Maker-centred in Classroom Learning: Metamorphosis of Primary Education in Malaysia

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Abstract

The paradigm shift from consumer to producer mindset to cultivate transversal competencies other than building a strong foundation in primary education is a major challenge for global educators and researchers. Therefore, as initial efforts, Malaysia has developed and strengthened the reasoning skill as one of the basic skills in primary education. The move to abolish examination by introducing classroom-based assessments has redirected the learning and teaching in the classrooms. Recently, project-based learning, problem-based learning and inquiry-based learning are being studied and applied. However, the rapid growth of hands-on activities has questioned the effectiveness of these learning approaches. Additionally, direct instructions to promote the 21st-century skills and inadequate use of technology, materials and science laboratories in primary schools are still unsolved issues. The smart entrepreneurs have transformed this loophole into a commercial value by creating makerspace or online makers learning for the elite community in Malaysia. This paper attempts to discuss the maker movement in Malaysia with a comparative study on Maker Education to initiate the ideas in Malaysian schools. Theories behind this playful exploration of ideas and materials will be addressed in this study to increase the relevant articles and resources on Maker-centred learning (MCL) in Malaysia. Furthermore, the idea of bridging the Maker concept with STEM education will be explored to turn it into a golden opportunity for researchers and educators to instil future skills with maker-centred learning in the classroom.

Keywords: Maker Education, Maker-centred learning, Primary Schools, STEM Education

INTRODUCTION

A reformation of primary education in Malaysia begins when the reasoning skill has been included as one of the basic or mastery skills other than reading, writing and arithmetic to establish the thinking and learning concept in the primary schools. The terms thinking and reasoning are used not only to characterise the logical thinking ability of interpretation, judgement and synthesis, but also to define a much broader and broader range of cognitive ability, including problem-solving, information gathering and creative thinking (OCR, 2011). Reasoning skill encourages the ability of students to offer cause and effect, reason objectively and rationally to solve a problem (CDC, 2012).

Furthermore, the implementation of school-based assessment (SBA) in primary schools has developed transversal competencies recognised in Malaysia as 21st-century skills. Under Malaysia National Philosophy of Education and the Standards-based School Curriculum, the school-based assessment framework is a holistic evaluation system conducted in school by subject teachers to test the cognitive (intellectual), affective (emotional and spiritual) and psychomotor (physical) dimensions of students (Hasnida & Ghazali, 2017). The product and process of every student are being assessed to monitor the individual potential and overall development in the classroom with a meaningful report from teachers.

However, the capacity to develop assessments that represent student transversal competencies has been seen as a significant barrier to the introduction of a 21st-century skills agenda in the classroom (Care, Vista, & Kim, 2019). Even though some of the teachers understand the principles of SBA, the problems in transforming the theory into practice remain unsolved (Singh, Supramaniam, & Sian Hoon, 2017). In this matter, a slow shift of the concept from school-based assessment (SBA) to classroom-based assessment (CBA) with an improved version in 2016 through the abolition of examinations for lower primary students (Year 1-Year 3) has catalysed the transformation of primary education in Malaysia. It has diverted the exam-oriented teaching and learning into skill-oriented teaching and learning gradually.

Thus, the notion of basic education in primary schools in worldwide has changed entirely due to forthcoming skills and requirements from this 21st-century. To cultivate the 21st-century skills, critical and creative thinking skills yet now the computational thinking have gained huge attention from educators and researchers. One of the learning strategies that can train students to innovate and improve creative thinking skill is by applying Science, Technology, Engineering and Mathematics (STEM) in learning (Chasanah, Kaniawati, & Hernani, 2017). However, Science, Technology, Engineering and Mathematics (STEM) concepts are critical domains in early childhood and elementary education (Robertson, 2020). The proposals and procedures for integrating STEM in Malaysian primary schools are still at the initial stages and need more inputs from researchers and educators to establish an effective way of incorporating STEM elements into primary education.

