21ST CENTURY TEACHING AND LEARNING FOR STEM

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THEME:

Innovative STEM pedagogy and curriculum

BACKGROUND AND AIMS

STEM teaching is informed by learning theories. However, current learning theories, such as Constructivism which is probably dominant in Australia, are essentially soft science and therefore based on qualitative, subjective guidelines that are open to interpretation and hence resulting in self-defined standards. A 10-year analysis of over 30 STEM units in seven institutions (two VET and five universities, including an Australian five-star teaching university) found a wide range in the quality of learning outcomes. Some units were far below any reasonable quality expectations (Maj 2021).

The American National Science Foundation (NSF) defined the Science of Learning (SoL) agenda with the goal of optimized learning for all (NSF 2013). This can only be achieved if a learning theory is based on quantitative hard science principles. Within Australia the Science of Learning Research Centre (SLRC) was established. Research papers and reports aside the final SLRC outcome with practical implications was 12 PEN (psychology, education and neuroscience) principles e.g., Multitasking impairs memory & learning – all of which fail to meet the SoL objective (Centre n.d.). SoL research has largely ceased both in Australia and internationally.

METHODOLOGY OR PROCESS(ES) UNDERTAKEN

In Constructivism students are guided to construct their own knowledge (Piaget 1952). An analysis of Constructivist based STEM teaching materials found extensive cognitive gaps i.e., missing elements and element relationships. This is important because it may result in student misconceptions which can be cumulative, persistent, hard to correct and may handicap further learning (Nakhleh 1992).

Cognitive Load Optimization (CLO), a new 21st Century quantitative learning theory, uniquely achieves the goal of the Science of Learning – optimized learning for all. CLO is an unorthodox paradigm shift and a practical methodology (procedures, guidelines metrics etc. – unpublished) that is based on optimized schemas (mental patterns of knowledge). These schemas are the easiest, most efficient learning paths and are the basis of instructional design, delivery and assessment. Significantly the optimized schemas are given to students. Unlike Constructivism in which students are guided to construct their own schemas.

RESULTS AND CONCLUSIONS

Using CLO results in significant improvements in STEM learning outcomes in the school, VET and university sectors in all delivery modes (face to face, blended and remote online) (Maj 2018) (Maj 2020, Maj 2021, Maj 2021, Nuangjamnong 2022). Using CLO, it is possible to create seamless articulation paths between the different educational sectors. Preliminary research indicates it works in the primary school sector.

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