudly and were still robust even though the school session was almost over. The teacher later instructed the pupils to open their mouths and count each other's teeth before starting his lesson.

The analysis of class observation and interviews shows that excellent teacher strategized well for a lesson for optimum learning. For most lessons, excellent teachers adopted constructivism, inquiry, contextual and mastery learning. Teachers were observed to have used things that pupils are familiar with for the lessons and encouraged communication among the pupils. ETPj responded, *'To me personally, for each T&L sessions I will try to make sure that the pupils enjoy themselves and be interested. I want them to learn while enjoying themselves ... and gain the knowledge that I wanted them to learn indirectly. (ETPj)'*. The teacher responded that he always makes sure that his classes are interesting so that he could motivate the pupils to learn science. He added, '*I want the pupils to be excited and happy in my class. I don't want them to feel bored, instead always looking forward to my lessons*'. ETPj stated that he should strategize well so that his classes are always enjoyable so that pupils look forward to his presence in their class and are well motivated to learn science.   ETPj believed that pupils should be allowed to communicate and work collaboratively in a group. He reflected his experience with a year 4 class where pupils were instructed to work on a project, '*One example is with a year 4 pupil. He planted some beans, watered them every day and observed them. Sometimes outside my teaching period, he will come and see me and reported that his bean has sprouted, or gained leaves. Even after I have completed the topic, he still kept and observed the plant…and came to see me one day to report that the plant has wilted.'* He mentioned that by making the pupils work collaboratively to grow seedlings and take care of them, the pupils became motivated and enthusiastic with the project, and reported every detail of the seeds' growth, even after he had moved on to a new topic.

For most excellent teachers, having good communication during lessons keeps the pupils alert and focused. Pupils should be allowed to ask questions, give ideas and work on the ideas. To encourage good communication, pupils were instructed to work in groups so that they could share ideas and help each other. Some responses received from the teachers are: '*By dividing pupils into multiple intelligence groups...pupils are more willing to share ideas. Some of them are weak, but have good ideas..so they involved themselves and get motivated from group discussions. They like to learn from friends...so I will usually use multiple intelligence groups for activities like projects* (ETSw)'. The teacher responded that she divided the pupils into groups of multiple intelligence so that pupils could help each other, support one another with the strength that each individual has so that they could collaborate to complete a given task. She added that, '*I will ask her to ask her friends, discuss in groups so that she will get the information indirectly from her friends. Friends which are more capable are instructed to help with the tasks. Sometimes I will get friends that have got the answers to help the slower groups. This make my work easier as the pupils learn from their friends'*. She believed that by allowing the pupils to work collaboratively as a team, they could discuss and communicate to help each other to improve understanding and work together to solve problems. In doing so, pupils gain experiences and knowledge that allow them to reach a higher level of understanding of the lesson (Anderson, 2001; Vygotsky, 1978).

Excellent teachers are also proficient in choosing a variety of resources for optimum learning. As discussed, being restricted to a certain time and space for learning will prevent pupils from exploring, visualizing and gaining new ideas. The ETs in the study were observed to go beyond classroom teaching and conduct classes outside the classroom or labs. The teachers believed lessons could be conducted using any readily available objects if they are unable to prepare any teaching aids, '*For example, I will use whatever that is in the classroom as teaching aids, like a pupil's water bottle.. as long as they are relevant or ask pupils' existing knowledge on the topic I was about to teach. I would* even conduct classes anywhere suitable for the lesson. *If the science room is not available, we can have the activities outside the classroom. The T&L of science is not necessarily done in the classroom... it can be conducted under the tree, at the school hall, or the canteen. The teacher needs to be creative and take intiative for it to be done. (ETSw*),' The teacher responded that he would use any readily available objects in the class to discuss a concept and that classes are not restricted to a classroom but any suitable places such as the school hall or the canteen. For example, one excellent teacher has taken the pupils out to the car park to experiment on the frictional forces. Pupils tested

the distance travelled by a toy car when it slides above cement, sand or paved road, and concluded their findings in an inquiry based lesson.

Excellent teachers were observed to use technology effectively for teaching, preparing materials, assessment and communication. An ET responded in an interview that he encouraged pupils to search for information from the Internet before coming to class, or use the Internet to look for information to complete a task. As stated by ETS, '*I give tasks and ask them to access the information from the Internet*'. For ETPj, he would instruct the pupils to search for information on the Internet before he begins the lesson or after completing a lesson, '*I will usually ask the pupils to search for information from the Internet, pupils from Kuala Lumpur usually have computers at home...After the T&L process, I will instruct the pupils to access the Internet by giving keywords to help them search for information and be focused on the item searched. We can give more tasks for the better pupils.*' As science lessons are conducted in Bahasa Malaysia, the pupils are given keywords to help with their search. ETPj uses multiple technological tools for a single lesson. For example, he began a lesson on defecation and excretion by showing a video of animals defecating, then instructed pupil to google search for ways that fish excrete and later showed a YouTube video of a cat using the toilet. While the teacher finds it hard to get all pupils to use the computer, he compensated for the lack of computers by engaging pupils in the learning process and showed interesting animated video clips. He also reminded the pupils to search for more information from the Internet when they get back home from school.

