Greening STEM: A Theoretical Exploration for the Malaysian Context

Aai Sheau Yean[a]
Suzieleez Syrene Bt Abdul Rahim
University of Malaya

Abstract: *This theoretical piece explores the frame of mind required for a Science, Technology, Education and Mathematics (STEM) education in an uncertain time. Predominantly argued from an epistemic standpoint, this paper analyses the relationship between environment, anthropomorphism, the essence of education, and our presumed mastery of nature. In the attempt to envision and realise a form of STEM education with sustainability as a frame of mind that would befit Malaysia, National Wildlife Foundation's Green STEM; Bybee's STEM Literacy; and Bonnett's idea of sustainability were explored. Through the exploration, a possible frame of mind for Green STEM that could facilitate learning and challenge the status quo of being emerges. Ultimately a STEM education with sustainability as a frame of mind is meant to encourage discussion and exploration of issues as it arises rather than being prescriptive. It is hoped that through such an educational approach, we will eventually arrive at a more harmonious way of being.*

Keywords: *Green STEM, Malaysia, Sustainability as a frame of mind, Emergent Curriculum*

Introduction

In line with the advancements made in the 21st century, the Malaysian Education Blueprint (MEB) that was revised and introduced in 2013 aims to transform the content, pedagogy delivery and assessment of Malaysian pupils (Bahrum, Wahid & Ibrahim, 2017). Claimed to be devised in accordance with the National Education Philosophy, MEB is designed to produce pupils that are nurtured intellectually, emotionally, spiritually and physically, in short, holistically. In the exact wordings of the blueprint,

> "such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards, and who are responsible and capable of achieving high levels of personal well-being as well as being able to contribute to the harmony and betterment of the family, the society, and the nation at large" (MOE 2013, p.2-2).

The MEB 2013 revisions placed Science, Technology, Education and Mathematics (STEM) approach at its core, hence allowing for the incorporation of teaching and learning geared towards higher-order thinking skills (Bahrum et al., 2017). STEM education is perceived as the key to propelling the nation from (1) the developing to developed, (2) a middle-income country to a high-income country, and (3) a semi-skilled workforce to a highly-skilled workforce (Bahrum et al., 2017; Shahali, Ismail & Halim, 2017). Putting the ethics of perverting education for economic advancement and personnel training aside (Jickling, 1994), the greater concern that the whole tone of the blueprint and STEM guideline is predominantly anthropocentric is of great concern. In an earlier piece exploring the epistemology of MEB, the concern that the environmental welfare of Malaysia has been side-lined in favour of economic prosperity have been discussed (see Aai, 2014 for details). In 2016, the release of STEM guidelines for all education levels has not adequately assuaged the anthropocentric

a Correspondence can be directed to: syean.aai.2012@my.bristol.ac.uk

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concerns raised in the article (Khalil & Osman, 2017). Takeuchi et al.'s (2020) critical review of the STEM education discourse globally raised similar concerns regarding the predominance of the "human capital discourse" (p.213) at the expense of a more nuanced interpretation of the field. This is especially concerning at a time when *human-induced* record-breaking temperatures were achieved on a yearly basis (Vautard et al, 2020). This translates to unfathomable disaster for the survival of species on land and in water (Smale, et al., 2019). Smale et al.'s (2019) article forewarned that anthropogenic climate change would disrupt global biodiversity and ecosystem for decades to come. Echoing Sen's (1999) argument, a human capital discourse emphasising economic growth and productivity fails to appreciate the potential of humans as more than just agent for economic production. To effect any sort of social change, he proposed the discourse of human capability, where the change beyond economic growth is embraced.

