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研究課題名（和文）Engineering active learning in a 3D virtual world

研究課題名（英文）Engineering active learning in a 3D virtual world

研究代表者

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研究成果の概要（和文）：The students have been engaged in a multitude of cognitive processes: recalling prior knowledge in their programming; classifying subject-specific issues; applying designs and implementations; analyzing problems and forming constructive solutions. They were working in the anti-disciplinary space.

研究成果の概要（英文）：The students have been engaged in a multitude of cognitive processes: recalling prior knowledge in their programming; classifying subject-specific issues; applying designs and implementations; analyzing problems and forming constructive solutions. They were working in the anti-disciplinary space.

研究分野：education

キーワード：virtual reality　education　learning　science

1. 研究開始当初の背景

Learning Science researchers have posited that Japan's assessment-focused education culture negatively impacts upon learners' capabilities to progress from static declarative knowledge to active procedural knowledge and, subsequently, to meta-cognitive knowledge (Bachnik, 2003; Towndrow & Vallance, 2013). Hase (2011) states: "The acquisition of knowledge and skills does not necessarily constitute learning. The latter occurs when the learner connects the knowledge or skill to previous experience, integrates it fully in terms of value, and is able to actively use it in meaningful and even novel ways" (p.2). One proposed solution to this current circumstance is to engage high school and undergraduate students by actively participating in collaborative tasks which integrate the design, construction and programming robots in both the real world and a novel, unique virtual world simulation. Students will be incentivized to use knowledge gained in theoretical technology courses to pragmatically solve challenges of increasing task complexity (Barker & Ansorge, 2002; Vallance et al., 2013) necessitating the use of competencies: generic (memory, new ideas, decision), declarative (viewpoints, explain, problem) and epistemic (understand, apply, reflect). These in turn lead to students' development of declarative (recall), procedural (apply and analyze) and meta-cognitive (understand) knowledge (Anderson et al., 2001; Schank, 2011).

A scalable solution to create a platform for real-world and virtual world simulation to support robot-mediated interaction (RMI) was therefore proposed; encompassing an improved interface to control the virtual robot inside a UNITY 3D virtual world and the LEGO EV3 robot in real world. The key to this new design was to present a friendly control system for the robot that will encourage both new and experienced users. This design also provides simulation of operating robots in a hazardous environment encompassing a virtual robot which imitates a real- world LEGO EV3 robot used in the navigations. 3D user-interface controls and a single video screen were viewable via an Oculus Rift HMD.

2. 研究の目的

Collaboration in robot-mediated active learning interactions will significantly increase participants' declarative, procedural and meta-cognitive knowledge

3. 研究の方法

The Fukushima Dai'ichi nuclear power plant disaster of March 2011 revealed much about Japan's lack of preparedness for nuclear accidents, and was therefore used as the context for the Virtual Environment; later termed Synthetic Learning Environment (SLE). The student developers adopted the Successive Approximation Model (SAM) to design, construct and implement their 3D virtual creations. SAM is a development model that uses a continuous iterative process to design, make and play. This was deemed more effective than using the traditional Instructional Design standard ADDIE model (Analysis, Design, Development, Implementation and Evaluation). The ADDIE model was considered limiting as each stage would have had to be corrected before moving onto the next stage. The SAM model allows for more diverse, creative, innovative and unusual possibilities during the creative process as opposed to an evaluation at the 'end' of a process.

To engage the student developers in the active design and construction of their learning environments both in the 3D virtual space and the real-world lab, the virtual Fukushima space was designed for training and familiarity with virtual maneuvers, interactions and 'emotion-mind' conflict that often results in motion sickness when using the Oculus Rift 3D Head Mounted Display. Donning the Oculus Rift Head Mounted Display, users maneuver a virtual robot to locate and pick up radioactive bins. Users must also gather information among debris and inside buildings. A control room with monitors of the Fukushima plant together with display panels throughout the space provide additional information regarding the causes of the accident. There is also a cross-section of Reactor no. 2 plus complete cooling towers. A birds-eye view is offered via a virtual drone. A radiation meter in the bottom right corner indicates radioactivity levels that provide a clue as to the nearness of the radioactive bins. All these structures provide a realistic scenario for students to learn about the basics of nuclear power and explore disaster situations.

