Lighting the Fuse for Creative Problem Solving

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Lighting the Fuse for Creative Problem Solving

Abstract:

Engineering programs have the unfortunate reputation of stifling the creativity of their students. While the validity of this belief certainly varies greatly depending on many factors, the reality is that the engineering education community can do better. The rigor and pace of the traditional curriculum, the myriad of extra and co-curricular activities associated with campus life, and the pursuit of the all-powerful "A", while important, fight against the joy of deep learning and the space for creative thought and exploration. It is vital to equip and permit students to cultivate their creative problem solving abilities; and let's face it, the world needs better creative problem solvers with a technical education. Unfortunately, engineering faculty face similar struggles when it comes to space and intentionality for creativity. Moreover, engineering educators as a whole are even less skilled at teaching creativity; some might even say that creativity simply can't be taught. But still, the world needs better creative problem solvers with a technical education.

This paper details a series of creative problem solving interventions at Rose-Hulman Institute of Technology (RHIT) implementing a creative problem solving tool with documented industry success. By having participants make individual connections with social, cultural, market, and technological trends, the tool, IdeaKeg^{TM}, has the primary goal of getting participants to simply ask better questions. It naturally follows that better solutions to a given problem can be found if starting from better questions. The IdeaKeg tool was implemented for both teams of faculty and teams of students in several different applications including faculty course development, department retreats, senior design projects, student composition projects, and more. This paper summarizes the IdeaKeg process, the different implementations of IdeaKeg at RHIT, feedback from both faculty and student participants, and reflections from IdeaKeg facilitators. Additionally, this paper provides the results of a study in which two separate groups of similar demographics were tasked with developing creative solutions to two posed problems. For one problem, the group utilized the IdeaKeg tool, for the other problem they worked using a traditional brainstorming process.

Introduction:

Engineering and creativity have always had a love-hate relationship. On the one hand, we own an overarching social contract, to create products, services, and infrastructure which are safe and useful for a public who must trust us. We draw on first principles and best practices whenever we can. We critique each other's work rigorously toward that end. And each team of engineers tends to build upon their own experience, repeating successful design methods and heuristics for efficiency and reliability. Like surgeons who specialize in one procedure, we could, reasonably, end up with all bridges of a certain span being a well-known truss design.

On the other hand, we would love to be designing unique and beautiful bridges like Calatrava's Peace Bridge, for example, which epitomizes the "pressing boundaries" side of engineering.[1] We also recognize, as scientists, that designs based largely on common practice are likely to be optimal only in cost. Everyone knows how to do it well and efficiently. Is that really all the public wants? If so, then, when they ask us to do work for them personally, like houses and office buildings where they will reside, why is there always an insistence on elegance and distinction? Going back to Plato, meaning itself resides in difference.[2] One more standard truss isn't it.

Engineering education shows a certain bent toward the conventional fueled by a combination of those first principles we hope infuse at the core of our students' learning, the hinge role we play producing people whose work society will rely on, and higher education's natural isolation from customer value quirks. Undergraduates are just learning the trade, as well, and their education only includes design of whole products for real clients toward the end. In a way, we are guided in curriculum building by Bloom's taxonomy, which now puts "creating" at the top -- the progression of layers promoting an assumption it should be left for last. There is an intended meaning that higher layers are more difficult and depend on mastery of the lower ones.[3]

At the same time, we feel an obligation to press into new areas with our students, to extend our art through research, and share with them, as much as possible, our derived wisdom. Say, describing to undergrads current research questions and how we are approaching them. We have a need to expose our students to testing the bounds of our theories in the great scientific tradition. For example, letting students replicate experiments with structures and materials. And we share a desire to turn out graduates whose work also improves people's life experiences in intangible ways. All these motivations require dipping our charges creatively into the unknown. Like repeating and testing the known, originative processes like brainstorming have best practices. What are these? How do we go about stretching our students? And, how might these methods be improved?

This exploration, of improving creativity in our students, is the territory we have been probing, with undergraduate engineering students and faculty, at Rose-Hulman Institute of Technology (RHIT). In particular, we have been testing a creative problem solving tool called IdeaKeg, which appears to have certain advantages for engineering education. The tool stimulates curiosity and asks participants to make individual connections with social, cultural, market, and technological trends, many of which they are familiar with. The tool thus resonates with them in various ways, getting brainstorming participants to ask better questions and find bases for deeper solutions. It reaches for possible intrinsic motivations in each person, nudging students toward "why they really are interested in engineering" versus just "getting an A." The IdeaKeg tool was implemented for both teams of faculty and teams of students in several different applications including faculty course development, department retreats, senior design projects, student composition projects, and more. This paper summarizes the implementation of the creative problem solving tool and results of interventions at the course and institute level.

