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Designing A Simulation Session: Implications of the use of the Cognitive Load Theory

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Abstract

In this article, the use of the Cognitive Load Theory will be critically reviewed and evaluated in the context of Simulation-Based Education and Learning with reference to current literature and debates. In particular, adult learning theories and the implications of CLT will be appraised in relation to the design of a simulation session with reference to improving future practice.

Keywords: Cognitive Load Theory; Simulation-Based Education; Clinical Education

Abbreviations: SBE – Simulation-Based Education; ST - Situativity Theory; CLT – Cognitive Load Theory

Introduction

Simulation-based education (SBE) is a teaching and learning technique, which finds its principles secured within social constructivism and experiential learning Kolb [1]; Taylor & Hamdy [2]. SBE allows the 'learners' to immerse themselves in an authentic and safe learning environment so that they are exposed, learn and/or consolidate prior or new learning. This is enabled by the design of the simulation session, which is normally structured to recreate the Kolb's learning cycle Kolb [1]. In fact, learning starts with the concrete experience, which is the exposure to the clinical scenario and then it moves towards the next two phases, which include a reflective component and a complex analysis of the scenario and the individual/group performance in order to return to the experiential world in the last phase. Within this process, learners are engaged within a situated social learning experience, which supports their ability to translate their learning from one context to another Yardley, Teunissen & Dornan [3]. This process is designed to improve learners' confidence and competency and facilitate the translation of learning from the simulation to the real clinical environment. In appraising the delivery of clinical education through simulation, it is a pre-requisite to highlight other informative theories such as the Situativity Theory (ST) Durning & Artino [4]. This theory emphasises the importance of context and community for learning and focuses upon the significance of learning and thinking as social activities, which is also highlighted by Mezirow, 2000 cited in Yardley Teunissen & Dornan [3] in his transformative learning theory. In fact, Mezirow, 2000 cited in Yardley Teunissen & Dornan [3], places emphasis upon the need for learners to participate in a constructive discourse with other learners to transform understanding of the experience.

Although it is very important to take into consideration the context of learning, humanistic and motivational theories Taylor & Hamdy [2] explain that individual learning can only take place if educational activities embed two critical elements: self-reflection and motivation. Within SBE, the reflective component is well established within the debriefing process, which takes place after the concrete experience during a simulation event Mayville [5]. With regards to the motivational component, it is mainly on an individual basis and it is a crucial and intrinsic drive for learning Knowles [6]; Ryan &Deci, [7]; Taylor & Hamdy [2]. Low expectation of success, attitude of learners towards education, judgement and complexity of the teaching sessions are potential barriers to intrinsic motivation Taylor & Hamdy [2]; Haji et al. [8] which might affect the learner's ability to understand and process information.

As explained by Josephsen [9] "a challenge of SBE is not to overwhelm learners with the complexity of skills and content in order to enhance the transferability of learning". This concept was initially explored by Sweller [10,11] in his Cognitive Load Theory (CLT), where he considered the link between the learner's cognitive architecture and the instructional design of the teaching session. Schema, working- and long-term memory and cognitive load are fundamental parts of the cognitive architecture, which will need to be taken into consideration while designing the simulation session, in particular its instructional component Fraser et al. [12].

Discussion

Each learner has a unique cognitive architecture, which will influence their ability to understand and process information and engage with the different phases of the simulation session. For example, during a simulation session, each learner is required to use prior-learning in the form of schema and long-term memory to process new information organized by the working-memory Josephsen [9]. Concurrently, the working memory is affected by the cognitive load created by the instructional design of the simulation session and long-term memory. In the learning process, new information is processed by the working-memory and stored in the long-term memory where a schema might be developed or further enhanced Josephsen [9]. On the occasion where schema and long-term memory are not sufficient or developed in relation to a defined area of knowledge, the working memory is overloaded, thus impacting upon the ability of the learner to process new information.

Fraser et al. [12] suggest that "learning can only occur when there is adequate room in the working memory for processing new information". Further analysis highlights the importance for educators to consider the stage of training or career development of learners in the design of the simulation session, in particular taking into consideration previous learning and/or professional experience. This will enable educators to have a broad overview of the current long-term memory of learners and how this might impact upon the achievement of the learning outcomes, also known as intrinsic load Josephsen, [9]; Fraser et al. [12].

