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Using Technology for Productive, Creative Purpose

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In this article, we explore how creativity is impacted, positively and negatively by educational technology, as fundamental constructs of 21st century education. Creativity is one of the most important and noted skills for success in the 21st century and it is essential to ensure its productivity. This article offers clear definitions of technology and creativity and suggest how ones creative productivity can be impacted upon due to a failure to recognise poorly developed technological skills. Students require time to learn the required technological skills and freely available software. Time must be devoted to learning the functions of the program application before developing creative solutions to problems. It is suggested that effective infusion of creativity and technology in education must begin with building technological skills before moving to a problem solving or a STEM approach to learning that builds creativity. This article provides practical implications with broad recommendations and builds discourse around infusion of creative thinking and technology in 21st century educational systems.

Keywords: *technology, creativity, inspiration, education, thinking, problem solving.*

1. Introduction

This paper examines and evaluates how creativity is commonly developed within technology-based courses and programs at university. It goes onto further demonstrate how design and technology, who are at first glance, opposing forces with one using logical thought and the other creative thinking can be juxtaposed in order to build create function in ones thinking. This paper synthesises and suggests ways the creative function could be built and used productively within secondary and higher education learning institutions.

Within this paper, creativity is defined as a spontaneous act that occurs mainly within two contexts: as a sudden experience where inspiration strikes without any notice, or as a product of continuous work that is carried out with tenacity involving deep concentration and perseverance (Oleynick, Thrash, LeFew, Moldovan and Kieffaber, 2014). Inspiration has been a subject of debate for many decades, lacking clear definition until Thrash and Elliott (2003), unified different concepts for the state of inspiration: evocation, transcendence, and approach motivation. They arrived at a model called 'the tripartite conceptualization'. As best described by Oleynick et.al.,(2014, p. 2), Thrash and Elliott's (2003) tripartite conceptualization specifies:

> "the three core characteristics of the state of inspiration are evocation, transcendence, and approach motivation. Evocation refers to the fact that inspiration is evoked rather than initiated volitionally by the individual. In other words, one does not feel directly responsible for becoming inspired; rather, a stimulus object, such as a person, an idea, or a work of art, evokes and sustains the inspiration episode. During an episode of inspiration, the individual gains awareness of new possibilities that transcend ordinary or mundane concerns. The new awareness is vivid and concrete, and it surpasses the ordinary constraints of wilfully, generated ideas. Once inspired, the individual experiences a compelling approach motivation to transmit, actualize, or express the new vision. This set of three characteristics is intended to be minimally sufficient to distinguish the state of inspiration from other states."

Seemingly, creativity and inspiration are impalpable and uncontrolled states that require the individual/s to dedicate their whole attention to it. According to Janhke (2011, p. 99) "noise, distractions and disruptions inhibit creativity, and conversely, the absence of these factors *facilitates* the emergence of creativity". Technology, or having to solve a tech issue, could potentially interfere with this fragile creative process as inspiration seems to transcend consciousness. In one of her essays written in 1940, Virginia Woolf wrote "the old problem how to keep the flight of the mind, yet be exact. All the difference between the sketch and the finished work" (as cited in Podnieks, 2000, p. 122).

Technology may be defined, for the purpose of this paper, as offering a vast array of technical tools, such as hardware, software and applications that improve efficiency and speed up the design and manufacturing processes (Bonnardel & Franck Zenasni, 2010). It is commonly

agreed that digital technologies are now embedded in the education curriculum and realm, in the shape of YouTube tutorials and videos, coding, and software such as CAD which provide great avenues for teaching and learning. However, technology is constantly evolving. To use it productively, teachers must understand how technology can be used to represent content and recognize how this may synchronise, or not, with possible teaching approaches (Mishra, 2012, p. 14). Henriksen, Fisser & Mishra (2016) explain that the force behind technology is innovation, which is driven by human creativity. For this reason, teaching and learning should naturally embed both technology and creativity as they are eternally connected (Henriksen, Fisser & Mishra, 2016; Henriksen, Hoelting, & The Deep-Play Research Group, 2016).

