Simulating Work-Integrated-Learning (WIL) – Learning from Health Professional Education

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SESSION S2: Educating the Edisons of the 21st Century

CONTEXT The use of simulation is gaining prevalence in a number of educational fields, including engineering education in the area of work-integrated-learning (WIL). Despite the utilisation of simulation as an educational strategy, the uptake of simulation in engineering education is incomparable to how it has been undertaken in health professional education. It is proposed that simulation is an educational strategy that can be harnessed further within engineering education.

PURPOSE The aim of this paper is to propose that scenario-based simulation and the Simulation Cycle, which have been developed within health professional education, can enhance the implementation of simulated WIL in engineering education context.

APPROACH The paper takes a theoretical approach by discussing existing applications of simulated WIL within engineering education. Current issues and limitations are identified. A discussion on how these issues can be addressed via the use of scenario-based approach using Simulation Cycle is discussed.

RESULTS It is proposed that 3 key areas of issues exist in the use of project-based simulation. These areas include i) issue of control and coordination of elements (including of human players) within the simulation to achieve learning objectives, ii) balancing industry's involvement and time required from them and iii) managing cognitive overload. In addition, the challenge of engaging students in meaningful reflection is also raised. It is suggested that the use of scenario-based simulation and Simulation Cycle can manage these issues.

CONCLUSIONS The authors are currently developing simulated WIL using the principles proposed in this paper. The focus of the simulation is on problem solving, specifically on the development of appropriate skills for problem analysis.

KEYWORDS Simulation-based education, simulation-based learning, simulation cycle, problem solving, work-integrated-learning

Simulation learning opportunity

The use of simulation is gaining prevalence in a number of educational fields, including engineering education. This is evident in research within engineering education that report the implementation of varied simulation-based learning (Arastoopour, Chesler, & Shaffer, 2014; Arastoopour, Shaffer, Swiecki, Ruis, & Chesler, 2016; Chesler, Arastoopour, D'Angelo, Bagley, & Shaffer, 2013; Davidovitch, Parush, & Shtub, 2006; Jollands, 2015; Lindsay & Good, 2005; Lindsay, Liu, Murray, & Lowe, 2007; Masethe & Masethe, 2013; Ponsa, Vilanova, & Amante, 2010; Prince, 2006; Zou & Chan, 2016). Despite the utilisation of simulation as an educational strategy, the uptake of simulation in engineering education is incomparable to how it has been undertaken in health professional education.

The use of simulation is commonly implemented as an educational method within health professional education. In health, the simulation industry is a billion-dollar business and is increasingly embedded in health services and education. Within this field, simulation education itself can be considered as a discipline. Using simulation for optimal impact requires specialised skills and in Australia, the government has funded a national training program to support health professionals learn to use the method effectively, National Health Education and Training in Simulation or NHET-Sim (The NHET-Sim Monash Team, 2012). The healthcare simulation education community has also matured to include specialist societies, journals, standards of practice and conferences.

Gaba (2007) defined the method as “a technique to replace or amplify real experiences with guided experiences, often immersive in nature, that evoke or replicate aspects of the real world in an interactive fashion”. Simulation can be used as assessment or for improving the learning experiences of students (Adamo, 2003). When used to improve learning experiences, simulation can give students applied problem based learning opportunity (Fanning & Gaba, 2007). Fanning and Gaba (2007) also believed that simulation can result in sustained learning as it requires the learner to be actively engaged in the process cognitively and emotionally. Cheong (2010) identified that the use of simulation can provide a learning opportunity that students may not have in the real world.

Nestel et al. (2014) found that “there is strong evidence for simulated learning technologies leading to increased knowledge and improved skills under specific conditions for several core graduate outcomes in health undergraduate curricula, when compared with no intervention” (p. 6). The positive impact of simulation-based learning on self-efficacy, including within engineering education, is often reported in studies (Cheong, 2010; Jollands, 2015; Zou & Chan, 2016). Given the overwhelming evidence that simulation can enhance learning, it is proposed that simulation is an educational strategy that can be harnessed further within engineering education. One area of application of simulation in engineering education is in work-integrated-learning (WIL) context.