Background and Literature Review:

Creativity has forever been integral to higher education. In the humanities, the main goal may indeed be to produce something new. What good are creative writers who mimic the style of Dickens, or painters whose results are just another Van Gogh? Approaches to teach novelty to students vary widely. Writers, historically, are taught to make first drafts from a "stream of consciousness," saving perfection for later. Composers noodle-out tunes on a piano. Artists and fashion designers open with a series of sketches. Most of these classic methods are targeted to the solo author.

Buried in the effort also exists the argument of whether creative people are born or bred. Can we really teach young people to be Mozarts or Edisons? We all have a sprinkling of students who come in bubbling with new ideas, seeming to be distinct from the rest in that regard. Can we press others into that mold?

There are many mechanisms we can suggest to students to improve creativity. Alex Osborn, who invented brainstorming, also famously carried around a notebook to capture ideas when he had them.[4] This sounds, to engineers, like a standard best-practice.

In engineering, creative acts are obfuscated by the complexity of the problems. A team almost always is required to effect an acceptable design. In the interest of maintaining a shared passion towards a solution, the team ignores being precise about who had what idea first. Results that are later lauded will be attributed to the entire group. So, efforts to instill creativity into engineers do not, so much, revolve around their practicing to gain personal recognition. More often, we build teamwork and sharing skills into students, at the same time as stimulating new ideas.

Thus, the history of teaching engineering creativity has involved processes like classic team brainstorming, where participants build on each other's ideas and take turns proposing new ones. Outside facilitators often are used, promoting the sense of equality among those participants. (As opposed to the team leader playing the facilitation role, or, worse, having the same teacher who grades them playing this role.)

To be fair, there always has been an undercurrent of resistance to team brainstorming.[5] Why can't the best individuals just come up with winning ideas, without this ego-flattening exercise? The fact is that the process is always done as a less rigorous, heads-up beginning that is followed by a plethora of more exacting work. At this front-end event, it is not easy to prove the validity of any particular method, or of group methods generally versus individual idea-hunting.

A famous 1958 Yale University study concluded that individual brainstorming was more productive than group brainstorming.[6] Proponents of group creativity events have noted that the study's authors did not follow best-practices for brainstorming, for example, not having real teams, not using a facilitator, and not having attendees be familiar with the problem or the brainstorming process ahead of time. These issues could have confounded their results. Follow-up studies yielding negative results have continued to have such flaws. (E.g., Only seven of the 50 studies Isaksen reviewed in 1998 used a facilitator, and the general lack of structure did not resemble brainstorming-in-practice.)[7]

Some practitioners point to how a group meeting, with one person proposing an idea at a time, is a slow process which favors more outspoken members. They also show concern that building on each other's ideas serially is a form of "group think," perhaps stifling unsynchronized alternatives.[8]

There are common brainstorming variants which overcome specific objections. With "brainwriting," for example, participants, in silence, all write on PostIts at once, with a facilitator organizing the parallel activity.[9]

Synectics long ago included interventions in their brainstorming, which prevent people from stifling their own thoughts as others suggest ideas. One help was for each participant to write what they were thinking on a pad, then find an opportunity to present those thoughts when they can. And round-robin contributions were often used.[10]

The flattened types of teams long common in engineering are now growingly dominant in other fields.[11] It is easy to argue for face validity to team brainstorming if you want a cohesive team -- it sets the stage for participants on the design team feeling like they are equally valued, and for them to be eager to share ideas with their colleagues.

When, in an engineering process, should a team invention act be invoked? There are surprising answers here. It is not just once you have a well-defined problem, and are ready to consider alternative solutions. The most famous, and original, process surrounding team brainstorming is Osborn-Parnes, and this method portrays multiple places where such team events can be effective.[12,13] Figure 1 shows a common version of this process, depicting six separate opportunities for brainstorming or cycles of divergent and convergent thought:

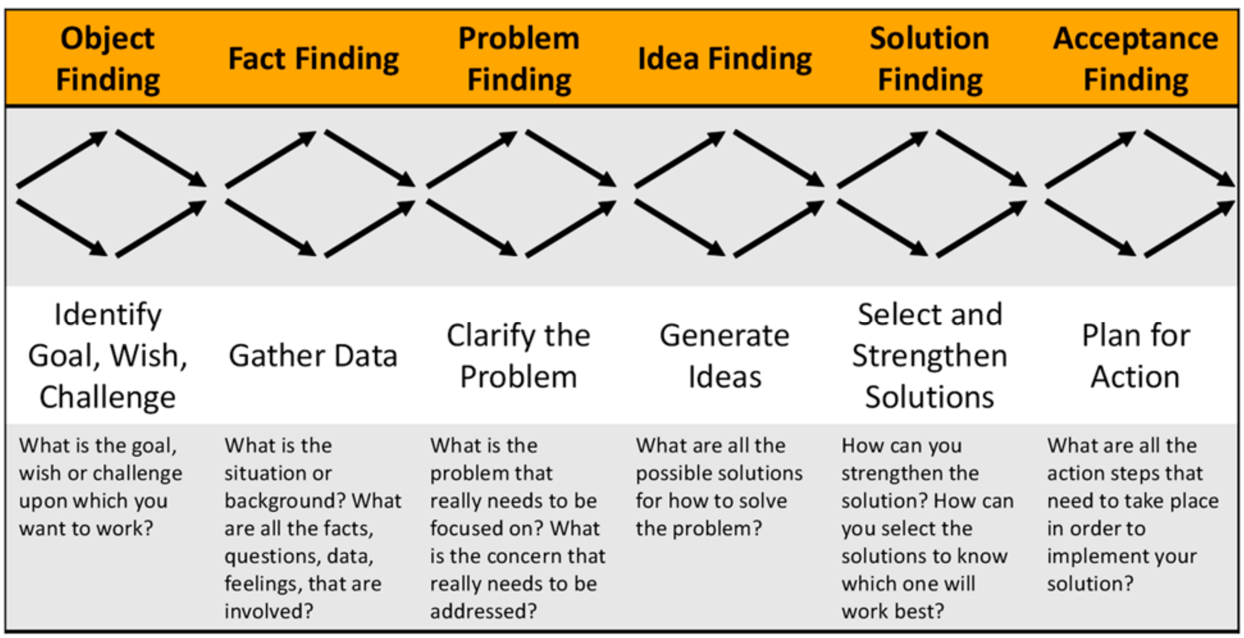

Figure 1: The Osborn-Parnes Creative Problem Solving (CPS) Process[14]

A quick inspection of this visual guide reveals that creative exploration is recommended, for example, just to clarify the problem, prior to trying for a solution. Or, to derive a plan for action, once a strong solution has been found. And at four other times. For a given engineering problem, the use of brainstorming at each stage, or not, would depend on how difficult the problem was and how creative the solution was expected to be. Or, more specifically, how do those questions apply to this aspect of the problem solving process? In engineering, the general identification of the problem-solving phases could be mapped onto particular engineering activities, like customer requirements gathering, high-level design, and acceptance testing.

Note the diamonds shown in this process depiction. These imply that each problem solving step includes both divergent thinking (the arrows which widen each diamond), and convergent thinking (the arrows that funnel down to a smaller number of ideas). Initial understandings, of what brainstorming "is," tend to center mostly on the divergent aspect, the part where you aren't supposed to get critical, but go-with-the-flow. This is really half of each part of the process of creative problem solving. In the end, there needs to be a small set of selected ideas, few enough that team members can go off and act on them. Having the responsible team be in on the selection process, and having them leave a brainstorming event with a list of things to do, are well-known keys to effectiveness.

The ideas of expanding, then contracting, the design space, fit well with standard engineering practices. In essentially all mature fields, teams are expected to come up with alternatives, use tables of associated criteria to weigh these, and then decide on a choice to proceed with. The morphological box is a typical example.[15]

It is probably fair to say that, for the many engineering domains, some form of divergent-convergent thinking is taught in their preparatory programs. And team projects practice using these processes in engineering schools. However, looking at these processes in the abstract, in a way which could be shared across engineering, is not necessarily done. This could cause issues with integrated projects, for example. And it could imply that some of our solution-seeking processes probably are more effective or optimal than others. If we haven't studied what people are doing in other fields, we at least can conclude that we don't know.

Surrounding most team activities, of exploration and decision, are heuristics and best practices about those. For example, it is now well known that participants should walk in the door, of a team participative event, as prepared as they can possibly be. They should know ahead of time the goal of the event and how it will be run, and they should agree to the ground rules. They should have worked on their own ideas, so that they have something ready to contribute.[7]

And they should expect to walk out with action items. These are largely principles for effective meetings in general!

An associated issue with teaching creativity is assessing the outcomes. How do you rate this fuzzy process, with a grade? Count ideas? Or, as suggested for our students over their long term careers, measure backwards from eventual results of the team they belonged to? Andrew Miller of Edutopia suggests assessing these creativity quality indicators, as examples:

- Synthesize ideas in original and surprising ways.
- Ask new questions to build upon an idea.
- Brainstorm multiple ideas and solutions to problems.
- Communicate ideas in new and innovative ways.[16]

Ronald A. Beghetto, recognizing that some assessment methods can actually kill creativity, recommends the following guidelines:

- Minimize social comparisons - focusing instead on self-improvement.
- Reward accepting challenges, believing in one's ability to be successful, and sustained effort in the face of difficulties.