Besides, the science laboratory activities carried out in Malaysia are mostly to explain the ideas discussed in the daily science class, and teachers and students alike do not see that the substantive knowledge obtained from the diabolical interaction of practical work and conversation further strengthens the understanding of the concepts (Lilia, 2017). The direct instructions to promote the 21st-century skills and inadequate use of technology, materials and laboratories or science rooms in primary schools, are another critical issue that needs to be addressed and rectified. In this regard, smart entrepreneurs have transformed this loophole into a commercial value by creating makerspaces such as ME.REKA, KakiDIY, MakerLAB, Fab Space KL, Arus Academy and online makers learning for the elite community in Malaysia. Most of these makerspaces have started to shine up in early 2016 in Malaysia. They have commercialised the concept of the maker movement by providing space and appropriate tools apart from teaching and guidance. In recent years, makerspaces have bloomed vigorously throughout Malaysia in some shopping malls, colleges, institutions, universities and hubs in states government such as DigitalPerak in Perak, Selangor Digital Creative Centre (SDCC) as co-working space in Selangor and Penang Science Cluster in Penang as non-profit organisation and many more.

Initially, a social enterprise Biji-biji Initiative in Malaysia, as reported in thestar online news on 10 April 2017, inspired communities to become makers through their open workshops in Klang Valley that guided how to develop a product and machinery to bring it into practice. Founded in 2012, the project facilitated up-cycling (upgrading recycled products) through the use of wood waste, scrap metals, petrol drums and many more. Although the making has developed out of schools, there is rising interest among researchers and educators to bring the maker concept into classrooms to create opportunities for students to engage in transversal competencies. The potential transition of these tools and technology into formal school environments has also been welcomed by several observers as meeting many existing educational imperatives (Godhe, Lilja, & Selwyn, 2019).

The educational world has taken the making as a curriculum strategy to encourage STEM curriculum because of its perceived potential as a catalyst of creativity, enthusiasm and innovation (Bevan, Gutwill, Petrich, & Wilkinson, 2015). According to Mustafa (2018), in the gig economy world, experimental learning, future-ready education and life-long learning mentality are key factors in uplifting our talents and attributes to thrive. Therefore, a groundbreaking study on the maker movement in Malaysia will be initiated by taking the above aspects into account. This paper aims to provide a better understanding of Maker Education and the needs of maker-centered classroom learning in Malaysian primary schools that promotes STEM elements with 21st-century skills.

MAKER MOVEMENT

The Maker Movement began with a group of enthusiasts, tinkerers, engineers, programmers and artists who design and produce projects creatively for fun and useful purposes (Martin, 2015) and the advancement of new information technology such as cloud computing, big data, open-source applications, 3D printing, digital devices, remote networking, etc. is now directly related to the emergence of the Maker Movement (Tian et al., 2020). The Maker Revolution is a cultural development that places value on a person's desire to be a producer as well as a customer. People who create things in this community are called "makers". Makers come from all walks of life, with varied sets of skills and interests. The element they share in common is creativity, an interest in instruments and raw materials for design and access that make development possible.

There is no set definition for making. Generally, Sator (2015) stated making is a mechanism in which people engage in design, create and develop things that are of value and benefit to them individually or to their society. Making, though, is not only about advanced technology; it is also the primitive obsession of humans to use tools to live in diverse situations. The history of mankind is a history of tooling and solving a variety of problems and challenges (Jaatinen & Lindfors, 2019). In common term, it also can be defined as DIY (do it yourself) practice which making is a partial development, alteration or repair of artefacts without the assistance of paying professionals. By taking these definitions, making can be summarised as a class of practises focused on the creation, development, alteration and/or repurposing of material artefacts for playful or useful purposes, aimed at creating a product of any kind that can be used, associated with or seen (Martin, 2015). The platform, process and product of making are the gist of thinking and learning. The rise of the maker movement is often attributed to the emergence of spaces for makers which is known as makerspace.

Makerspaces

Since the advancement of computer modelling and fabrication, the spaces for hands-on research and learning through making so-called "makerspaces" in formal and informal education have achieved global popularity (Alley, 2018). Thus far, makerspaces, also known as hackerspaces and fablabs, are collaborative learning environments where students can gather together to share knowledge and resources, collaborate and build projects (Aoki, 2018). Makerspaces foster problem-solving approaches that require tolerance of self-discipline and complexity, documenting processes related to creativity; learning new skills in a welcoming atmosphere makes people better prepared for the confusion that follows innovation (Holm, 2015).

However, the growing number of makerspace is the starting point for the maker movement in Malaysia. Makerspace activities have entered almost most areas, such as universities, colleges, schools, industries, shopping malls and centres in offices. Even though these digital and fabrication hubs are rising in number throughout the nation, there is a need to address and discuss about this maker movement. In order to overview their roles in Malaysia, a list of makerspaces in Malaysia has been prepared as an initial phase. Descriptions of makerspaces in Malaysia, as listed in Table 1 below.