There is limited recent research explaining the impact of technology on creativity in learning situations. According to Mishra (2012), traditional education settings have been "chrono-centric", believing our current technology is the only one that matters; Mishra (2012) argues the TPAK framework (Technology, Pedagogical, and Content knowledge)(Koehler & Mishra, 2009) provide educators a better understanding of what and how to teach technology, emphasising the importance of "teacher creativity in repurposing technology tools for make them fit pedagogical and disciplinary-learning goals" (Mishra, 2012, p. 14).

Providing a framework to ensure creativity is established within the education system is an obvious solution but this is not as easy to do as it sounds. Although children are naturally creative, it is important to remember their creative instincts have been supressed by the education system, which favours other 'more important' subjects such as maths or English and perpetuates "intellectual conformity" (Sternberg, 1999). This paper argues that technology can be both beneficial and detrimental when it comes to inspiration and creativity, as learning new technology is time consuming and as such, should be given a higher status and importance within the Higher Education teaching programs. Technology is an excellent tool to expand and share knowledge and ideas, however, productivity is negatively impacted if the creative thought process, and how inspiration flows, is interrupted. For example, not knowing how to operate technology tools, creates distractions and interferes with the creative process. Once distraction or inattention appears, design fixation can sabotage the creative freedom (Cardoso & Crilly, 2017). It is apparent that inspiration is ethereal and its main enemy is distraction and not knowing how to operate technological platforms impacts both productivity and creativity if the skills have not previously been developed. In accordance with the 1999 Committee of Information Technology Literacy of the National Research Council (as cited in Koehler & Mishra, 2009, p. 63), pre-service teachers need to be able to understand "information technology broadly enough to apply it productively at work and in their everyday lives, to recognize when information technology can assist or impede the achievement of a goal, and to continually adapt to changes in information technology". It is proposed that is not occurring in university studies.

One possible solution to this conundrum would be dedicating sufficient time for pre-service teachers at or pre university to build the skills required to us technology tools in a comprehensive, efficient and creative way. This in turn would avoid time being wasted which ultimately would create an interference in the creative process. This could be integrated into university programs through the dedication of semester one at university to technological skill building that could be carried out at university or a range of other institutions such as Technical and Further Education institutes (TAFE) in Australia.

2. Creativity within Higher Education teaching programs

Secondary Teacher Education programs are packed full of courses whose content is dictated by university rules and requirements, mandatory accreditation requirements from state and national bodies, prescribing rules and content that must be fulfilled if the students are gain employment. The government even prescribes literacy and numeracy testing before employment. Prescribed courses are included the teaching of subject content within a curriculum, problem solving skills, practicum and internship experiences in communities of practice, quality teaching and learning, pedagogical practices, indigenous education, special education, student psychology, student sociology, research and communication, literacy, numeracy and technacy skills and most importantly we teach students to think and to teach their students to think.

The higher education program curriculum is filled with many curricular and accreditation demands. With programs striving to meet accreditation requirements at times standards are lowered and “things” missed in order to meet the greater need of accreditation. Creativity, a concept that uses the highest form of thinking, can take valuable time and be difficult to teach. Within these education programs the author posits that students need to perfect their skills and use of technology as a first step in building creativity. This needs to be done before being asked to use technology to creatively and innovatively solve problems. Currently students face a conundrum when it comes to fostering creativity when they haven’t yet mastered the skills required to design and manufacture innovative solutions to the problem they have been given. The author suggests that there needs to be an equilibrium where technology tools are given a higher status and importance, allowing students to develop deep understanding of different technology platforms and software that will be used during problem solving. When skills are taught well, productivity increases when synthesising creative solutions.

