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SOLVING *TITANIC* PROBLEMS: THE CONTRIBUTION OF DESIGN AND KNOWLEDGE

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ABSTRACT
This paper compares the results in terms of idea generation and creative problem solving from three teams of BA Material and Product Design Engineering students. Teams used a design thinking methodology and the principles of knowledge building to solve a "wicked" problem, (actually we chose a titanic one), the sinking of RMS *Titanic* in 1912 resulting in the death of more than 1500 passengers and crew, only just over 700 survived. Students were figuratively "placed on deck" one minute after *Titanic's* collision with an iceberg and given the problem; "How could more lives have been saved?" The aims of the study were to investigate the effect of combining the process and practices of design thinking with the principles of knowledge building on innovative idea generation. Also, to explore ways of communicating the design thinking and knowledge building concepts to students meeting them for the first time. Student teams using a design thinking methodology developed creative solutions which *may* have saved over 700 additional lives. However, teams using a design thinking process combined with the principles of knowledge building worked creatively with knowledge and developed solutions that *may* have saved the entire ship. Observations made during the study allowed us to suggest why this was the case and offer some suggestions as to how the concepts of design thinking, knowledge building and diverse thinking styles may be communicated to students in a meaningful way.

Keywords: Design thinking, knowledge, innovation, diversity

1 INTRODUCTION

We have been using a design-thinking methodology to assist multidisciplinary student teams unlock their creative potential and generate innovative solutions to complex, ambiguous design problems, (so-called "wicked" problems) [1]. According to Nonaka & Takeuchi, [2] the key to innovation is knowledge and complex problems require both creativity and knowledge to solve them [3]. Observations made on the most highly effective teams working on these types of problems reveal they adopt an effective knowledge acquisition and sharing strategy within a design thinking framework and use this knowledge to collectively improve ideas to create radically innovative solutions. The methods they use are associated with the principles of knowledge building [4].

We have modelled this behaviour and combined the process and practices of design thinking with the principles of knowledge building to develop a unified approach. There is a potential relationship between knowledge building and design thinking. Both adopt a constructivist approach to learning, both address real-world problems and focus on working creatively with ideas. There are differences though, "knowledge building is more concerned with the advancement of knowledge as a learning outcome whereas design-thinking often requires the production of a product or artefact", [5]. This unified approach has been evaluated in several studies where student teams are given a challenge that requires both creativity and knowledge to solve it. Half the teams use a design thinking methodology and half use a design thinking methodology supported by knowledge building principles and the resulting concepts evaluated. Our conclusion is that this approach does help students frame problems at a higher level and generate more innovative solutions relative to students using design thinking alone. However, this presents us with a pedagogical challenge, specifically how two ambiguous concepts can be communicated to students meeting them for the first time and how the value knowledge building brings to design thinking can be demonstrated in a meaningful way. Understanding does emerge over time but we were looking for ways to facilitate the process.

1.1 Communicating Design Thinking and Knowledge Building

Design thinking is a creative problem solving process that starts with understanding user needs, framing problems to establish real needs, generating ideas then prototyping and testing the most promising solutions. It has however attracted a level of criticism over the years and some of this criticism has implications for teaching design thinking and its potential as a driver of innovation. A widely acknowledged issue in the design thinking discourse is the difficulty explaining what design thinking is, there is no generally agreed definition and the "literature on which it is based is contradictory" [6]. Rylander [7] suggests that it is "hard enough understanding design and thinking, let alone design-thinking". Knowledge Building also has some challenges when it comes to communicating the concept to students. While it has an agreed definition as a social activity focused on the continuous generation and improvement of ideas [4], it is based on a set of principles aimed at maintaining creative, sustained idea improvement rather than a "process", practices or a prescribed methodology. In our experience, novice designers who lack domain experience or procedural knowledge benefit considerably from a process. Scardamalia & Bereiter, acknowledge that adhering to a principled rather than a procedural approach has undoubtedly impeded the spread of knowledge building, [4].

