Channelling Artscience Through Fan-Fiction for Diversifying STEM Approaches in Participatory Learning in Malaysia

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Abstract

Fan-fiction is proposed as a participatory and discovery-learning approach to science, technology, engineering, and mathematics (STEM) education; communication; and collaboration through the epistemic third space afforded by artscience. The objective is to increase the affective dimension in STEM instruction by allowing STEM to enter intimately into social spaces, all the while drawing interests from girls and women. There is strong female participation in fan-fiction creation, whether in the form of textual stories or other transmedia objects, that could be used to develop more multi-dimensional STEM-based experiential and imagination-centric learning without ex-cluding the more technical aspects of the science – in fact, the technical aspects could be woven in as a STEM problem or project to be collectively tackled through the communal experience of creating and responding to fan-fiction. Moreover, the world-building capability of fan-fiction, with its ability to bring together multiple fandoms such as multiple works from the same creator or different creators within similar genres, means that there is ample room for using fan-fiction during interdisciplinary en-gagement for STEM problem-solving or research creation approaches to learning and doing. In this article, some examples of activities are taken from workshops targeted at Malaysian audiences to explore the possibility of deploying fan-fiction approaches to STEM, or STEM through the lenses of artscience, within the culture of learning and

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doing in Malaysia. These workshops were not originally conceived with fan-fiction as method and medium in mind and yet, were found to share certain similar traits with fan-fiction. The world-building capacity of fan-fiction could be deployed to mainstream the incorporation of indigenous and cultural ways of knowing within Malaysia into the rubrics of institutionalized STEM education. However, the convergence and compatibility between fan-fiction and participatory design, which were featured in at least three of the four workshops depicted here, are the reasons for the choice, while the fourth workshop considers the practice of fan-fiction and its relevance to more informal practices in STEM publishing and communication at a meta level.

Introduction

This article proposes how artscience-based reflexive participatory practices in science, technology, engineering and mathematics (STEM) education that focus not merely on the intellectual, but also the affective, is deployed throughout the learning process. The prescribed participatory practice does not only increase science literacies across age groups, through formal and informal instructions, but also improve learners' confidence in dealing critically with technical STEM content while challenging the 'canons' of the STEM objects they are taught. This article focuses on a range of critical learning practices that had been deployed outside of a conventional classroom context, but which could still be deployed in a classroom setting. It will present activities from four workshops conducted between 2019 and 2021 to illustrate how participants are ecologized in artscience/STEM-based knowledge-making to allow for diversity in knowledge systems and thought styles (Chilvers & Kearnes, 2020).

The artscience conceptual framework developed here focuses less on what is constituted as object knowledges in art or science, but rather, is targeted on a process that complicates any possibility of a clear delineation at either end of the binary, which is then read against developments in the new science of complexity involving self-organization, evolution, non-linearity and chaos (Heylighen & Petrović, 2021). Therefore, artscience constitutes an emergent epistemic culture that is not reducible to debates over how artistic practice benefits science; or how some of the techniques and practices in scientific experimentation had inspired new consideration into art techniques and materiality (Rockford, 2019). In debates on the unity of art and science, there are two forms of monist discourse, one that denies that there is such a thing as a dualist ontology: one is cognitive monism that claims art as a subdivision of science and the other is aesthetic monism that sees science as a subdivision of the arts.

In the case of cognitive monism, art is seen as differing from science in its degree of precision and universality. While art may be using symbols common to science for expressing truths, the manner whereby those truths are represented may differ from science (although such a difference is considered secondary). On the other hand, in aesthetic monism, the scientist is considered an artist with the appearance of cool detachment and objectivity although reality suggests otherwise. One could see this through the histories of sciences where certain theories are accepted for their aesthetic elegance or rejected because of their inexplicable imperfection (Richmond, 1984). However, whether art or science, both are about the imagination that provides a balance to an otherwise excessive emphasis on rationality that would be an obstruction to risk-taking.

Historically, artscience was derived from the melding of the supposed 'two-culture' binaries, with knowledge practices that had undergone centuries of development, and a network of complex differences in the domains even within the epistemic pillars of the arts and sciences (Heylighen & Petrović, 2021). Vaage (2015) has noted the difficulties for both sides to communicate during collaborations due to different expectations, epistemic language and even lack of familiarity with each side's methodology of practice, as well as the exclusion of certain categories of practices that are contributory to artscience due to 'gaps' within each 'culture'. Further, the choice of calling it artscience, rather than art-science, is intentional for the presentation of artscience as an emergent epistemic third space rather than as a combination of two binaries.

