Research Article **ISSN: 2393 – 9532**

International Journal of Arts and Science Research

Journal home page: www.ijasrjournal.com

https://doi.org/10.36673/IJASR.2020.v07.i02.A10

INTRODUCING THEORIES IN EDUCATION TO SIMULATOR BASED MARITIME TRAINING

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ABSTRACT

This study conducts a theoretical analysis followed by a synthesis to enhance the excellence of maritime simulator-based training where Briefing, Scenario and De-briefing are the main analytical environment. Synthesizing the Cognitive Load Theory, the Briefing phase is identified as the locale of the Intrinsic Cognitive Load and the Extraneous Cognitive Load which is non-essential to the learning task. This study hypothesizes an information overload in the Briefing phase. The Scenario phase is the center of construction for the Germane Cognitive load where tenets of Vygotsky's Cognitive development theory are synthesized. The Briefing phase is juxtaposed with Vygotsky's ‘cannot do alone’ phase and the Scenario phase with the "Zone of Proximal Development’ where cognitive abilities are mutually built and constructed. Entering the Debriefing stage the cadets will enter the ‘can do alone’ stage. Conclusively, maritime students’ achievement levels during simulator training are enhanced through the application of theories in Education.

KEYWORDS

Maritime education, Vygotsky’s Cognitive development theory, Cognitive load theory and Maritime simulator training.

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INTRODUCTION

Seafaring is a dynamic decision -making process in time-critical domains which are unpredictable working environments. According to Sawyer (2004)[1] there are often no correct or prescribed actions and decisions undergo constant and disciplined improvisation. Encountering complex situations, the number of possible actions and decisions which should be taken are infinite and cannot be pre-determined (Orasanu and Connolly 1993)[2]. Artman *et al*, (2013)[3] state that effective maritime training should ultimately achieve performance improvement. This calls for a structured approach to the design of simulator training where pedagogical approaches and the use of scenarios and performance measurements are specifically tailored to train the sought for skills (Cook *et al*, 2013)[4]. Maritime simulators are used to develop ship handling skills and theoretical understanding of ship motions in naval training. Simulator-based training in maritime education should be transferrable to a professional seafaring skills and knowledge which not only meet local but also satisfy International Maritime Organization (2010)[5] requisites. Maritime expertise claim that seafaring skills and knowledge encompass situation and cue assessment, problem diagnosis, decision making and action coordination, proactive response to a critical incident at sea.

The current dynamics of the global maritime environment demand incorporating professional practices with research and creation of knowledge. This necessitates maritime education to transcend from a hands-on approach to tertiary education and develop a strong pedagogical culture based on theoretical qualitative synthesis. Emad and Roth (2008)[6] conclude that very often the learning objectives are not fulfilled in a majority of Maritime Education and Training (MET) systems. They state that instead of striving to learn the skills and knowledge required on board ships, the objective in the current MET systems is to pass competency tests. Gekara *et al*, (2011)[7] identify the danger in such practices and state that they pose a possible safety hazard for the shipping industry. Thus the implementation of a learning objective-oriented development of MET in simulation scenarios is recommended by a multitude of maritime scholars (Baldauf *et al*, 2016[8], Grech *et al*, 2008[9], Grech *et al*, 2012[10], Saus *et al*, 2010[11]). Thus, the objective of maritime simulator training should be to produce sharp end operators who interact in highly safety-critical environment. This requires multi-pronged demands for upgrading maritime education. Though maritime simulator facilitators do follow education theories they rarely align such theories to their practices. The theoretical frame work of this study conducts a theoretical qualitative analysis followed by a synthesis to enhance the excellence of maritime simulator-based training through the application of Cognitive Load Theory and Vygotsky's Cognitive Development Theory to simulator based maritime training. In this endeavour this study aims to juxtapose selected education theories to the three stages of maritime simulator training: Briefing, Scenario and De-briefing phases which are the main analytical environment of the study.

Theoretical framework: A qualitative analysis

This theoretical framework firstly conducts a qualitative analysis of the Cognitive Load Theory and then moves to analyze Vygotsky's (1978)[12] Cognitive Development Theory within a MET perspective.