Applying simulation within WIL context

Though not mandated yet, engineering degrees are expected to accommodate a WIL component. In a 2009 report submitted to the Australian Teaching and Learning Council (ALTC) it was found that not all students can access traditional WIL due to factors such as visa restrictions for International students, language, cultural background and disability (Patrick et al., 2008). Some of the key challenges of implementing WIL is to fulfil both the requirements of the university and the organisation, as well as controlling the outcome and process in traditional WIL to ensure that students get the most benefit (Patrick, et al., 2008). Despite reported benefit of WIL for industry organisations such as being able to access expert knowledge of the partnering university and advantages for recruitment (Li & Randhawa, 2009; Patrick et al., 2008), traditional WIL takes considerable investment of time and commitment from the industry partners. Organisations involved in WIL believed that the cost of mistakes that students can make while working in their organisation also needs to be considered (Patrick et al., 2008).

The benefits that simulation-based WIL can offer are the following: a) can be used to overcome opportunity limitation; b) requires less implementation time/risk of/to real industry, and c) can be tailored for specific learning opportunities. In addition, though within health professional education, the research of Watson et al. (2012) and Hayden et al. (2014) found no statistically significant differences were found between students engaged in traditional clinical placement and simulated clinical placement. This suggests that simulated WIL can be used to give students experiences that mimic real work placement.

Simulated WIL in engineering education context

The implementation of simulated WIL within engineering education context are exemplified in current literature (Jollands, 2015; Masethe & Masethe, 2013; Ponsa et al., 2010; Zou & Chan, 2016). Jollands (2015) developed a simulated WIL which comprised of a real project involving an industry partner. The project ran for 12 weeks and adding to the authenticity of the experience, students were mandated to adhere to special conditions including strict attendance and professional behaviour. Students were also required to attend workshops that covers professional and personal skills which include resume writing, interview skills, teamwork and communication. Like Jollands (2015), Masethe and Masethe (2013) implemented a project-based simulation. Students in their study designed and developed a mobile application through to putting it on the market. An industry partner was involved actively as mentors to the students. Students' learning was also supplemented by formal workshops and seminars.

Ponsa et al. (2010) utilised a project-based simulation using both computer-based and role-play modality. Their project was a joint-collaboration between two units within the Autonomous University of Barcelona (The School of Engineering and Sports Services Area) and a number of other institutions including the Technical University of Catalonia and 2 high schools. The Sports Services Area of the university acted as a client. Engineering students from the university were invited to submit CVs and their rationale for project participation. Students then took on professional roles and had regular meetings with the client as the project progressed. The simulated environment required students to design solutions for their client on a software-based application. In addition, students from the Technical University of Catalonia and the 2 high schools undertook specific roles such as software developers, designers and project managers to support the simulation activity.

In Hong Kong, also incorporating role play into a project-based simulation, 151 civil engineering students took on the roles of professional engineers, working in groups on a project involving a number of stakeholders (Zou & Chan, 2016). The project was borrowed from a real existing project. In the middle of the project, an emergency scenario was also introduced to students. This was done to replicate real industry conditions. Professional engineers were also at hand as advisors and facilitators. Unlike the simulated WIL developed by Jollands (2015) as well as Masethe and Masethe (2013), students' learning was not supplemented by seminars and workshops. Students were expected to be self-directed rather than guided by formal lectures.

Issues with project-based simulations: Adopting scenario-based simulation in engineering education

WIL simulations within engineering education often use a project within a team-based environment (Jollands, 2015; Masethe & Masethe, 2013; Ponsa et al., 2010; Zou & Chan, 2016). This mode of implementation may be driven by the nature of engineering work. However, as briefly mentioned by Zou and Chan (2016) such simulations made coordination challenging. In addition, since the value of simulation-based learning is the ability to design experiences in a controlled manner to achieve learning objectives (Fanning & Gaba, 2007), how much control can be applied within a project-based simulation is unclear given the larger scope and complexity.

The other issue of using project-based simulation is the prolonged involvement of the industry partner to add authenticity to the experience. Given that staffs from the involved organisation are often time-poor, this arrangement can be problematic from the perspective of the industry partner. However, involvement from the industry is vital as Jonassen, Strobel and Lee (2006), and Beder (1999) identified that problems faced by engineers in the real workplace differ significantly from those presented in a university setting. Balancing involvement and time required in a simulation-based learning activity can be challenging.