Artscience as framework for coproduction and relational imaginary with an affinity for non-linear reflexivity could also be deployed in citizen science practices where the participants have a right of intervention, as well as access to the supposed language and methods of science. This gives a more active role to the citizen scientist than the usual practice of the citizen scientist as a data collector, although being a data collector is suggestive of the idea of being an active participant in the process of making and developing the instruments of data collection (Phillips et al., 2014), just as one would, as a student, be involved in the design and development of their science projects.

Therefore, it is not about the public being interested while remaining passive stakeholders in scientific knowledge production; rather, it is about them feeling equipped to challenge and critique both epistemic and social norms in the practice and production of science (Giordano, 2018). These lay participants are viewed as having significant impact on open science culture, making even the more esoteric of science knowledge relevant to non-specialist communities. The more studied examples of these could be found among members of the do-it-yourself (DIY) biology community (Golinelli & Ruivenkamp, 2016).

By proposing the case of citizen scientists as knowledge co-designers and co-producers, the public is no longer viewed as merely passive recipients constituting a knowledge-deficit model of the public, but a public competent and able to handle and negotiate its own relations to science as well as background materials informing the science (Davies et al., 2008). This goes beyond the usual definition of communicating science as sufficient grounds for scientific literacy, whereby science communication is

seen as 'organized, explicit, and intended actions that aim to communicate scientific knowledge, methodology, processes, or practices in settings where non-scientists are recognized part of the audiences' (Horst et al. 2017, p. 883).

The bridging STEM education with artscience-directed, participatory-design-based, citizen science will be explored by repurposing one of the most active 'lay' activity that could combine design, fiction, various STEM knowledge, rationality and the imagination to build a series of possible, plausible, probable and preferred worlds: fanfiction. Fan-fiction is a transmedia affair that is already multidisciplinary in nature and generative of discursive exploration. Fan-fiction shares many of the same characteristics with other participatory forms of engagement in terms of passion for the work (or at least in the sense of having sufficient interest in contributing their time and labour), epistemic identity building, critical response to a primary knowledge/cultural object that inspired 'lay' activities surrounding them and a desire to appropriate portions of the world for creative ownership claims.

Just as with fan-fiction created around other socio-cultural objects, affective investments play a role. Fans with different visions or values when it comes to interpretation or inspiration of their source material could gain their own corner by building their own communities of like-minded fans around these shared values rather than being forced to serve dominant ideology or adhere to the canon. Therefore, the use of fan-fiction as a pedagogical tool that could bridge the affective with the rational, making the learning more personal and relevant to interests beyond pure utility while navigating gendered and other inequalities, makes this approach suitable for tackling learning (and teaching) anxieties especially in the more abstract STEM subjects. As the next section will show, there have been attempts in pedagogy to demonstrate how abstract concepts could be delivered through approaches that give priority to the sensual and the affective.

Even with seemingly progressive and innovative approaches to STEM education, there is still an ideology that views science as value-free, neutral and apolitical in its curriculum, while at the same time, focussing on the 'students' conformity to authoritative knowledge and scientific discourse that are relevant to research scientists, be it "discovery learning" or traditional lecture style learning. This is certainly the experience in the STEM classrooms of Malaysia, with curriculum that did not attempt to question the foundations and politics of the "imported" disciplinary knowledge transposed upon a postcolonial education system, and the imperial imperative that had informed the development of the earliest Malaysian universities that became the model for later newer universities. Classroom research shows that students are generally taught one way of representing "nature" and solving related problems and are graded on their abilities to conform and on their ability to mimic what was taught' (Lee & Roth, 2003, p. 404), which means that students, with exceptions, seldom would question the way in which STEM topics are being presented to them, especially within the top-down form of management in mainstream Malaysian education. This contributes to a sense of alienation and distance of these topics to the practicalities of navigating the quotidian.

Such conformity appears to be reinforced and perpetuated in supposedly free-choice learning environments such as at science centres or science museums which may get visitors to experience a science specifically curated to produce the outcome intended by the 'experts' without challenging the dominant expert view (Rennie & Williams, 2006). The same applies to a 'discovery-style' mathematical learning programme called Junior Undiscovered Math Prodigies (JUMP) proposed by playwright and mathematics tutor John Mighton. Although the programme is a definite step in a positive direction by challenging the usual top-down and rote-based approach of math learning, that does not sufficiently account for the differentials between each level of mathematics education, let alone the cognitive development of the learners (Anderson, 2017).