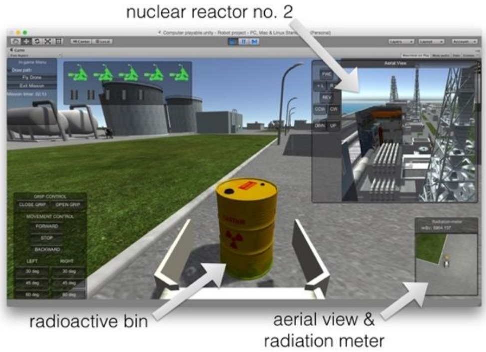

Figure 1. Robot retrieving a radioactive bin in the virtual Fukushima SLE

Figure 2. Switching to drone view

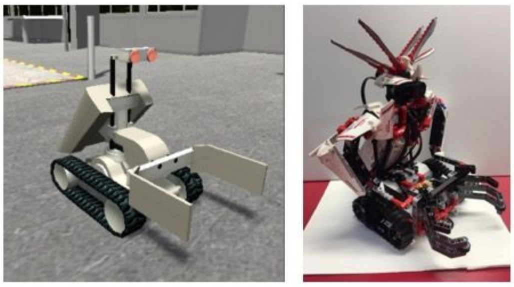

Fig. 3. Virtual & real Mindstorms robots

Fig. 4. Students collaborating

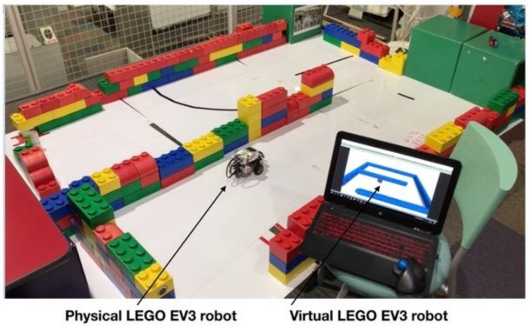

Fig 5. Virtual-to-real robot navigation

4. 研究成果

Over time, the students' development of the Synthetic Learning Environment began to represent the desired education paradigm shift. The students began to learn from each other "through a dynamic form of reciprocal apprenticeship, exploring creative solutions to problems, negotiating worldviews, and socially constructing skills and knowledge" (Marone, 2016). The students were also able to transfer their own learning to unique situations. They began to transfer knowledge, generalize concepts experienced in developing the virtual Fukushima, its components and its activities. Through their transboundary interactions the students developed communication and social skills, digital literacy, and recognition of multi-modal literacies. These are the traits often considered of experts. Through pedagogic partnerships and mutually informative collaborations, students started to think like designers, think like programmers, and think in a shared construction space. They were creating a Synthetic Learning Environment through shared modelling, designing and programming. Essentially, students were learning 'in' technology. They were working in an 'antidisciplinary' space.

Regarding the LEGO Mindstorms robot implementations, twenty tasks of increasing complexity, as determined by the Circuit Task Complexity (CTC) values, were undertaken by the same participants. Competency data was collected for all 20 tasks. The Likert scores of each competency were summed for each task. The totals for Generic, Declarative and Epistemic were then correlated with Reflect values using a Pearson's Chi Square Test. Using the iNZight statistics application the totals were also subset by each Circuit Task Complexity (CTC) value. This 'three-variable' data illustrated where specific tasks (as determined by its CTC value) were located 'within' the Reflect versus Competency data (see Figs. 6, 7 and 8). Competencies were:

generic (memory, new ideas, decision), declarative (viewpoints, explain, problem) and epistemic (understand, apply, reflect).

It was found that irrespective of a task's complexity, as generic competency increases so do Reflect values (see Fig. 6). Declarative competency and Reflect values are clustered in the high-high quadrant which suggests that meta-learning is most prevalent when declarative competency is high (see Fig. 7). However, the data for Epistemic competency was dispersed suggesting that the value of task complexity has no impact on a student's capability to transfer his knowledge to other situations (see Fig. 8). This seems at odds with 'common sense' as it would be expected that learners who have a high meta-learning capability would be able to transfer their knowledge to unique situations. Students' feedback revealed more pragmatic reflections and does not show any examples of students' awareness of capabilities which can be used in other situations such as in their Final Year projects or Programming courses. This may be due to their current inability to explicitly associate one learning scenario to another possible scenario in a different context. This remains a challenge to advocates of meta-learning and multi-disciplinary teaching.

