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Are there differences between science and engineering majors regarding the imagination-mediated model?

Hsiu-Ping Yueh[a], Chi-Cheng Chang[b], Chaoyun Liang[c,*]

[a] Department of Bio-Industry Communication and Development, National Taiwan University, Taipei, Taiwan
[b] Department of Technology Application and Human Resource Development, National Taiwan Normal University, No. 162, Heping East Road Section 1, Taipei, Taiwan
[c] Department of Bio-Industry Communication and Development, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei, 10617, Taiwan

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ABSTRACT

The current study is aimed at analyzing how selected personal and contextual factors influence academic performance through their impact on imagination, and comparing differences between the imagination-mediated model of science majors and that of engineering majors. The participants were a sample of 876 undergrads which were divided into science and engineering groups. An analysis of structural equation modeling was used to test all the hypotheses proposed. The results showed that the initiating imagination of the science group had a negative and direct effect on their academic performance, whereas the conceiving imagination of the science group had a positive and direct effect. The transforming imagination indirectly influenced academic performance. Through the mediator effect of imagination, self-efficacy, generative cognition and conscientiousness had strong effects on the academic performance of both science and engineering majors. The results also indicated that the imagination-mediated models of both science and engineering groups were similar, but each variable had different influences. The major differences between these two models were the effects resulting from initiating imagination, conceiving imagination, self-efficacy, and conscientiousness on students' academic performance. The results will be appreciated and the instructional strategies will be developed under the premise that imagination and creativity are valuable to science and engineering education.

1. Introduction

Gelm (2013), awarded the 2010 Nobel Prize in Physics, indicated that it is not that scientific discoveries no longer occur but that the rate has slowed. Without new knowledge, Gelm argued that only derivative technologies are possible, however these technologies are incapable of sustaining the sorts of economic growth rates the world has enjoyed since the coming of the industrial revolution. Although many educators seem to agree that imagination is at the root of how human beings modify their material world, Van Eijck and Roth (2013) found that the process by which this scientific imagination in education occurs has rarely been conceptualized.

Swirski (2010) indicated that how we envision and contribute to our educational, social and cultural landscapes is only limited by our imagination. Imagination in learning environments will frame educational activities and facilitate innovative assessments which allow our students to explore, question, and make sense of the diversity surrounding them. Murphy,

* Corresponding author. Tel.: +886 3 3355681; fax: +886 3 4638277.
E-mail addresses: yueh@ntu.edu.tw (H.-P. Yueh), samchang@ntnu.edu.tw (C.-C. Chang), cliang@ntu.edu.tw, iccylian@saturn.yzu.edu.tw (C. Liang).

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Peters, and Marginson (2010) also contended that cultivating imagination should be viewed as cornerstones of learning because basic discovery requires high levels of creative thinking. Classroom practices should then change to encourage imagination, inquiry, invention, and initiative as described by Hiam (2011).

Two areas where the imagination is particularly important are science and engineering (Holton, 1998; Pritchard, 2001), yet there is a distinction between the two that may influence the role imagination does and should play. Accordingly, scientists seek cognitive knowledge, whereas engineers aim at practical ends (Poser, 1998). Anyone who cares about science and engineering education will pay attention to how students think, learn, and how the contextual and personal factors can influence their imagination. The purpose of this study was threefold: (1) to analyze how student imagination influences academic performance; (2) to examine how selected personal and contextual factors influence academic performance through student imagination; and (3) to compare differences between the imagination-mediated model of science majors and that of engineering majors.

2. The role of imagination in science and engineering

Science and engineering have different goals and methods. Science generally refers to knowledge based on observed facts and tested truths which are arranged in an orderly system that can be validated and communicated to other people. In contrast, engineering usually refers to the creative application of scientific principles used to plan, build, direct, guide, manage, or work on systems to maintain and improve our daily lives (National Society of Professional Engineers, 2006). In short, scientists seek to understand what is, whereas engineers seek to create what never was (Von Karman, quoted from Petroski, 2010, p. 25).

Taking proposed solutions as examples, Bybee (2011) explained that the solutions made by scientists refer to the construction of theories. A theory becomes accepted when it has multiple lines of empirical evidence, greater explanatory power, a breadth of phenomena it accounts for, and has explanatory coherence and parsimony. In contrast, engineers usually propose a systematic solution to problems that is based on scientific knowledge. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, and compliance with legal requirements.

Over the past decade, many scholars have devoted themselves to the study of scientific imagination (e.g., Holton, 1998; Maeyer & Talanquer, 2010; Taylor, Jones, Broadwell, & Oppewal, 2008). For example, after interviewing 58 scientists and science educators, Taylor et al. (2008) stressed that there is a need to teach science students critical thinking and inspire creative imagination. A study done by Maeyer and Talanquer (2010) concluded that it was very important that science students develop and apply analytical reasoning and be able to evaluate the effectiveness of intuitive heuristics in different contexts.

According to the extant literature, engineering scholars seem even more enthusiastic about imagination, creativity and innovation than scientific scholars (e.g., Charyton & Merrill, 2009; Coeckelbergh & Wackers, 2007). For example, Coeckelbergh and Wackers (2007) claimed that engineers need imagination to transcend their expertise-specific perspectives in order to improve the robustness of their organizations and to be better prepared for crisis situations. Charyton and Merrill (2009) developed the Creative Engineering Design Assessment to evaluate general creativity and creative design ability of engineering majors. In addition, Liang, Hsu, Chang, and Lin (2012) made an effort to establish an assessment index of imaginative abilities for virtual experience designers.

In developing the Imaginative Capability Scale, Lin, Hsu, and Liang (2013) empirically categorized human imagination into three types: initiating, conceiving and transforming. Initiating imagination consists of three indicators, namely exploration, novelty and productivity. It refers to exploring the unknown and productively originating novel ideas (e.g., Folkmann, 2010; Gaut, 2005). Conceiving imagination consists of five indicators, namely concentration, dialectics, effectiveness, intuition and sensibility. It refers to grasping the core of a phenomenon utilizing personal intuition and sensibility, and formulating effective ideas for achieving a goal through concentration and dialectics (e.g., Cartwright & Noone, 2006; Reichling,1990). Transforming imagination consists of two indicators: crystallization and transformation. It refers to crystallizing abstract ideas and apply what is known to different tasks and in various situations (e.g., Liu & Noppe-Brandon, 2009; Vygotsky, 2004). This study adopted the construct of imaginative abilities proposed by Lin et al. (2013).

Based on the aforementioned literature, we proposed the following three hypotheses:

H1. Initiating imagination will influence academic performance.

H2. Conceiving imagination will influence academic performance.

H3. Transforming imagination will influence academic performance.

3. Personal and contextual influences on imagination and academic performance

Many scholars suggested that to fully understand human imagination and creativity, it is necessary to consider interactions between personal and contextual factors (Ivcevic & Mayer, 2006–2007; Shalley, Zhou, & Oldham, 2004). Hennessey and Amabile (2010) held that if studies are to be made in different domains (e.g., sciences, humanities, and arts), a deeper understanding about human imagination and creativity is needed, their process, their antecedents, and their inhibitors. Hennessey et al. suggested that personal (i.e., neurology, affect, cognition, and personality) and contextual (i.e., group,