Nonetheless, design (in the form of design fictions or speculative design) has the potential to enculturate artscience practices in the formation and pursuit of questions associated with STEM fields, often drawing on tacit knowledge to give more priority to ideas that are enriching but could not be provided with rational explanation, thereby hinting at a logical gap between existing knowledge and knowledge still to be discovered, or invented (Rust, 2004). In fact, Rust discussed the use of design artifacts as tangible provocateurs that could then be used to stimulate uninhibited imagining by the participants without being constrained by their lack of technical aptitude or expertise; he used the example of a cardboard computer representing the different parts of an actual computer system that allow participants to suspend their judgement over how to legitimately proceed and 'hack' their way around, something which became impossible in latter-stage prototypes replete with technical functionalities that have to be taken into account.

Literature Review

There has been research into the gender problem in STEM, ranging from the varied perception that certain fields are too masculine, to negative stereotypes about female abilities, to the lack of diversity in representations of female (Ikkatai et al., 2021) and other minorities. These problems are connected to local cultural expectations and beliefs of the place including how smartness is gendered. This perception of smartness also shapes the self-conception and belief in their ability to succeed in a domain, with positive reinforcement through the support of peers as social buffer.

It was found that gender bias increases in the mathematical and physical sciences, especially at the tertiary education level (Robnett, 2016). Even from the time of elementary school, anxiety in mathematics has been the bane of the female teachers and the girl children they have charge over (Beilock et al., 2010). Although overall findings of self-conception and intellectual confidence of women in STEM fields appear depressing, Malaysia is found to be one of the countries with higher level of mathematical self-conception for female (M = 0.06) than male students (M = 0.04). The findings commensurate with the higher average mathematical achievement scores found in five countries: Bulgaria, Lithuania, Latvia, Malaysia and Russia Federation (Niepel et al., 2019). However, this higher self-conception has not translated to there being more

professional mathematicians or women working in fields requiring high-level knowledge of mathematics in Malaysia.

Research focussing on gender diversity in STEM-related professions have mentioned (Niepel et al., 2019; Goy et al., 2018), though not dived deeply into, the building of diverse STEM cultures. One of such attempts involved deploying art-based pedagogy in STEM learning targeting girl students. In spite of the semblance of reflexivity, the laudable examples mentioned here do not extend to engaging with the fundamentals of the STEM topics at a critical level. One such instance involves using dance choreography and music to provide sensual and tactile experiences in particle physics. In a workshop divided into two sections, the first section involved introducing a group of young teenagers (aged 12–13) to certain key technical aspects of particle physics, through a game of 'trump' cards drawing and subatomic 'plushies', with the assistance of 'expert' physicists.

The second part involved choreographing dance movements, with the guidance of dance teachers, to interpret the abstract ideas in particle physics the students had been introduced to, and the students were tasked to create the movements collaboratively after a series of warming-up exercises to prepare them (Nikolopoulos & Pardalaki, 2020). The use of dance provided an affective dimension to an otherwise intellectually intensive learning process, although it stops short of asking more fundamental questions that connect the physical movements of dancing at macro-space with the proposed physicality of the microscopic entities, and whether dance could have anything to offer to particle physics beyond pedagogy!

By and large, the deployment of arts pedagogy into STEM instruction tends to be even more conservative than the aforementioned example, even if the approach they deploy has the potential to be more exploratory and challenging of the status quo. For instance, the use of fairy-tale quasi-theatrical scenarios to teach Diophantine algebra to pre-teens and young teens would make the learning environment more affective. However, such affectivity does not extend to the mathematical objects that are inserted into the heart of role-playing without having more fundamental epistemic impact on the design of the story – such as how one could navigate an essentially noetic science through actions and reactions (Grozdev & Nenkov, 2018). In this and the previous case, one could not consider the engagement of arts pedagogy in STEM teaching as representative of the artscience epistemology described in the previous section.

The interesting findings from these two examples is concerned with how arts intervention into STEM objects echoes certain characteristics of fan-fiction: taking an original work and embedding them upon other media forms (as extra-textual production) in a manner that injects greater affective connectivity to the original work. Further, many fan-fictions get to the heart of both the vulnerable and the intimate (Hellekson & Busse, 2014; McGee, 2005; Barnes, 2015). It does not matter whether the intervention from the 'fan' diverges completely from, or is reproduced as, extra fillers that remain consistent with the 'canon'.

