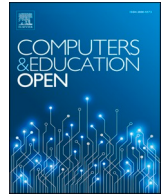Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Nurturing positive social values with the Socially Responsible Behaviour through Embodied Thinking (SORBET) Project

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1. Introduction

The COVID-19 pandemic has significantly affected all aspects of life across the globe. Children of school-going age have experienced a number of disruptions to their daily lives. These include the closure and / or suspension of schools (and the attendant shift to home-based learning), parents and guardians working from home, the cancellation of group activities such as team sports and the adoption (and in some cases enforcement) of public health measures such as social distancing in public spaces. These changes to students' lives, and to the lives of those around them, would have given them an idea of the size and severity of the COVID-19 pandemic, even if they do not fully understand what viruses are and how they spread through the population.

The authorial team designed the 'Socially Responsible Behaviour through Embodied Thinking' (SORBET) Project – an immersive learning environment – as a tool to help students learn about mathematical models of disease spread and appreciate the need to practice personal protective measures such as social distancing. The project was conceived in March 2020 as a way to translate a physical activity (conducted in Singapore secondary schools) in which students simulate the spread of an infection through play to remote / home-based learning and blended-learning contexts. The authorial team developed the SORBET learning environment using an open-source immersive environment platform (OpenSimulator) which allows for easy scaling and which can be used in both classroom as well as in online learning contexts. This paper describes the results from two runs of the project, namely a pilot which took place in July and August 2020 [1], and an intervention at another school which was enacted in October 2020.

In what follows, we offer Gee's [2] notion of Projective Identity as the theoretical framework undergirding our study. A review of literature – drawn from work in embodied cognition, virtual environments and dispositional change, and social responsibility and citizenship education – is shared. The research question driving the study was: to what extent might a learning intervention which combines a virtual environment with post-exploration discussion suggest that nurturing socially responsible dispositions is possible? The review of literature contextualises this research question and the methodology. The latter is followed by a sharing of results and a subsequent discussion section, before ending the paper with some concluding thoughts.

2. Review of literature

2.1. Projective identity

This paper describes the conduct of a study in an immersive learning environment which models the spread of an infection. The learners' embodied activity within the environment is complemented by dialogue and discussions to 'unpack' students' observations and understandings with a view to sensitising them to issues that relate to civic consciousness and active citizenship and, more importantly, predispose them to behaviours consistent with socially responsible attitudes that eventually manifest themselves in the real world.

Gee [2] describes how game players project their real-world identity onto the virtual identity of the game character they are playing as, developing a Projective Identity as a kind of synthesis which allows them to relate and reflect on both identities (real-world and virtual). A Projective Identity is not necessarily limited to the duration of game play; it can even influence values and behaviours in other (non-game) contexts. This suggests the importance of Projective Identities in the design of game-like learning environments. This idea is also further explored in Barany's and Foster's [3] presentation on how such identity exploration trajectories are mediated through the designed contexts of the environments presented to the learner.

The authorial team's goal was to complement the experiential learning involving the student's projective identity in the SORBET environment with teacher-facilitated dialogue and reflection in the classroom. Students' engagement in these learning activities places them on a developmental trajectory of learning where they learn to

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become "good" citizens via participatory appropriation [4].

2.2. Embodied cognition

Gee's ideas build on the concept of embodied cognition ([5, 6]) and situate it within the context of learning. Embodied cognition highlights how our senses enhance immersion and understanding ([7, 8]). The term refers to the idea that cognitive process are not solely situated in the mind but are in fact structured by our body and senses with respect to one's physical surroundings and immediate situation ([8, 9, 10]).

This stance of embodied cognition is supported by work in neuroscience. Ratey [11], for example, has described how emotional impulses are transmitted directly to the amygdala and the insula; these – in turn – lead to actions in the motor system. In sum, mediations at both the individual and social levels involve thought, action and emotion. The three form mutually complementary facets in understanding learning. In this framing, meanings are appropriated through such mediations. Emotion is an integral part of the experience from which subsequent meaning-making is based. Understood thusly, intuitions gradually develop into scientific concepts; conversely, scientific concepts are translated to reflexive action.

Shapiro and Stolz [12] have described an overview and development of embodied cognition and outline the educational impacts of embodied cognition to enhance educational practices, which in turn can maximise the effectiveness of the teacher in bringing about student learning. Embodied cognition has also been applied towards the study of human-computer interface technologies such as virtual reality and smart devices (Mahon (*ibid*); Amin, Jeppsson, and Haglund [13]). Work by Miller et al. [14] shows that social interactions in virtual spaces have persistent effects on human behaviour even after the interactions in the virtual spaces have ended.

2.3. Virtual environments and dispositional change

Trevors and Duffy [15] have recently underscored the importance of being cognizant of learners' misconceptions with respect to the design of educational resources in response to the COVID-19 pandemic. An appropriate sense of "what counts as learning" must revolve around students learning to be and to become certain kinds of people: in short, on being ([16]) and becoming. The goal does not primarily revolve around acquiring content knowledge. Instead, the goal is to develop a set of attitudes, values, and beliefs that underlie dispositions to act in certain culturally preferred ways. Examples include the attitude of capitalizing on cultural and racial diversity and the values of vigilance and collaboration.