Table 1: The descriptions of makerspaces in Malaysia

Makerspace	Type	Location	Purpose	Service
ME.REKA	Profit Organisation	Kuala Lumpur	Education Centre	Textile & Design studio, Virtual reality facilities, Wood & Metal workshop, Electronic lab, Co-working space
KakiDIY MAkerLAB	Profit Organisation	Cyberjaya	Education Centre	3D printing, Upcycling &

				Recycling, Tools, Robotic, STEM, Software and web Integration
Selangor Digital Creative Centre (SDCC)	State Government	Selangor	Co-working space	Networking, mentoring, resource sharing, e-commerce classes.
InspireWorks Studio	Profit Organisation	Negeri Sembilan	Education Centre	Makerspace, woodworking& workshops, Team Building

Makerspace	**Type**	**Location**	**Purpose**	**Service**
Penang Science Cluster	Non- Profit Organisation	Penang	Community Centre	Science Cafe, TechMentor, Electronics, robotics, 3D printing, coding, woodworking, arts& crafts
Fab cafe	Profit Organisation	Kuala Lumpur	Education Centre	Laser cutter, Embroidery, UV Print, 3D Print, CNC Milling Machine, 3D scanner, sewing machine, space rental
Taylor's Me.reka Makerspace	Private University	Selangor	Learning Centre	Workshops, space rental (Fab lab, Electronic lab, VR lab, Design lab) Machinery Access, Consultancy
Sunway Innovation Labs (iLabs)	Private University	Selangor	Learning Centre	Ultimaker 3D printers, Laser cutters, IOT kits& devices, Adobe Design Software, Hands-on workshop, workspaces.
Telebort (Penang Digital Library)	Profit Organisation	Penang	Education Centre	Programming, Consultation on computer science and engineering

				syllabus and set up in-school digital maker lab
InspireWorks Studio	Profit Organisation	Negeri Sembilan	Education Centre	Woodworking& workshops, Team Building
Chumbaka (digital maker hub)	Profit Organisation	Cyberjaya	Education Centre	Coding & robotic programs, school holiday camp, workshops
DigitalPerak	State Government	Perak	Community Centre	ICT courses, Digital Training, makerspace, 3D Printing, DIY projects, Robotic, STREAMakers
Arus Academy	Profit Organisation	Penang Selangor	Social Enterprise	Programming, coding, project management, presentation and design thinking

The restructuring of education in Malaysia has been motivated directly and indirectly by the makerspaces mentioned in Table 1. The Malaysia Digital Economy Corp (MDEC) and the Communications and Multimedia Ministry play a vital role to gather all the makerspaces leaders in Malaysia under the Digital Maker Association (DMA). This private-sector initiative to spur Science, Technology, Engineering and Mathematics (STEM) literacy in the country. The existence of DMA makes it possible to link makerspaces in universities, schools and shopping malls across the nation. If makerspace becomes more common in educational contexts, it is an obligation to ensure that students in a Makerspace engage in the promotion of self-knowledge and growth rather than relying on the resource provider's economic benefits (Hira & Hynes, 2018).

As reported by local journalists, the Malaysia Digital Economy Company (MDEC) has acknowledged the maker movements in Malaysia. It has worked with the Ministry of Education on the policy front to design a curriculum that includes the element of the maker. The subject that used to be known as life skills (Kemahiran Hidup), for example, is now referred to as Design and Technology (Reka Bentuk dan Teknologi). Even though many initiatives are being studied and implemented by the maker movement in Malaysia, to further strengthen, the essence of maker education needs to be understood with well-structured as well as tested curriculum design and instructions for teachers to implement and for students to have meaningful and fun learning with appropriate and sufficient tools and materials in primary schools.

The role of computer labs, science labs or special rooms in primary schools in Malaysia needs to be activated. Arzi (2003) emphasises that better science facilities are associated with active learning styles and that when teaching is carried out in spaces with integrated classroom and laboratory facilities, a higher degree of investigative methods have been developed relative to teaching in separate classrooms and laboratories. The future advantages of Makerspaces for education have not been captured in funding to encourage the scale-up of Makerspaces in schools for educators. This leaves a distance between Makerspaces' perfect existence and those in educational environments that are evolving. Through more study and practice that contributes to the development of resources to aid this scaling-up, this difference can be narrowed (Hira & Hynes, 2018).