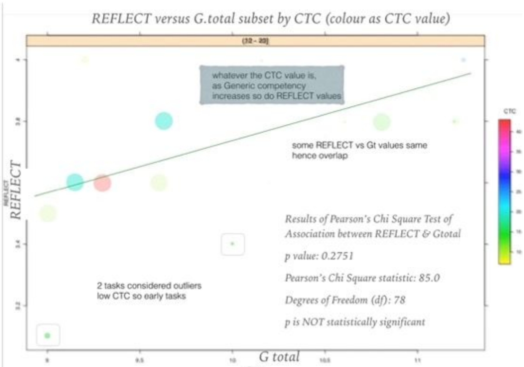

Fig. 6. Reflect versus Generic competencies

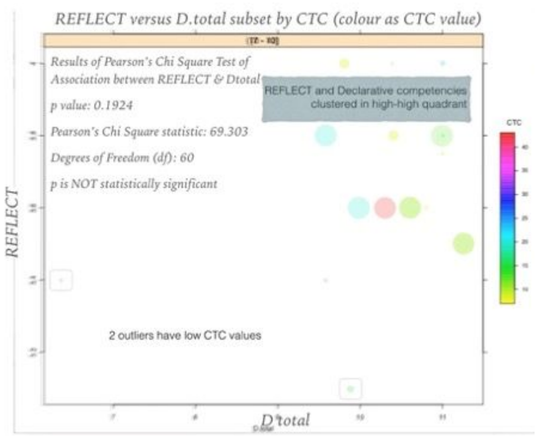

Fig. 7. Reflect versus Declarative competencies

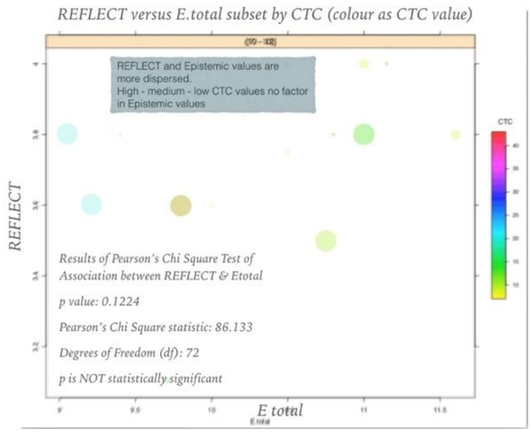

Fig. 8. Reflect versus Epistemic competencies

As the project emerged, it also became apparent that there was much learning occurring among the student developers. For instance, it was observed throughout this project that the students have been engaged in a multitude of cognitive processes: recalling prior knowledge in their programming; classifying radiation issues to be incorporated into the environment; applying a number of skills in the designs and implementations; analyzing problems and forming constructive solutions; evaluating each other's contributions in constructing a collaborative space; and creating 3D object designs, animations and learning tasks.

To sum up, active learning should be replaced by, and implemented through, experiential learning (see Fig. 9).

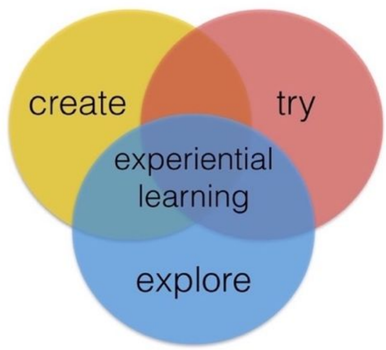

Figure 9: Experiential learning

In conclusion, it is acknowledged that learning is an extremely complex process that occurs within the learner, is unobserved, occurs in random and chaotic ways, and is a response to a personal need and, often, occurs to resolve some ambiguity. It is associated with making new linkages in the brain involving ideas, emotions, and experience that lead to new understandings about self or the world. It is reasoned that a 3D virtual world as a simulation for collaborative efforts can result in measurable learning outcomes. Research into the efficacy of online 3D virtual collaborations for effective learning must therefore be persevered in order to determine its value to educators and promote new, transformative learning in Higher Education.

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