It can be deduced from the literature that there are different strategies to reduce the intrinsic load in SBE to enhance the learning experience for students Taylor & Hamdy [2]; Josephsen [9]; Tweed [13]; Reedy [14]; Haji et al [8]. The first strategy is the use of the "scaffolding" process, which allow the educators to support the learners to move from a learning threshold to the next one with the right amount of new information to challenge the learners into the zone of proximal development Vygotsky [15]. This process will reduce the risk of overwhelming the learners and is achievable by referring to the course specification or previous clinical experience of the learners and by aligning the learning outcomes and the design of the simulation session i.e. fidelity to their current stage of learning. This is also underpinned by the application of the Miller's Pyramid Miller [16] within medical education. In fact, educators can support learners to move on the "clinical competence scale" by facilitating their progression through the establishment of the learning outcomes desired at that specific time of the participants' learning curve and experience. On reflection, the need to align the learning outcomes and the complexity of the simulation session to learners' stage of learning is highly important to enable participants to process new information and enhance the learning experience.

Another strategy used to reduce the intrinsic load is a well-planned pre-briefing. Stephenson & Poore [17] recommend different aspects to be covered during this phase in order to reduce anxiety and facilitate a supportive learning environment. "Orientation" is one of the most important ones as learners are introduced to the equipment, environment and manikins. In relation to CLT, learners will have time to process this information and familiarize themselves with these items which will impact favorably upon their ability to concentrate to different information when the scenario starts. Therefore, pre-briefing will potentially reduce the intrinsic load by enabling the learners to create room for new information in the working memory during the concrete experience.

In relation to CLT, educators must also consider the two other aspects of CLT: extraneous and germane loads. Extraneous load is defined as "the mental processes that are imposed by poor instructional design and are not relevant for learning" Fraser et al. [12]. Increased extraneous load might lead to split-attention and redundancy effects due to the multiple sources of the same information or the same information presented in multiple times Josphesen [9] which will affect the ability of the working memory to process information. Therefore, it can be deduced that extraneous load might be linked to how students prefer to learn and their learning styles. In fact, as explained by Abdul-Rahman & Du Boulay [18], the engagement of learners with old and new information is influenced by the methodology of presentation of this information and the preferred learning styles. Moreover, learning styles can affect the extraneous load thus reducing the ability of the working memory Abdul-Rahman & Du Boulay [18]. On reflection, recommendations can be explored in order to reduce the extraneous load, which include a well-planned instructional design where content is presented clearly, and they are relevant to the expected learning outcomes of the session Shibli & West [19]. Furthermore, avoidance "to provide insufficient guidance and thereby forcing learners to employ weak problem-solving methods such as trial and error or to search for information needed to complete the task" Young et al. [20] will enhance the design of the session and educators must reduce distractions which impose additive extraneous load to participants Young et al. [20]. Finally, Josephsen [9] suggested the use of "worked-out example" to decrease the extraneous load by exposing learning to an expert modelling before the simulation, which has been found very successful with novice learners.

In the appraising of the CLT and its implications for the design of a simulation session, it is also important to discuss the last area of cognitive load described by Sweller [11]: germane load. Germane load involves learner engagement in deep cognitive processes in order to lead to the construction and subsequent automation of schemas De Jong [21]; Josephsen [9]. Instructional designs should stimulate and guide learners to engage in schema construction by reducing the effects of intrinsic and extraneous loads on the working memory in order to allow room for schema development and therefore, to increase germane cognitive load De Jong [21]. Concurrently, educators must be aware that since the memory capacity is limited, even positive processes may overload the working memory, thus impacting upon the ability

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to create schemas for future transferability of learning De Jong [21]. "Germane cognitive load might cause overall cognitive load to exceed learner working memory limitations and therefore, the germane load could effectively become a form of extraneous load and inhibit learning" Kalyuga et al. [22]. On reflection, educators must take into consideration the level of learning and participants' previous clinical experience in order to facilitate their progression to the zone of proximal development without the risk of overwhelming and preventing the acquisition of schemas. Moreover, educators are recommended to apply strategies such as "self-explaining effect" to increase the ability of learners to process information and retain them in the long-term memory under new schemas Josephsen [9].

Conclusion

In conclusion, this article has appraised the key adult learning theories related to SBE, in particular the Cognitive Load Theory. Furthermore, strategies to reduce the cognitive load and enhance student learning have been evaluated and synthesized including the necessity for educators to plan the instructional design of the simulation session taking into consideration the learners' profile. In particular, several recommendations have been appraised to improve future practice in the context of SBE which encompasses the use of an extended time for "orientation" during the pre-briefing, explicit agreement of the learning outcomes according to the participants' level of learning and previous clinical exposure and the need to avoid the redundancy effect in order to facilitate students progression to the zone of proximal development without the risk of overwhelming and preventing the acquisition of schemas. This will enable the educators to reduce the intrinsic and extraneous load as well as to increase memory capacity for schemas acquisition, which will influence the transferability of learning from the simulation session to the real clinical environment.

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