- Minimize the pressure of assessment, reducing surveillance and the sense that students are working for a grade.
- Focus on informational aspects of assessment.
- Recognize risk-taking and creative expression. Show that unconventional ideas are welcome.

Beghetto sees the difficulty in working this territory -- For example, can you reward very creative projects that end up failing to meet other standards? How does that look to other students whose projects succeeded?[17]

One can picture how training will be required for educators whose courses newly include a creative component. Can they say, "I'll know creativity when I see it?" Student ideas which are truly new may not be understood completely by their professors! For fun, let's present some possible solutions, to one of the three problems given to Yale students in the 1958 study testing the creativity of individual versus group brainstorming.[6] This is the problem of enticing more European tourists to visit America. Suppose you had six students (or teams) give the following answers:

1. Pay the tourists' airfare, assuming they will be more eager to come, thus in a mood to stay longer and/or do a lot more spending.
2. Send them coupons good at the tables in Las Vegas -- "can't lose" gambling.
3. Have a campaign for families here to invite their relatives in Europe.
4. Send Americans to Europe as emissaries, showing how friendly we are.
5. Find another group to take their place -- say, people from the Middle East.
6. Lower the value of the dollar.

How would you allocate grades to the six students presenting these ideas? Do you intuitively find one more appealing, yourself? Does this mean it should get an "A"? Indeed, you may envision problems with some of the ideas, and downgrade those as infeasible, going for the one you can picture succeeding. But, creative ideas usually sound like there is something wrong with them, and more effort is required to overcome the issues. All the ideas have possible hurdles, like who pays for what in # 1 - 4? And how about idea # 5, which diverges from even solving the problem you asked? Does that make it more creative, or do they get an "F"? And how about idea # 6? In 1958 it probably sounded absurd. More recently, China has gotten a lot of mileage out of it.

At the heart of the assessment question is the fact that creativity is a different kind of animal from what we feel comfortable in teaching. Creative acts almost portend to be magic, so direct processes, which we teachers might define to get there, aren't reliable. Indeed, people with new ideas often claim they resulted from flashes of insight, even while a careful debriefing shows that they were working hard on the problem, and their flash might as well be explained in more rational ways.

Liu and Schoenwetter described the problem of a lack of teaching emphasis on creativity, in engineering education. We faculty are not, in general, explicitly trained to be experts on this side of engineering. A strategic piece, which makes an idea creative, usually is analogic thinking -- transferring from some other domain.[18] Yet this process is a glimmer, always weaker than any more specific problem solving process which is known to work. In school, we more often are rewarded for knowing or inventing a straight-line solution process. Analogic problem solving is almost indistinguishable from "guessing," which tends not to be rewarded in engineering classes.

In favor of slippery creativity stuff, we should point out that science does have two parts, the systematic one where you rigorously test hypotheses, and the ill-defined one where you propose those hypotheses. To have science, you need both. Traditional undergraduate engineering education tends to be more about learning what's already known. Yet making creative engineering products is more like coming up with those new hypotheses. In both cases, the motivation is to do a thought experiment about something you believe will have an effect, and which can be tested for that. It is a skill we should be teaching our students, even if nobody has a cut-and-dried method for it.

An example of a creativity technique using associations is mind mapping, a variant of brainstorming. Here, the goal is to create a shared, cartoonish picture, showing links from one part of the problem space to another, or from the real problem to analogies, or from problem to possible solution.[19] For engineering teams using these, they may start out as just a representation of the problem as described by a customer, then grow features over time as the team moves toward a solution. An advantage of mind mapping is that it enriches verbal descriptions with its pictures and relationship arrows.

There are hundreds of different variations on brainstorming and creativity techniques that are useful in engineering education. All have in common a step where the participants are challenged to widen their view of the issues to be solved, so as to bring in a solution from a wider field. Burnett and Figliotti's book is an example of one targeting the classroom as the domain for building creativity skills.[20]

A Creative Problem Solving Tool: IdeaKeg

Clearly stated, there are innumerable tools for implementing creating problem solving techniques in the classroom. One such tool is IdeaKeg™, a component of Kiln Ideas Ltd.'s broader collaborative innovation framework known as FuseTrail™ which closely follows that of the Osborn-Parnes CPS model. We picked the IdeaKeg problem solving tool for several reasons. One is that the tool is used by companies for inventing new products and services. It also has been associated particularly with generating ideas and solving problems for startup businesses, and we wanted our engineering students to model this experience in our curriculum. It includes progressive layers of deepening associations for the participants, ending up with an example of how a problem was solved in some other domain, strongly suggesting a possible process for solving the problem at hand for a team of students. Finally, the metaphor turns into a topic of popular interest, something that is catching on, which tends to create further interest in applying the solution across domains.