Malaysia, as the home to one of the 17 mega biodiverse hub[1] worldwide holds great responsibility in ensuring its citizens are fully capable of appreciating it and safeguarding it from unsalvageable disruption. A human-capital discourse focusing on economic growth alone would not be sufficient in preparing Malaysia's citizens for the environmental crisis. Smith and Watson (2019) supplant that the prevailing "techno-optimist neoliberal" (p.1) discourse in STEM education is unable to prepare the students to live sustainably, rather it perpetuates the environmentally damaging way of life. To achieve a meaningful change, "greater imaginations of critical transdisciplinary" (Takeuchi, Sengupta, Shanahan, Adams & Hachem 2020, p.241) is required in STEM education through the inclusion of other disciplines to orient us and steer us away from restrictive and environmentally damaging discourses in the form of instrumentalist ideology. As is currently promulgated, STEM education fails to be the critical voice needed to challenge the current unsustainable "assumptions, worldviews, myths and metaphors underpinning business-as-usual education" (Smith & Watson 2019, p.2). For the purpose of environmental sustainability, the current STEM guidelines need to be questioned critically, and fine-tuned further towards environmental sustainability rather than paying cursory mention of it in the form of eclectic courses. As such, this paper would like to argue for a Green STEM approach based on Bonnett's (2002) sustainability as a frame of mind to the current STEM education for environmental sustainability.

What is STEM education?

Science, Technology, Education and Mathematics (STEM) was said to be a generic label for 'any event, policy, program, or practice that involves one or several of the STEM disciplines (Bybee, 2010a, p.30) when it was first used. Like Bonnett (2002) who dissected the three main issues—semantics, epistemological, and ethical— plaguing sustainable development, this article argues that the same issues plague the inception and development of STEM education as a field:

(1) Semantics: The term was so loosely used that when it was first adopted into the field of education it is poorly understood and ambiguous to many who came across it. The T and E were claimed by Technology educators, Career and Technical educators, and Engineering educators concurrently (Sanders, 2009). Given its ambiguity, some lament that the acronym does little, but beyond being bandied as a slogan (Bybee, 2010a).

(2) Epistemological: STEM education is promoted heavily as the most effective means to prepare pupils of today for the many global challenges (Bybee, 2010a) we are and will be experiencing; energy, health and environment being a few of the more notable examples. However, questions remain on what areas of the subject to emphasise within and across the disciplines. Should the criteria used to determine its inclusion be based on the economic needs of the country or its environmental and social concerns? (Ortiz-Revilla, Adúriz-Bravo & Greca, 2020) Who is in a position to judge which need prevails? (Takeuchi, et al., 2020). The prevailing scientific view in many STEM education

approach of today is poorly reflective of the complex relationship between science and socio-cultural values (Ortiz-Revilla et al., 2020) much less the environment.

(3) Ethical: With the link to real-world issues being emphasised, there is a need to consider the implications of what is included versus what is not. Whether the different approaches to STEM education would widen the apparent technology divide of the North versus the South[2]?

From the brief discussion of issues elucidated above, it is obvious that matters concerning social responsibility predominates other concerns in STEM education. Within the scientific community, the concept of social responsibility came in vogue after the European Union gave the concept a necessary boost. However, the consideration or socially beneficial impacts of science and innovative technologies were not explicitly stated in policies (Owen, Macnaghten & Stilgoe, 2012), hence does little in binding any of its practitioners. For that reason, Owen et al. (2012) call for a re-evaluation of "the concept of responsibility as a social ascription in the context of innovation as a future-oriented, uncertain, complex and collective endeavour" (p. 757). Similarly, in STEM education, where the focus lies largely in giving the coming generation of learners the skills to address the pressing socio-environmental problems of today (Marginson, Tytler, Freeman, & Roberts, 2013), due consideration needs to be given to the idea of social responsibility.

In light of these considerations, the question of what a socially meaningful, humanistic, representation of STEM education looks like took hold. Sanders (2009, 2012) argued that integrative STEM education where intentional integration of technological/engineering design-based learning approaches with the concepts and practices of science and/or mathematics education should be the answer. However, Sanders' emphasis is on promoting the importance of technology literacy in the improvement of STEM education. Bybee (2013) offered another possibility in the form of STEM literacy made up of four components:

(1) knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural and designed world, and draw evidence-based conclusions about STEM-related issues;

(2) understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design;

(3) awareness of how STEM disciplines shape our material, intellectual, and cultural environments; and

(4) willingness to engage in STEM-related issues with the ideas of science, technology, engineering, and mathematics as a constructive, concerned and reflective citizen (p.xi).