Virtual learning environments have positively contributed to the development of behavioural skills. Çakiroğlu and Gökoğlu [17] found that students' fire safety behavioural skills significantly improved with the use of virtual reality-based training and most of the students could transfer their behavioural skills to real environments. Sanina and Balashov [18] provide a detailed examination on the educational possibilities and potential of digital simulation games in higher education by examining co-creative gamified social science classrooms. They found that besides previously studied benefits such as enhanced motivation, enthusiasm, collaborative participation, and interactions with the instructor; the combination of the co-creation technique and simulation game development as a part of the educational process in social sciences can improve student performance, course outcomes, and course evaluation.

Game-based learning environments allow students freedom to navigate a space to interact with game elements that foster learning, i.e., lead to high levels of student engagement and motivation during learning of complex topics, resulting in greater learning outcomes. Taub et al. [19] and Shaffer [20] have separately described several game-based projects that involve immersing students in the practices and culture of specific professional disciplines such as mechanical

engineering and journalism. Shaffer (*ibid)* found significant evidence that students involved in the games showed significant learning gains and, more importantly, demonstrated a far greater depth of situated understanding after the activities were over. He reported that these activities work because they engage the students in authentic professional practice. By carrying out the same tasks that a professional would and making use of similar, simplified, tools, students learn to imbibe the values and practices of those professionals and consequently become equipped with a worldview suitable for understanding academic disciplines in depth. Equally important, the tasks that were designed for students to carry out are not necessarily very different from those that might typically be assigned to students; however, the task is situated in an authentic context of practice. There are two consequences that follow. First, the task at hand is consistent with the context of practice in which students are immersed; second, the tasks are imbued with meaning by virtue of the context of practice.

As an example of the authenticity of situated practice, in a study perhaps closest in intent to the intervention described presently, Krebs et al. [21] designed an environment within the virtual world of Second Life to help hospitalised smokers practice coping strategies to manage triggers and urges so as to enable them to quit smoking, in preparation for returning home after hospitalization. Their Virtual Reality Coping Skills (VRCS) environment comprised full scale examples of typical spaces within the home, such as the living room and the kitchen, populated with common triggers to smoke, and – importantly – a toolkit of scripted actions that enabled the patient, through his or her avatar, to rehearse various coping strategies. Similar to this VRCS environment, the SORBET approach described in this paper also comprises two complementary halves designed to act together to encourage dispositional change.

2.4. Social responsibility and citizenship education

There have been attempts to incorporate virtual game-like environments in social responsibility and citizenship education. An example would be Yang's et al. [22] development of an online educational game to educate young adults on scepticism toward online information and information discernment skills.

Since the start of the COVID-19 pandemic, there have been reports of youths not adhering to recommended safe distancing protocols (see, for example, National Post [23] and CNN [24]). Daly and Robinson [25] and Gadarin et al. [26] have separately documented cynical reactions of the general public and the polarising nature of the news coverage of the pandemic. In Singapore, after a successful early lockdown in April and May 2020, reports soon surfaced in the press about complacency amongst the public (see, for example, Today [27]).

Blyth [28] has identified three facets of citizenship education, namely:

- education about citizenship: providing students with sufficient knowledge and understanding of national history and the structures and processes of government and political life;
- education through citizenship: learning by doing through experiences in and out of school; and
- education for citizenship: developing skills and values as a means to encourage active citizens, through focusing on an appropriate balance between what the individual gives to and expects from society.

As a corollary of its abstraction from the real world, the SORBET environment does not directly address education about citizenship. Instead, it affords students vicarious opportunities to experience education through citizenship – affording students through their respective avatars to participate in various everyday activities, thereby leading to education for citizenship.

In turn, Selwyn [29] has identified four broad ways in which technologies for learning might be applied to citizenship education. Briefly,

these are using such technologies:

- as a source of citizenship information;
- as a means of engendering citizenship discussion;
- to help learners produce citizenship materials; and
- for whole-school citizenship activities and practices.

Selwyn's framing suggests the potential for a theoretically informed design of a learning environment to engender positive social behaviours and reflection as part of a more fundamental developmental trajectory of identity construction.

In the context of the COVID-19 pandemic, an early attempt at such a design was a resource kit developed by the Smithsonian Institution in collaboration with the Interacademy Partnership. Titled *COVID-19! How can I protect myself and others?* [30], it circumscribed a series of hands-on tasks for children to be introduced to the science undergirding protocols of socially responsible behaviour.

3. Method

Based on the review of literature in the preceding section, the authorial team designed the SORBET environment to comprise two complementary halves, both or either of which may be conducted in face-to-face / remote-learning / home-based learning / blended learning contexts (or, any combination thereof).

In the first half, learners - through their avatars in an open-source virtual environment - are given visual augments of safe radii, colour-coded depending on proximity to others. Fig. 1 depicts an example.

