CREATIVE CROSSROADS: COMBINING ENGINEERING AND ARTS FOR CREATIVE DEVELOPMENT

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The significant global challenges faced in the world today require innovative solutions and creative thinking. In traditional postsecondary education, technical programs such as engineering often focus on technical competencies as opposed to creative thinking. However, as industry demands for creative technical employees continue to increase, postsecondary institutions must adapt their education accordingly. This work combines ideation and creative writing techniques with engineering design to turn initial ideas into significant ideas using an avant-garde literary device referred to as `pataphysics. Tested by both faculty and student demographics, the final three-module framework uses disruptive thinking that leads to the accelerated development of creative solutions.

Many of the world's most significant challenges require new and innovative solutions. Organizations such as UNSECO have identified global problems that necessitate international collaboration and cross-disciplinary problem-solving skills (UNESCO, 2018). Industry leaders actively seek postsecondary graduates with the ability to think creatively while applying technical knowledge (Charyton, Jagacinski, Merrill, Clifton, & DeDios, 2011; Nisula & Kianto, 2018; Intel Education, 2018; Google, 2018; Microsoft Education, 2018). However, barriers such as low creative confidence and discomfort with creative practice may prevent students from individually or collaboratively applying creative practice techniques to create innovative solutions (Niku, 2009; Sweeney & Imaretska, 2016). This becomes more prevalent as companies seek to innovate and keep pace with technological advancement.

This work explores the development of a module series for developing creative thinking ability in postsecondary course work, leading to career transferable skills for graduates. The combination of individual and collaborative ideation techniques allows participants to develop some of the necessary skills to become creators and innovators. The interactive exercises bring students together as collaborators for problem-solving. While there are varied definitions and models of creativity, this paper follows Lubart's definition of creativity as "a sequence of thoughts and actions that leads to novel, adaptive production" (Lubart, 2001, p. 295).

This paper discusses ways to integrate and teach creative thinking skills in technical postsecondary areas. In addition, the preliminary results demonstrate that participants learn techniques for improving their own creative self-efficacy while developing their engagement and confidence towards innovation. The main contributions of this paper are:

1. Development of cohesive methods for engaging in divergent thinking and ideation.
2. Use of collaboration and 'pataphysics as a means to accelerate and maximize the innovative potential of ideas.
3. Implementation of tested techniques for encouraging creative thinking and self-efficacy in postsecondary courses.

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The rest of this paper is organized as follows: In the Background section, the motivation of the work is presented, along with the technique of plussing, ‘pataphysics, and the engineering design process. In the Research Methodology section, the integration of plussing and ‘pataphysics is discussed and the pedagogical module series is outlined. The Preliminary Results section describes early results from various implementations of the module series, and finally, the Impact section discusses the significance of this work for creativity in technical teaching and learning.

BACKGROUND

This work combines interdisciplinary concepts to develop postsecondary teaching and learning experiences in creativity. Creative thinking skills, ideation techniques, creative writing techniques, and engineering design are integrated to develop ideas and inform outcomes relating to innovation.

Bloom’s Taxonomy indicates that students learn and retain information most efficiently when they are creating and evaluating, rather than just remembering (Wilson, 2018). However, students often have little self-efficacy in regard to creativity, and traditional lecture formats do not encourage a culture of creativity (Daly, Mosyjowski, & Seifert, 2014; Liu & Schonwetter, 2004; Kelly, 2016). In traditionally technical programs, such as engineering, creativity tends to be limited to design-based courses, rather than the technical courses that make up the majority of a program (Daly et al., 2014). Arts courses, on the other hand, often develop creativity through discipline-specific processes, including imagination exercises and collaboration (Robinson & Azzam, 2009).

“Plussing” is an example of a technique used to encourage divergent thinking and creative culture (George Lucas Educational Foundation, 2008). Inspired by improvisational theatre, where actors are required to build on one another’s actions and decision, plussing enables collaborative idea generation by avoiding common pitfalls and barriers such as criticism, early closure, echo chambers, and empty support. Rather than subtracting or negating an idea, team members must add on to individual ideas by saying “Yes, and…” to further develop ideas or inspire varied alternatives.

The literary field also employs unique techniques to encourage creative ideation and concept development. One such creative writing technique is called ‘pataphysics, which is the art and science of creating imaginary solutions to real problems (Hugill, 2012). ‘Pataphysics is an avant-garde creative writing technique that taps directly into the realms of the possible and virtual. This creative technique is a "wormhole" to the land of innovative thinking, moving innovators rapidly from the realm of real-world problems and conventional approaches to the realm of possibilities without constraint.