The learner-centred and knowledge-centred interpretation of STEM education is arguably a more meaningful representation, compared to one in which STEM education is perceived as a mere tool for topping international student assessments and addressing the STEM pipeline (Sanders, 2009). Although Bybee's (2010b; 2018) argument for the emphasis on STEM literacy is valid, especially so when he stressed its importance particularly in relation to the global challenges we are faced with, this interpretation of STEM education is still insufficient. The problem lies with the rhetoric such interpretation entails. Pushing for a market-driven and consumer-oriented entrepreneurial citizenship through STEM education (Takeuchi et al., 2020) fails to address the root cause of anthropocentric driven environmental degradation. Rather, what would be is merely encouraging the rhetoric of experimental entrepreneurship, turning students into complicit agents of "oppression or dispossession" (Irani 2019, p.217); orienting the focus towards "projects that generated novel lines of flight but occluded the possibility of …politics that destroy" (ibid). It is with this thought that we will turn to the next section on Green STEM.

Green STEM: Sustainability as a Frame of Mind

Conceptualising Sustainability as a Frame of Mind

Education's purpose is "ineluctably environmental" (Bonnett, 2017, p.333). If STEM education is to be the platform for understanding and addressing the global challenges (which are ultimately environmentally centred) we face, there is a pressing need to re-orient STEM education along the line of sustainability as a frame of mind. Huckle (2012) opines that such a "way of relating to nature" (p.36) seeks the evolution of all species on earth to arrive at a state of sustainable relationship beneficial to both the biophysical and social world. Education is ultimately environmental, as, at the heart of it, the "question of what it is to be human" (Bonnett, 2017, p. 334) is addressed. To elaborate on his point,

> "human consciousness is ecstatic in this sense of existing in a constant (and complex) motion of standing out towards things beyond itself in the world—and hence, we can say, *environmental*." (p.335, emphasis in original)

That is to say, as humans, our consciousness responds to stimulus beyond the boundaries of our mind and body. The stimulus in question is the environment. Ontong and Le Grange (2018) reasoned that such framing engenders nature as "independent of human will, but not unaffected by it" (p.S3). While positing the bio-physical structure of nature as existing independent of human activity in a realist frame, nature is "nevertheless affected by society" (Huckle 2012, p.36). Hence, in the event where education deals with the essence of being human, it serves to reason that it needs to be environmental. Even then, it seems to be a huge leap of reasoning to equate the environment with sustainability. In response to this, Bonnett (2002) argued that sustainability is rooted "in the notion of *truth*" (p.18, emphasis in original) and it is central to being human. Truth in this sense refers to our consciousness of the world around us that is a blend of what we anticipate and what we experience or observe as is. As humans, we will not be able to realise our full potential until we acknowledge the value of and appreciate the bio-physical forms of reality for what it is (Huckle, 2012).

Green STEM as Viewed by National Wildlife Foundation (NWF)

Similar to integrative STEM where the four disciplines are connected purposefully for specific learning outcomes (Sanders, 2009), Green STEM was designed to achieve the same through the incorporation of nature studies into the mix (NWF, 2015). NWF's approach to "formal instructional programs that adopt local natural and socio-cultural environments as the context for student's educational experiences" (NWF 2015, p.16) are:

(1) interdisciplinary learning—blurring of the line between subjects through the connection of nature and socio-cultural themes;
(2) project-based learning experiences where understanding and experience is gained through solving real-world issues;
(3) student-centred instruction—a student-directed approach where learners are responsible for leading the pace of their learning; and
(4) constructivist approach—where learning is slowly built upon previous skills, knowledge and constant reflection.

Although infusing natural and socio-cultural environments into STEM is a good move, surface inclusion of the relevant themes would not address the root cause of the current environmental crisis. Just as sustainability education has been value-laden and manipulated to champion the status quo (Jickling, 1994), Green STEM could end up making no discernible impact without critical consideration of its underlying rhetoric. As Takeuchi et al.'s (2020) analysis suggests "*who* the learners are, *how* they are positioned in relationship to STEM and for *whom* STEM is oriented" (p.215), would affect its practice in classroom settings. Likewise, it is the opinion of this paper that uncritically accepting the underlying rhetoric below would compromise the potential of Green STEM:

(1) interpretation of interdisciplinary learning without realising the underlying oppression it perpetuates (Takeuchi et al., 2020);
(2) connotation of project-based learning and its relation to *entrepreneurial citizenship* that serves to encourage economically driven inventions (Irani, 2019)
(3) Americo-centrism influence in policy which might not consider the inclusion of and is insensitive towards students of different cultures, background, and experiences even if it is theoretically designed to be constructivist and student-centred (Takeuchi et al., 2020; Mclean, 2013).