From the perspective of public health, the mathematical models of the spread of an infection aim to understand how individuals in a given population transition between three states in a so-called SIR model [31]: namely susceptible (S), infected (I) and recovered (R).

For the interventions described in this paper, the following assumptions were made in order to simplify the mathematical model of virus spread in the SORBET environment. Firstly, infected avatars do not recover; that is, they remain in the infected (I) state until the end of the simulation. Secondly, the population is evenly mixed and so any susceptible avatar has an equal chance of catching the virus from contact with an infected avatar.

The first half of the SORBET pedagogical approach consists of a virus simulation activity in the open-source immersive environment which lasted five cycles. At the start of the activity, teachers determine the cycle length, select one avatar to be Patient Zero (or allow the system to randomly select an avatar) and determine how contagious the virus is. If desired, they can discuss these factors with the students. Alternatively, teachers may choose not to reveal the fact that a (virtual) virus is being diffused around the environment, till the end of the five cycles. This latter choice was in fact exercised by the teachers during the study described in the present paper.

In terms of curriculum, the environment within which cognition is situated within SORBET was landscaped to be suggestive of everyday lived experience of the students – as such, there were elements within the environment such as public housing, a school building, public transport, sports facilities and a playground, and water features. This was to aid transfer of learning through projective identity from the learners' avatar selves to their respective real-world identities. A second reason for this design decision was to facilitate teachers' customisation of the activities tasked to the students, with respect to domain-specific concepts such as space and place (geography), probability (mathematics), and personal values (social studies and citizenship education). For the particular cohorts of participants described in this paper, the ostensible purpose of the activity tasked to the students was framed as a treasure hunt, namely to roam the environment searching for tokens of different shapes and colours.

Once all five cycles were played, the second half of the SORBET pedagogical approach would begin. In the second half, the teacher and the learners had the opportunity to access and examine the (simulated) 'infection data' through a web-based dashboard, designed in accordance with worksheets originally put together by Mathematics teachers in a Networked Learning Community at the Academy of Singapore Teachers.

Participants were encouraged to critically examine the interaction data, to discuss their observations and to formulate their own hypotheses. In this way, they were able to receive immediate feedback on their decision-making behind their actions, in a way which is not yet practicable in 'real world' settings.

The preceding description is summarised in Fig. 2 below.

The SORBET learning environment was conceptualised and designed in April 2020 and piloted during mathematics lessons in a state-funded

Fig. 1. Screenshot of the SORBET environment showing visual augments for safe distancing.
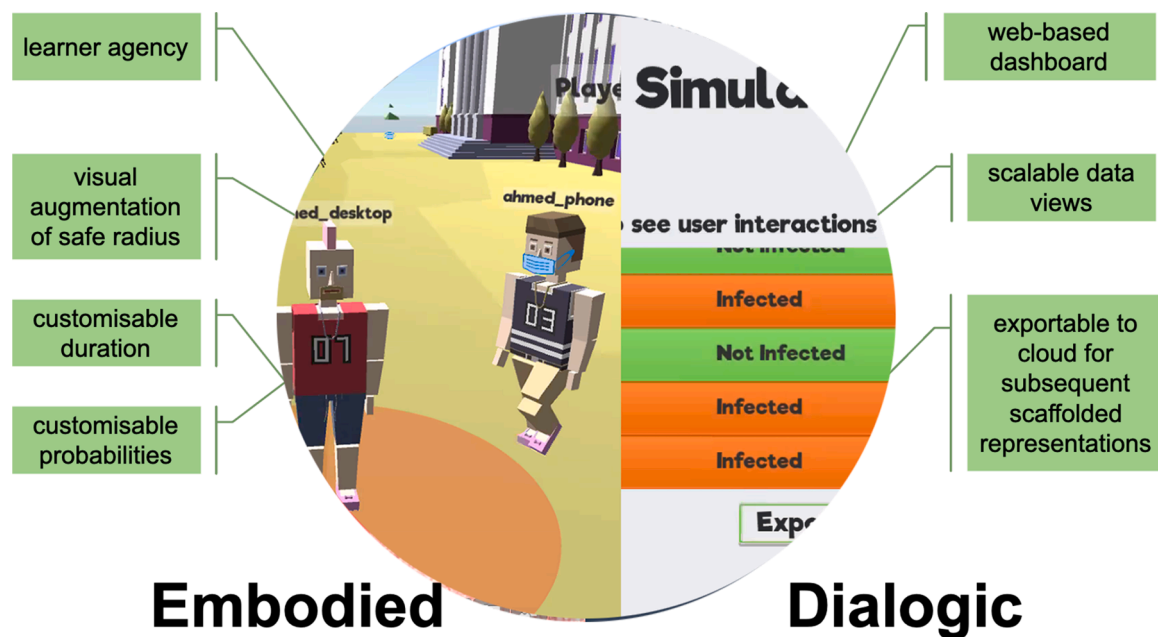
Fig. 2. Conceptual diagram depicting the two complementary halves of the SORBET Project.

secondary school in Singapore in July / August 2020. Following the pilot, there was a second enaction in another state-funded secondary school conducted by mathematics teachers in October 2020.