Another concern in implementing a project-based simulation is ensuring that learners are not overwhelmed by information and the tasks that they have to complete over the lengthened simulation duration. In Cognitive Load Theory, Sweller, Ayres and Kalyuga (2011) suggested that there is a limitation on how much learners can process information at one time. This has an impact on teaching and learning design. There is a need to consider issues of cognitive overload when carrying out simulations (Josephsen, 2015; Reedy, 2015).

In summary, it can be proposed that implementing a project-based simulation can be challenging in three areas: i) the issue of control and coordination of elements (including of human players) within the simulation to achieve learning objectives, ii) balancing industry's involvement and time required from them and iii) managing cognitive overload.

In contrast, within health professional education, team-based simulations are often scenario-based. That is, a specific event is played out with a healthcare team required to recognise and respond to the cues they are given in their effort to provide safe care. The use of simulated scenarios in engineering education context is achievable as exemplified by the work of Prince (2006) as well as Zou and Chan (2016). Prince (2006) used role-play and simulated scenarios to teach ethics, related to moral dilemmas to engineering students. The use of scenarios may also focus industry's involvement to the development of the scenarios, minimising industry partners' commitment during the actual simulation. Via scenarios, the teacher may be able to target narrower but more specific learning goals which may not overwhelm the students, thus considering aspects of cognitive overload.

The challenge of engaging students in reflection

Engaging students in reflection is a challenge in the design of any learning activities. Apart from Jollands (2015), in the previously discussed literature on simulated WIL, how students were engaged in the process reflection seemed to be unclear. Jollands (2015) recognised that the process of reflection is crucial for learning and implemented discussions together with the use of personal journals in her simulated WIL. However, in his study on the use of online reflective journal, Palmer (2004) found that students were only reflecting as necessary to complete their assignment and were unlikely to engage in the process when the assignment was over. This suggest that students may not be actively engaged in the process of reflection even if personal reflection is being enforced.

In addition, young engineers do not perceive the process of reflection as important (Adams, 2010; Belski & Belski, 2014; Harlim & Belski, 2010). Young engineers only tend to reflect if a mistake happens (Harlim & Belski, 2013a). While the use of simulation can provide a safe learning environment for students to make and learn from their mistakes (Ziv, Ben-David, & Ziv, 2005), the simulation implemented needs to facilitate opportunities for students to engage in meaningful personal reflection. This is supported by the research of Davidovitch, Parush and Shtub (2006). Industrial engineering students were asked to complete project management case studies on a computer-based simulator. The researchers then compared the performance of students in different groups, a) those who did not have any recorded history which they can use a way to gain feedback on their performance, b) those with automatic saving of recorded history and c) those who used student-led (manual) history recording. It was found those that had access to the history of their past performance outperformed those who did not have recorded history, during subsequent simulations. This shows that the simulation activity alone is not sufficient for effective learning. Mechanisms that facilitate reflection need to be considered when using simulation as an educational tool.

The Simulation Cycle - Learning from Health Professional Education

A systematic approach to simulation-based learning design experience can be utilised in simulation of events. The systematic approach, referred to the Simulation Cycle (The NHET-Sim Monash Team, 2012) considers simulation as a whole process and is made up of the following phases: i) preparation, ii) briefing, iii) simulation activity, iv) debriefing and feedback, v) reflecting and vi) evaluating. The Simulation Cycle as depicted in Figure 1, accommodates the processes that learners need to ensure effective learning can occur via simulation.