Each edition of IdeaKeg contains seven wrapped objects, selected because they represent a social, cultural, market, or technological trend. For example, IdeaKeg sessions at RHIT have included a sundial watch (Edition 34), men's designer underwear, and a plastic telescoping periscope (Edition 35). Each object also comes with a brief description of the trends that the object exemplifies. Speaking in regards to the plastic telescoping periscope, an exemplified trend might reference the phone app Periscope,[21] which permits live streaming of video, and include a discussion of the potential impacts of this type of social media.

A team leader (IdeaKeg facilitator) would use the IdeaKeg tool with his or her team to help provide a solution to a problem (expressed as a *Wish*) of a Problem Owner. Specifically, the IdeaKeg tool is used to facilitate divergent thought among the team and aid in the development of new and better problem frames. An IdeaKeg meeting follows the following process:

1. *Observations*: Each object is passed among the members and each member takes turns offering observations about the object. At first the object is wrapped, and, after a period of time, the object is unwrapped and observations continue.
2. *Meanings*: Next, the object continues from person to person, and each team member responds to the following prompt: "What does this object mean to you?"
3. *Trends*: The accompanying notes regarding the specific object are then read to the team. The team is then asked to further connect the object to trends and identify connections.

During each of these steps, the facilitator is careful to document all generated data (Observations, Meanings, and Trends) that are identified by the group in a way that is visible to the entire group. This process can be repeated for up to six more objects in an IdeaKeg edition.

To finish the meeting, the team uses the data as fodder to generate new problem frames expressed in the format: "How might we…" The goal of this exercise is to promote divergent thinking to a particular challenge domain to develop new, bolder questions and determine the problem that deserves energy and attention. This is arguably the most difficult phase in the CPS process, and it is where the IdeaKeg tool proves helpful. The collection of observations, meaning, and trends are used to facilitate forced object association and mash-up thinking between the *Wish* and the IdeaKeg objects. Ideally, this process produces breakthrough questions into new problem spaces leveraging the identified object trends or other insights generated by the process. The new problem frames are shared among the group, and the team votes on which problem frame to further develop.

At this point, the team then works to generate ideas and solutions to the newly posed problem frame. Similar to classic brainstorming, this exercise can be done in person or virtually. As ideas begin to converge, ideally a solution will be formed and an action plan will be developed to bring the new idea to fruition and ultimately as a fulfillment of the Problem Owner's wish. And in the spirit of true creative pursuits, the cycle would begin again with a new wish.

Implementation of IdeaKeg at RHIT:

At RHIT, our wish was to bring creative problem solving into our undergraduate classrooms. Six faculty at RHIT were trained by Kiln Ideas Ltd. to facilitate IdeaKeg in an attempt to bring this industry validated tool into higher education. From September 2015 through January 2016, the trained faculty have facilitated IdeaKeg experiences with 24 separate undergraduate classes (415 separate students) and two faculty groups for department retreats (44 faculty) (Table 1).

Table 1: IdeaKeg Implementations at RHIT

<table>
<tr><th colspan="4">IdeaKeg Implementation</th></tr>
<tr><th>Department</th><th>Event</th><th>Participants</th><th>Problem Owners' Wish</th></tr>
<tr><td>Biology and Biomedical Engineering (BBE)</td><td>Department Retreat</td><td>BBE Faculty</td><td>To develop annual department goals</td></tr>
<tr><td>Civil Engineering (CE)</td><td>CE486 – Civil Engineering Design and Synthesis (2 Sections)</td><td>Civil Engineering Seniors</td><td>To develop projects solutions that meet client's known and unknown needs</td></tr>
<tr><td rowspan="4">Humanities and Social Science (HSS)</td><td>Department Retreat</td><td>HSS Faculty</td><td>To find engaging external advisory board members that ignite the intellectual life of the department</td></tr>
<tr><td>RH131 – Rhetoric and Composition (6 Sections)</td><td>Multidisciplinary Students Project Teams</td><td>To better understand the culture we live in</td></tr>
<tr><td>RH330 – Technical Communication (6 Sections)</td><td>Multidisciplinary Students Project Teams</td><td>To develop creative Grand Challenges modules that appeal to and educate middle school students about STEM</td></tr>
<tr><td>GS130 – Introduction to Sustainability (2 Sections)</td><td>Multidisciplinary Students Project Teams</td><td>To develop a wide range of ideas to address issues with a sustainability project</td></tr>
<tr><td rowspan="2">Mechanical Engineering (ME)</td><td>ME380 – Creative Design (2 Sections)</td><td>Multi-Disciplinary Creative Design Students</td><td>Several Wishes:
• To develop solutions for SpaceX posed problem
• To develop a simplified interface for a tensile testing machine
• To correct a wobbling issues with a mechanical arm</td></tr>
<tr><td>ME470 – Capstone Design (6 Sections)</td><td>Mechanical Engineering Seniors</td><td>To generate bold new solutions for the students' final projects</td></tr>
</table>