For the pilot, a total of 105 Grade Eight students (13 to 14 years of age) participated. Given the timing of the pilot during an on-going pandemic, the authorial team deliberately kept to a bare minimum the contact times between themselves and the students. The 105 students therefore constituted a convenience sample as chosen by the teachers who elected to pilot the intervention. Familiarisation of the teachers to the SORBET environment was conducted online with Zoom, in advance of the dates of the actual intervention. The dates were chosen to coincide with when students were allowed back to school. Once back in school, protocols required each class of students to be split in to two halves, with each half occupying a computer lab. There was a teacher in each lab, each assisted by a member of the authorial team (for technical support). To reduce social mixing, teachers in the two labs kept in touch with each other through their handphones. Both halves of the class benefitted from each teacher's co-teaching; this was achieved through screen sharing via Zoom between the two labs.

Data from the pilot was in the form of an audio recording of a group of four students as they interacted with each other during the activity, as well as post-activity feedback sought through the administration of an open-ended statement (namely "please share your comments on your experience"), and through the administration of four questions on a five-point Likert scale. The questions were administered online through Google Forms.

As will be reported in the following section, data from the pilot suggested anecdotal evidence that the intervention might be effective in helping students connect their embodied experiences from participation in the activity to real-world contexts outside the classroom. Seeking to support such anecdotal evidence in a more robust manner, a second intervention was conducted in a school with similar demographics to the first. For the second intervention, a total of 114 Grade Eight students participated. Again, severe constraints on the collection of data were imposed by the on-going pandemic. The 114 students constituted a convenience sample as chosen by the teachers who elected to pilot the intervention. The focus of investigation for the second intervention was to build on the data from this second round was in the form of responses to pre- and post- attitudinal questionnaires on a six-point Likert scale from an instrument used by Lim and Chee [32] in a study investigating

the use of a citizenship education videogame. The questions were administered online through Google Forms.

4. Results

This section reports responses from students to the instruments described in the preceding section. With respect to the pilot, the descriptive statistics pertaining to students' responses to four statements on a five-point Likert scale (where '1' is 'strongly disagree' and '6' is 'strongly agree') are presented in Table 1 below.

Responses to the post-intervention open-ended question on how they felt about having participated in the activity add some nuance to the 3.55 mean score for the corresponding Likert-scale statement. Responses to the open-ended question were found to fall to themes which largely found parallels in the design principles of Lim's [33] Six Learnings framework. Specifically, the emergent themes were: those emphasizing the ludic nature of the learning activity, those emphasizing the social nature of the activity, those highlighting the affordance of the environment for self-directed exploration, and those highlighting the connections of the activity with the world beyond the formal classroom environment. Samples of such responses for each theme are given in Table 2 below.

Many of these preceding themes which emerged as what students came away with from their participation in the activity are also illustrated in the following excerpt of a conversation which took place amongst a pair of students during the 'in-world' embodied half of the SORBET approach. For context, the excerpt begins as a student is trying to locate his friend within the environment (which includes replicas of

Table 1
Descriptive statistics from the pilot.

Statement	n	Mean score (max 5)	Standard deviation
I found the activity interesting	105	3.55	1.217
I faced difficulty participating in the activity	105	3.68	1.114
I would like to play more of this activity in school	105	3.43	1.322
I would like to play this activity from home	105	2.7	1.345

Table 2

Sample utterances grouped according to theme.

Theme / Design principle	Response
The ludic nature of the activity	Was able to play games while doing math
	The implementation of mathematical concepts in interesting activities
	it makes the assessment not stressful
The social nature / Learning by collaborating	playing and interacting with friends with an avatar online
	You get to play and interact with your classmates
	how we can interact with others
	Moving around with my friends in the game
	bonding with friends
	I like that I can interact with friends in the game
	it is fun and u can interact with other ppl
	I like that it is a multi-player game and you can interact with people and also objects
	can help people
The exploratory nature / Learning by exploring	We had different places to go to and find the hidden treasure hunt
	Get to explore a virtual world with friends/ classmates
	Treasure Hunt
	the scavenger hunt
	Finding tokens
	finding stuff
Connections with the 'real world' / Learning by being	It interesting of how the game is played and know more about the COVID situation
	I like how there were infected people
	I like that fact that we can use this pandemic for a math project. Some out of the box
	I like that it was related to real-world problems. Related to real life experiences
	the area is pretty and relevant in our lives
	it was something that was out of classroom/ textbook
	It is a visual stimulus and is more interesting than facing textbooks and worksheets
	It's interesting and at the same time shows us how viruses spread.

public housing units built by the Singapore Housing and Development Board (HDB)), and unwittingly ends up spending about two minutes stuck in an elevator within the environment, together with several other classmates. In Fig. 3 below, the HDB block of flats is shown in the background.

In the excerpt, relevant utterances are coded according to theme.

