SSTRF 2020 PROJECT FINAL REPORT

<table>
<tr><th colspan="2">Project Title</th></tr>
<tr><td colspan="2">Designing Considerations for Interactive e-Assessment Test Items using Open Source Tools

Is this project confidential or contains sensitive information/content? Yes ☐ No ☒</td></tr>
<tr><th colspan="2">Project Team</th></tr>
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<u>Mentor:</u>
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Provide the names and designations of project team members.</td></tr>
<tr><th colspan="2">Abstract</th></tr>
<tr><td>This study examined the feasibility of including simulations made in an open-source tool called Easy JavaScript Simulation (EJSS) toolkit, as assessment stimuli on an e-assessment in the Exercise and Sports Science (ESS) O-Level subject. The ESS Paper 1 is conducted in the e-mode at the National Examinations. The current ESS e-paper includes the use of non-interactive media such as pictures and videos as</td><td>This will be published in the T.H.I.N.K. portal for reference.</td></tr>
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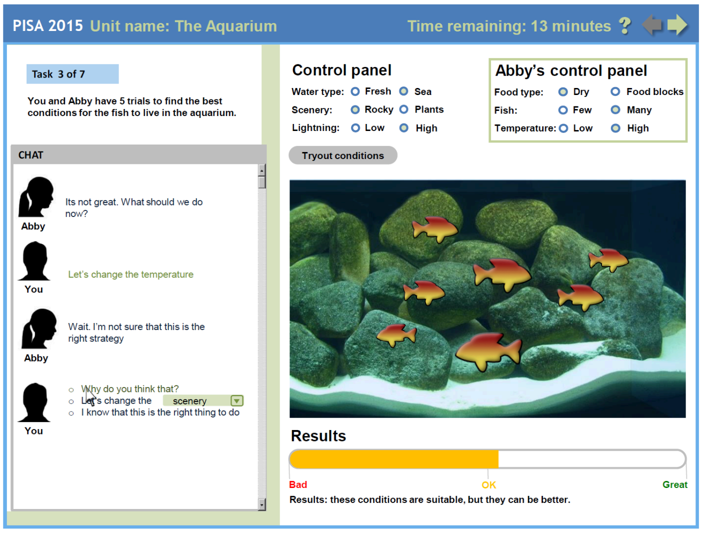
assessment question stimuli. The 6 simulations were designed based on principles gleaned from published PISA 2015 Science Interactives. The design principles applied for each simulation question set include (1) an introduction to the scenario; (2) clear instructions on how to manipulate the variables; (3) increasing cognitive demand of the questions, and (4) to include not more than 3 variables and 2 observed outcomes. Six interactives were developed based on inputs from ESS teaching notes from and interactive designer (PI) from MOE and assessment questions from SEAB. The participants were 51 students and 3 teachers from 3 schools. Students did well on the e-assessment items, except for 2 items. Upon examining, the questions required further refining, such as positioning of text within the simulation or re-phrasing of the question. Based on the performance of the 51 students, it appeared plausible that students were able to better demonstrate their content knowledge through simulations. From survey findings, students enjoyed the e-assessment and would like to partake in such e-assessment tasks in the future. The simulations afforded interactivity which allowed them to derive their answers through observation of outcomes from their interactive experimentation. They indicated that the simulations, 1) being time dependent, were more real life-like, 2) able to show visualization based on varying variables, 3) supported better sense making, and 4) provided a more engaging experience.	The abstract should be no more than 300 words and include: (a) research questions, (b) brief description of the research methodology, and (c) brief summary of the research findings and their impact.
Purpose and Objective(s)	
<u>Objective(s)</u> It is common to find educational games and simulations widely used in teaching and learning. Educational games and simulations have been found to be effective in motivating students to learn (Council, 2011; Finkelstein, Adams, Keller, Perkins, & Wieman, 2006). Simulations are defined as tools used to explore a real-world or hypothetical phenomenon by approximating the behaviour of the phenomenon (Holec & Pfefferova, 2006). Simulations are interactive multimedia with dynamic elements (sliders, radio buttons, drag and drop manipulation) which presents opportunities for students to actively conduct investigations by manipulating the interactive elements (Christian & Esquembre, 2012; Engelhardt, 2012).	State the purpose and objectives/ research questions.