Cognitive Load Theory (CLT)

Cognitive load is the amount of information that working memory can hold at one time. Sweller (2011)[13] and Kester and Van Merrienboer (2010)[14] link research to instruction design through the CLT which examines how the cognitive load produced by learning tasks can enhance or impede learners' ability to process new information and to create long-term memories. Cognitive load takes one of three forms.

Intrinsic cognitive load is the inherent level of difficulty associated with a specific instructional topic. (Chandler and Sweller, 1991)[15]. The load exerted on a learner depends on the complexity of the task set or concept being presented, and a learner's ability to understand the new information. An intrinsic cognitive load makes an activity challenging. However, the cognitive load resulting from a complex task can be reduced by breaking it down into smaller, simpler steps.

Intrinsic load is also reduced where individuals have a strong background of prior knowledge. Sweller, Van Merrienboer and Paas (1998)[16] report that where material has a high intrinsic load, using visual/audio presentations was far more effective than where text and explanation (which both require verbal processing) are used. Thus, in simulation the use of visu0-spatial and audio mode enhances the Intrinsic load and as a result accelerates the learning process.

Extraneous Cognitive Load

This is non-essential to the learning task and often induced by poor instructional design. Extraneous Cognitive Load makes learning unnecessarily complex or distract the learners from information they are trying to pay attention to and will increase the learners cognitive load as they are processing it. As the result of higher a cognitive load, a stimulus is more difficult to pay attention to, rehearse and remember, making learning less effective (Sweller, 1994)[17]. Research (Jones and Macken, 1993[18], Sweller, 2011[13] conclude that educators can reduce the additional extraneous cognitive load by identifying and removing stimuli which may distract learners. The instructional method envisaged in this study aims to minimize the Extraneous Cognitive Load through the utilization of current learning objective-oriented development of training scenarios.

Germane Cognitive Load

This cognitive load results from the construction of schemas and is considered to be desirable. A memory schema is a conceptualization of a particular idea or object which tells us what to expect when we encounter it in the future. According to Sweller (1994)[17], 2011[13] gradual introduction of information into long-term memory through short-term memory requires repetition and such information must be linked to already existing information or prior schemata in the brain. Short-term memory only has the capacity to store very limited amounts of information at a time. The use of divided pieces of information ensures that schemas in the brain are effectively and efficiently built-up and automated. Thus the goal of the Cognitive Load Theory according to Mulder (2017)[19] is to optimize the learning process.

Vygotsky's Cognitive Development Theory

Vygotsky's Cognitive Development Theory (1978)[12] is one of the foundations of Constructivism. Constructivism according to Maclellan and Soden (2004)[20] postulates that knowledge is not passively received from the world or from authoritative sources but is constructed by individuals or groups making sense of their experiential environments. Erlam, Smythe and Wright-St Clair (2017)[21] state that Constructivist Design Principles include new habit formation through experience and interaction with a "mature social medium" in the form of a simulation facilitator. According to Vygotsky (1978)[12] environment and interactions with the people in it play a critical role in the cognitive development and capabilities, both dependently and independently. This illustrates the importance of action, perception, and dialogue for learning. He further states memory not only makes fragments of the past more available, but also results in a new method of uniting the elements of past experience with the present" (pg. 36). Thus, cognitive development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the learner (intrapsychological).

Further, Vygotsky's Cognitive Development Theory asserts three major themes regarding social interaction, the More Knowledgeable Other (MKO), and the Zone of Proximal Development (ZPD). ZPD describes the difference between what a learner can do with assistance and what they can do alone (i.e., without guidance). According to Vygotsky (1978, 86)[12]. "It is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers". Vygotsky claims that learning occurs in this zone. Dynamic functional and psychological learning systems are in a constant state of change "in which diverse internal and external processes are coordinated and integrated" (John-Steiner and Mahn, 1996, p. 194)[22].

Vygotsky discussion of the ZPD includes MKOs. Who have a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The MKO in the context of Maritime simulator training are the facilitators oreven the technology within the simulator. The ZPD is associated in the literature with the term scaffolding (Wood *et al*, 1976)[23]. Scaffolding is the support given during the learning process which is tailored to the needs of the student with the intention of helping the students achieve their learning goals. This learning process is designed to promote a deeper level of learning. It is the task of the educator to identify this zone, to determine where the student is situated within this zone, and to build upon their specific level through a 'scaffolding' process (Forrester and Jantzie, 1998)[24]. Once the student, with the benefit of scaffolding, masters the task, the scaffolding can then be removed and the student will then be able to complete the task again on his own. The scaffolding process, according to Van Merrienboer, Kirschner and Kester, (2003)[25] is a process of 'performance support and fading' where support is available when required by learners and inhibited as the students achieve the desired goals.