A: now bro get over here [Social]
B: oh oh oh what are you doing. where are you. [Social]
A: I jump high enough you can't see me. [Ludic]
B: wait where are you. [Exploratory]
A: ha ha gone. [Ludic]
B: I see someone in HDB I'm going to assume that's you.
A: no that's not me
B: I am going to search for you [Exploratory / Social]
A: ok. we're supposed to find things
B: no I'm searching for people. I'm trying to be annoying. #38 has offered to teleport (time index 21:39) ok apparently #38 wants me to go to their location. do you know who #38 is? [Social]
A: no
B: oh I'm stuck I'm stuck in the lift oh no this was a bad idea no no wait I'm actually stuck in the lift
A: who's #38? I'm searching for #38 [Exploratory / Social]
B: who locked me in this lift? where are you? there's a lot of people stuck in the lift
A: oh you see I'm walking past you, ha ha
B: get me out get me out [Social]
A: how how?
B: offer to teleport me to your location, please, please. teleport. you know how to teleport, right?
A: no I don't. ha ha you're going to get stuck in there [Ludic]
B: no
A: ha ha ha
B: no I don't wanna be here. wait. I'm going to find my own way. I'm going to self-teleport somewhere. I'm pressing teleport. I'm out (time index 23:08)

The following excerpt documents the exchange between the same pair of students (A and B) and two of their friends (C and D), during the second – dialogic – half of the SORBET approach. For context, by this stage the students have logged out of the virtual environment and are discussing their experiences amongst themselves, with reference to the 'infection' data through standard web browsers. The emergence of sociability as a theme is quite clear, and the excerpt has therefore been

Fig. 3. Part of the SORBET environment with replica of public housing in the background.

coded for utterances which illustrate the other afore-mentioned themes, particularly the hitherto tacit theme of 'connection to the real world'.

B: dude I have like so many interactions

A: ya I have a lot

B: I have so many interactions with #29. hmm. I wonder why. all my interactions are with #29 and #25. wait how many interactions did you get?

A: 37

B: 49

A: wow

C: I only have 6

B: just living the extrovert life, you know

C: I'm very sad I only got 6

D: I only got 35. that's not good enough [Ludic]

B: near the end I got trapped in the lift, and that's when a lot of interaction happened [Connection to real world]

A: you're a very lucky man

B: how does that make me lucky

C: I needed more interactions

B: I find it funny how I have one page that's just dedicated to #29 and #25

A: wow you interacted with him a lot

B: I was like trying to find him, you know. I have four interactions in round 1. round 2 I have a lot of interactions. round 3 I have more than two pages of interactions

A: the more the better

B: yes, the more the merrier. I have 49, A has 36. because we were very busy men.

A: we were busy exploring. [Exploratory]

B: we were doing some Dora stuff. I was Dora. A was Boots. [Connection to cultural reference (animated TV series '*Dora the Explorer*')]

A: imagine having absolutely no interactions. [Metacognitive rise-above: connection to real world]

B: that's the epitome of loneliness. [Existential insight]

The anecdotal nature of the preceding excerpts prompted the authorial team to seek to investigate some of these themes in a more robust manner (to the extent that robust intervention designs could be conducted in the first place under pandemic protocols). A second enaction was thus conducted. With respect to the second enaction of the intervention, data was in the form of responses to pre- and post-questionnaires about attitudes to citizenship education on a six-point Likert scale (where '1′ is 'strongly disagree' and '6′ is strongly agree', $n = 114$). The statements were identical between pre- and post-questionnaires and are listed in the Appendix. Results from paired sample t-tests performed on the responses are listed in Table 3.

Using the commonly accepted threshold of statistical significance $p < 0.05$, of particular note are the responses to the following statements:

1.   I can make a difference to how Singapore responds to the COVID-19 pandemic.
2.   I think about how my actions can affect other people.
5.   I believe that problems should be solved by people working together to find a solution.
6.   I care about how my actions can affect other people.
9.   As young children, we are able to contribute to the community.
11.   I feel that I can make a positive difference to my country.

Going beyond aggregated data, analysing the survey responses by the participants' respective classes suggested some insight, as well. The Singapore education system is in the process of transitioning to what is known as Subject-Based Banding, in which students will be afforded curricular opportunities to pursue each of the subjects they opt for, to a degree of academic depth that matches their interests and abilities. Until Subject-Based Banding is fully rolled out to all schools in Singapore, students are still organised in classes which cater to academic ability at a coarser level. With this context in mind, of the 114 students who participated in the second enaction of the intervention, 82 were in classes from the so-called 'Express' stream, and 32 were from a class whose curriculum was structured with more scaffolding. Tables 4 and 5 present results from the two classes in the 'Express' stream, while Table 6 presents results from the third class.

Using the commonly accepted threshold of statistical significance $p < 0.05$, of particular note are the responses to the following statements:

1.   I can make a difference to how Singapore responds to the COVID-19 pandemic.
4.   I am not bothered by the group's goals as long as my own goals are met.

Using the commonly accepted threshold of statistical significance $p < 0.05$, of particular note are the responses to the following statements:

1.   I can make a difference to how Singapore responds to the COVID-19 pandemic.
10.   As young children, we don't need to care about the country.
13.   If people did what was best for themselves, our world would be a happier place.