The deployment of dance and music choreography as methods for studying the interactions of entities constituting the standard model in particle physics has stronger

affinity with the spirit of fan-fiction in terms of how the participants were able to inject themselves more fully into the work, both emotionally and intellectually, compared to scenario-driven role-playing in mathematics learning that only permitted limited interventions from the participants who may take on different roles without altering the essence of pre-designed scenarios. Therefore, one could take the STEM objects with their surrounding narratives as the canon, with creative reproduction of the narratives as forms of 'fanon'.

An important aspect of fan-fiction is its ability to build communities and engage with other fans; the greater the attraction to the original work, the greater the quantity of fan production in the form of lovebour, a labour of love that seeks social recognition within the targeted fandom rather than from material gain (Stanfill, 2019), hence becoming dedicated champions of the original work. Successful engagement between the instructors/learning facilitators and the target participants are best measured by how the participants are sufficiently moved into becoming champions of STEM, even if not as professionals, but as 'good' citizens sufficiently literate to be able to think critically and reflexively about the scientific knowledge they are confronted with, regardless of whether they are part of the STEM professions or not.

Affectivity is often discouraged during engagement with STEM topics due to the façade of objectivity, which has had a hand in contributing to building a wall towards these topics as being unattainable to most of the 'lay' population, evidenced in the research cited here. The focus on developing one's relationship with a cultural/knowledge object is more important than adherence to more formalized 'standards' associated with 'higher' artforms encouraging the inclusivity of a wider range of speculative engagement and 'free expressions and listening without inflexible judgments' (McGee, 2005, p. 166).

The nature of fan-fiction makes it open to interactions between the author/creator and audience/reader in a way that finished published work do not usually enjoy. While some of these interactions serve as fan-service on the side of a fan-fiction author trying to draw interest to their work, such an arrangement also allows for an easier solicitation of feedback from other readers to gauge the popularity of the scenario or plot used, especially for fan-fiction written as part of a longer series. Imagine transferring such flexible arrangements to participatory engagement in STEM education or communication, contributing in a way to the 'death of the author' while dissipating the focus from the expert/author/facilitator as creative director.

Fan-fiction is not about developing fiction to meet industry standard, but rather to meet the demands of the fandom, with elements that one would not find in the standard featured works (Barnes, 2015). Hence, it is unsurprising that there are now studies into the use of fan-fiction as a medium for nurturing writing skills within a supportive community with a diversity of creative experiences in fandom (Rouse, 2021). The identity of the 'amateur' and 'task-oriented' approach to creation in fan-fiction means that it matters less whether the work meets 'professional' standards (although some nearly do) than whether it serves the object of its creation in the first place, which is to

further engagement with the source material or to meet the personal desires and interests of the creators.

Prototyping Design for Potential STEM Instruction: Artscience World-building

The evolution of learning design from more 'orthodox' forms of participatory-design learning to community-based STEM learning through fan-fiction will be demonstrated through four workshops: two face-to-face Kuala Lumpur-based workshops from 2019 and two webinars from 2021 – all of these workshops are targeted at Malaysian participants. These workshops were not designed for deploying fan-fiction as an approach for artscience-based STEM learning, but rather, were the proto-inspiration for the presently, still-developing study into the use of fan-fiction in artscience projects, within or beyond STEM education. These workshops are developed to demonstrate how one could incorporate Malaysian-based indigenous objects and cultural knowledge to contemporary disciplinary knowledge; in the two physical workshops, participants even contributed their situated knowledge through the background knowledge and experience they have gathered from having studied or done creative projects in Malaysia. Such workshops are in line with the growing popularity of hackathons in Malaysia except in these cases, what are being hacked are the participants' own fundamental expectations and understanding of disciplinary knowledge, a rare occurrence in Malaysia.

The two physical workshops were from April 2019 (organized in collaboration with an arts-based collective) and Dec 2019 (organized through a Malaysian state library network). The two webinars were, respectively, hosted by the Science University of Malaysia (Universiti Sains Malaysia, hence known as USM) in June 2021 and Putra University of Malaysia (Universiti Putra Malaysia, hence known as UPM) in August 2021. However, rather than discussing each of these workshops in detail, the paper presents selected activities from the workshop containing elements of fan-fiction potential, even if not fully realized at the time of implementation.