Other Theoretical Considerations

This theoretical analysis is also informed by Piaget (1964)[26] who introduces an accommodation and assimilation process, where individuals are able to construct new knowledge from their experiences (Forrester and Jantzie, 1998)[24]. According to Piaget: 'To know an object, to know an event, is not simply to look at it and make a mental copy, or image, of it. To know an object is to act on it. To know is to modify, to transform the object, and to understand the process of this transformation, and as a consequence to understand the way the object is constructed'. New behavioral patterns are acquired through direct experience or through the observations of the behaviors of others (Bandura, 1977)[27]. Observers within the system transform, classify and organize the information into schemata that can be easily remembered, rather than becoming instruments that store representations of modeled events (Tudge and Winterhoff, 1993)[28].

Theoretical Framework: The Synthesis

Scholars (Boethel and Dimock, 2000[29], Fox 2001[30], McLeod, 2003[31]) state that an effective instructional framework takes into account the theoretical bases in which it is grounded which results in effective learning which is meaningful and offers challenging problems for the learner to unravel. Based on these tenets this synthesis aligns the main tenets of the Cognitive Load Theory and Vygotsky's Cognitive Development Theory with Briefing, Scenario and De-briefing phases generating a framework for Instructional Design in maritime simulator training.

The synthesis of CLT and Briefing, Scenario and De-briefing phases

According to Chu (2014)[32] for optimal learning, Cognitive Load Theory can be applied to any instructional learning context to decrease extraneous load, increase intrinsic load, and maximize germane load. Guided by the literature on CLT this study breaks down complex simulator-based tasks by reducing them into smaller, simpler steps and aligning them to the theoretical tenets of CLT. This synthesis builds a robust study design on the foundations of the Germane Cognitive Load. Thus repetition (with the non-experienced seafarers) and linking to already existing information or prior schemata (with the experienced seafarers) are envisaged to accelerate the transferring of Short-term memory information through working memory to the corpus of long-term memory.

As illustrated in Figure No.1 above the Intrinsic, Extraneous and Germane Cognitive Loads are distributed along the Briefing, Scenario and De-briefing phases. The learners enter the Briefing phase with an information overload created by the extraneous Cognitive Load which is non-essential to the learning task and impedes learners' ability to process new information. The Scenario phase, it is envisaged, moves to reduce the extraneous Cognitive Load and optimize the Germane Cognitive Load. Within this phase the short-term sensory memory generated at the Briefing phase will move to working memory during the task performance which are kinesthetic, psychomotor activities done by the learners.

Kalyuga, Chandler and Sweller (2000)[33] state that through a combined method of audio and Visuo-spatial delivery at the scenario phase the learners are better able to utilize their working-memory. This positively influences the student's ability to recall the subject matter at the Debriefing Phase. As illustrated in Figure No.1 above, during the Debriefing Phase after elaborative, maintenance rehearsal and encoding it is postulated that the information is stored in Long-Term Memory.

The synthesis of Vygotsky's Cognitive Development Theory and Briefing, Scenario and De-briefing phases

Applying Vygotsky's Cognitive Development Theory to the Briefing, Scenario and De-briefing phases this study constructs the following learning environment. At entry level learners carry a high weight age of maritime tasks which are beyond the learners' capabilities and exist in the 'Cannot do alone' zone. They have to construct new knowledge during the Briefing phase and retain the input. Here they follow an accommodation and assimilation process. At the Scenario phase the ability to do tasks under guidance with scaffolding from MKOs, Technology and tools is generated. Scaffolding is provided by simulator trainers and the visuo-spatial environment. Dynamic, functional psychomotor tasks are carried out by the trainees with the scaffolding provided within the simulator. At the De-briefing phase MKO scaffolding is removed and to trainees arrive at the 'Can do tasks independently' stage.

Framework for Instructional Design for the Simulator training: A synthesis of theories on Cognitive Development

Synthesizing the theories on Cognitive Development this study, at this juncture constructs the framework given in Figure No.3 below. Amalgamating the main tenets of the theories the following percepts too are fulfilled.