Using the commonly accepted threshold of statistical significance $p < 0.05$, of particular note are the responses to the following statements:

1.   I can make a difference to how Singapore responds to the COVID-19 pandemic.
2.   I think about how my actions can affect other people.
3.   I find it difficult to see things from another person's point of view.
5.   I believe that problems should be solved by people working together to find a solution.
6.   I care about how my actions can affect other people.
9.   As young children, we are able to contribute to the community.

Table 3
Results from the pre- / post-questionnaires (aggregated).

Statement	Pre-survey		Post-survey		t(113)	p
	M	SD	M	SD		
1	4	1.17727	4.67	1.01451	5.018441	< 0.001
2	4.59	1.26914	4.92	0.88995	2.367645	.0196
3	3.07	1.2546	3.21	1.32104	0.877226	.38223
4	3.52	1.35824	3.3	1.38212	−1.215211	.22682
5	4.68	1.0996	4.93	0.95676	1.825797	.07052
6	4.73	1.12325	5.04	0.89175	2.487397	.01433
7	4.57	0.99529	4.72	0.91699	1.114893	.26726
8	5.19	0.92053	5.09	1.00935	−0.819118	.41444
9	4.38	1.14745	4.71	0.90938	2.395964	.01822
10	2.39	1.32116	2.18	1.09904	−1.392449	.16652
11	4.3	0.91138	4.6	0.95676	2.325635	.02182
12	4.87	0.84679	4.89	0.85568	0.229809	.81866
13	3.38	1.41039	3.46	1.63035	0.438663	.66174
14	4.28	1.09309	4.24	1.20693	−0.341264	.73354

Table 4
Results from the pre- / post-questionnaires ('Express' class 1).

Statement	Pre-survey		Post-survey		t(41)	p
	M	SD	M	SD		
1	4.05	0.88214	4.57	1.10747	2.626759	.01207
2	4.81	0.99359	4.74	1.08334	−0.380179	.70578
3	2.9	1.14358	2.95	1.1677	0.197699	.84426
4	3.38	1.14663	2.76	1.20587	−2.307792	.02613
5	4.86	1.04931	5.02	0.92362	0.721714	.47457
6	4.93	0.86653	4.98	1.04737	0.251151	.80295
7	4.69	0.8692	4.71	0.96993	0.104744	.91709
8	5.48	0.77264	5.24	1.00752	−1.16749	.24976
9	4.6	0.7345	4.64	0.98331	0.24341	.8089
10	1.83	0.72974	1.86	0.71811	0.177522	.85997
11	4.33	0.8742	4.24	0.95788	−0.48061	.63335
12	5.02	0.84068	4.86	1.00174	−0.816023	.4192
13	3.05	1.36064	3.24	1.63513	0.581952	.56379
14	4.24	1.0777	4.05	1.26785	−0.881097	.3834

Table 5
Results from the pre- / post-questionnaires ('Express' class 2).

Statement	Pre-survey		Post-survey		t(39)	p
	M	SD	M	SD		
1	4.2	1.2237	4.8	0.93918	2.423732	.0201
2	4.8	1.15913	5.1	0.74421	1.373716	.17737
3	3.25	1.27601	2.85	1.33109	−1.346831	.18581
4	3.55	1.51826	3.18	1.31826	−1.282497	.20724
5	4.7	1.06699	4.75	1.10361	0.236208	.81451
6	4.92	0.88831	5.1	0.74421	1.021612	.31326
7	4.55	1.03651	4.6	0.95542	0.259533	.79659
8	5.12	0.75744	5.22	0.86194	0.598162	.55319
9	4.4	1.23621	4.75	0.86972	1.432701	.15991
10	2.68	1.36603	2.15	1.12204	−1.942302	.05935
11	4.52	0.84694	4.72	0.96044	0.915811	.36539
12	4.95	0.78283	4.88	0.79057	−0.452927	.65311
13	3.22	1.42302	2.72	1.37724	−1.802776	.07915
14	4.38	1.03	4.38	1.16987	0	1

Table 6
Results from the pre- / post-questionnaires (Class 3).

Statement	Pre-survey		Post-survey		t(31)	p
	M	SD	M	SD		
1	3.91	1.25362	4.62	1.00803	2.434468	.02087
2	4.34	1.42805	4.97	0.73985	2.154233	.03911
3	3.19	1.37811	4.16	1.24717	3.477846	.00152
4	3.75	1.29515	4.28	1.32554	1.656995	.10761
5	4.56	1.01401	5.03	0.84003	2.463121	.01953
6	4.34	1.38213	5.06	0.89175	2.487397	.01433
7	4.59	0.9456	4.91	0.77707	1.379919	.17748
8	4.97	1.17732	4.75	1.10716	−0.826626	.41477
9	4.22	1.33765	4.78	0.87009	1.93447	.06223
10	2.69	1.51205	2.66	1.35859	−0.095165	.9248
11	4.09	0.81752	4.94	0.80071	3.677531	< 0.001
12	4.5	0.84242	4.97	0.73985	2.278946	.02971
13	3.91	1.2791	4.75	1.13592	3.171342	.00341
14	4.19	1.20315	4.38	1.1288	0.641014	.52622

11. I feel that I can make a positive difference to my country.
12. Citizens should care about the social and political problems that affect the country.