<u>Research literature on how simulations can be used in e-assessment is sparse and limited.</u>
Researchers tend to focus on novel practices such as the design of virtual worlds and/or simulated environments and in investigating the validity of the design of such environments in measuring students' skills such as collaboration and/or problem-solving.

For example, the nascent PISA 2015 Collaborative Problem Solving Task required students to interact with computer agents, by communicating information with the computer agents to problem solve an assigned task, as a measure of student's collaboration skills. In the sample unit task named "The Aquarium" presented in the Figure below, the test-taker and Abby (a computer agent) collaborated to find the optimal conditions for fish living in an aquarium. The test-taker controlled three variables (water, scenery and lighting) while Abby was in control of three other variables (food, fish population and temperature). Within each unit, there were several tasks, each of which might contain one or more assessment items. Scores were accumulated based on the test-taker's performance on individual items. In this unit, the test-taker demonstrated collaborative problem solving (CPS) skills by establishing a shared understanding of the problem, clarifying misunderstandings, and building consensus with Abby on the actions to be performed.



<u>Figure P1: PISA 2015 "The Aquarium" Collaborative Problem-Solving Task</u>

The subject of focus in PISA 2015 was Science. PISA 2015 also included a series of simulations designed to measure students' scientific inquiry skills[1]. An example interaction, "Running in Hot Weather" presented a scientific inquiry case study related to thermoregulation. Students were able to manipulate the air temperature and air humidity levels experienced by long-distance runners, as well as whether the simulated runner drank water. After running the simulation, the runner's sweat

[1] https://www.oecd.org/pisa/pisa-2015-science-test-questions.htm

volume, water loss and body temperature would be displayed. When the conditions triggered dehydration or heat stroke, those health dangers would be highlighted.

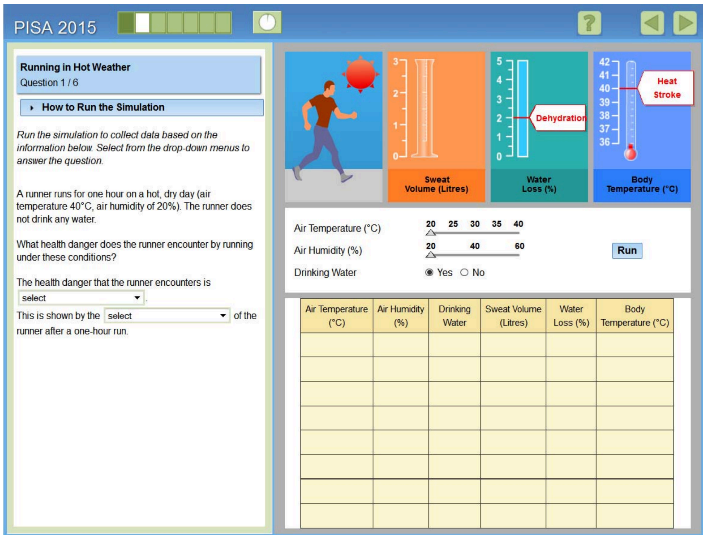


Figure P2: PISA 2015 "Running in Hot Weather" Interactive

Research publications generated from PISA 2015 Interactives were focused on the validity and reliability of the simulations in measuring students' inquiry. Aligned to the usual practice by PISA, the organisation focused on reporting the comparison of students' performance on the assessment items across countries, and variables such as gender. **Information such as the design considerations of the interactives for e-assessment or how questions should be written for interactives is not available.**

The research objective was to pilot a set of interactives designed based on ESS content, taking reference from the design and format of questions from the 2015 PISA computer-based assessment with simulations to measure scientific inquiry[2].

Research Questions

1. What were the design considerations for creating simulations-based e-assessment questions?
2. How did students perform on simulations-based e-assessment?
3. What were students' perceptions of simulations-based e-assessment?

Research Design and Methods

[2] https://www.oecd.org/pisa/pisaproducts/PISA2015-Released-FT-Cognitive-Items.pdf

On-Screen Framework on why simulations?