With the points above in mind, we will turn towards the examination of Sustainable Development and sustainability, which lies at the heart of Green STEM.

The Underlying Rhetoric in Green STEM

Sustainable Development, a concept that is intricately linked to sustainability education, has "suffered as a catch-all buzzword" (Katzchner, 2011, p.161; Lele, 1991) since its introduction in the 1980s. It has been moulded to fit many intentions without much concrete commitment to back up such a claim. The energy, fashion, aviation, steel and cement industry among others have been using the term liberally to boost their development without committing to major carbon cuts capable of capping the warming at 1.5^0C. Additionally, although the term is strongly related to the environment and green agenda, the fact that "environment"—which is central to the discussion—has been rendered open to various interpretation and legitimization due to its malleability and ambiguity (Luke, 2001; Sterling, 2017) is disconcerting. For the convenience of mankind, the term *environment* has been associated with wilderness far from civilisation, the green space mostly untouched by development (Sterling, 2017). The immediate surrounding around us, such as the clogged drain and the odd grass patches, were excluded in our schemata of it. It is not surprising then that the same ambiguity seems to have found its way into the conceptualisation of sustainability-related education, a problem in which the term, though all-encompassing and is increasingly emphasised as a whole, has been manipulated by various stakeholders utilising it to represent different perspectives and epistemologies (Le Grange, 2017; White, 2013; Jickling, 1994). Likewise, developed from as malleable a concept as sustainability, Green STEM could be just as easily manipulated. In the end, it could end up dissociating our environment into schemata convenient for maintaining the status quo (Smith & Watson, 2019).

In pursuit of this argument, there is a distinction between science as a field of research, and scientism. Of which, the latter was conceptualised as "a set of presumptions about the significance and application of the assumptions, methodologies, and findings of this field of research in our daily lives" (Bonnett, 2017, p. 341). Arguably, the presumptions, if framed in the language of the current status quo of anthropocentrism, would end up being manipulated to benefit human wants and greed. Therefore, Bonnett (2017) is right to be cautious of the progressive emphasis on the value of the natural world as a resource for Man's continued "self-defined comfort and self-given projects" (p.342). The argument might seem brash, and in some way unpalatable, especially when human's superiority is questioned. However, the truth remains that we end up in the current environmental crisis because nature has been deemed inconsequential, of no immediate value to humans, and could therefore be subjected to our whims, fancy (Orr, 2011) and expropriation (Foster & Clark, 2020).

We may pride ourselves as autonomous individuals with the freedom to choose, but where sustainability is concerned the false belief that we are independent of our surroundings have done ourselves and the environment more harm than good (Jucker, 2012). The reason as Van Poeck and Vandenabeele (2012) opines, is simple— "every 'private' decision has 'public' consequences and social conditions affect individuals' freedom of choice" (p.542). In this web of life where all living beings co-exist at the same time, in the same sphere, and connected in a complex manner, our actions and decisions are bound to affect others intentionally or otherwise. As such, sustainability education ought to prepare learners to be able to judge, evaluate, and actively participate in the various contesting discourses under the sustainability umbrella rather than simply providing a specific interpretation of sustainability as deemed appropriate by the selected few (Smith & Watson, 2019; Jickling, 1994). According to the author, there is a world of difference between the two notions of sustainability education. One encapsulates the essence of education, while the other is training. Following this line of thought, there is a fine line in educating a future generation of STEM learners who are conscious of the various perspectives on what they have learned, and those whose learning had been dictated to follow a set trajectory. As Bonnett (2017) would have argued, detailed pre-specification stymied learners' genuine engagement with the natural environment. The consequence is severe. We could only begin to challenge our presumed metaphysical mastery of nature through lived-experiences and reflections when we inhere authentically with the surroundings we intend to understand. Likewise, for Green STEM to be meaningful, it is important for the parties involved, both teachers and learners, to (1) reflect by asking the *whys*, and (2) experience before we explore the *hows*. Taking an excerpt from the Green STEM guidebook as an example:

> "Students are posed the essential questions "How can science and technology help to restore the degraded ecology of the New York Harbour Estuary?" and "What can people do to change their impact on the marine environment?" Oysters are one crucial component of our solution, but by no means the only response." (NWF, 2015, p.54)

Before we could ask about the possibility of STEM helping in restoring a degraded ecology, there is a need to explore (1) *why* we should or should not do so, (2) what we did or did not do to change the environment around us, (3) *how* can we go about addressing the issue without presuming ourselves the master of nature. There is no easy way in which the answers could be derived, and no right answers for any of them, but there are plenty of presumptions based on a different frame of mind. Hence, if we are to educate our learners rather than imposing our views on them, reflecting and exploring is the least we could do with them.

