

Effects of Biology 21st Century Teaching Strategies on Students' Motivation

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ARTICLE INFO

Keywords: Biology Education, Teaching and Learning, Pre-Experimental, Music Inventory, Motivation

Received : 22 December

Revised : 26 January

Accepted: 28 February

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ABSTRACT

Malaysia national education aspirations in the Malaysian Education Blueprint (2013-2025) implies the importance of holistic and resilient talents development program in educating the new generations. Educators as facilitators are demanded to be more proactive in designing classroom activities to achieve the vision. This study investigates the 21st century classroom activities involving 4C (creativity, communication, collaboration, critical thinking) elements in high school science students which believed able to enhance students' motivation. The sample involved 91 form 4 students and data collected using instrument adapted from MUSIC Inventory. Analysis using SPSS 21 shows significant difference in all domains; empowerment, usefulness, success, interests and caring. Overall mean difference of all domains is $M = -4.98$ ($SD = 1.13$). Dependent t-test analysis shows $t = -4.2$, $df = 90$ while p-value is 0.00 ($P < 0.05$). The finding implies that the learning techniques adapted involving 4C elements significantly increases students' motivation.

INTRODUCTION

Malaysian government has developed the Malaysia Education Blueprint in 2013 mainly to enhance 11 different aspirations, strategics and operational shifts which align with the national education visions. These transformations also aim to raise these students to the international standard as well as preparing the children for 21st century challenges (MOE, 2013). The visions focus on various fields especially the development of science and technology education. However, after few years of implementation, the trend of science stream students' enrolment decreasing by years (LPM, 2018). The trend is worrisome as this will affect the development of human capitals and national talents in the future. Science stream students are source of intellectuals which drive the development of science and technology industry especially in a developing country. In Malaysia, industrial employers are still hiring foreign consultants to lead multinational projects. Local experts are given less opportunities for presenting impactful ideas and delivering higher performance due to low expectation towards work quality and individual perseverance. Hiring the outside talents may increase in the operational cost which can be reduced by grooming the local graduates to be the best. Thus, it is important for Malaysia to continue thriving in producing higher quality graduates to be positioned as demanded by the field to reduce foreign employments.

Developed countries have long begun to use 21st century skills in class which affect significantly on education (Dahalan & Ahmad, 2018). However, it is found the implementation of 4C elements in teaching in Malaysia are still at moderate level. Some teachers seem need more help in term of fundamental knowledge and skill regarding 21st century learning. Not that they do not be given chances to learn and explore the possibilities but they hesitate to open up their perspective towards recent pedagogical findings. They preoccupy themselves with the traditional teaching methods and believe it to be the only ultimate way to educate. Though several efforts from the ministry to fund introduction and courses have been presented in school. Teachers are the exemplar to education change (Brown et al, 2021). Agents of change are the vital factor towards school improvement and efficient operations. Therefore, educators ought to provide themselves with maximum amount of knowledge regarding 21st century education. 21st century skills have become the solutions to the life challenges to the IR 4.0 era.

The skills have become the primary elements of education curriculum around the world (Alismail & McGuire, 2015). Thus, having knowledge in 21st century skills and activities are important for teachers in Malaysia to have profound encouragement towards students' performance. Therefore, this study is urgently needed to examine the effectiveness of Communication, Collaboration, Critical Thinking and Creativity elements in teaching strategies to increase students' motivation in terms of empowerment, usefulness, success, interest and caring. Our purpose of study was to examine how 21st century class activities including the 4C elements affected students' motivation and whether their motivation differed from before activities. The research question would be;

To what extent do Form 4 Biology students' motivation about Meiosis change as a result of 21st century class activities.

LITERATURE REVIEW

In industry, talents with scientific reasoning skills and problem-solving skills are highly in demand (Shanta & Wells, 2020; Md Jais et al., 2021). Being critical during decision making process for better service, higher quality of product, and increase professionalism characters are essential to survive in current dynamic economy (Roekel, n.d). Chiruguru (2020) defines collaboration as group of students' able complete tasks effectively, achieving the same aim as well as share responsibilities. Chiruguru promotes working in groups collaboratively to create knowledgeable nation. Collaboration and communication can be difficult to be differentiated as to complete a task and shared common goal needed skills to articulate ideas effectively so that the discussion reaches understanding. Without communication and collaboration there is no way class activities can occur smoothly, hence the importance of 21st century skills (Yusof et al., 2022).