Within education programs the author suggests that students need to perfect their skills and use of technology before being asked to use technology to creatively and innovatively solve problems. The problem arises because learning to use technology skills involves students following procedural instructions. This includes the use the lower order thinking skills, (Bloom, 1956), of recall and comprehension which traditionally do not have a place at university. Skill are currently studied during technical education. It is suggested that a solution to this obvious problem would be for students to spend a year of their degree learning the skills that are

currently taught by technical facilities before building their levels of thinking to higher levels of evaluation and synthesis where they integrate these with skills learned in order to creatively and innovatively solve problems.

3. Thinking creatively

In Australian curricular the main thinking process used to build design and creativity skills in secondary students is taught within a subject called Design and Technology. The process itself is called the design process. The design process involves students in project-based learning. Here, the secondary students are taught a range of skills that are needed to solve the authentic problem that they will be given. Students work through the process involving ideation, research, communication, prototyping, and manufacturing with ongoing evaluation carried out throughout the process. This is the same process is used in Science, Technology, engineering and Mathematics (STEM) education, with a focus on the integration of the specific STEM subjects into the design process listed above.

The Design Process's and STEM's potential is founded in its ability to improve a student's learning experience by assisting in the ability to transfer school-based learning to real and authentic situations in the individual's life (Berry, Reed, Ritz, Lin, Hsiung, & Frazier, 2004). Students can solve new problems and draw conclusions based upon previously learned principles applied through science, technology and engineering, and mathematics. It is suggested that implementing teaching strategies, such as problem-based learning through a STEM/design based curriculum, may reinvigorate students' desires to understand the world around them, build their creativity and engage them in creative classroom activity (Havice, 2012).

Teachers recognise and are concerned that students' enthusiasm for their own education is waning (Havice, 2012). Teachers' must reengage them in their studies because many are losing their natural inclination for learning. Havice (2012) has found that students who are exposed to integrated problem-solving curriculum display increased engagement, creativity, satisfaction and express enjoyment in their learning. This is encouraging and teachers should use this in their classrooms to refocus and motivate their students.

Deslauriers, Schelew, and Wieman (2011) have confirmed that students become more creative and show greater enthusiasm when problem-based instruction is incorporated. They explain the brain learns through association and analysis. Therefore, it is recommended that teachers adopt a variety of methods of instruction, including one in which the students are actively engaged in the learning process. When utilizing an inquiry and problem-based method of instruction, the teacher spurs student creativity through questions, and students respond through collaborative discussion (Zambon & Lempinen, 2011).

4. University student experiences, problems and ways to prevent them

It is expected that in the year 2020 all university students should have well developed technacy skills as they are labelled by Prensky (2012) 'digital natives'. However, in Australia, the reality frequently differs from the expectation. Lorenzo, Oblinger & Dziubam, (2006) explain that the populous of Australian university students is composed of students from a range of socio-economic status, a variety of cultures and a wide age range age. As such, these students have had diverse experiences and exposure to technology use and application. Most students possess core technology capabilities and skills but a large number of pre-service teachers experience difficulties with the technological expectations posed on them (Caruso & Kvavik, 2005). Koehler & Mishra (2009, p. 62),explain that "acquiring a new knowledgebase and skill set can be challenging, particularly if it is a time-intensive activity that must fit into a busy schedule". In their paper on student experiences at university, Alhamami & Costello (2019, p. 593), found that a great amount of "teacher training in this technological discipline is either ad hoc or self-taught". The problems experienced include the premise that technology pre-service teachers are expected to come with a set of tools that do not correspond with reality where a large number of students lack basic knowledge of required skills such as CAD programs or visual/digital imagery software (Lyendo and Alibaber,2015) Research by (Bonnardel & Franck Zenasni, 2010, p. 189) support this by stating, "the use of new technologies may need not only some training but also a real period of familiarization with new systems. Otherwise the new computational system may constitute more of a concurrent task than an effective support for users".