A second issue is the type of innovation that might be expected from the human-centred design-thinking approach and the role of empathy as a starting point for radical innovation. Human-centred design has been criticised for lacking the skills & knowledge required to generate radical innovation [8]. Knowledge building has as its starting point a critique of the status-quo and use of expert sources of information.

2 METHODOLOGY

Ten BA Materials and Product Design Engineering students, (2, 4 & 6 semester), were divided into three mixed semester teams and informed that the problem they would be solving was: "Following the RMS *Titanic's* collision with the iceberg, how could more passengers and crew have been saved?" In terms of prior knowledge, several of the students had heard of design thinking but none could articulate the process. None of the participants had heard of knowledge building as a concept. All had heard of the *Titanic* and had seen James Cameron's 1997 epic romance-disaster film at some point. The teams were given a briefing consisting of a list of facts & figures known to the crew of the *Titanic* at the time. It became quickly obvious to the Captain and chief officers that the ship would sink in under two hours, (it actually sank two hours 40 minutes following the collision). 2,227 passengers and crew were on board and 20 lifeboats were available, each with a maximum capacity of 65, enough for only 53% of the passengers and crew.

The teams were provided with information about the scene of the collision. It was a clear night and the sea was flat and calm. A ship, the SS *Californian* had been sighted approximately 6 miles in the distance but is not responding to the *Titanic's* distress signals. The iceberg is less that one mile away. The teams were then instructed to construct a "mock-up" of the scene approximately to scale using materials made available. Teams were further informed that the passengers were initially calm following the collision and reluctant to go towards lifeboats feeling safer with the ship and its captain. The *Titanic* had a reputation of being unsinkable, (though the owners, the White Star Line never made this claim), and had several safety features. All teams were then taken through the college's design-thinking process model and practices which consists of five phases: a research stage followed by problem framing, idea generation, prototyping and concept testing.

The challenge was run in two phases. Phase one was the design thinking round where the teams were instructed to generate solutions using the design thinking process and practices. A facilitator was available to provide assistance, answer any questions and keep team's on-track in terms of time but not to provide or evaluate solutions. A time clock showing ship's time was projected onto a screen starting at 11:40 when the *Titanic* struck the iceberg and displaying information as it became available to the crew in real time. This included: at 12:25 a rescue ship, RMS *Carpathia* sails towards the *Titanic*, estimated time of arrival – four hours. After 60 minutes, the teams were asked to present their ideas to the facilitator and estimate how many lives their concepts might have saved.

In phase two of the challenge, students were introduced to the principles of knowledge building and scaffolding. The principles are aimed at keeping the focus on the continual improvement of ideas and scaffolding, which in this study, took the form of questions that help bridge the gap between problem and solution. The teams were then taken back to the start of the unified model. Unlike design thinking, which takes understanding user needs as it starting point, knowledge building takes a critique of the status-quo and making use of exert sources of information as its starting point. Teams were asked to carry out a critical analysis of the events following *Titanic's* collision with the iceberg and frame a series of questions to be put to an expert, in this case the facilitator who had read into the events surrounding the sinking of the Titanic's in some detail. After a further 60 minutes, teams prototyped their best solutions and estimated how many passengers and crew they were likely to save.

3 OBSERVATIONS AND RESULTS

During phase one, (the design thinking phase), all teams framed the problem in a similar way: "How do we save as many passengers as possible?" They reasoned that people being reluctant to get into lifeboats might be due to a lack of information. The ideas generated in phase one of this challenge can be seen in Table 1.

In phase two of the challenge, where knowledge building principles were introduced, the teams generated a list of questions which challenged the status quo of events following the collision, for example: "Why didn't 53% of passengers make it into the lifeboats", (only 33% survived) and, "Were all lifeboats launched and how full were they?". These are obvious questions and the facilitator was prepared for them. Only 18 out of 20 lifeboats were launched. The consensus in the literature is that there was a general reluctance to abandon the ship and the captain's order "women and children first" was interpreted as "women & children only". As a consequence, several lifeboats were launched with plenty of room for more passengers, simply because there were no more women & children in the immediate vicinity [9].