Maker-centred Learning

The progressive learning theories of thinkers such as Lev Vygotsky, Jean Piaget, John Dewey and Seymour Papert are profoundly grounded in Maker-centered learning. It is also closely tied to educational approaches such as peer learning and computational thinking. The maker-centred learning (MCL) is a pedagogical approach to thinking and learning by making. The practice of incorporating making in educational contexts has created the real 21st-century classroom setting for students with a playful exploration of ideas and materials. A new type of hands-on pedagogy, a pedagogy that facilitates community and cooperation (a do-it-together mentality), distributed teaching and learning, boundary-crossing, and responsive and adaptive teacher activities, was proposed by Maker-centered learning (Zhu, 2020).

In Finnish compulsory school, there has been a long history of the 'maker’. The practice of makerspaces in comprehensive schools for 7 to 16 years old students is unique (Jaatinen & Lindfors, 2019). There are currently a variety of research programmes in Finland concentrating on the implementation of educational technologies, including maker practises that accompany the new curriculum (Wang, Lim, Lavonen, & Clark-Wilson, 2019). Whereas, the DDMT teaching model consists of four phases: ‘Discover’, ‘Define’, ‘Model & Modelling’ and ‘Transfer’ in the Latest Curriculum Guidance of Taiwan's 12-Year Basic Education;' with all four phases revolving around maker practice, scientific inquiry and design thinking to impart STEAM components in the Tsing Hua STEAM School project teaching (Lam, Wang, Vun, & Ku, 2019). A research conducted in Indonesia with makerspace approach in the classroom, the data suggest that the Makerspace approach promotes integrated STEM education and the creation and demonstration of 21st-century skills (Blackley, Rahmawati, Fitriani, Sheffield, & Koul, 2018).

In Canada, the British Columbia (BC) Ministry of Education has introduced a newly defined subject, ADST (Applied Design, Skills, and Technologies), which is a new curriculum area for the elementary grade-level. The skills associated with this reading are closely connected to maker-centered teaching and learning (Zhu, 2020). In Singapore, the Infocomm Media Development Authority (IMDA) launched its Code for a fun enrichment programme in elementary schools, which was piloted in 2014. Since 2015, the curriculum has been launched in 110 schools, with about 34,000 students participating. The purpose of the curriculum is to introduce a broad student base to the principles and coding of Computational Thinking (CT) and to develop a generation of staff armed with basic coding and CT skills (Tangney, Jake Byrne, & Girvan, 2020). In Malaysia, MDEC has also introduced the #mydigitalmaker campaign in 2016 apart from implementing Design and Technology subject for Year 4-Year 6 in primary schools. The project involves a proposal to integrate computer skills into the curriculum and set up hubs for digital makers across the country. Besides this, the robotic, coding classes and digital competitions are being conducted in selected primary schools as after-school programs by some non-profit and profit organisations.

However, many researchers argued that the inputs of technology are more compare to Science in maker education (Godhe et al., 2019). A makerspace, however, does not need to contain any or even any of these machines to be recognised as a makerspace. It's more like the mentality of the creator of making something out of nowhere and finding the core of a makerspace for your interests (Caballero-Garcia & Grau Fernandez, 2018). Computers are not necessary but they supercharge the creation of projects by expanding the breadth, depth and complexity of what is feasible (Martinez, 2019). Thus, there is a need for a well-balanced and simplified version of STEM elements in the common classrooms of primary schools. The best situation for maker-centered learning is design-based Makerspace. With design-based makerspaces, learning outcomes and effective instruments for measuring those outcomes are identified, transforming the informal and playful makerspaces into formal learning environments, where the required curriculum can be covered for any subject area (Garcia & Fernandez, 2019).

Bridging Maker-centred Learning with STEM Education

Student-centered, interactive learning in small communities, teachers serving as facilitators, problem-solving practise in real-world environments and acquisition of understanding must be the STEM education technique through live activities (Baharin, Kamarudin, & Manaf, 2018). STEM education requires innovative teaching to engage students in developing their critical thinking and constructing their understanding (Jiun, Kamarudin, Khairul, & Ahmad, 2019). In this matter, the role of STEM elements can be easily activated since makers' concept is closely related to STEM education. By its essence, STEM-Rich Making is interdisciplinary (Bevan, 2017).