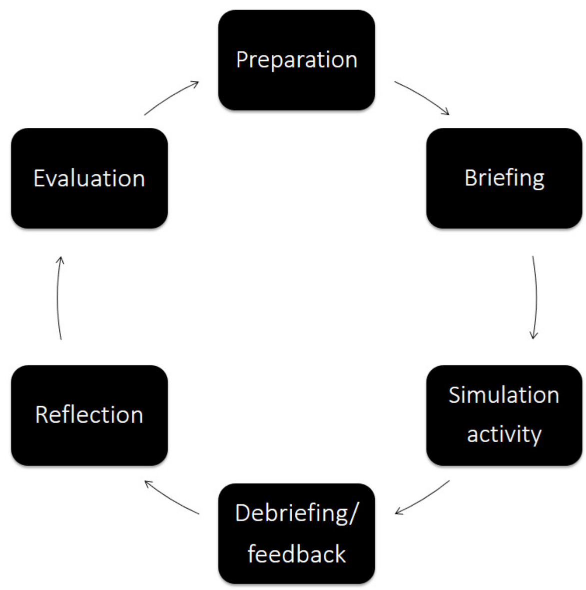

Figure 1: The Simulation Cycle, Source: Adapted from the NHET-Sim Program

The *preparation* phase refers to all the activities that take place before the simulation event starts, including the identification of learners' needs; setting learning objectives; designing the scenario, sourcing what is needed for the simulation such as rooms, props, human resources etc. The *briefing* phase is crucial to ensure that a valuable learning experience can be achieved (Gough, 2016). This phase helps to orient the learners prior to the simulation activity. The briefing would include explicit explanation of the simulation activity as well as the students' and facilitators' responsibilities. Reedy (2015) proposed that by preparing student mentally on what is going to happen during the simulated event can reduce cognitive overload. In addition, students can be assured that the simulated event is a safe place to make mistakes during in this phase.

During the *simulation activity,* the learner(s) participate actively in the simulation. To ensure that students are aware that the simulation has begun and thus, they are engaging in a safe place to make mistakes, it is important to indicate a clear start to the simulation. Within a project-based simulation, it is challenging to implement this as students enter and exit the simulation without a clear indication, contributing to the challenge of control and coordination of the learning environment.

The process of *debriefing and feedback* is used a pre-cursor to self-reflection. Within health professional education, this phase is considered to be the most important part of simulation-based education. It is suggested that this is the process that leads to effective learning (Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005; Motola, Devine, Sullivan, & Issenberg, 2013; Shinnick, Woo, Horwich, & Steadman, 2011). Going beyond discussions which are often implemented within simulated WIL in engineering education, formalised feedback and debriefing sessions may be used to promote reflection. Evidence of the effectiveness of debriefing has been reported (Benbow, Harrison, Dornan, & O'Neill, 1998; Cheng et al., 2014; Decker et al., 2013; Fanning & Gaba, 2007; Issenberg et al., 2005; Motola et al., 2013; Rudolph, Simon, Dufresne, & Raemer, 2006). In addition, the process of debriefing may also be more representative of what takes places within the engineering profession, adding to authenticity to the simulated WIL. Within the *reflecting* phase in the Simulation Cycle, learners are encouraged to make sense of the simulation in the light of their own experiences, individually. By engaging students in the process of debriefing prior to personal reflection (either via personal journal or other means), it is hoped the discussion during the debriefing session would activate their own locus of control to engage in meaningful reflection.

Finally, the *evaluation* phase refers to assessment of the success and limitations of the simulated session in meeting its goals. This phase is about ensuring continuous improvement in the use of the educational strategy. It is proposed that the adoption of a scenario-based simulation accommodate the use of the Simulation Cycle, which may be used to overcome the issues that have been identified in implementing simulated project-based WIL. It is also believed that the Simulation Cycle may also address the challenge of encouraging meaningful reflection in engineering students.

Conclusion - Where to from here?

It is suggested that the use of simulation can be further harnessed within engineering education, particularly in the development of simulated WIL. It is proposed the practices within health professional education can improve the utilisation of simulation as an educational strategy. These include the use of scenario-based simulations rather than project-based, and the use of the Simulation Cycle.

The authors of this paper are working on developing 2-3 simulated scenarios-based WIL with the involvement of industry partners that focus on aspects of engineering problem solving, related to problem analysis skills. The focus of development is such as it is well identified that problem solving ability is an important skill for professional engineers (Beder, 1999; Engineers Australia, 2013; McCarthy, 2009). In addition, research found that problem finding or the skills to diagnose problems properly is vital for problem solving performance (Belski, Adunka, & Mayer, 2016; Harlim & Belski, 2013b).

References

Adamo, G. (2003). Simulated and standardized patients in OSCEs: achievements and challenges 1992-2003. *Medical Teacher, 25*(3), 262-270.

Adams, J. (2010). *Improving Problem Solving Skills and Developing Creativity in First Year Engineering Undergraduates.* (Doctor of Philosophy), University of Northampton, UK.