5. Discussion

The results presented in the preceding section have suggested not only that the SORBET approach is effective in nurturing a sense of personal agency amongst participants with regards the potential impacts of their personal decision-making on society (as evidenced, for example, by the statistically significant affirmative responses to the statement "I can make a difference to how Singapore responds to the COVID-19 pandemic"), but also how the approach of the project might be achieving this. These latter insights are gleaned from analysis of the qualitative data from the study.

The excerpts of peer-dialogue presented in the preceding section highlight the importance students attach to the affordance of sociability when participating in learning. This appreciation of sociability also comes across in the words of a fifth student who participated in the study, Student E: "I had a very good experience with the SORBET project. It was a really fun game that I really enjoyed. One of the interesting aspects of the game is that I was able to interact with my friends in the game and the interactions would be recorded. This recording would be used in the virus part. Which is another unique part of the game. Overall I think the game was really interesting and unique because being able to interact with your friends is a very uncommon thing to see in these types of educational games. This taught me about social distancing as it showed how fast the virus can spread from one person to many others. As for real life now as covid-19 is a real virus that is also deadly, it is important that we students learn about how to

prevent the spread of it."

What is interesting is that during this post in-world, dialogic, phase of the overall curricular unit, it emerges that as this group of students reflected on their interactions, they were variously trying to deconstruct the circumstances which led to their interactions, as well as performing self-evaluations on their own decision-making and behaviours – and the consequences thereof – and, towards the very end, the trajectory of their conversation went from self-reflection, to a connection with a cultural reference, and then on to a metacognitive rise-above which bridged from their immediate learning experience to the world outside the classroom through an invitation to hypothesise, and finally to an existential insight. In the case of Student A, he was able to apply a metacognitive connection to reality from his social interactions with others. Considering these were Grade Eight students from a regular state-funded school, this trajectory is noteworthy.

Taken together, the two excerpts of peer dialogue from the preceding section suggest the potential for the two halves of the SORBET approach – the 'in-world' embodied half and its subsequent dialogic half – to work together complementarily to create conditions which nurture the trajectory of dispositional change that represents the core objective of the Socially Responsible Behaviour through Embodied Thinking Project. This is aligned with Gjicali's, Finn's and Herbet's [34] and Marcos's et al. [35] respective theses on how increased social exploration actions undertaken by individuals encourage increased competency and learning performance. A sixth student who participated in the study, Student F, described these connections as follows: "I had an interesting experience with the SORBET project as it was educational and engaging. SORBET taught me the importance of social distancing and how easily a virus can be spread. In SORBET, one may contract the virus by coming into contact with an infected user. This can be applied in real life to teach students how to be more self-aware when we're close to one another."

In the context of day-to-day interactions with others in a time of COVID-19, there is a disconnect between everyday interaction (and the decision-making processes underlying it) with feedback on our action and decisions (with respect to the practice of social responsibility) which presently comes the following day through the publication of case numbers. this feedback suffers from (a) a time lag, and (b) a lack of context - the feedback is general to the population as a whole and not particular to the decisions and actions of any given individual / learner.

Further, there is currently no practical way of visually augmenting the 'safe' radius of interaction - this is especially important to younger learners, though sometimes adolescents also need timely reminders. Thus, for example, some students in China wear 'one-metre-hats', but this is not practicable on a daily basis.

Existing learning resources targeted at helping pre-tertiary level students (and lay audiences) better understand mathematical models of infection spread are either text-based materials [30] or web-based simulations with minimal interactive elements [36].

In contrast, with its emphasis on learner agency and ownership of their behaviours, learning in SORBET is active and embodied. Bailey, Bailenson and Casasanto [37] have made a case that virtual environments have the potential to afford learners sufficiently grounded experiences from which they can subsequently draw on to influence their actions in the 'real' atomic world. For instance, Student B's utterances upon his discovery that his avatar was stuck in an elevator, and his reflections thereafter, speak closely to Gee's [2] notion of Projective Identity, and Shaffer's [20] subsequent work on games as affording epistemic appropriation. The reader is invited to notice that when Student B's avatar gets stuck, Student B expresses his dismay using the first person singular: for example, "oh I'm stuck I'm stuck in the lift oh no this was a bad idea no wait I'm actually stuck in the lift", "who locked me in this lift?", and "get me out get me out". Student B's sense of being physically trapped and having his movements restricted are quite palpable through his use of repetition and rapid-fire utterances, even though his actual atomic body was at all times free to move in the

classroom.

Likewise, during his reflection after the incident, Student B continued to refer to the episode in the first person singular, and also was able to make the connection between his recent entrapment to the sudden rise in infectious interactions, as evidenced by "near the end I got trapped in the lift, and that's when a lot of interaction happened".