The April 2019 workshop held at a studio space belonging to the art collective was a starting point for exploring the use of simple scenarios and props to get the participants to collaborate in developing what-ifs from what are possible, plausible, probable and preferable. In this workshop, the focus was more on the development of a methodology for instigating a departure from the familiar to motivate the building of their own narratives. The participants were encouraged to develop their own projects but also find points of divergence and convergence between each project to build a composite collaboration.

The workshop was about introducing the participants to artscience as creative enterprise, an interface between 'boundary method' and 'boundary object'. The boundary method focuses on the operation of the trading zone of interactional ideas for encouraging participants to work with one another as well as with new ideas, whereas the boundary object is focussed on the process of translation and interpretation, that

'third space' for engaging in research and creation (Wienroth & Goldschmidt, 2017). The props deployed were imaginary examples of an artscience studio-laboratory, with objects that could be substituted in and out – these objects could be viewed as narrative tools or building blocks for participants to engage in play. These are the fundamentals that go into fictional world-building (see Figure 1)

The December 2019 workshop was focussed on deploying artscience for history and philosophy of science instruction to a mix-group of polytechnic and university students, a workshop that also presented science as part of a fictional enterprise. The workshop operates primarily through improvisation, and alternates between the delivery of short lectures for providing theoretical framework and activities that urged for critical reconsiderations of abstract ideas. The abstract ideas were unpacked using tools that allowed the participants to 'sense' rather than only be intellectually stimulated. The participants were first asked to simulate how informational timelines were built up with social media on the board, while engaging in actual search on social media and the interwebs for factoids that could then be used as building blocks for the narratives created. Then, using a combination of playdough and other stationery, each group of students were tasked with building stories that represented their interpretation of certain philosophical concepts or tropes (see Figure 2).

In the process of designing, making and even writing out the narrative, the students were provoked into asking questions about concepts in a way where the concepts were not merely a bunch of theories they must get right, but rather, a part of a natural world of curiosities that mattered for how they perceived their world. Similar forms of artscience facilitation had been discussed more generally elsewhere (Wienroth & Goldschmidt,
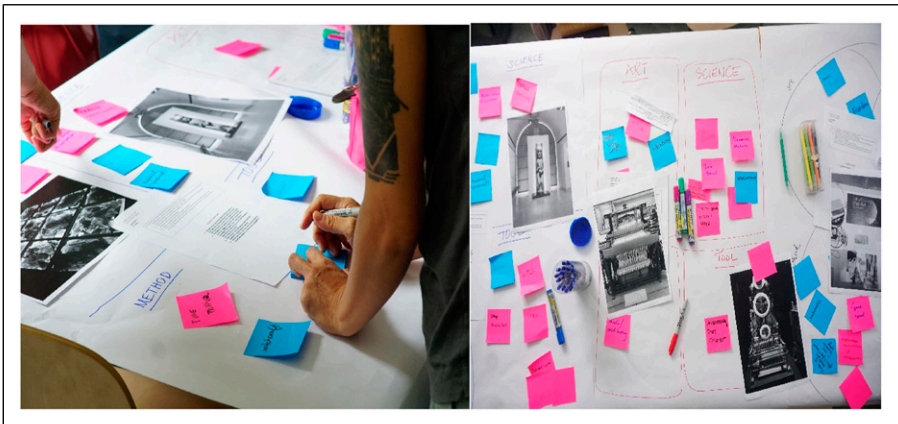