Conversely, fields such as engineering use convergent thinking to determine a solution to a client’s problem or needs. The engineering design process moves from understanding and defining a problem to determining potential solutions, followed by the design and testing of a prototype (Gomez Puente, van Eijck, & Jochems 2013; Plattner, 2011). Engineering and design cycles are widely discussed in current literature and are taught to post-secondary students. However, development of innovative and novel ideas is not as widely discussed in an engineering context compared to other pedagogical practices (Kelly, 2016). Innovation in engineering design could benefit from more emphasis on the ideation process to avoid early closure before the stages of prototype design and testing.

RESEARCH METHODOLOGY

The interdisciplinary design methodology combines techniques from engineering and arts to develop instructional material and practical exercises into a module series, developed and led by the interdisciplinary research team. The techniques of ‘pataphysics and plussing are combined to create a catalyst for encouraging accelerated ideation and inspiration. This interdisciplinary approach disrupts the implicit expectations of innovators and opens new avenues of thought. Ideation exercises are used to practice the technique of plussing, including rapid idea sharing and collaborative teamwork. ‘Pataphysics is then used to repeat and expand the ideation process, accelerating idea hybridization while continuing the collaborative plussing exercises. While an initial solution to a proposed design problem may exist in the realm of the actual, the module progression can be used to further develop solutions in the realms of the probable, possible, and finally the impossible. These increasingly complex and deepened ideas are then brought back into a real-world context using engineering design principles to provide guiding constraints. The outcomes of the module series include defining and practicing several methods to engage in divergent thinking and ideation while using collaboration as a means to improve and maximize the innovative potential of ideas.

Many countries and organizations such as the United Nations have outlined global grand challenges that must be solved for the future of humanity (UNESCO, 2018). For example, Grand Challenges Canada supports innovation around challenges such as humanitarian issues, scalable global health, and global mental health (Grand Challenges Canada, 2018). These large-scale, complex challenges require interdisciplinary innovation to create effective, scalable solutions. The module series introduces a design challenge to provide context for participant practice. However, participants are also given the option to ideate around a global grand challenge of their choice, following a challenge brainstorming session. This provides a collaborative opportunity to ideate around problems that require social innovation, human-centered design, and disruptive creativity.

Module 1: Divergent Ideation

The first module is developed as an introduction to ideation. Participants begin with an assessment package to better understand their beliefs and attitudes towards creativity. Following a short informational lesson on the motivations behind creativity in education, participants are presented with an initial design charge. Individuals are asked to generate an idea-list, allowing each participant to bring their own ideas into the collaboration process. The technique of plussing is then used to help participants practice divergent thinking by producing and sharing ideas. As participants rotate between collaborative partners, their ideas undergo hybridization without criticism or early closure.

Module 2: Ideation Acceleration Using ‘Pataphysics

The second module is designed to accelerate the ideation hybridization process through the technique of ‘pataphysics. Participants are introduced to the concept of ‘pataphysics and learn how they can apply creativity and imagination as they repeat the idea generation process from the previous module, this time developing ‘pataphysical solutions for the same design charge. Both individual ideation and group collaboration are again encouraged through ‘pataphysical plussing. Participants are encouraged to share their complex imaginary solutions with the entire group.

An example of the ‘pataphysical ideation technique is provided to the participants in the form of a hypothetical design charge- to eliminate dripping water from tea bags. An initial realistic solution might be to design an ornate holder. However, applying ‘pataphysics might inspire a completely different idea where an elephant is brought into the room and tasked with eating the used tea bags, leading to a reduction in waste and a well-fed elephant. While the idea might sound ridiculous at first, it can be adapted into real-world solution possibilities, such as a portable elephant-shaped collector that can compost the tea bags.

Module 3: Converging on a Solution

The third module is designed to teach convergent thinking as participants refine their previous practical and ‘pataphysical ideas into more detailed solutions. Participants are taught about the engineering design process and how to analyze the ideas that resulted from the divergent thinking progression. A corresponding matrix, shown in Figure 1 and developed specifically to support the module series, is used to assess the feasibility and impact of each idea. Participants are asked to work in teams to select their final design solution. Early forms of prototyping are used to present the ideas, which may include a descriptive poem, a skit, a physical model, a sketch, or even a design specification. As groups share their solutions, feedback is provided by peers and facilitators in an iterative critique process. The final solution prototypes are presented and each participant concludes with a repeat assessment of creative thinking and self-efficacy.

Idea Assessment Matrix

		Idea:	Idea:	Idea:
Impact				
Target Audience	Who uses this? Who does not use this?			
Created Opportunity	Does it improve society's well-being? What need does it fill?			
Existing Alternatives and Substitutes	What is out there that does the same?			
Feasibility				
Team Competencies	What sets you apart? Why can you do that others cannot?			
Missing Knowledge	Do you know what you are making? What gaps will you need to fill?			
Reasonable Development Plan	Can your team deliver? How will you gain missing knowledge?			
Final Ranking				

Figure 1. Participants assess the impact and feasibility of their solutions using the developed matrix.