Some excellent teachers are not as lucky as their urban counterparts as their pupils or schools lack easy access to the Internet or computers. Some of the problems faced are, '*Some pupils especially the weaker ones usually do not bring any material. Some do not have computer or the Internet at home. So I sometimes bring materials that they can share, discuss in groups and present (ETSw)*' and '*I have problems with the use of ICT in the T&L process as the school was flooded and all computers could not be used anymore. Anyway, I can still teach effectively by being creative ... use real objects'.* The teacher from Sarawak agreed on the importance of using technological tools for teaching, but in reality most of her pupils do not have access to computers and Internet at home. She could not use the school's computers as they were destroyed when the school was flooded. The teacher claimed that she can still teach effectively by being creative and create a conducive learning environment for her pupils. She believed that by being creative, improvising and using real objects for her teachings, she could create an effective learning environment for science learning. She overcame the problem of pupils not having computers at home by putting them into groups with those who have computers and Internet facility at home.

Teaching for the 21st century skills needs pupils to be actively involved in their learning. However, using technological tools would not guarantee that pupils will be successful, skilful and able to compete globally. Teachers need to revise their role to integrate the technological tools into their lessons so that pupils could gain knowledge and skills crucial for their survival in the 21st century. The following Table 2 shows the trends of instruction of the seven science excellent teachers based on the skills needed for the 21st century learning which are: critical thinking and problem solving, communication, collaboration, creativity and innovation (NEA, 2013).

Table 2 Participant Characteristics

21st century skills	Observation
Critical Thinking & problem solving	categorize, compare and contrast, classify, predict, make conclusion, relating, generate ideas, making inferences,
Communication	good communication between and pupils,
Collaboration	Conduct group work, multiple intelligences
Creativity and innovation	innovate for teaching, creative

The findings of the study indicate that excellent teachers in the study have taught pupils to think critically and creatively. However, the critical thinking skills are limited to categorizing, comparing and contrasting, classifying, predicting and making conclusion (KPM, 2011). Pupils were also encouraged to think creatively by relating, generating ideas and making inferences. These skills were gained by the pupils when they seek to answer the questions posed by the teachers, doing inquiry based activities, working in groups to discuss the findings and finally agree on a certain conclusion.

The excellent teachers observed practiced good communication with their pupils. Pupils found the teachers approachable and were willing to ask questions or seek help from the teacher when they were trying to complete a task. Pupils were allowed to communicate well in the classroom, discuss and work together in groups and later present their ideas. They collaborated to complete tasks given and made their own conclusions. Excellent teachers were observed to have encouraged creativity among the pupils by allowing them to create and present their ideas. The analysis of pupils' work shows that pupils were able to draw mind maps creatively with different styles based on their perceptions of the topic.

Findings of the study indicate that most excellent teachers in this study are able to conduct classes which are student centered. They are able to choose appropriate learning environments that are suitable for the topics and sometimes conduct simple project based activities. One pupil responded, '*In teacher's ETPj's classes, he always take us out of the classroom for a walk to visit places.. It never happens in our previous classes, we just sit in the class or go to the science room',* indicating the pupil's preference to learn in multiple learning environments not enclosed in the classroom.

CONCLUSION

The study shows that using technology to aid the learning process depends on the school location. For some schools, the limitations are that they did not have access to computers and Internet to have a completely 21st century learning environment. As mentioned by one of the excellent teachers, some households still do not have computers and Internet, making it impossible to make pupils complete a task or communicate from home. Teachers in the study however, managed to compensate for the absence of technological tools by creating a learning environment that is lively, student centered, contextual and project based. However, this is only true for some excellent teachers, but for others, the teachings are exam oriented where the teachers' quests are to complete the syllabus and drill pupils for an exam.

Some excellent teachers in the study were observed to have encouraged pupils' creativity by allowing them to do inquiry and project based activities. The pupils were allowed to explore and discover for themselves the outcomes of their activities and later allowed to design and create based on their understanding. These activities usually involved pupils' communication, arguments and exchange of ideas.

The findings of the study show that some of the excellent teachers in this study were able to create a learning environment for 21st century learning. Technological tools are well utilized that pupils communicated and collaborated to complete a task in project based learning. Teachers however need to think about how to create a 21st century learning environment so that learning is not confined to a certain

space and time. For teachers in the rural areas, there are no limitations teaching for the 21st century skills. A 21st century learning environment is still possible even with limited technological tools. By adopting the project based or problem based teaching, teachers allow pupils to create and improvise to find ways to complete the given task. To do that, teachers need to be creative, and encourage creative thinking among the pupils, and apply the ideas in the form of innovation or creation of teaching tools.

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