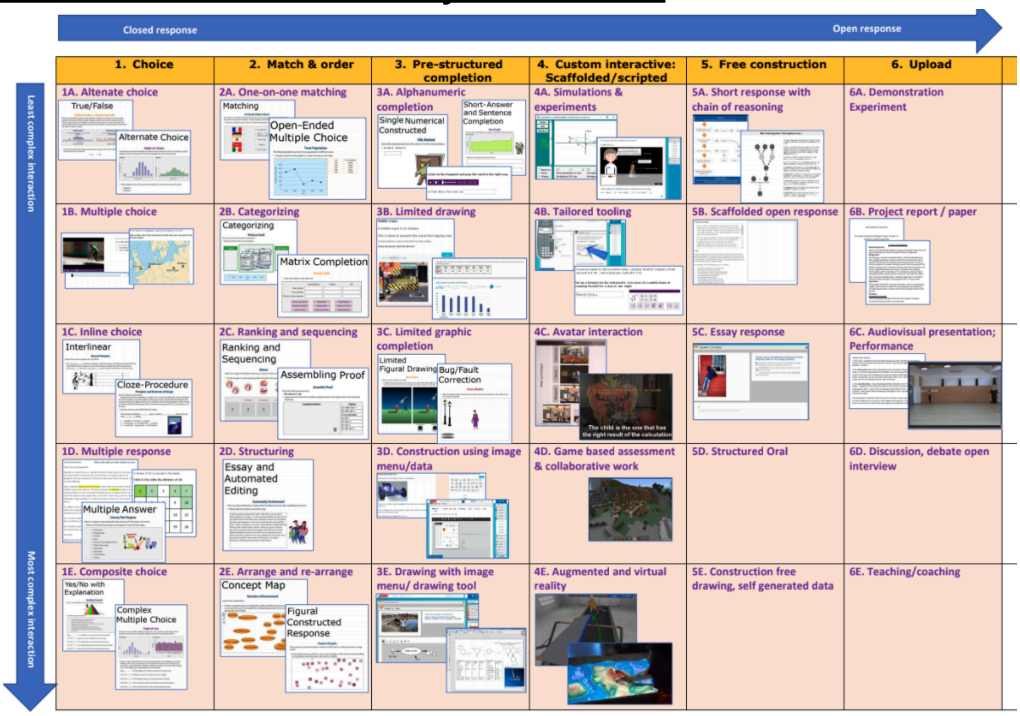


Figure RDM1: Framework for on-screen assessment, showing the table of complex interaction and response openness. The "4A. simulations and experiments" were classified as the simplest interaction that allows for open responses under the column of interactive.

In the framework (Jongkamp & Hamer, 2019) for on-screen assessment "4A. Simulations and experiments" was one type of assessment classified. When viewed from a less-is-more perspective, it can be interpreted simulations were the most suited interactive as it was easiest for students to use reliably and yet was open enough for authentic on-screen e-assessment.

Design of simulations-based e-assessment

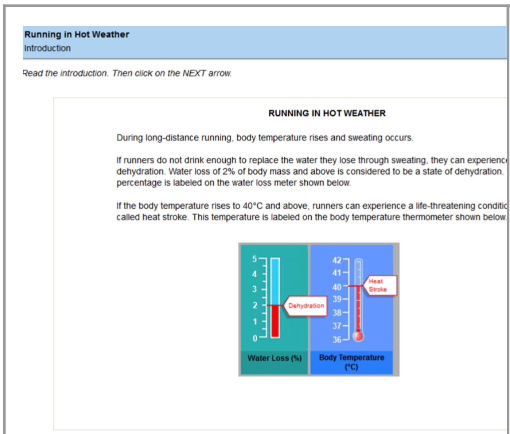
A descriptive qualitative case study approach was undertaken.
The design and format of questions from the 2015 PISA computer-based interactives to measure scientific inquiry, were examined intently. Through collaborative discussion and brainstorming with the curriculum and assessment experts (SDCD and SEAB), a set of 6 interactives were designed and questions crafted. These were iteratively refined through internal review and feedback.