- Student motivation is maximized through the generation of self-responsibility and self-reflection. (Jonassen, 1994)[34]
- In the process of knowledge construction not only situation awareness but also self-awareness will be enhanced. (Honebein, 1996)[35]
- Student autonomy and initiative are maximized. (Brooks and Brooks, 1993)[36]

The virtual environment within a simulator is an organization of sensory information. According to Blascovich and Bailenson (2006, p. 230)[37] the perceptions of a synthetic environment on the basis of organized information via any sensory channel or combination of sensory channels and develop the ability to make timely, appropriate, and effective decisions which is an essential competence required by maritime trainees.

Simulator training is experiential learning of risk management at sea. a practicum where applying knowledge and skills in simulated to real situations and overcome cognitive challenges as those in the real world

Thus to maximize the outcomes of simulation-based learning exercises where trainees comprehend inputs from the Briefing stage experiences, processed them intra-psychologically and create behavioral outputs not only at the Senario phase but develops the resultant skill transfer.

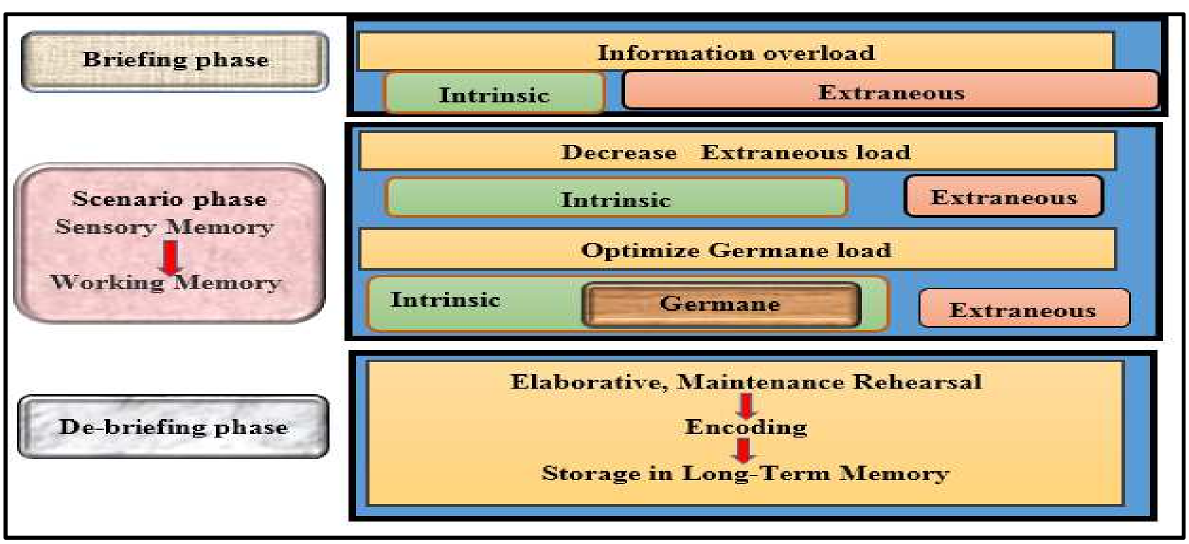

Figure No.1: Framework for Instructional Design: Simulator training based on CLT

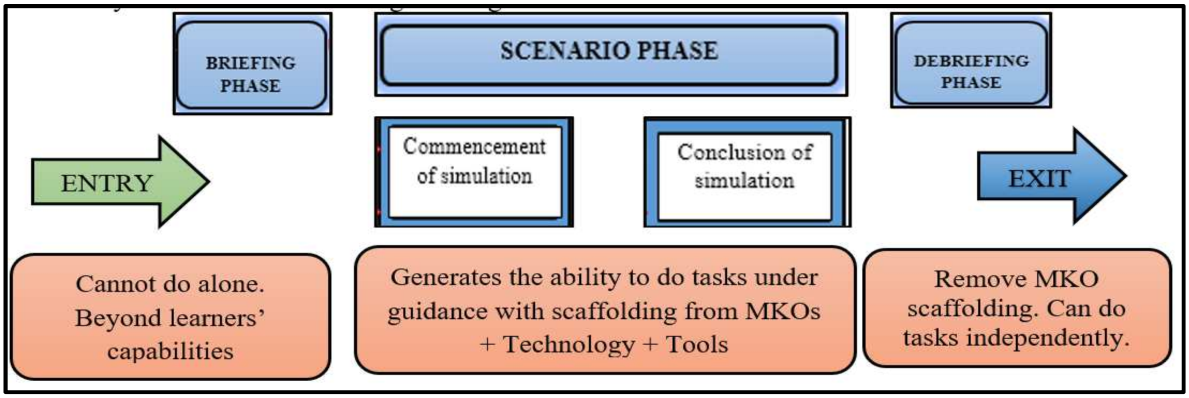

Figure No.2: Framework for instructional design: Simulator training based on Vygotsky's Cognitive Development Theory

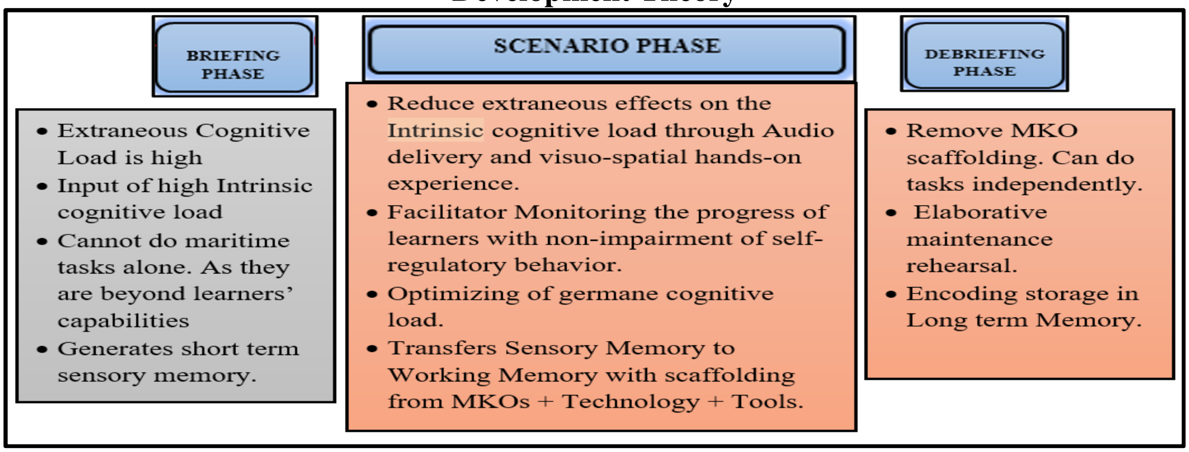

Figure No.3: Framework for instructional design for the Simulator training: A synthesis of theories on Cognitive Development

CONCLUSION