Arastoopour, G., Chesler, N. C., & Shaffer, D. W. (2014). Epistemic persistence: A simulation-based approach to increasing participation of women in engineering. *Journal of Women and Minorities in Science and Engineering, 20*(3).

Arastoopour, G., Shaffer, D. W., Swiecki, Z., Ruis, A., & Chesler, N. C. (2016). Teaching and assessing engineering design thinking with virtual internships and epistemic network analysis. *International Journal of Engineering Education, 32*(2).

Beder, S. (1999). Beyond Technicalities: Expanding Engineering Thinking. *Journal of Professional Issues in Engineering, 125*(1), 12-18.

Belski, I., Adunka, R., & Mayer, O. (2016). Educating a creative engineer: learning from engineering professionals. *Procedia CIRP, 39*, 79-84.

Belski, R., & Belski, I. (2014). Cultivating student skills in self-regulated learning through evaluation of task complexity. *Teaching in Higher Education, 19*(5), 459-469.

Benbow, E. W., Harrison, I., Dornan, T. L., & O'Neill, P. A. (1998). Pathology and the OSCE: insights from pilot study. *J Pathol, 184*(1), 110-114.

Cheng, A., Eppich, W., Grant, V., Sherbino, J., Zendejas, B., & Cook, D. A. (2014). Debriefing for technology-enhanced simulation: a systematic review and meta-analysis. *Med Educ, 48*(7), 657-666. doi:10.1111/medu.12432

Cheong, D. (2010). The effects of practice teaching sessions in second life on the change in pre-service teachers' teaching efficacy. *Computers & Education, 55*(2), 868-880.

Chesler, N. C., Arastoopour, G., D'Angelo, C. M., Bagley, E. A., & Shaffer, D. W. (2013). Design of a professional practice simulator for educating and motivating first-year engineering students. *Advances in Engineering Education, 3*(3), n3.

Davidovitch, L., Parush, A., & Shtub, A. (2006). Simulation-based Learning in Engineering Education: Performance and Transfer in Learning Project Management. *Journal of Engineering Education, 95*(4), 289-299.

Decker, S., Fey, M., Sideras, S., Caballero, S., Rockstraw, L., Boese, T., . . . Borum, J. (2013). Standards of best practice: Simulation Standard VI: The debriefing process *Clinical Simulation in Nursing, 9*(6), S26-S29.

Engineers Australia. (2013). Australian Engineering Competency Standards - Stage 1 In *Competency Standards For Professional Engineers* Canberra.

Fanning, R. M., & Gaba, D. M. (2007). The role of debriefing in simulation-based learning. *Simulation in Healthcare, 2*(2), 115-125.

Gaba, D. M. (2007). The future vision of simulation in healthcare. *Simulation in Healthcare, 2*(2), 126-135.

Gough, S. (2016). *The use of simulation-based education in cardio-respiratory physiotherapy.* Manchester Metropolitan University,

Harlim, J., & Belski, I. (2010, 5-8 Dec). *Young engineers and problem solving: The impact of learning problem solving explicitly.* Paper presented at the 21st Annual Conference for the Australasian Association for Engineering Education, Sydney, Australia.

Harlim, J., & Belski, I. (2013a, 8-11 Dec). *Educating a reflective engineer: learning from engineering experts.* Paper presented at the 24th Annual Conference of the Australasian Association for Engineering Education, Gold Coast, Queensland.

Harlim, J., & Belski, I. (2013b). Long-term Innovative Problem Solving Skills: Redefining Problem Solving. *International Journal of Engineering Education, 29*(2), 280-290.

Hayden, J. K., Smiley, R. A., Alexander, M., Kardong-Edgren, S., & Jeffries, P. R. (2014). Supplement: The NCSBN National Simulation Study: A longitudinal, randomized, controlled study replacing clinical hours with simulation in prelicensure nursing education. *Journal of Nursing Regulation, 5*(2), C1-S64.

Issenberg, S. B., McGaghie, W. C., Petrusa, E. R., Lee Gordon, D., & Scalese, R. J. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Med Teach, 27*(1), 10-28. doi:R3P0QDKQ9XBG5AJ9 [pii]

10.1080/01421590500046924

Jollands, M. (2015). *Effectiveness of placement and non-placement work integrated learning in developing students' perceived sense of employability.* Paper presented at the 26th Annual Conference of the Australasian Association for Engineering Education (AAEE2015).