Administering the e-assessment

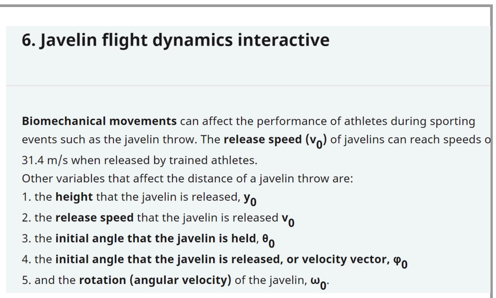
We selected 3 mainstream schools based on all their ESS students, with a spread of ability to address the data collected to be free from bias. 3 teachers from 3 different schools implementing ESS as a subject volunteered to participate. The teachers administered the test to their Secondary 3 students after their end of year examination. The students had learned the content necessary to complete the e-assessment.

<u>Briefly</u> describe the research design and methods of data collection and analysis.

Teachers assigned the SLS quiz to the students. School | Number of students 1. CHS | 17 2. WWS | 35 3. STC | 10 Total | 51 *Table RDM1: Breakdown of students in different schools (anonymous)*	
Findings	
Design considerations for creating simulations-based e-assessment questions All the questions were designed with reference to the 2015 PISA interactives for science inquiry. Every PISA interactive (those that are publicly released) includes the following elements: 1. An introductory text is always included. 2. Instructions on how to manipulate the variables in the simulation follows the introductory text. 3. The cognitive demand of the questions progresses from low to high. a. Low cognitive demand questions required students to carry out a one-step procedure, for example recall of a fact, term, principle or concept or locate a single point of information from a graph or table. b. Questions of medium cognitive demand require students to use and apply conceptual knowledge to describe or explain phenomena, select appropriate procedures involving two or more steps, organise/display data, interpret or use simple data sets or graph. c. High cognitive demand, students analyse complex information or data, synthesize, or evaluate evidence, justify reasons given various sources, develop a plan or sequence of steps to approach a problem. 4. Where appropriate there should not be more than 3 variables and 2 observed outcomes. For each question, there would be **an introductory text** to frame the scenario.	Describe the key research findings and the extent to which the objectives of the research have been achieved. Where appropriate, relate the significance of the findings to other research work in the field.



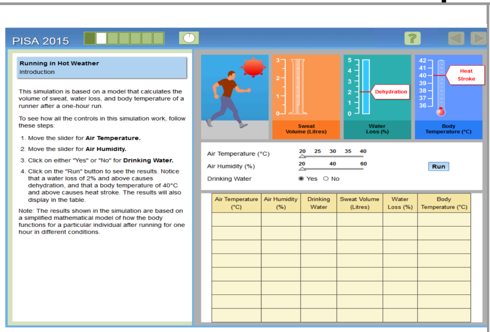
PISA Interactive



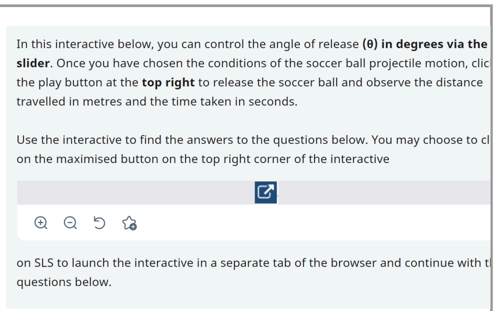
Research Assessment Task Question 6

Figure F1: Design Consideration 1: Introducing the Assessment Scenario

Instructions must be provided for students (test-takers) to **clearly state the variables that can be manipulated.**