Results of IdeaKeg Survey:

To assess the impact and perception of the IdeaKeg tool at RHIT, a survey was distributed to both problem owners and participants. Of the 459 participants, 120 (117 participants and 3 problem owners) completed the survey. Survey responses were divided into two categories: participants (Figure 2) and problem owners (Figure 3). The survey was seven questions on a four point Likert Scale from strongly agree to strongly disagree.

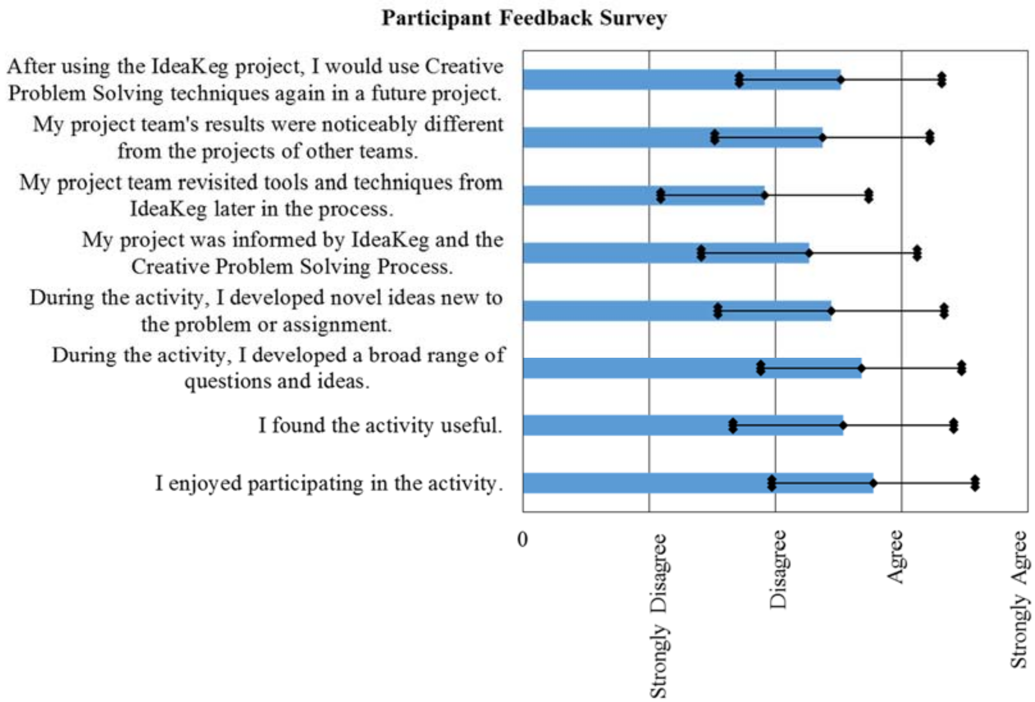

Figure 2: IdeaKeg participant survey results

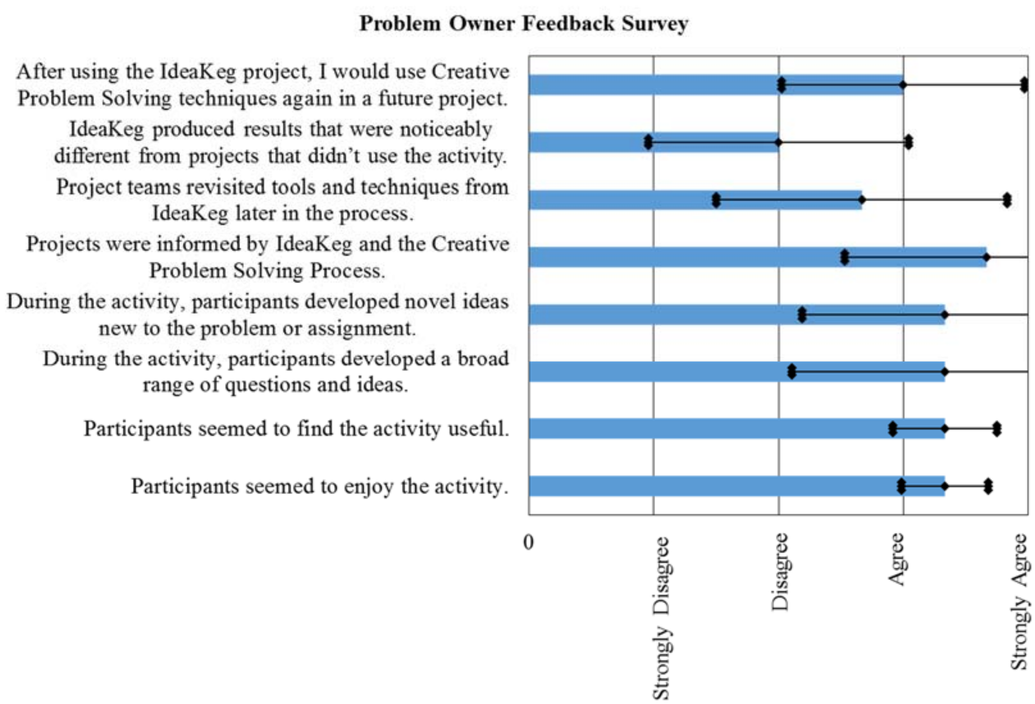

Figure 3: IdeaKeg problem owner survey results

While problem owners tended to be favorable toward the impact of the IdeaKeg interventions, the participant responses were neutral at best when looking at the average. Problem owners believed that team members developed novel solutions and that the activity was useful for team members. While the problem owners would use the IdeaKeg methodology again, the average consensus is that the CPS tool did not result in noticeably different results from previous experiences.