Viewing Sustainability as a Frame of Mind in Green STEM

With this frame of mind, where the emphasis of education lies in the development of systemic wisdom on the current global issues "that is rooted in learners' life-world enriched through a direct acquaintanceship with nature" (Bonnett, 2017, p.346), we arrive at a better interpretation of sustainability education as a frame of mind. In doing so, we could reconnect Bybee's (2010a) interpretation of STEM education with Bonnett's (2017) interpretation of sustainability to arrive at a better conceptualisation of Green STEM. That is, education that addresses:

(1) knowledge, attitudes, and skills to reflect on questions and problems in life situations, connect the experiences gleaned from nature with the designed world, and draw informed conclusions about STEM-related issues;
(2) STEM disciplines and their pervasive use of anthropomorphism in its vocabulary;
(3) how STEM disciplines shape our material, intellectual, and cultural environments judged against our false sense of metaphysical mastery over nature; and
(4) willingness to engage in STEM-related issues with sustainability as a frame of mind.

With this frame of mind as a reference, we shall turn towards the analysis of Malaysia's STEM curriculum.

Malaysia's STEM Curriculum: Ideal versus Reality

Mpofu's (2019) study on STEM approaches revealed four commonly observed interpretations: (1) isolated and independent S-T-E-M, (2) duet, most commonly SteM, (3) one into three E S-T-M, and (4) integrated—STEM. The confusions and misconception among STEM were said to be related to the mixture of approaches adopted in a different educational context, sometimes even occurring within the same country (Mpofu, 2019). STEM was conceptualised as a field, a stream, and an approach following the official STEM guideline (MOE, 2016a)[3]. Mpofu's (2019) interpretation of the STEM approach refers to the theoretical framework adopted by governing bodies. Deviating from Mpofu's (2019) interpretation of the STEM approach, MOE's operation definition for it refers to "teaching and learning strategy involving the application of knowledge, skills, and values" (Shahali, et al., 2017, p.126) of STEM. From the description of Mpofu's STEM approach which covers different ways individual disciplines fuses, it is more closely related to the definition of the STEM field offered by MOE. STEM field, according to the MOE (2016a) refers to all the traditional and specialised disciplines offered by the system. Science and Chemistry are examples of the prior, while Medical and Bio-Chemistry are examples of the latter.

STEM education in Malaysia was designed to target all levels of education, starting from pre-primary to tertiary. In the STEM education implementation guideline, integration of the four fields is mentioned as a key or its successful implementation (MOE, 2016b). However, further examination of how it was planned out seems to suggest that the integration does not necessarily refer to all four fields combined. Rather, at the pre-primary level, a duet focus on Science and Mathematics was adopted to promote inquisitiveness and develop 'early science and mathematics process skills' (Shahali, et al., 2017, p.127). At the primary and lower-secondary school levels, the STEM field is still largely dueted in nature, with the primary focus being science and mathematics (ibid). In addition to the duet focus, the STEM approach with an emphasis on scientific attitudes and values have been infused into the curriculum. Throughout the education levels, STEM delivery retains the discipline characteristics with the most common approach of integrating technology into mathematics, and science being practised at the secondary level. The approach reflects Mpofu's (2019) one into three STEM interpretation, which is clearly not fully integrated by any means.

Ideally, for STEM to work as intended, that is, interdisciplinary in its delivery, it needs to be integrated. With clear connections being drawn between all four subjects as much as possible (Sanders, 2009). However, its application in classroom settings was limited by the long-held tradition in curriculum favouring learning through individual discipline (National Academy of Engineering and National Research Council, 2014). As with problems encountered by teachers in the United States a decade ago, Bahrum et al. (2017) noted that teachers in Malaysia held the same misconceptions. The authors note that STEM education in Malaysia focuses predominantly on the two fields Science and Mathematics, with elements of computer or internet use infused as representative for the Technology element. The engineering component is, more often than not, considered troublesome and unnecessary.