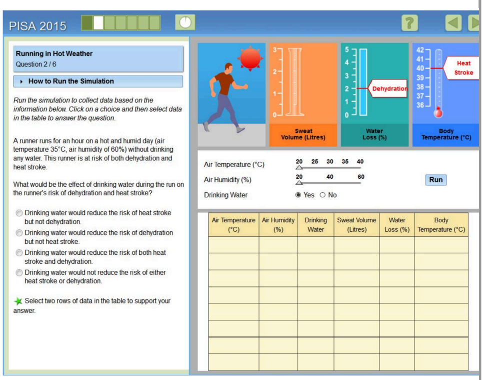
PISA Interactive



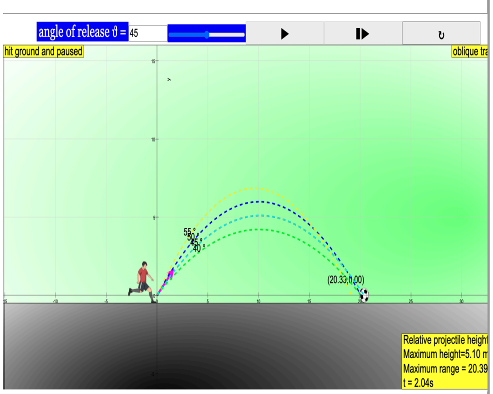
Research Assessment Task Question 1

Figure F2: Instructions on how to manipulate the Simulation

The **cognitive demand** of the questions progressed from **low to high**.



Question 2 of 6 (*Low Cognitive Demand*): Students are asked to run the simulation holding 2 out of the 3 variables constant while



Use the interactive/simulation to estimate the angle of release of the football when the range is the greatest.

varying only 1 variable, and make their observation *PISA Interactive*	1. 40 degrees 2. 45 degrees 3. 50 degrees 4. 55 degrees Question 1of 3 (Low Cognitive Demand): Students are asked to run the simulation varying only 1 variable and make their observation. *Research Assessment Task*

Figure F3: Low Cognitive Demand of Beginning Question in the Question 1 to 3

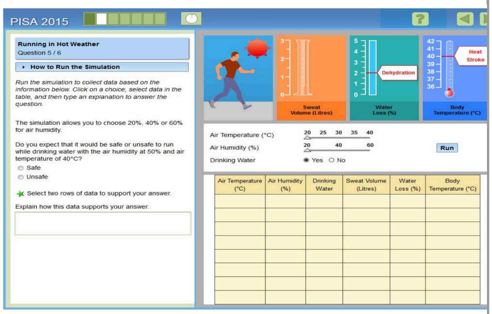
 Question 5 of 6 (High Cognitive Demand): Students use the simulation to develop a hypothesis about the safety of running at 40°C at 50% humidity (a humidity value that cannot be set on the slider). *PISA Interactive*	 Sam claimed that the angle of release of the football does not affect the maximum time of flight of the football. Do you agree? Explain. Question 3 of 3 (High Cognitive Demand): Students used the simulation to validate a hypothesis by varying the angle of release (small value to large value), and observe the time taken. The correct answer is that as the angle of release increases, the time taken increases. Steeper launch angles have a larger vertical velocity component, hence increasing the launch angle increases the time in air. *Research Assessment Task*

Figure F4: High Cognitive Demand of Final Question in the Question Set

The maximum number of variables was capped at 3 variables, with not more than 2 observed outcomes, for all 6 simulation scenarios.

Students’ performance on simulations-based e-assessment

The tabulation of students’ performance is presented for discussion.

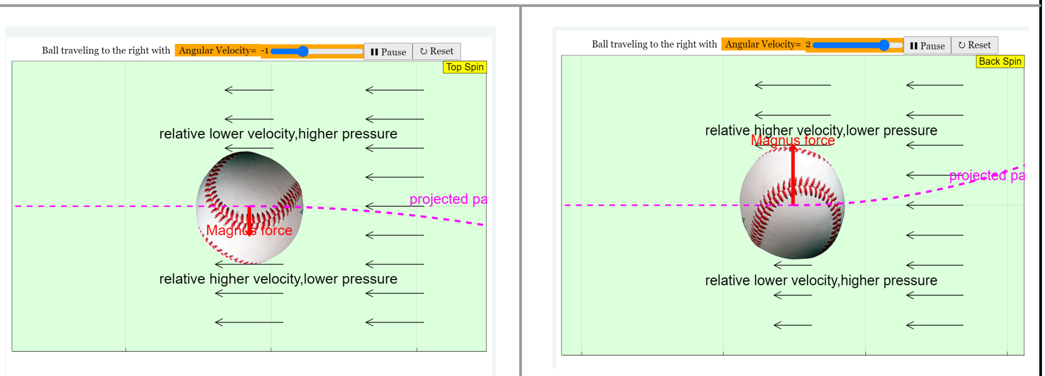
			No of Student Responses						
Question	**ESS Content**	**Item Type**	**correct**		**partially correct**		**incorrect**		**total**
1a	Angle of release projectile motion interactive	MCQ	41	80%			10	20%	51
1b		Open-Ended	31	62%	13	26%	6	12%	50
1c		MCQ	41	82%			9	20%	50
2a	Velocity of release projectile motion interactive	MCQ	21	43%			28	57%	49
2b		Open-Ended	35	71%	10	20%	4	8%	49
2c		MCQ	37	76%			12	24%	49
3a	Relative projection height projectile motion interactive	MCQ	42	86%			7	14%	49
3b		Open-Ended	39	80%	7	14%	3	6%	49
3c		MCQ	45	92%			4	8%	49
4a	Magnus force for sports and science interactive -baseball	T-F	18	37%			31	63%	49
4b		MCQ	31	63%			18	37%	49
4c		Open-Ended	34	69%	9	18%	6	12%	49
5a	Magnus force for sports and science interactive -beach ball	T-F	45	92%			4	8%	49
5b		Open-Ended	21	43%	22	45%	6	12%	49
5c		MCQ	48	98%			1	2%	49
6a	Biomechanical movemen	FIB Table	14	29%	21	44%	13	27%	48