21st century greatly demands workforce that are able to communicate respectfully, critically reason, creatively solve problems and collaborate in different perspectives to achieve higher quality in industry. In fact, Zhao (2012) believes that learners today have to nurture the right characters to survive the global economic demand. Learners should start thinking like an entrepreneur. Be knowledgeable, flexible and creative (Li & Ismail, 2022). Eric Sheninger concluded these characteristics as competencies. This leads to a discussion within employers whether is it enough for students to only be prepared to well modelled with the 21st century skills but not competent enough to apply them in real world. This also to prepare students not just to survive their hired job but also to succeed in the job that has not been created before.

The essential competencies suggested is align with all standards globally including the International Society for Technology in Education (ISTE) standards both for learners and educators. Being creative, manage to collaborate with partners anytime and anywhere, able to communicate effectively, manage to handle problems and critically solving them, entrepreneurship, connected globally, competence with technology, able to create and publish digital content responsibly. This is a new perspective that has to be the preliminary concern of school leaders and educators in moulding students and prepare them for the future.

The essential competencies profit the companies in many ways and manage to assist company thriving during the economic turmoil. Practices in classroom will be a good start to create such resource. Thus, educators' responsibilities are significant to emphasize the aims as early as possible. Hence the importance of 21st century education to be familiarized particular skills to prepare the students for such goals. In addition, these practices in class proven to increase students' motivation in learning the subject (Sedden et al, 2016). Motivation is a force in humans to stimulate them endure hardship to achieve their target goals. Hidi et al (2000) suggest that interests and goals are two

important variables for learning. They also suggest that multidimensional nature of motivational forces may contribute to the enhancement of academic performance including the intrinsic and extrinsic motivations. These motivations are resulted from a series of meaningful learning that students receive in class. Once students feel motivated the cycle continues by having repeated meaningful learning followed by feeling motivated repetitively leads to impactful academic performance.

Meaningful learning does not only depend on teaching techniques, school surroundings or students' talents but also affected by students' motivations. In the process of learning, having great interest in science would be an important factor to explore more information regarding the subject (Ismail et al, 2022). Interest is one of the five elements to measure motivation in various group of people as proposed by Brett Jones using Music Model Inventory (Jones, 2017). A handful of research had strengthened the Expectancy-value theory by proving that students' motivation affects their choices, hard work, consistency in learning and performance (Simpkins et al., 2006).

In the Music inventory there are five elements that defines motivation which are empowerment, usefulness, interest, caring and success. Hidi and Renninger (2006) defines interest as an affectionate emotion and cognitive attention. Teachers can trigger students' interest for them to be motivated. Empowerment defined by Kember (1997) is student-centred program that students themselves are encouraged to make their own decision with guidance. There are findings proving that ability for students to choose during learning will increase their motivation and engagement (Patall, Cooper & Robinson, 2008). As they feel motivated, they will think of possibly being successful. Jones (2009) also includes caring in the inventory as motivation involves safe and loving environment by the people around including classmates and instructors. To justify the implementation of MUSIC inventory in a study, Jones (2009) suggested that when students feel in control of what they are learning (*empowered*), they would perceive the topic is *useful* and have faith in *success*. They will also begin to have *interest* in the subject and feel *cared* by people in the environment.

Salleh et al. (2021) revealed that Cell Division is one of the topics that identified by both teachers and students to be difficult to teach and to learn. In KSSM Form 4 Biology Syllabus, Cell Division is the 6th topics after Metabolism. In the latter survey, one of the teacher respondents said that the topics are difficult due to various different terminologies and concepts which are tough to understand. Students are confused with both cell divisions; mitosis and meiosis (Gungor, 2017; Kindfield, 2014). Within this topic, concepts involving cell cycle, chromosome and homologous chromosome are the essence to Biology in tertiary level (Kiliç, 2018). Students should comprehend Cell division to further understand genetics and molecular biology. Students will face a difficulty to suggest solutions to genetics issue (Tekkaya et al., 2001). Salleh et al. (2021) stated also that having difficulties in the subject will affect motivation negatively, thus will fend effective learning. Good attitudes and excellence in learning will not deny the need to be motivated, allowing learning to take place (Othman et al, 2009).

METHODOLOGY

This study employs quantitative approach using a pre-experimental research design. To conduct pre-experimental study, we adapted methods recommended by Ismail et al. (2022) in which the study follow the model of 'one group pretest and posttest study' as shown in Figure 1.