PRELIMINARY RESULTS

The proposed modules have been implemented and tested for both faculty professional development and postsecondary student audiences, with approval from the Conjoint Faculties Research Ethics Board. The audience of the professional development workshop included university graduate students, faculty, and staff, as well as interested industry representatives. The workshop participants voluntarily selected to join the program which was listed as one of several possible professional development courses offered through campus educational training. A revised version of the workshop was also integrated into a Winter 2018 interdisciplinary engineering course and was presented to two sections for a total of 256 students. Rather than implementing a final prototype, students assessed their ideation results using the engineering design process and speculated on how they could use a similar process for their course project. This allowed the module content to integrate with curriculum content, regardless of subject or technical requirements, while scaling for a large course enrollment.

Throughout the modules, all participants worked in collaborative groups to solve a real-world problem. Facilitators led the participants through adaptable, interactive ideation exercises that encouraged rapid idea generation and sharing, first in the possible realm, and then in the impossible realm. This helped participants to increase the rate of hybridization of their ideas, which were applied to team discussions as groups worked to solve real-world global challenges.

Both the professional development and student offerings of the module series were implemented to achieve three primary learning objectives related to creative thinking and development:

1. Define and practice several methods to engage in both divergent and convergent thinking.
2. Use collaboration as a means to improve and maximize the innovative potential of ideas.
3. Provide participants with tools to implement and encourage creativity, whether in a post-secondary classroom setting or for their own personal work.

The initial design charge used for both audiences was to design a humane spider or bug trap. Participants were allowed to define “humane” in their own way. Example of early ideation solutions included: “a big robotic spider that can catch bugs and take them outside the house” and “a directed energy gun that uses microwaves to quickly boil bugs.” ‘Pataphysical solutions included: “the wall, ceilings and floors of a building are predatory. They eat any bugs that are on them” and “a bug trap that would lead bugs in to a different dimension in which bugs could live peacefully.”

The professional development offering was also presented with a secondary design charge halfway throughout the series where groups could choose to solve a global grand challenge. Those working on the global challenge chose to solve the issue of homelessness in urban areas, resulting in solutions such as rotating schedules for group housing, stacked living spaces, and even adapting ideas from nature.

Following the conclusion of the module series, professional development participants provided feedback about their achievements and learning in the course. These responses were analyzed using emergent coding to identify themes for future in-depth exploration. Participants expressed outcomes related to creativity and innovation pedagogy, self-confidence, flexibility, and interdisciplinary connections. The following sample quotes demonstrate improved self-efficacy and changes in views towards creativity:

> "I saw some cool ways to teach creative skills."

> "I think I saw that it is less intimidating to "be creative" – that there are skills you can use to generate ideas – and that we all have very different lenses and perspectives from which to be creative."

> "I connected with people I would not otherwise encounter in my profession. I was inspired and I now view creativity in a more dynamic way."

Participants also identified what they felt was the biggest impact of the course. Themes that emerged included application, engagement, and open-mindedness. The following sample quotes demonstrate awareness and exploration of the creative process:

> "Potential for applying some of the structure in other communities."

> "I learned how to be more effective in coming up with ideas! i.e., not shutting down/honing in on a solution too early, and not rejecting ideas too soon. It's made me more effective both at work and in my personal life."

> "It was great to see people engaging with each other and exploring ideas."

> "An awareness of real world applications."

Both the professional development and student audiences noted initial discomfort and awkwardness towards the ideation exercises. Facilitators also observed a quick increase in comfort level, enthusiasm, and engagement from participants, particularly as the rapid ideation exercises forced individuals to practice creative thinking without time for self-doubt or criticism.

IMPACT

The proposed pedagogical modules explore creative thinking development and collaborative ideation techniques that allow learners to develop some of the necessary skills to become creators and innovators. The participants described the following outcomes from the proposed framework: knowledge of creativity and innovation pedagogy, self-confidence, flexibility, and interdisciplinary connections. These attributes are especially important for post-secondary education as they provide students with tools to develop both the divergent and convergent areas of creative thinking while reducing barriers such as low creative confidence and discomfort towards creative practice. The modules provide skill practice through specified design challenges which can then be applied to the development of solutions for global challenges or issues within a particular technical field. Future studies are planned to further examine the data collected on self-efficacy and changes in perceptions towards creativity, as well as potential revisions to the module format to include more time for prototyping and showcasing final design solutions.

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