6b	ts-javelin throw	Open-Ended	13	28%	21	40%	14	32%	48
6c		MCQ	13	81%			15	19%	47
6d		Open-Ended	33	72%	10	22%	3	6%	46
6e		Open-Ended	36	78%	4	9%	6	13%	46

Table F1: Students' Performance on the Question Items

Majority of the students scored well on the e-assessment items. The exceptions were Q2a and Q4a. As the Q2a asked for maximum range, 27% of the students choose d, 45 m as it was the largest number. The probable reason for only 43% correct suggested students were easily "mislead" when the options were good distractors.

Q4a is as follows:
A student claims that when there is higher velocity between the motion of the ball and wind, a higher-pressure zone is created. True or False?
The correct answer is False.



True (Incorrect) | False (Correct)

Figure F5: Q4a True-False Question

Q4a was a trick question with a "False" as correct, so only 37% students were very careful in observing the simulation data, can they "observe" from the text-hint from top of the ball. The words presented in the simulation stated, "relative higher velocity, lower pressure". Students might not have noticed the words in the simulation. At higher velocity, the ball spined faster. The faster spinning action associated with higher velocity, might had misled students to think that a higher-pressure zone was created.

It might appear that students did not perform well on Q4c, Q6a, and Q6b, due to the low percentage of correct responses. These questions were of high cognitive demand, and Q6a consisted of 6 Fill-In-The-Blank questions. It was noted that the percentage of students who received incorrect responses was low for all these 3 questions, implying that majority of the students received partially correct responses instead.

Students' perceptions of simulations-based e-assessment

Students completed a short survey immediately after they completed their e-assessment.

Tabulation of the responses received on 2 of the questions are presented for discussion.

Survey questions	Disagree	Neutral	Agree
These simulations assessment items are rich interactive types compared to traditional text and picture assessment items.	3%	29%	68%
I would like my teachers to design and use such interactives in ESS e-assessment.	11%	18%	71%

Table F2: 2 Survey Questions showing 70% of students agreeing that simulations assessment items are rich interactive types and suggesting usage by their teachers.

Students agreed that the simulations-based e-assessment afforded a richer and more authentic experience as compared to just the inclusion of non-interactive media items. This was supported from qualitative feedback received on the survey such as

- *"Allows me to see for myself the changes when variables [in the interactive] are adjusted"*
- *"The (e-SBA) interactive is helpful to imagine and visualize the situation of the assessment better."*
- *"The simulation gives a better idea…. to better visualize and state[answer] what is needed."*
- *"It[simulation] has a clearer description than on paper."*