Figure 1. These are the project outcomes from the April 2019 workshop, where participants from each team built composite artscience collaborative projects that began as personal curiosities. For the December 2019 workshop, the participants were asked to share their thoughts by listing out what they had learned and what else they wished they had learned or had been able to do during the workshop.
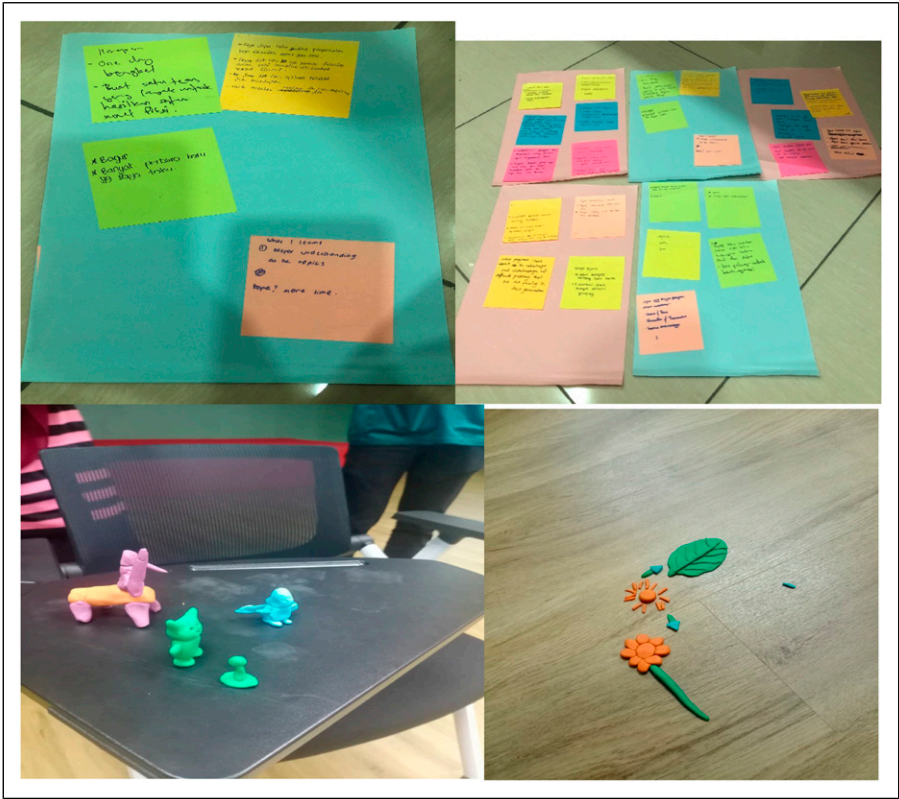
Figure 2. The top two photos are the informal written-notes feedback I had the student participants do at the end of the workshop, whereas the bottom two are examples of narrative models created by the participants. The top right response highlighted here had a sticky note where a participant stated how it would be cool to have a much longer series of workshop that would allow them to produce a collaborative novel, although the present workshop had been focused on the philosophy of science.

2017). By the time the participants presented their negotiation and team discussions at the end of the workshop, they had already expanded from the 'canon' using building blocks from philosophy and history of ideas in ways that connected with their groups' interests. Since the workshop took place in the library, I even had them select random high-school science textbooks in any science disciplines and used some of the contents as their narrative prompts.

The webinars, on the other hand, received their inspiration from the exercises of *Artscience: A Curious Education* (Lee, 2021), and had to consider the constraints of not knowing who the audience members were and how the audience members might not be comfortable with doing non-linear activities. The first one from June 2021 was about

research creation that focussed on demonstrating the relationship between the arts and sciences as symmetrical, emphasizing how perspectives from either side were determined by the participants' choices. The most relevant example is the world-building role-playing game that took its cues from Mary Shelley's *Frankenstein*, from the creature that Frankenstein brought to life. By focussing on techno-ethical-social questions surrounding how a new creature is brought into a world envisioned by the creator, the responses are arrived at collectively, even when there were divergences in opinions, as the players selected thematic cards.

For the webinar, I took the game and levelled it up by creating thematic blocks with questions to be addressed so that the creature could first be created as part of a collective effort. Then, I chose to draft out the rudimentary versions of different worlds, not unlike the building of alternate universes in the fandoms, which could be combined to produce permutations of possible worlds. Finally, there were certain roles that the participants could take ownership of and then develop. During the webinar, the participants were asked to draw on the whiteboard of the platform used for the presentation, and some of the participants began doing so even as the speaker provided more background to the narrative being constructed.

There was another exercise from (Lee, 2021) which attempts to synthesize artscience thinking from the perspective of indigenous knowledge. However, this world-building is a little different since they involve working with objects that are derived from the natural world while giving priority to a different form of fictionalization through oral storytelling. While exercises from the book suggested approaches for the observational method as well as stories mined from local folktales, the activity from the webinar decided to re-create an 'augmented reality' story that tried to combine certain metaphors, ideas and objects found in a Malay folktale (*Puteri Gunung Ledang/Princess of the Ledang Mountain*) that could be resituated within modern sciences, before combining them with an 'analogue' physical computing structure built out of a 'world' situated in soil (a metonymic representation of Earth). The ambient 'data' that could be collected from the soil's transmedia data embody a narrative of earth spanning thousands of years (geological time), while remaining potentially predictive of the future.