Accompanying a lack of skills, issues such as lack of time to learn the skills needed, software not available free of cost to students, students dedicating more time to learning the functions of the program application instead of devoting that time to developing their creativity. The 2108 national student survey compiled by Judith Sachs found that many university students have time-management issues due to poor organisations skills, working fulltime or part time jobs, having families, experiencing fear of failure, feelings of frustration along with an increase in the number of students with mental health issues all contribute to the feeling of impotence when dealing with technological issues. These problems affect their levels of creativity, their learning, their assignments, their grades and most of all it affects students own belief in their competences and self-efficacy (Güner Berkant, 2016). Pre-service Technology Education teachers are especially vulnerable as they are advocates for technology and they "need to have attitudes and self-efficacy beliefs about computers because as teachers they are expected to use computers effectively in classroom activities" (Güner Berkant, 2016, p. 124). Pre-service teachers "generally need guidance and assistance in developing course materials and conducting successful classes and training sessions for their future students." Alhamami & Costello (2019, p. 593).

These issues could be minimised if universities took the time to build technological skills before expecting students to apply to problem based learning which demands high levels of

synthesis, creativity and thinking. Universities often offer a 'onesize-fits-all' approach to the integration of technology, which is inadequate training for future teachers, as 'teachers operate in diverse contexts of teaching and learning' (Koehler & Mishra, 2009, p. 62). Technology pre-service teachers should be armed with a comprehensive set of technological skills, both for the workshop and the design elements of their degree, to address the future issues they will encounter in the classroom.

5. Using the university experience to build productive creativity.

Universities play a crucial role in providing a platform for students to develop and build productive creativity, they must foster the creation and realisation of new ideas and innovation (Jahnke, 2011).

University students are expected to not only learn, use and apply a wide range of competencies and skills, they must then use these skills to challenge, investigate and discover ways "to form new relationships between established elements as well as to discover entirely new concepts or previously unconsidered connections" (Jahnke, 2011, p. 96). This infers that it is essential for students to thoroughly understand the technacy involved before using this technology to create new concepts, connections and solutions to problems.

Technology and design education programs incorporate a vast array of contemporary changes such as fully utilising technology in the classroom (Leonard, Fitzgerald, & Bacon, 2016), integrating blended learning situations (Alammary, Sheard, & Carbone, 2014), using flipped classrooms (Howitt, & Pegrum, 2015), integrating e-learning (Weng, Tsai, & Weng, 2015) or considering the vertical integration of subjects using a science, technology, engineering and mathematics (STEM) approach (Doe, 2016; McAuliffe, 2016). These strategies promote analytical, independent and creative thinking through: project-based learning, problem solving using authentic learning experiences in communities of practice with experts in the field. These build creativity through building lower to higher order thinking skills by ensuring adequate skill based technological learning exists before it is applied.

In Australia, technology and design pre-service teachers are encouraged to solve authentic problems by generating ideas that foster creative and synthesising innovative solutions where sustainability is a major focus and collaborative groupwork is anticipated (NESA, 2017).This fusion is important because creativity is often the fruition of collaborative work, as group work enables diversity and "the ability to see objects and relationships from different perspectives, to abandon habitual patterns of thinking and finally to create and implement entirely new ideas" (Jahnke, 2011, p. 98). An optimal way to encourage students to 'think the impossible' and not be afraid of being ridiculed or wrong, is by providing ongoing support to students, helping them understand that venturing in uncertain territories and taking risks with their thinking is what is needed for innovation as well as "encouraging participants to behave ethically and with

social responsibility promoting creativity as means of making a difference to people or adding value to the world" (Jackson, 2010, p. 25).

