Proceedings of the 54th Hawaii International Conference on System Sciences | 2021

Innovations in Collaborative Environments and Learning Technologies

Integrated Minitrack: *Advances in Teaching and Learning Technologies*, *Human and Artificial Learning in Digital and Social Media*, and *NeuroSE: Neurophysiological and Psychophysiological Assessment in Software Engineering*

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In recent years we have seen a proliferation of research and innovation in teaching and learning technologies aiming to improve students' preparedness to real-world settings and reduce education-job misalignment in skills [1, 2]. These developments are also driven by a shift in a learners' profile who are seeking active, personalized and collective learning as Communities of Practices (CoPs) where knowledge has to be "in the service of solving problems for themselves or helping others to solve problems" [3, p. 1368]. To tailor educational programs to the workforce and learners' needs educators have been embracing transformations in:

- learning environments to model critical thinking, problem-solving, collaboration,
- new technologies to improve students' learning experiences, and
- the integration of artificial intelligence and machine learning to support knowledge processes.

This year's pandemic has brought numerous disruptive changes in our daily lives and intensified the need for innovative solutions and ways of dealing with the "new normal". Adaptability, collaboration, communication and e-learning tools have become of utmost importance to address the lack of physical communication and to accommodate for various personal circumstances [4, 5]. The aim of our integrated minitracks is to disseminate innovative insights on learning environments, processes and technologies to help overcome todays' challenges in education. In this year's contribution, the emphasis has been on recent developments in the area of 1) Virtual Reality, 2) Collaborative Environments, and 3) Learning Technologies.

The Virtual Reality session focuses on the systematic review of immersive educational VR apps, the design recommendations for VR-aided courses and the role of spatial ability in VR learning. The mapping between learning content, design elements, and application domain provides valuable insights for educators in practice to assess the adoption of available applications in their courses. To maximize the effectiveness of VR applications, the educators should also consider the effect of spatial ability on learning performance. The ability to understand 3-D structures and object positions is important to solve spatial problems and it varies among learners. Thus, various spatial features in VR applications will have a different impact on learners with low- and high-spatial ability. Finally, Virtual Learning Environments show the capability to include activities improving soft skills, such as creativity, self-monitoring, and independent thinking.

The Collaborative Environments session assesses the flipped classrooms experiences from a learner's perspective, the importance of experiential learning to simulate "on-the-job" teamwork experiences and help improve real-world skills, the development of a cybersecurity program, and the use of non-human collaborators in learning environments. The assessment of flipped classrooms provides several key elements

URI: https://hdl.handle.net/10125/70612
978-0-9981331-4-0

that educators should consider for improving learning experiences and outcomes, such as digital learning content (interactive and game-based), community building, learners' background (practitioners versus students). The evaluation of experiential learning reveals the role of a team-based real world project in aligning learning competencies and reducing the gap between academic learning and real workforce settings. Furthermore, valuable guidelines are provided for curriculum development in the area of cybersecurity, using job placement criteria to assess the effectiveness of program or curriculum changes. Finally, the notion of human-machine collaboration increasingly becomes a reality with the uptake of smart technologies in our society, at work and in education [6]. The question arises how people and artificial intelligence start to interact and even collaborate when engaged in learning, sensemaking and problem-solving [7]. Our understanding of collaboration is therefore extending to non-human collaborators in our social structures (such as networks and communities). These non-human collaborators have not only the capacity to process information, increasingly they are able to perform cognitive functions, learn and help to facilitate community learning.

The Learning Technology session introduces research on adaptive empathy learning tools, the use of eye-tracking in code comprehension, learning analytics information systems, and serious games for lifelong learning. Understanding emotions and human behaviour has always been a challenge. Particularly, with the transition to distance-learning, the empathy training requires innovative ways to teach students to perceive and react to the emotions of others, which is essential in many real-life scenarios (e.g., client communication, agile teamwork). One such solution is the development of a web-based empathy learning dashboard. Similarly, understanding the differences in behaviour between expert software developers and novices is an important part of improving how we develop software. Such understanding will help us train the software developers of tomorrow. Neuro- and psychophysiological measurements give us a window into understanding human behaviour. NeuroSE explores the use of neurophysiological and psychophysiological measurements, for example electroencephalography (EEG), pupil dilation, galvanic skin response (GSR), and or eye tracking to get a more direct assessment of the impact of the practice under investigation on the human. Such measurements allow us to better assess such things as cognitive load, mental effort, and stress. Finally, the development of a theory-based learning analytics information system offers an innovative way to assess learners and learning processes incorporating both computational and educational frameworks.

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