The final and most recent webinar from August 2021 took its narrative prompts from a forthcoming book chapter 'Diagramming ArtScience: Designing at Knowledge Intersections' that encourages the crossing of artifacts between science fiction, science communication and philosophical considerations of artscience. This webinar-workshop is the least interactive of the four discussed here as the webinar's purpose was more about introducing the presenter's research to the audience. Nonetheless, as the content covered in the webinar could become abstract and esoteric, I chose to bring in a very suggestive invocation of fan-fiction by introducing the audience to *Archiveofourown*, one of the biggest archives of fan-fiction; paralleling ArXiv, one of the biggest repositories for pre-prints and other unpublished scientific articles.

As the audiences primarily comprised those from the STEM fields, I wanted to get the audience to consider convergence in the setup between Archiveofourown and

arXiv. Even if the style and purpose of writing of either might not seem relevant to each other, they comprise repositories of stories to fulfil the function of communication, community and even speculative knowledge building. ArXiv not only contains your standard articles, but also articles where the contributors found themselves trying out ideas that interest and inspire them, but which may never make it through official publication channels.

These articles were produced because some scientists were compelled to work through an idea that intrigued or obsessed them in writing, even if they knew such ideas might not contribute to professional advancement directly. Such forms of writing form a big proportion of the motivation for writings found in *Archiveofourown*. The use of this example was also an attempt to introduce fan-fiction as a pedagogical approach in STEM and to broach the possibility of having a 'third space' archive as a boundary space for the aforementioned artscience practice, with art as the technique and method for engaging critically with STEM topics.

Responding to Collaborative Narrative Building

While there was actual feedback, even if done somewhat informally, from the first two physical workshops, it was not so possible to have separate feedback for the webinars, other than indirectly through a small participatory, questions and answers (Q&A) and discussion sessions that came during the presentation and towards the end of the sessions.

For the first two physical sessions of 2019, the feedback obtained were both through direct oral input, the writing of short notes and the deployment of a short survey. For the first workshop, there were pre- and post-surveys. In the pre-survey, the participants were queried about their background knowledge on artscience, their expectations and creative experiences, while allowing the workshop designer a sense of the demographical background that produced those responses.

The post-survey, on the other hand, revealed what the participants were able to take back from a 3-hour workshop, as well as what their preferences would be for such participatory-design workshops. The most relevant feedback to this article concerns the participants' interest when it comes to participating in activities that allow them to push the limits of their imagination while tying in their creative desires with a pre-determined task at hand. This means less information dumping would be the preferred way to go.

During the post-workshop debriefing session, all the participants agreed that they would have enjoyed having more time to deep dive into the world-building aspect of the workshop. These oral emphases by the participants influenced the design of the second physical workshop. I will not venture into the details of the survey as the original survey was aimed more at gauging participants' experiential responses to the methods employed for deploying speculative-participatory design, which is the deployment of speculative design as a form of participatory and collaborative engagement in anticipatory practice, scenario casting and even forecasting, further explained in Lee et al. (2021), to artscience practices that attempted to convey particular contents through the

methods. But what was evident is the desire for more time to explore and engage in cross-collaborative dialogues between teams that could then be implemented on a larger narrative scale.

As previously mentioned, the webinars did not involve the solicitation of feedback from the participants, although for the June 2021 USM webinar, there was an extended discussion on the 'augmented reality' soil as a physical computing project. More of the discussions could be viewed on the YouTube site of the organizers (Muzium & Galeri Tuanku Fauziah, Universiti Sains Malaysia, 2021). The video contains documented evidence of the participation of the audiences in the role-playing games accompanying the session, although time constraints did not allow the game session to be handled separately. For the final webinar of August 2021, there was insufficient time to engage in any feedback, as the time for the event was under 2 hours, although the presenting of the ideas to the stakeholders of a Malaysian university's institute of mathematical research could be the beginning of the next step in bringing such an idea to fruition once the right test subjects are found. The presentation could be viewed on the institute's Facebook page (INSPEM, 2021).

The original intention had been to take the exercises from the *Artscience* book and turn them into prompts, to be supplemented by any STEM topic pertinent to the audiences involved. However, the fluctuating situation of COVID-19, coupled with difficulties in carrying the planning of a completely online event, given certain requirements for tactile interactions as well as physical making and doing, shelved the plan for the time being. However, it was also around the period between July and September 2021 that I became interested in the possibilities of fan-fiction as a medium of artscience collaboration, communication and world-building not yet practiced in the manner proposed, although fan-fiction has always been an affective extension to canonical works of classic science fictional works, such as in the case of Dr Who and Star Trek (Tulloch & Jenkins, 1995).