Jonassen, D. H., Strobel, J., & Lee, C. B. (2006). Everyday Problem Solving in Engineering: Lessons for Engineering Educators. *Journal of Engineering Education, 95*(2).

Josephsen, J. (2015). Cognitive load theory and nursing simulation: An integrative review. *Clinical Simulation in Nursing, 11*(5), 259-267.

Li, J. S. J., & Randhawa, S. (2009). *Work integrated learning for engineering students at Flinders University.* Paper presented at the 20th Annual Conference for the Australasian Association for Engineering Education, 6-9 December 2009: Engineering the Curriculum.

Lindsay, E., & Good, M. (2005). Effects of laboratory access modes upon learning outcomes. *IEEE Transactions on Education, 48*(4), 619-631.

Lindsay, E., Liu, D., Murray, S., & Lowe, D. (2007). *Remote laboratories in engineering education: Trends in students' perceptions.* Paper presented at the Proceedings of the 18th Conference of the Australasian Association for Engineering Education.

Masethe, M. A., & Masethe, H. D. (2013). *A Mentorship Model for Simulated Work Integrated Learning using Windows Phone.* Paper presented at the Proceedings of the World Congress on Engineering and Computer Science.

McCarthy, N. (2009). *Engineering: A Beginner's Guide*. Oxford, England: Oneworld Publications.

Motola, I., Devine, L., Sullivan, J., & Issenberg, B. (2013). Simulation in healthcare education: A best evidence practical guide. AMEE Guide No. 82. *Medical Teacher*, 1-20. doi:10.3109/0142159X.2013.818632

Nestel, D., Harlim, J., Smith, C., Krogh, K., & Bearman, M. (2014). *Simulated Learning Technologies in Undergraduate Curricula: An Evidence Check review for HETI*. Australia.

Palmer, S. (2004). Evaluation of an on-line reflective journal in engineering education. *Computer applications in engineering education, 12*(4), 209-214.

Patrick, C.-j., Peach, D., Pocknee, C., Webb, F., Fletcher, M., & Pretto, G. (2008). *The WIL (Work Integrated Learning) report: a national scoping study [Final Report]*: Queensland University of Technology.

Ponsa, P., Vilanova, R., & Amante, B. (2010). *The use of role playing in engineering curricula: A case study in human-automation systems.* Paper presented at the Education Engineering (EDUCON), 2010 IEEE.

Prince, R. H. (2006). Teaching engineering ethics using role-playing in a culturally diverse student group. *Science and Engineering Ethics, 12*(2), 321-326.

Reedy, G. B. (2015). Using cognitive load theory to inform simulation design and practice. *Clinical Simulation in Nursing, 11*(8), 355-360.

Rudolph, J. W., Simon, R., Dufresne, R. L., & Raemer, D. B. (2006). There's no such thing as "nonjudgmental" debriefing: a theory and method for debriefing with good judgment. *Simulation in Healthcare: The Journal of The Society for Medical Simulation, 1*(1), 49-55.

Shinnick, M., Woo, M., Horwich, T., & Steadman, R. (2011). Debriefing: The most important component in simulation? . *Clinical Simulation in Nursing, 7*, e105-111.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory* (Vol. 1): Springer.

The NHET-Sim Monash Team. (2012). The National Health Education and Training - Simulation (NHET-Sim) Program. Retrieved from http://www.nhet-sim.edu.au

Watson, K., Wright, A., Morris, N., McMeeken, J., Rivett, D., Blackstock, F., . . . Watson, G. (2012). Can simulation replace part of clinical time? Two parallel randomised controlled trials. *Medical education, 46*(7), 657-667.

Ziv, A., Ben-David, S., & Ziv, M. (2005). Simulation based medical education: an opportunity to learn from errors. *Medical Teacher, 27*(3), 193-199.

Zou, X., & Chan, B. (2016). *Developing professional identity through authentic learning experiences*. Paper presented at the Research and Development in Higher Education: The Shape of Higher Education, Fremantle, Australia.