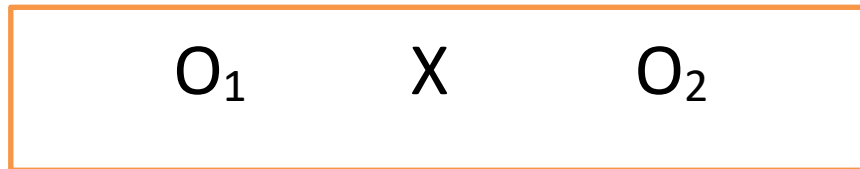


Figure 1. Model of One Group Pretest and Posttest Study

A total of 91 students of Form 4 urban students in a Malaysian secondary school were selected as respondents in this study. They were 43 boys and 48 girls randomly selected from 145 of the population, currently studying Biology KSSM. All of the students obtained minimum B in their internal final year school examination in 2021. Not only did they obtain great results then, they also show average performance in Biology during first diagnostic test (UD1) conducted by the School Biology Department in May 2022. Their age was ranging between 15 to 16 years old. 2 teachers who were involved in facilitating the interventions have more than 5 years of experiences in teaching science subjects in Malaysian national schools. They were graduated with honour in their teaching programmes.

Data were collected using questionnaires known as MUSIC Inventory adapted from Jones (2017). MUSIC Inventory was constructed by Brett D. Jones and valid for 5th grade to 7th grade of science classes students (Jones et al., 2017). The evidence of validity shows a good value of Cronbach's alpha in which all the domains scored above .7 (empowerment $\alpha = .72$; Usefulness $\alpha = .80$; Success $\alpha = .84$; Interest $\alpha = .77$; Caring $\alpha = .85$) conducted on fifth grade to seventh grade students in science classes (Jones et al., 2017). A study by Parkes et al. (2017) with fifth grade to twelfth-grade students in music and band ensemble classes shows higher validity evidence of Cronbach's alpha (empowerment $\alpha = .73$; Usefulness $\alpha = .86$; Success $\alpha = .92$; Interest $\alpha = .91$; Caring $\alpha = .92$) in which the fit indices of a confirmatory factor analysis is acceptable. A mean score interpretation table has been developed by Ismail et al. (2021) that shows average mean of 1.0 - 2.9; low, 3.0 to 4.9; moderate and 5.0-6.0; high while using MUSIC Inventory identifying students' motivation. We had obtained permission from the instrument owner and considered all the ethical procedures such as asking permission from the school principal and the respondents' parents. Pretest questions were executed as a prior data collection. The questionnaires were transformed into a google form and the link was shared through students google classroom class site. Respondents had ample of time to answer the questions as the link were shared when they were at home during school break. The purpose of pretest is to

identify respondents' level of motivation before learning about Cell Division particularly Meiosis using 21st century approach.

The intervention took 9 days to complete due to scattered schedules involving 3 consecutive classes timely 1 hour per class. As shown in Figure 2, there are 3 different phases of intervention and each phase involve at least 2 to 3 elements of 21st century learning. Students are having prior knowledge toward Cell Division by learning Mitosis in previous Biology classes. During the first phase, students were introduced to the importance of Meiosis activity named 'Exploration session' using given Chromebook as shown in Figure 1.



Figure 2. The Learning Process of Students During Phase 1 the 'Exploration-Session' of Intervention While Using Chromebook Provided by the School

They discussed in groups and shared their findings. They presented their findings in front of the class. This first session involved communication within the group member, collaboration between different group and critical thinking in presenting their findings. In the second phase, students were provided with plenty of different colours of clay or plasticines for them to create their own interactive 'Meio-timeline' on a large paper to elaborate the process of Meiosis. Once completed each member of other groups went around inspecting and left their opinions and understandings by writing notes for correction or encouragement. If there is error to be fixed the group member who stayed will asked for explanation. This session is called Creating Your Own 'Meio-timeline'. Hands on activities are also one of the 21st century activities involving elements of creativity, communication, collaboration and critical thinking. Last session students were given topics on ethical issue involving cloning, tissue culture, IVF procedures and cancer. This session involved the understanding of both concepts; Mitosis and Meiosis. The first half an hour, students were given time to explore those topics using Chromebook and another half an hour, students discussed to justify the applications of the techniques and technology in society concerning ethics. After the intervention students were asked to answer post-test questions. The flow of the intervention has been summarized in Figure 3.