As mentioned prior, the STEM initiative in Malaysia was devised to propel the nation from developing to developed, a middle-income country to a high-income country, and a semi-skilled workforce to a highly-skilled workforce (Bahrum et al., 2017; Shahali, Ismail & Halim, 2017). Hence, it is not wrong to assume that the initiative is economically motivated. To reach the goals aforementioned, the initiative has been designed to ensure the "STEM pipeline" (Sanders, 2009, p.22) retains a sizeable number of tertiary graduates capable of fulfilling the demands of industries. The emphasis has been so heavily played that teachers mistook STEM education's focus as purely industry-based (Bajuri, et al., 2020).

These misconceptions led Bajuri, et al. (2020) to argue that it is the weakness in Malaysia's STEM education's philosophical foundation that has led to its problematic implementation. However, deviating from the authors' attempt to address the weakness through a phenomenological exploration of knowledge and examination of the forms it took for integration to occur, this article attempts to explore the issue from a sustainability perspective. Echoing Bonnett's (2017) argument of education's purpose being ultimately environmental, this article argues that a stronger philosophical foundation for STEM education could be found if the approach to its *whys* and *hows* is more environmental in nature. It has been said that the shift of focus in education—from learners being passive recipients of education to being active participants—the landscape of education has been altered (Biesta, 2009). Corresponding to such changes research is increasingly geared towards the *how* in learning rather than *why* we need to learn in the first place. However, without a firm grasp of the *why*, the *how* in learning seems to be built on a shaky foundation, thereby enabling problematic implementation. As such, the section below is an exploration of supplanting *how* with a *why* firmly rooted in the sustainability rhetoric.

Greening STEM Education in Malaysia

From the brief discussion of Malaysia's STEM education outlined above, the language of capitalism and anthropomorphism is very much apparent in the curriculum design. In the guidebook for STEM education implementation (MOE, 2016b), education has been likened to an "investment" (p.2) that would pay dividends in the form of increased competitiveness on an increasingly globalised platform. The whole design is an antithesis to Bonnett's (2017) version of education which is concerned with learning through experiencing, to gain systemic wisdom of the problem afflicting the world today. This form of education means that rather than viewing learning as an "investment" for "economic competitiveness", the attitudes and values that should be promoted shall encourage a wider interpretation of success in life beyond materialistic richness (Bonnett, 2002).

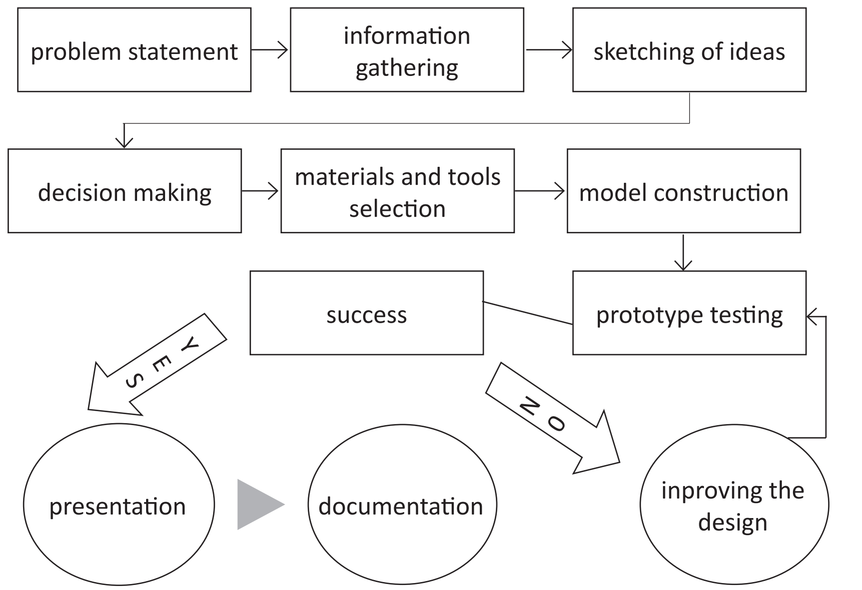
STEM education conceptualised as an approach was meant to ensure meaningful and engaging learning (MOE, 2016b), however, they were essentially prescriptive and inhibitory. To that end, videos were distributed to the relevant teachers to ensure "students' interest and curiosity on STEM subjects could be reignited and misconceptions avoided using the videos in their learning process" (MOE, 2016a, p.2 - 18). Additionally, STEM gamification and reality TV programme has also been included as par for the course in the effort to make learning fun. At first glance, the efforts made in encouraging a fun learning experience seems laudable. However, delving deeper into the *whys* revealed that it might not seem as attractive as it was thought to be. Being guided with pre-specified videos for fear of learners going off-course, and the introduction of games and reality TV programmes with rigid codes, and pre-determined scripts is not true learning. It was made even more so when teachers have had their hands tied preparing learners for "an examination focused education system" (Arsad, et al., 2020). As Jickling (1994) and Bonnett (2017) would have emphasised, detailed pre-specification deters genuine engagement with one's learning. This in turn defies the essence of education, which is associated with the effort to elicit the innate potential of learners by providing them with the necessary experiences to do so.