Teenaged girls had complained about science fiction's detachment from reality due to their perception that science fiction, as a hybrid of the scientific and the fantastical, is disconnected from their concerns, with insufficient depth in the consideration of the human relationships, emotional lives of the characters, as well as the depiction of female characters. However, it is ironic that the preferred TV genre of choice, which is soap opera, also draws on an arsenal of romantic tropes that are fantastical and idealized (regardless of whether the idealizations are healthy or otherwise). The construction of 'subtext' seems of particular concern to these teenaged female audiences (pp. 91–93), and these subtexts are grist to the mill of fan-fiction. Therefore, fan-fiction had often focussed on the emotional and other affective dimensions of human characters even in works of science fiction.

The attempts among fan-fiction writers to fill these gaps, and to expand the canon forward and backward in time, make fan-fiction relevant for alternative world-buildings. The world-building contributes to break out of current 'canonical'

approaches in STEM instruction and science communication that constrain the limits of discovery-mode learning and doing.

The next challenge would be to connect what had always been viewed with intellectual indifference or considered as neutral to something that has intrinsically been seen as excessively focussed on the realization of affective desires. Fan-fiction can consider minority views, given its function, and therefore, could draw out those who may find their worldview, background and even preferences under-represented, if represented at all, in mainstream narratives, including scientific stories. However, it could be that a successful combination of these two aspects in teaching, learning and creation that the hostile environment could be changed overtime not just for one gender, but for a diversity of communities.

Conclusion: Moving Forward

The consideration of fan-fiction as an artscience platform has never been explicit despite the promise it holds for alternative world-building beyond the canon, therefore expanding the possibilities through which one could envision many possibilities not only for a single theory or experiment in a STEM topic, but also for building fictional characters (or fictional characters based on real people) around theory and experiment, therefore bringing the social into the same space as the technical. Through my previous studies in high and low literature and pop-culture, I have not seen such level of open and exciting, multi-level community engagement when it comes to just working with the so-called 'standard' cultural objects (the more conventionally published novels, TV shows or films) if they did not penetrate into the realm of fan-fiction, and are dependent on either a single or small team of creators.

Moreover, one interesting aspect of fan-fiction is the rich inter-connectedness between the universes of fan-fiction, containing shared details and even references to details that were not present in the original works, therefore expanding on the fictive and speculative universe while allowing more room for theorization. This means that the generated fan-fiction content that might have its source material from STEM topics/questions/themes could also be used as research material.

However, not all practices in fan-fiction are good. There are numerous discussions, both in scholarly research and on social media discussions of fandoms, regarding certain obsessions within fandom that advanced either toxic or problematic expectations, behaviours and cultures that are unhealthy. While all genders are affected by such toxicity, the prevalence of women as fan-fiction creators also meant that such toxicity would then circulate among girls and women consuming such works. Hence, it is important for the deployment of fan-fiction for either pedagogical, communicational and collaborative purposes to be aware of such problems that could arise, especially when the target participants in fan-fiction are young girls.

One of the dilemmas of deploying fan-fiction as pedagogical tool is knowing how to balance between the freedom that fan-fiction affords for their participants to engage in their passions unrestrained, and the potential for these obsessions to go out of hand.

Hence, the challenge is to make use of the infrastructure built around fan-fiction communities for making engagement with STEM topics affective (rather than being viewed as coldly scientific and disconnected from reality) without devolving into the development of irrelevant stories. At the same time, one does not want to overly control what should or should not be allowed through. My own observation is that those who are faithful adherents of the fan-fiction of a fandom, or across multiple fandoms, are capable of critical engagement with the texts in question (not just as overwrought fans seeking a dopamine rush), and even contribute interesting insights to the intellectual culture underpinning the content of the fandom.

At the end of the day, fan-fiction is an artform, even if it is an artform that has often been dismissed as part of low culture. I would argue that it is, instead, a part of a 'mundane' culture that allows insights into how participants in fan-fiction creation think, and therefore, mirror the actuality of their preferences in a way not found in other more 'technical' and methodical forms of participatory cultures. Therefore, more research should be done into the deployment of fan-fiction, with or without artscience, into making STEM relevant to the lived realities of those involved.

Declaration of Conflicting Interests

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