Participant responses were perplexing, to say the least, to investigators based on the feedback we had verbally received from many students. Upon closer inspection, the standard deviations of the responses are quite large. Another item on the survey requested that participants identify their mindset during the event. The participant responses were separated based on a more negative mindset (*Annoyed, Apprehensive, Bored, Confused, Frustrated, Nervous, Reluctant, Resistant, Skeptical*) – 36 participants, versus that of a more positive mindset (*Amused, Curious, Engaged, Enthusiastic, Excited, Open-Minded*) – 79 participants. Figure 4 displays the parsed survey results. In every survey response the positive mindset group proved to be more agreeable. As this might suggest, and as might have been predicted, some participants may have been unsure about this new method and its utility. While the problem owners surveyed would use the IdeaKeg methodology again, the average consensus participants surveyed after one initial exposure to IdeaKeg is that the tool did not result in noticeably different outcomes from previous experience.

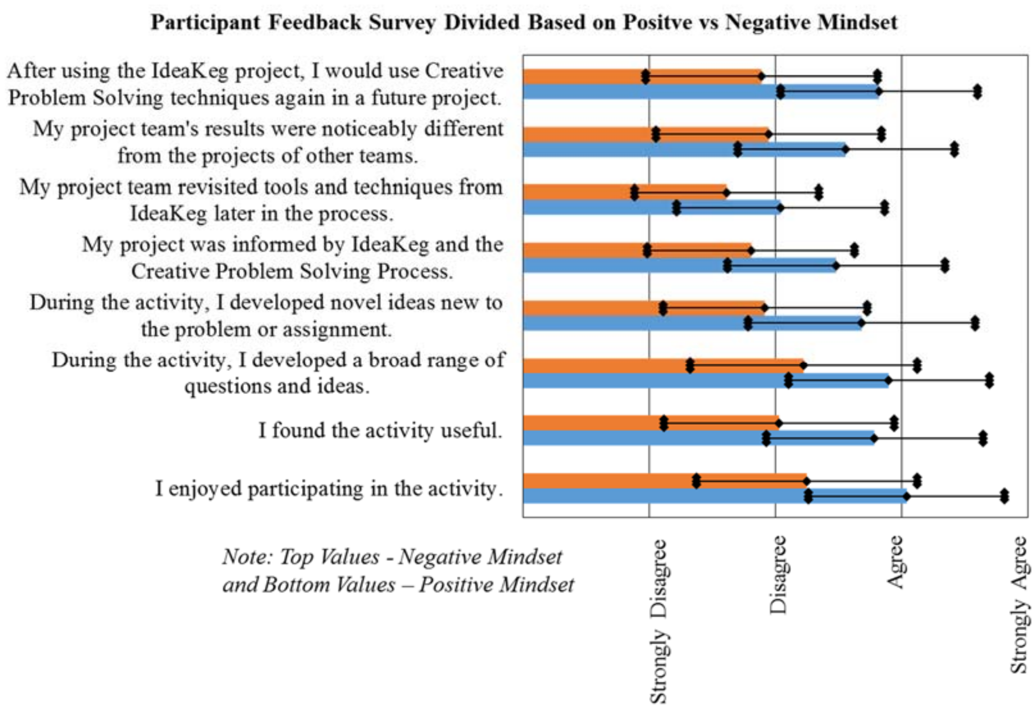

Figure 4: IdeaKeg participant survey results parsed by positive and negative mindset