Dissemination

1. **SLS Community Gallery Lesson**. An SLS lesson has been published in the Community Gallery[3] to benefit ESS teachers to edit and re-publish the e-assessment with the SSTRF artefacts, either as a quiz to reinforce the teaching and learning of these concepts, or for implementing simulation-based e-assessment. 2. **Sharing Session with ESS Officers and/or SEAB Officers**. A sharing session with ESS Officers to raise awareness of the design considerations required on simulation-based assessment items, and to share the findings of students' performance and perception would be arranged.	List the various platforms at which the findings of the study have been shared, or will be shared.
Application	
The prototype e-assessment provides a glimpse of how simulations can be included in an ESS e-assessment beyond just non-interactive media (pictures and videos). The design principles were shared with ESS and SEAB assessment officers. The 6 simulations were shared with the ESS community of teachers such that they could edit and re-publish, either as a quiz to reinforce the teaching and learning of these concepts, or for implementing simulation-based ESS e-assessment.	Describe any deliverables which can be used by school practitioners or MOE HQ officer.
Reflection	

Simulations in e-assessment

Simulations in e-assessment present interesting and challenging scenarios for students to problem solve. While challenging and students may require additional learning support, students do performed better on the interactive, simulation-based assessments (Quellmalz, Timms, Silberglitt, & Buckley, 2012) than when responding to pen-paper tests. Based on the performance of the small sample of students, it appeared plausible that students were able to better demonstrate their content knowledge through simulations.

Insights on EJSS as authoring toolkit for creation and customization of ESS interactive

The project was able to iterate the 6 simulations, either made brand-new ones (Simulation 1,2,3 and 4) or from an existing library (Simulation 5 and 6) from the EJSS toolkit. Customization was conducted by research assistants supervised by the PI and as the PI was familiar with EJSS, a lot of EJSS capabilities were harnessed to support the requests made by the project members. For example, to take the existing ESS teaching guide and design suitable interactive (Simulation 1,2,3 and 4) to support interactive manipulation to

[3] https://vle.learning.moe.edu.sg/mrv/community-gallery/lesson/view/3e2e32c2-0769-481a-bc35-daffa2cedb11/cover

allow students to conduct what-if-scenarios. Simulation 5 was designed to support if students were to view in 3D the motion of a beach ball in top, bottom, left or right spins to visualize the different trajectories. Simulation 6 was a realistic physics of flight on a javelin that supports visualize and more complex data collection, arguable similar in promoting critical analysis to 2015 PISA's Running in Hot Weather - OECD, multi-variable interactive. Our project trainer in Spain, continue to support our interactive design and implementation as issues crop up but we were able to overcome all difficulties.

Using SLS as e-SBA platform

SLS supported 2 ways of using interactive, as a media upload or embed through code using an external whitelist website. Due to the speed of loading up, the project uploaded all 6 interactives (typically small 2 MB zip files created by EJSS toolkit) onto SLS. The experience of using SLS was enhanced since, and we use 1 simulation to field 3 to 5 questions, to test students' ability and understanding. Setting up the SLS assignments with the teachers required some creative solution by setting the team members as co-teachers. Collecting the learning data and cleaning the data took some effort and supervision.

Were there any circumstances which aided or impeded the progress of the research? The emergence of COVID19 with restricted travel guidance, halted the plans for the trainer to fly in from Spain to Singapore to support our project in 2020. The project has kept the funds in 2021 and hopes to utilize the funds for face-to-face collaboration in 2021 and 2022 if the pandemic situation improves for safe international air travel. We consulted our trainer using WhatsApp to overcome some of the technical issues with creation of simulations.	If YES, explain the steps that the project team took to overcome them.

Other comments/feedback.

NIL

Final Statement of Accounts

Items	M	E / F	M / C	T / M	Total
Total Approved Grant (1)	31,360.50	0	0	22,000.00	53,360.50
Total Actual Expenditure (2)	24,047.98	0	0	0	24,047.98
Total Outstanding Commitments (3)	0.00	0	0	0	0.00
Total Grant Balance (1)-(2)-(3)	7,312.52	0.00	0.00	22,000.00	29,312.52
Utilisation Rate [(2)+(3)]/(1)	77%			0%	45%

Note: **M** denotes manpower;

E/F denotes new equipment/facilities;
M/C denotes materials/consumables;
T/M denotes training costs/other miscellaneous costs

Reference:

Christian, W., & Esquembre, F. (2012, Jul 04, 2011 - Jul 06, 2011). *Computational Modeling with Open Source Physics and Easy Java Simulations.* Paper presented at the South African National Institute for Theoretical Physics Event, University of Pretoria, South Africa.

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