Taking an example of the activities suggested in the guidebook as a discussion point, see Figure 1 below, the presumption of human's mastery over nature is apparent:

Figure 1: Example of STEM activity from guidebook (MOE, 2016b)

Subject	**Basics of Sustainability**
Theme	Designing Cooler Box
End Product	Cooler Box
Scenario	Learners are required to design and produce a cooler box meant for use on a three days two-night camping trip

Figure 1: Example of STEM activity from guidebook (MOE, 2016b) (continued)

Subject	**Basics of Sustainability**
Steps for testing the design	

Bonnett (2017) has been adamant in his argument that “the potential for debilitating personal disengagement” (p.344) mounts, as the ranges of acceptable responses for learning narrows, and the rigidity of what is to be learned increases. Drawing from the example above, rather than fixing the end product as such, an emergent form of learning involving observations, reflections and experiences gleaned from nature would benefit the learners in the long run. The scientific processes exemplified above is sound if we are looking at a classic STEM framework. But in a Green STEM frame of mind, the language used and the underlying presumption needs to be put into question. This is especially true in the context of STEM conceptualised base on the deeply anthropogenic and manipulative western culture (Orr, 2011). Rather than learning the process of science geared towards bringing nature to serve human will, as the whole exercise seems to suggest, perhaps the focus should be on questioning the presumed mastery we had over nature. If the intention was to learn about the construction of a cooler box, it would serve the learners better to (1) question the purpose of it, (2) examine the construct of one, and (3) engineer an alternative based on their experiences gleaned from nature. The intention is to ensure that nature could be ascribed as possessing inherent intrinsic value rather than being viewed as a tool to be disposed of after use.

There are more points to address than the deleterious effect of anthropocentric language, rigid learning, and misguided metaphysical mastery of nature readily observed in the STEM guidebook. However, it is beyond the scope of this paper to address it all, neither is the intention here to go beyond exploring the possibility of Green STEM from a theoretical perspective. As such, the last part of this paper shall be directed towards the exploration of the potential and limit of Green STEM with sustainability as a frame of mind.

Green STEM with Sustainability as a Frame of Mind: Possible or Illusion?

As we are enjoying the comforts of today, struggles to cap global warming at 1.5^0C to minimize the possibility of irreversible ecosystem collapse is or should be, underway. Yet doubts on whether anything substantial could be achieved before it is too late is aplenty. While education's role in this fight against time is contentious. Amidst the mounting signs of a planet under multiple stresses, gearing our learners towards an education pathway for purely economic reasons seems counterintuitive. Likewise, STEM education that could support the learners of today for an uncertain tomorrow is not one that dictates learning, but one that facilitates learning. This could be done through conscious efforts in redesigning learning to encourage experience and reflections. Ultimately, the goal is to facilitate learners' ability to challenge our presumed mastery of nature.