Student B's experience finds echoes in the following anecdote as related by a seventh student, Student G. In student G's words: "Overall, I find this experience pretty enjoyable. It teaches me that social distancing reduces the chance of unknowingly infecting others or being infected by others when there's less interaction. An example of not social distancing could be about register number 25 and 31. They are close friends in school and outside school. During cycle 2, they've decided to find the tokens together, unknowingly be infected. This shows the consequence of not social distancing with friends. Its difference is it demonstrates [the consequences of our decisions], instead of explains. Demonstrating is one of the most important aspect of teaching since people understand it through seeing it." In this context, the affordances of the SORBET approach of the ability to provide near immediate feedback to students of the consequences of their decisions and behaviours are reinforced.

6. Concluding remarks

This paper has described the conduct of a study on the enaction of the SORBET pedagogical approach — involving the use of an immersive learning environment which models the spread of an infection complemented by dialogue and discussions to 'unpack' students' observations and understandings — with a view to its use in citizenship education in both co-located as well as remote learning contexts. The research question driving the study was: to what extent might a learning intervention which combines a virtual environment with post-exploration discussion suggest that nurturing socially responsible dispositions is possible?

Analyses of both quantitative and qualitative data from the study suggest the potential of the SORBET approach to sow the seeds for dispositional change and more authentic understandings of the need to practice social distancing, in the long run. The authorial team hopes that this approach helps learners not only come away with a deeper understanding of how viruses spread but also a greater appreciation of the need to practice health measures such as safe distancing during the COVID-19 pandemic.

Limitations of the study reported here arise primarily from the constraints imposed by protocols seeking to limit the diffusion of COVID-19. Specifically, the study described in this paper was conducted in the context of students returning to school after an extended break, with strict social distancing and contact protocols in place. Opportunities for interaction between members of the authorial team and the students were therefore deliberately kept to a bare minimum, with consequent implications on the robustness of the design and enaction of the study. When the very first class of students returned to school, they and their teachers faced difficulty logging in to the environment for reasons as varied as having forgotten their respective passwords (after the extended break), to confusion over seating assignments (taking in to account social distancing), and lag within the environment (due to the teacher's computer having to deal concurrently with hosting the environment as a server, as well as streaming the teacher's instructions live over Zoom).

Future work that potentially suggests itself includes investigating the SORBET approach through a variety of disciplinary lenses, such as geography (for example, on the topic of spatial diffusion), biology (such as on the topic of epidemiology), mathematics (probability theory), and social studies (positive social values). The approach could also be trialled with learners of age groups different from those who participated in the study described in the present paper. Follow-up studies could also be done to investigate the ways in which students with differing trajectories of academic achievement respond to the approach, as

suggested by the analysis of quantitative data arising from the present study, as a comparison between Tables 4, 5 and 6 reveals. Likewise, follow-up studies could also be conducted amongst students who have already experienced the SORBET approach at least once (and would therefore know that a virtual virus is being passed around). The decisions these students make within the SORBET environment, with this knowledge, could be compared to their original decision-making. Anecdotal observations of students who have 'played' SORBET more than once does suggest that they do modify their respective decision-making matrices.

To this end, the authorial team has designed the SORBET learning environment around the principle of scalability and to be compatible with differing infrastructural requirements of co-present and remote learning. At one technological extreme – as alluded to briefly in the Introduction – SORBET has pre-pandemic roots in a pen-and-paper based activity, during which students would be co-present and record dice throws each time they had a social interaction within a bounded space (such as a school hall). For especially resource-poor learning environments, such a non-digital approach could still provide students with an approximation of the affordances of the SORBET approach.

Further along the digital spectrum, for co-present contexts, the SORBET approach can be carried out without the need for internet access, as students in a class can access the SORBET environment hosted on a portable USB thumb-drive via local network. For remote learning contexts, the SORBET environment can be hosted on a cloud service, allowing students to access it from their respective locations (such as their homes). Work-in-progress beyond the particular October 2020 iteration of the environment which was used in the intervention described in this paper includes a complete re-write of the codebase to make the SORBET approach compatible with mixed-device platforms, in which students may be accessing the shared SORBET environment through a variety of means, such as smartphones, tablets and laptops.

Over the long run, SORBET seeks to nurture the disposition of learners taking responsibility for their actions, particularly in the social context of an epidemic / pandemic. Human agency therefore lies at the heart of the SORBET Project.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. Statements used in the pre- and post-surveys on attitudes to citizenship education

1 I can make a difference to how Singapore responds to the COVID-19 pandemic.
2 I think about how my actions can affect other people.
3 I find it difficult to see things from another person's point of view.

4 I am not bothered by the group's goals as long as my own goals are met.

5 I believe that problems should be solved by people working together to find a solution.

6 I care about how my actions can affect other people.

7 I make my decisions based on what I think is fair and unfair.

8 Sometimes what is fair for someone may not be fair for everyone.

9 As young children, we are able to contribute to the community.

10 As young children, we don't need to care about the country.

11 I feel that I can make a positive difference to my country.

12 Citizens should care about the social and political problems that affect the country.

13 If people did what was best for themselves, our world would be a happier place.

14 I would participate as a volunteer in a community event if I knew I could contribute.

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