The teams were encouraged to further critique the status-quo and this generated additional questions: "How sure are we that the ship is sinking, isn't it supposed to be unsinkable?" "If the ship is sinking, could anything be done to prevent this or at least slow the process down?" "How big is the hole in the hull?" "Can holes be plugged in some way"? The "expert" was able to offer answers to these questions. For example, there is a well-known technique at sea called "*fothering*" where a heavy sail is drawn under the ship and the pressure of the water drives the sail into the leak. Teams 1 and 3 asked if there were any photographs of the iceberg. There are and this drew comments from both teams that it looked a lot flatter than they had imagined and generated the question, "Would it be possible to put passengers on the iceberg?" The expert replied that people have survived shipwrecks by climbing onto ice floes and invited the team to think of ways in which they could establish the feasibility of this idea.

Teams were encouraged to use a *knowledge building cycle*, a section added to the design-thinking model which encourages team members to reflect on what they know, what their most promising ideas so far are, what they still need to find out and how they might close the knowledge gap. The action plan for answering these questions was "ask the experts". The teams reframed the problem to how to delay the sinking of the *Titanic* and keep passengers out of the water *for three hours.* This reframe with the shorter time-frame had the effect of adding feasibility, in the team's eyes, of several of their solutions. After 60 minutes, teams were asked to present their most promising ideas and estimate the number of passengers and crew their suggestions might save, (see Table 1):

Table 1. Student team ideas and estimates of lives saved as a result of their suggestions

Phase one: Design-thinking	Phase two: Design-thinking plus Knowledge Building
Team 1: Frame: *How to save as many people as possible?* Get as many people as possible into lifeboats.(Convince people the ship is sinking, structured evacuation plan, fill boats to 130% capacity) Use floatable materials to make rafts. Make catamaran structures between rafts. **Ideas: 3. People saved: 1670 (75%)**	**Team 1:** Reframe: *Keep the ship afloat as long as possible.* Sail a lifeboat towards the *Californian* to attract attention. Arrange a chain of lifeboats towards the *Californian*. Use every means possible to attract the attention of the *Californian*, (rockets & ships horn). Allow the Titanic to flood evenly. Block the holes in the hull with lifeboat covers/canvas, (*fothering*). Connect lifeboats with canvas to form trampolines. Put passengers & crew on the iceberg **Ideas: 7. People saved: 2205 (99%).**
Team 2: Frame: *How can we save more passengers?*	**Teams 2:** Reframe: *How to delay the sinking of the ship?* Send an experienced team to fix the hole on the ship.

Get more people into the lifeboats. (Communicate & keep people calm). Use floatable objects as rafts. **Ideas: 2. People saved: 1336 (60%)**	Close off sections of the ship. Anchor the ship to the iceberg. **Ideas: 3. People saved: 2205 (99%)**
Team 3: Frame: *How can we save more passengers?* Steer ship towards the *Californian.* Communicate the real danger to passengers and crew and organise loading procedures. **Ideas: 2. People saved: 1225 (55)%**	**Team 3:** Reframe: *How to keep people out of the water for 3-4 hours.* Put more than 65 people in each lifeboat. Assign experienced crew: lifeboat loading, building rafts, damage control, (including blocking holes in the hull). Shuttle passengers in lifeboats to the *Californian.* Find alternative ways to communicate with the *Californian.* Re-start the ships engines & use steam to warm the sea-water. Balance the flooding of the ship so she sits evenly in the water. Put passengers & crew on the iceberg. **Ideas: 7. Passengers saved: 2205 (99%)**

3.1 Discussion

All teams managed to save significantly more passengers than the 705 (33%) that actually survived the sinking of the *Titanic*. However, the teams were working with hindsight and near perfect information. Their “passengers” were compliant model figures rather than real passengers in an increasing state of distress and panic and with crew having to cope with a deteriorating situation. Their solutions only had to be prototyped rather than implemented in real life.