One of the challenges faced by both students and teachers at university is assessment, as creativity can be considered subjective and difficult to evaluate (Gaspar & Mabic, 2015). University tutors and their peers "influence the tutor's decision-making processes, make up this social environment for the students' creative outcomes and socially validate and encourage students' creativity" (Jones, Rodgers & Nicholl, 2013, p. 4). Disparities between university tutors and students regarding perceptions of creativity ultimately create tensions and affect the creative potential of students (Rodgers & Jones, 2017). This issue could be addressed by tutors facilitating creative environments that encourage supportive, risk-free, innovative and self-directed work (Rodgers & Jones, 2017) and by removing the ambiguity that surrounds the concept of creativity; this could be achieved by formalising creativity as a key skill and ensuring it is embedded across the whole curricula (Jackson, 2010) through the implementation of teacher education, assessment and educational policy (Henriksen, Fisser & Mishra, 2016).

6. Conclusion

In order to improve the level of creativity, quality and productivity of innovative solutions in tertiary education programs, students need to perfect their skills and use of technology before integrating creative thinking to solve problems. Pre-service teachers will increase both creativity and productivity by learning to efficiently use emerging technologies. It is suggested that a solution to this problem would be for students to spend up to a year of their degree learning technical skills before using high level skills, higher order thinking and creativity to solve problems innovatively. Although the technological world is dynamic and software is constantly updated, there are some basic skills that would prove highly beneficial for technology pre-service teachers; programs such as CAD, Arduino, or administrative digital technologies, namely Microsoft, Apple or Google packages, would help pre-service teachers improve time-management strategies as learning the basics would ensure more time is dedicated to encouraging creativity and problem-solving rather than technological issues.

The aim is not to avoid technology tools, but rather, to use technological tools to promote creativity and innovation when solving problems in innovative ways. One must evaluate and synthesise how the technological tools are used to creative advantage during the first stages of the creative and design process. It must be ensured that they are not counter-productive during 'early ideation'. Ensuring the students have mastered the use of the technologies before being given an authentic problem will prove beneficial in defining the main sources of inspiration as time is be wasted trying to work certain technology but instead completely focused on developing that first idea. Providing constraints to the design would also avoid designer fixation (using previous ideas) which in turn would give the designer a greater degree of freedom. Once that initial idea is defined, then the pre-service teacher/designer would be able to use technologies in its fullness.

Creativity is increased when students show greater enthusiasm and this occurs when problem-based instruction is incorporated Deslauriers, Schelew, and Wieman (2011) as the brain learns through association and analysis. When utilizing an inquiry and problem-based method of instruction, student creativity is increased and more productive.

The 2018 national student survey compiled Judith Sachs found that many university students experience a lack of technological skills, a lack of time to learn the skills needed, unavailable software that is free of cost to students causes students to dedicate more time to learning the functions of the program application instead of devoting that time to developing their creative solutions to problems. Students also have time-management issues due to poor organisations skills, working fulltime or part time jobs, having families, experiencing fear of failure, feelings of frustration along with an increase in the number of students with mental health issues all contribute to the feeling of impotence when dealing with technological issues. These problems affect their levels of creativity, their learning, their assignments, their grades and most of all it affects students own belief in their competences and self-efficacy Güner Berkant, 2016). These are the factors that work together to inhibit creative response.

The university experience is a great vehicle that can be used to improve students' creativity. They must incorporate a vast array of contemporary changes including thoroughly understanding how to use the technology before using this to create new concepts, connections and, using flipped classrooms, integrating e-learning and considering the vertical integration of subjects using a science, technology, engineering and mathematics (STEM) approach.

In the 21st century with the use of evolving information and communication technologies (ICT), and digital media and information, there must be innovations in educational pedagogy. Creativity and innovation play an important role in developing students thinking and solving authentic problems. An innovative educator constantly formulates new ways and approaches to teaching and learning to maximise student learning outcomes. Higher education is experiencing major transformations in terms of access, equity, quality, ICT, creativity and higher order thinking. These cause changes in the conception of the teaching and learning process In this regard, the innovations in higher education by integration of technology in various aspects of higher education will produce productive creativity.

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