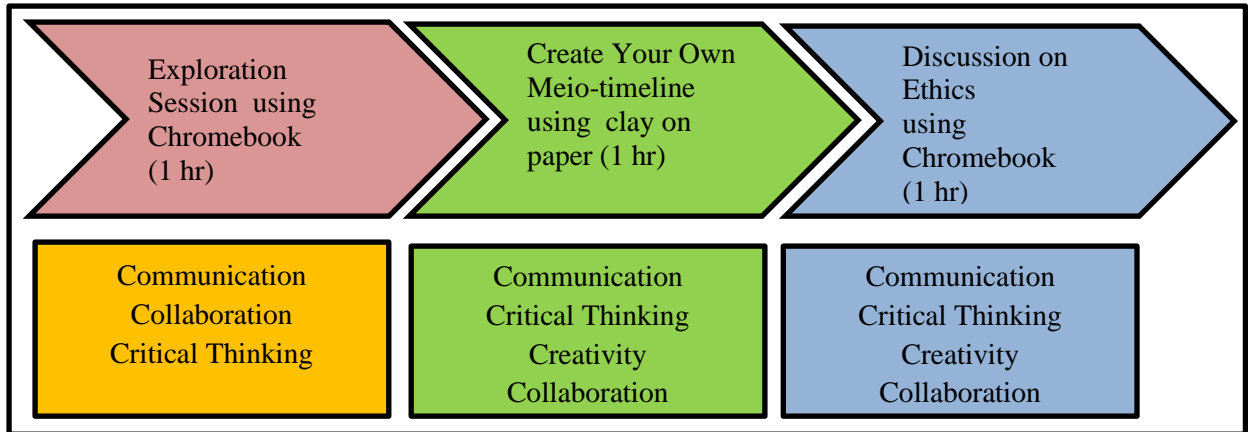


Figure 3. Flowchart of the intervention

RESEARCH RESULT

SPSS (Statistical Package for Social Sciences) 21 was operated to analyse data. Firstly, descriptive analysis was performed to calculate the means and standard deviation to work out the differences of all 5 domains between 2 set of data (before and after intervention). Secondly Dependent T-test was run to compute the difference among both set of data before and after intervention. The research questions were analysed by means, standard deviations and dependent t-tests.

As shown in Figure 3, the overall trend of students' motivation is the same as before. Highest is caring, followed by interest, then empowerment and usefulness and lastly is success. In Table 1, the total average of domain of all domain shows significant difference compare the data before and after intervention. Total average of *Empowerment* is $M=4.8303$ before while $M=5.0714$ after intervention; *Usefulness* is $M=4.7932$ before and $M=4.9744$ after; *Success* is $M=4.6405$ before increase to $M=4.7912$ after; *Interest* increases to from $M=4.8978$ to $M=5.1429$ (highest difference); *Caring* increases slightly from $M=5.4300$ to $M=5.4835$ (least difference).

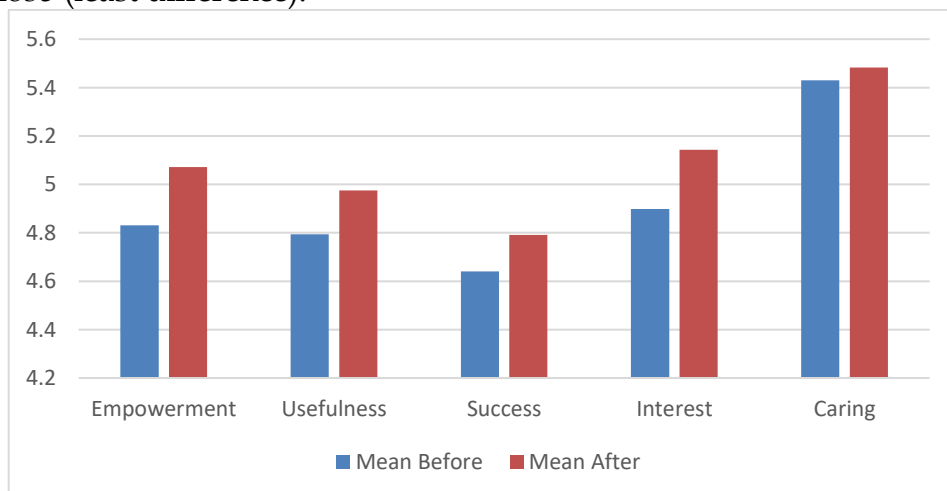


Figure 4. The Difference in Total Average of all 5 Domains in Music Inventory Before and After Intervention

In Table 1 shows the result of the dependent-samples t-test indicates that there is a significant difference between the scores of motivations between before and after the intervention, finding shows the mean difference between all domain before and after the intervention is $M = -4.9846$, $SD = 1.13196$. The result also shows that the t value is $t = -4.201$, $df = 90$ while p- value is 0.00 ($P < 0.05$). This means that there was a significant difference between the total mean of motivation before and after the activities.