The framework postulated by this study is in agreement with Van Merrienboer, Kirschner and Kester (2003)[25] who with regard to novice learners, advocate full support in order to reduce the extraneous effects on the cognitive loading. The benefits derived from an adaptive environment are largely due to the process of the facilitator continually monitoring the progress of the students, and offering timely support as and when it is required. But this adaptive support is required to be implemented cautiously, so that the support offered in no way impacts the self-regulatory behavior on the part of the students Azevedo and Cromley, (2004)[38]. The synthesized theoretical framework envisages optimizing learning outcomes with simulation-based learning designs.

CINEC Campus, Malabe, Sri Lanka has freshly introduced a simulator module as a component of the Officer Cadet Training Programme for its Navigation and Engineering Cadets. CINEC's vision is to upgrade from a professional Maritime qualification provider and produce high end Maritime graduates who are globally employable. The employability skills of Maritime graduates will be vastly enhanced by incorporating rapidly evolving theories in education to improve the quality of Maritime Higher Education. Increased access to higher education in Maritime Sciences is beneficial for economic development through the value-added services provided by Maritime graduates. Though, this qualitative theoretical synthesis and analysis primarily informs the Maritime simulator expertise within the locale of CINEC Campus it can be extended, with further research work, to other simulator training setting.

ACKNOWLEDGEMENT

The authors which to express their sincere gratitude to Department of English, CINEC Campus (Private Limited), Malabe, Sri Lanka for providing necessary facilities to carry out this research work.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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