Admittedly, strict adherence to Bonnett's (2017) frame of mind intimates:

> "an approach to thinking about (STEM) education that valorizes receptivity, concreteness and particularity over the abstract and the analytic; holism and the ontological over the atomistic and the epistemological; "Cosmo-centrism" over anthropocentrism and cosmopolitanism; sensitivity to immanent organic elemental powers directly experienced as against abstract formulation" (p.345)

However, such an approach to learning assumes that the essential expertise to realise this ambitious overhaul is readily available. Great responsibility is placed on the policy team, the curriculum team, and the teachers, requiring them at the least to be (1) well-versed in their field to be flexible in seizing the opportunities that emerge for learning, (2) trained to recognise and resist the underlying anthropomorphism pervading STEM education, (3) sensitive to their natural surroundings, recognise its intrinsic value and able to convey as much to learners, and (4) capable of viewing learning in a holistic manner. Yet, studies of local authorities' understanding of sustainability do not lend confidence to its feasibility. Joseph (2013) found that even among those directly involved with sustainability initiatives in the government tends to commodify nature or believe humans to be the master of it in the attempt to preserve it for the future generation. Studies on teachers' knowledge of the environment suggest that their understanding is limited to the environment in the abstract sense and information they have been trained with (Esa, 2010).

That said, all is not lost in the push for Green STEM. We are, at present, in a day and age where awareness of the environmental crisis and will for change is greater than before. Miller's connection theory of responsibility (Brock, 2017) serves to reminds us of our culpability, directly or otherwise, and rendering any attempts at feigning ignorance redundant. Our actions are intricately connected to another's situation either directly, or indirectly. Directly, by being morally responsible, or causally responsible; Indirectly, by benefitting from it, being capable of assisting, or associated through the community. As such, education does have a role to play in providing learners with the experience and reflection needed to explore an alternative view of development and human flourishing (Bonnett, 2002).

Additionally, Malaysia, as home to one of the only 17 mega biodiverse hubs worldwide, presents us with a unique opportunity to explore and develop a "frame of mind—or perhaps, better, way of being—that is energised by loving allowance rather than unbridled calculative imposition" (Bonnett, 2002, p.343). That means, in the course of developing the necessary knowledge, attitude and skills to better reflect on question and problems as mentioned in the proposed frame of mind, greater incorporation of engagement with nature for STEM education is needed. By encouraging the opportunities to dwell on natures' stimuli as it emerges and reflect on its wonder, and immersing our senses in the environment, we are better equipped to reflect on our presumed metaphysics mastery of nature.

Embedded in this exploration of a possible interpretation for Green STEM education are several fundamental questions challenging the status quo in education: What shall our relationship with nature be? In what sense shall we contemplate the concept of sustainability? Whose voice takes precedence in the race against the sixth mass extinction? Through the contemplation of all these and then some, envisioning and realising a STEM education that is explicit in its exploration of the curriculum's epistemic underpinning is of utmost importance. As such, the proposed frame of mind specifically conceived to be critical of anthropomorphism and designed to adopt the sustainability lens could enrich and supplant the 'neoliberal, hi-tech growthist perspective' (Smith & Watson, 2019, p. 8) propagated by STEM education in its current form. Only through this enhanced form of STEM education would we be able to populate a generation of forward-thinking learners who can judge, evaluate, and actively participate in the muddle that is sustainability discourse whilst developing a beneficial way of being for all.

Notes

1 According to the World Conservation Monitoring Centre under the United Nations Environment Programme (UN-WCMC) (2014), Malaysia is one of the 17 countries identified as home to the world's most biodiversity-rich countries in the world. This translates to the fact that a small number of countries hold a disproportionate number of the world's biological resources and therefore holds greater "political responsibility for conservation and biodiversity management" (UN-WCMC, 2014, p.1).

2 At the risk of simplifying a complex topic, the North-South divide alludes to the unfair categorisation of countries with different development status. The "North" refers to those with better socio-economic status while the "South" or the "Third World" were used to refer to those with lesser socio-economic status (see McFarlane, C., 2006). Cruz-Jesus, et al. (2015) among others suggests that educational imbalances led to the digital divide of citizens; that there emerges a difference incapacity of its citizens in understanding, adopting, consuming technological innovations due to educational attainment. Hence there is a valid concern that different approaches to STEM education due to the technology and knowledge capacity of the country could exacerbate the digital divide thereby allowing the continuation of a vicious cycle.

3 Following the guideline, what was referred to as a STEM approach by Mpofu was perceived as a STEM stream by the MOE. To ease subsequent discussion of STEM approach, field and stream based on the MOE guideline, Mpofu's (2019) STEM approach will be addressed as STEM field henceforth.

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