Table 1. Results of the Dependent t-test

Compare Before & After	Mean	SD	95% Confidence Interval of the Difference		t	df	Sig (2-tailed)
			Lower	Upper			
	-4.9846	1.13196	-.73420	-.26271	-4.201	90	.0

While in Table 2 shows results of descriptive statistics to indicate all domains in motivation, items categorical based on domain, number of samples, mean values and standard deviation of each domain before and after intervention. **Table 2.**

Table 2. Descriptive Statistics

Domains	Items	Intervention	N	M	SD
Empowerment (4 items)	5, 12, 16, 18	Before	91	4.83	.847
		After	91	5.07	.81
Usefulness (3 items)	1,9,13	Before	91	4.79	1.05
		After	91	4.97	1.10
Success (4 items)	2,4,7,10	Before	91	4.64	.81
		After	91	4.79	.87
Interest (3 items)	6,8, 17	Before	91	4.89	.93
		After	91	5.14	.91
Caring (4 items)	3,11,14,15	Before	91	5.43	.85
		After	91	5.48	.86

DISCUSSION

The purpose of this study is to understand the effectiveness of 21st century activities towards students' motivations in class. Due to the data analysis obtained from the SPSS program, we understood that the finding was the same as the past results. The 21st century activities in class with students which involve communication, creativity and critical thinking able to increase students' motivations. The findings imply that hands on activities that demands students' involvement significantly influence their ability to make decisions (empowerment), benefits of learning (usefulness), way of thinking differently (creativity), willingness to learn (interest) and possibility to succeed (success). Research also suggests that students develop higher motivation when teachers have clear objectives, dynamic classroom environment, and execute different teaching techniques (Sedden et al, 2016). Different learning environment compared to the routine in class would increase students' creativity and ability

to find solution in a creative way (Nissim et al, 2016). Several research obtained significant positive results in activities to enhance students' motivation in class (Weissblueth et al, 2014) (Assor et al, 2000).

During the intervention, students were excited every time class was announced to be held in the computer room. Having technological devices aiding their understanding clearly would enhance their interest by anticipating the excitement that they will experience. This can be seen not only through their behaviour but also through their facial expression. Not only they were looking forward to the classes, they also came in early. That shows their high interest and fully ready to be engaged in learning the subject. These observations were in line with the findings of other studies such as Nissim et al (2016) and Scott-Weber et al. (2013). 'Meio-timeline' activities were the spark point of the intervention when one of the students was implying that he understood the concept immediately after the discussion of the clay-made meiosis process. This event supported the survey results shown in the table that mean difference between students perceive success before and after intervention. Align with results from previous research showed one of the significant factors influences the ability to obtain higher marks on learning are interesting learning process and teaching methods (Chan et al, 2011).

Teaching methods using technological devices as platform to explore information regarding cell division during the first phase of intervention, successfully attracts students' attention as well as manage to enhance their excitement to attend the class. Knowing that they will be learning the topic using computers few days earlier has created a positive learning environment prior to attendance. They even tend to anticipate what kind of content they would find by having the Google Chrome application button in front of them. However, it can be denied that there were also mischievous thoughts linger around their mind to explore other than the teaching topics. For instant the score of recent football match, the updates on social media or messages in their inbox. The situation was really within the teachers' creativity to create interests in the process. Teachers facilitated the activities until they would not be even thinking of googling other than the discussed topics. Tavares et al. (2021) supports the positive impact of using technology in science education and able to improve students' performance. Computer software is also proven to be an effective tool to deliver abstract knowledge in class (DSKP, 2018). The 'Exploration-session' also tend to create a learning environment of their choice. Students be given freedom to explore within their interest with guidance and able to decide suitable information to share with other group members.