The maker elements have the potential to instil not only STEM education but forthcoming knowledge and skills under one roof. There is an increasing awareness of the worth of maker-centred learning in the classroom and the benefits to individuals and societies have also been increasingly acknowledged. A Google Scholar search by Chen and Wu (2017) has discovered more than 10,000 articles in total with the question of "makerspace," "maker movement" and "maker culture" as the amount of literature increases exponentially, a comprehensive analysis of makes' research and their current problems becomes necessary. Based on our finding in the Scopus, there are 470 articles on “makerspaces”, 273 articles are on “maker movement” and 47 articles are on “maker-centred learning”. This reflects a growing pattern of researches in maker education. Although Malaysia does not involve directly in the study of the maker movement, it has been addressed in some of the international comparative studies on STEM education with school clubs or societies' hands-on activities or after school programs as makers' activities. There is no direct research or study on the maker movement so far. As an initial effort, a collection of studies on STEM infused maker-centred learning are listed to foster maker elements in Malaysian schools. Table 2 below illustrated the purpose or finding of some of the studies related to STEM infused maker-centred learning in the classroom.

Table 2. Some of the research related to STEM infused maker-centred learning.

Author	**Purpose / Finding**
Wang, Lim, Lavonen & Clark-Wilson (2019)	A comparative study on maker-centered science and mathematics education in Taiwan, Singapore, Finland and England are discussed briefly. It summarises the study on making and scientific argumentation by Hsu, Lee, Ginting, Smith, and Kraft (2019).
Blackley, Rahmawati, Fitriani, Sheffield & Koul (2018)	In integrating students in the STEM space, the Makerspace approach was very successful and students were often challenged to work together in groups mentored by pre-service instructors.
Godhe, Lilja & Selwyn (2019)	It concluded that education for maker could not be seen as a ready substitute for formal schooling. Instead, in the pressures and limitations of contemporary education environments, teachers and schools are likely to need sustained assistance to make the most of maker technologies.
Bevan (2017)	This paper takes a critical view of the arguments about Making as a positive method of teaching and learning in science and discusses the substantiation of how Making benefits the agency of students, encourages active engagement in science and engineering activities, and leverages the cultural capital of learners in the current research literature.
Schlegel, Chu, Chen, Deuermeyer, Christy & Quek (2019)	Their findings show the usefulness of curriculum-aligned making, especially in terms of promoting self-efficacy, the identity of science, and possible selves among underrepresented groups of students.
Garcia & Fernandez (2019)	Findings in this research affirm the advantages of school makers'

spaces as learning areas that inspire students to learn science, so they highly advocate using these spaces to teach science, encouraging students to discover their interest and promote a love of learning.

A barrier to developing STEM-infused maker-centered learning for primary schools in Malaysia is breakable based on information, suggestions and recommendations provided in the studies above. The guidance in term of research design and methodology are available with sufficient information on the maker's terminology and concept. However, a systematic search of literature review on the maker movement, makerspaces and maker-centred learning is recommended for further study.

CONCLUSION

Any classroom should be a place of creativity where children have the tools, time, agility and flexibility. The use of maker innovations in the classroom is increasingly required to develop students' skills and knowledge in contemporary industry, higher education, entrepreneurship and creativity in Science, Technology, Engineering and Mathematics (STEM) subjects. Owing to this, a good understanding of maker education is essential to integrate maker education in primary schools. The concept of maker education as argued by some researcher is not only on digital and technology learning, the 'maker' tag has lately been used for all sorts of classroom events, from teaching, computer, engineering to cooking and gardening (Godhe et al., 2019). The current interest and intent in maker-centred learning are to explore transversal competencies with great creation, innovation and improvisation of materials with tools and a presentation in form of oral or written by collaborating with others.

Thinking and learning by making is the gist of maker-centred learning. In-depth researches to transform a common classroom into a maker-centred classroom, restructure the process of student-centred learning into maker-centred learning and selection of appropriate assessment to identify and recognise the mixed abilities of students' thinking skills based on the end products need to be conducted before integrating with a subject context or design a curriculum on maker education. This concept paper would be a catalyst for a big shift in primary education. A holistic and well-balanced input of STEM education will be possible with maker-centred learning approach in Malaysian primary schools.

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