In evaluating the team’s suggestions, we consulted the extensive literature available concerning how more passengers on the *Titanic* might have been saved and which consists of numerous websites, journal articles, blogs, books, videos, documentaries etc.

All teams addressed the unfilled lifeboat issue highlighted in the brief. The team’s solutions, had they been implemented, would have saved more lives. Constructing improvised rafts, making greater effort to contact the *Californian*, and plugging the holes in the hull are ideas that might have saved lives or delayed the sinking of the ship. Placing people on the iceberg was arguably the most controversial suggestion. It is a much-debated topic and opinion is divided about the practicalities however, there have been many documented cases of passengers surviving shipwrecks by climbing onto ice. The team’s suggestion to discover if this was possible was to send a lifeboat with crew equipped with lights, ropes, ladders, spikes etc. to assess the situation. Not all suggestions made by the teams would have been effective, the literature suggests that balancing the flooding of the ship would not have delayed sinking and anchoring the ship to the iceberg would have involved considerable risk.

In interviews with team member’s post-challenge, all were of the opinion that the design thinking process and practices were helpful in solving this challenge. They found that framing the problem “how could more passengers be saved?” helped focus on developing floatation devices and prototyping helped test ideas. Concerning the introduction of knowledge building, all felt that critiquing the status quo was a useful path to generating new ideas and more innovative solutions at a higher level. The opportunity to “consult the expert“ was highly valued and helped teams validate or reject trains of thought. The principles of knowledge building were relatively easy to understand and the knowledge building cycle, a main addition to the design thinking model, helped them reflect on what they knew and what they needed to know which drove them to seek more knowledge. Asked if they could apply the combined approach in future projects they thought they could *with expert facilitation.*

The facilitator reported he had little to do in the design thinking phase of this challenge, the teams “just got on with it”. He observed that all teams exhibited aspects of design fixation, latching onto an idea and sticking with it. The facilitator had a different experience following the introduction of knowledge building. The unified model promotes critical thinking and enquiry so he faced a lot of questions. Also, several of the knowledge building principles, scaffolding, maintaining a knowledge-building discourse, and sustaining idea improvement required explanation and reinforcement. He observed that using knowledge building principles help keep students in *design mode*, [10], focusing on the improvability and developmental potential of ideas throughout that phase of the challenge. This demand on facilitators has implications for future studies in terms of their level of expertise and familiarity with leading knowledge building workshops.

4 CONCLUSIONS AND FURTHER RESEARCH

The aims of this study were to communicate the concepts of design thinking and knowledge building, why it makes sense to combine the two methodologies and illustrates what this means in terms of increased concept innovation. Teams using a design thinking methodology proposed an average of 2.3 solutions which if successful would, in theory, save over 700 additional passengers and crew by ensuring lifeboats were filled to capacity and by framing the problem as one of keeping people out of the water and constructing prototype floatation devices. Teams using the combined approach produced more innovative ideas, to develop on average 5.7 solutions that may have saved on average over 1,500 additional lives, almost all passengers and crew. This indicates subsequent knowledge gathering can enhance creative problem solving. They did this by critiquing the status quo, making effective use of expert sources as a starting point to close gaps in their knowledge, reframing the problem at a deeper level and scaffolding their knowledge to improve ideas. Our conclusion is that teams using the combined approach, navigating between the diverse critical and design modes of thinking, work *creatively with knowledge.* The source of innovation lies not just within creativity and stated needs but also in how teams use knowledge to collaboratively improve ideas. The *Titanic* case is an engaging one with a sufficient level of complexity, a stimulus for authentic activity and it enables students to apply diverse thinking styles. It appears to facilitate the communication of the design thinking and knowledge building concepts, and the value they bring to each other. Although this study involved a small number of students, it does support the findings from previous studies with design and business students. Further work on investigating how students combine creativity and knowledge to solve complex problems and over a longer time-frame continues.

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