2nd phase of the intervention focuses on hands on activities able to stimulate students' creativity in moulding the dynamic changes in structure of chromosomes throughout the process. Among the importance of hands-on activities is to attract involvement of students by engaging in every phase of the activities preventing them from feeling left out and unimportant. The element of communication and collaboration also successfully induced while they struggle to create nice looking chromosome to be compared among each other. This process demands students' understanding deciding which structure of

chromosome to be used such as chromatin, chromatid, sister chromatid and homologous chromosome in different phases. They also needed to decide when chromosomal behaviour differs, nuclear membrane appear and disappear as well as formation of spindle fibre along the timeline. These events had to be accurate to be presented to the rest of their classmates. There were still errors occur but with the 4C elements, other students will suggest improvements to be done. The scenario promotes tolerance, sharing and reasoning. The activities indirectly inculcate positive attitudes in students.

4C elements were further intervened while discussing the ethical issues regarding cell division. The issues seemed complicated but surprisingly fruitful. These 16-year-old students managed to share their knowledgeable thoughts and opinions based on their brief research and previous experiences. Some of them agreed with cloning and tissue culture and some of them strongly against the application if it were to apply in human. As for IVF procedures, most of them agreed. They suggested that more efforts to educate the society should be implemented regarding IVF. They were able to evaluate and make own decision when it came to real-life problem. Hence explains the significant increase mean value in domain usefulness of learning Meiosis.

In Biology education, public school students will be evaluated through the Sijil Pelajaran Malaysia (SPM) based on the national education policy at the end of high school academic session. The private school might be having other means of examination that will include Biology subject. That would be the priority of secondary school education in Malaysia. This allows local students to apply placement in the tertiary level of education. Thus, being motivated, having interest to learn Biology and being competent to verse about the subject matter is greatly assisting in achieving higher achievement compared to students without motivation. In the 21st century education, biology students not only expected to be able to explain factual mechanisms and layout processes that occur in human body, but also able to relate daily routine and diet intake not only in human but also other organisms in the ecosystem to any occurrences which demand them to improvise or improve. This purposely to create a more sustainable living condition for humans and organisms around. Motivated learners have higher compassion and empathy in decision making. Mustopa et al (2020) supported that learning motivation has significant correlation towards learning process and expected achievement. Expecting to achieve higher and believe to be succeeded in learning drives greatly in creating confidence. Confidence not only internal but can be seen through they way a student explains, answers and comprehends other people around. Confidence also can lead to applying the knowledge in life. Real life problem is the situation where students need to be matured enough to decide the most practical solutions to solve the problem with minimal damage and harm to the surrounding and people around. Kortam (2018) supports that motivation in learning Biology correlates with problem solving skills.

Through this research students understand that to be motivated they really need to enjoy the lesson, decide the best way to explore the knowledge, positively believe that topics learnt could be useful in life and able to achieve higher in evaluation. Educators should play an important role in preparing

materials and activities as well as facilitate the learning process to create a better surrounding. Not only managing the activities, they also need to empathize the process and students' responses for better motivations. Finally, the authorities particularly the ministry need to relate the components of 21st century activities and its impact towards students' motivation and achievement. Teachers passions and understandings shall lead to a better implementation.

CONCLUSIONS AND RECOMMENDATIONS

Since the introduction of 21st century skills, many educationalists had directed their focuses on the importance of communication, collaboration, creativity and critical thinking (4C's) in classroom activities to increase students' engagement and interest. Especially in sciences subjects which demand hands on approaches to deliver clear teaching for students to really understand. Teachers have critical roles to manipulate teaching approaches for instant internet exploration, creative way of gallery walk and debate regarding ethics. Teachers must begin to synchronize their technique with the trends of technological usage which profoundly known able to attract 21st century generation towards learning. Unlike the traditional way, teachers must have the correct attitudes to be open to any kinds of advancement in class. Regardless how well developed KSSM as curriculum or how interesting and highly educated teachers are, without 21st century activities and approaches, students' will be less motivated to attend the classes for Long-Life Education.

For future research, it is recommended to investigate teachers' competencies level in implementing 21st century skills in class. Most teachers especially with 10 to 15 years experiences feel complacent and hesitate to learn and grow. With lack of understanding, steady income and traditional teaching techniques, 21st century activities seem less important to achieve uncommon outcome.

ADVANCED RESEARCH

In writing this article the researcher realizes that there are still many shortcomings in terms of language, writing, and form of presentation considering the limited knowledge and abilities of the researchers themselves. Therefore, for the perfection of the article, the researcher expects constructive criticism and suggestions from various parties.

ACKNOWLEDGMENT

The authors would like to thank students and biology teachers of MOZAC school. This study has not received funds. The authors declare no conflict of interest as a result of this study.

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