Experimental Investigation of Ideation Tool:

In addition to the various implementations of IdeaKeg, an experiment was developed to assess the effectiveness of idea generation using the IdeaKeg tool compared to that of traditional brainstorming. The trial investigation was conducted in a creative design course over a period of two days. The class, comprised of mechanical engineering, civil engineering, biology, and electrical engineering students, was asked to complete the Basadur Creative Problem Solving Profile.[22] The profile is a documented instrument that is purposed to identify how individuals solve problems. The types of problem solver, as identified by Basadur, are Generator, Conceptualizer, Optimizer, and Implementer. The class was then divided into two groups by balancing both preferred problem solving preferences and sex. Group A consisted of 12 students and Group B consisted of 11 students.

On day 1, students met in a single classroom and were introduced to the first wish: "*I wish for a quick interface*." The problem owner of the wish was a Mechanical Engineering Senior Design Team working on the development of a quick interface between a grip system and a tensile testing machine. Both groups received the same 5 minute introduction to the problem. Students were permitted to ask any questions regarding the posed problem.

Then, Group A was moved to a separate room, given 40 minutes to develop ideas to address the posed problem with no additional instruction or facilitation. Group B remained in the room and was led through the IdeaKeg process. Two objects were used during the session: men's designer underwear and a plastic telescoping periscope. Students were given 25 minutes to proceed through the observation, meaning, and trend generation as well as problem framing. The final 15 minutes of the class were used to perform ideation, or brainstorm ideas for the new problem frame.

On day 2, the roles of the two groups were reversed. A new problem owner (another Mechanical Engineering Senior Design Team) posed a new wish: "*I wish the arm didn't wobble*." This ME team was working to fix a robotic arm that had a wobble causing suboptimal performance. For the second day, the same objects were used and the same time frame was observed.

For both days and both groups, the ideas were cataloged. Additionally, each group was observed by a third party member to document student behavior and engagement in 5 minute intervals.

Results of Investigation:

Each day the two groups generated a list of ideas to address the posed wish on sticky notes. On day 1, Group A – no instruction / intervention generated 83 ideas and Group B – IdeaKeg intervention generated 71 ideas. On day 2, Group A – IdeaKeg intervention generated 91 ideas and Group B – no instruction / intervention generated 47 ideas. The ideas generated by the separate groups were collected and evaluated based on a creativity rubric. The rubric contained criteria developed following a modification of an academic definition of creativity as defined by Hennessey and Amabile[23] and modified based on a similar study by Davis et al.[24] The criteria for judging each idea were as follows:

- Novel – The idea is new, different than something you have seen before
- Useful / Practical – The idea is something that people could reasonably implement

- Valuable – The idea is worth pursing and/or has a potential for great value
- Wow Factor – The idea exemplifies outside of the box thinking, elegance, simplicity, ingeniousness
- General Impression of Creativity – The overall impression of the creativity of the idea

Each criteria was scored on a three point rubric: 3 – Definitely, 2 – Partially, and 1 – Definitely Not. The ideas from each group were mixed randomly for each wish and evaluated by the course instructor. Table 2 summarizes the results of the scoring exercise. For entries with two numbers, the first number is the number of 3 scores (Definitely) and the second number is the number of 2 scores (Partially).

Table 2: Ideation Results of Ideation Experiment

Ideation Results			
Session	Criteria	Group A	Group B
		(# of 3 Scores / # of 2 Scores)	
Day 1 (Group B IdeaKeg)	**Total Ideas Generated**	**83**	**71**
	Novel Ideas	(47 / 26)	(29 / 31)
	Useful Ideas	(11 / 6)	(2 / 2)
	Valuable Ideas	(13 / 39)	(1 / 32)
	Wow Ideas	(0 / 6)	(0 / 2)
	General Creativity	(5 / 37)	(1 / 21)
Day 2 (Group A IdeaKeg)	**Total Ideas Generated**	**91**	**47**
	Novel Ideas	(43 / 38)	(17 / 29)
	Useful Ideas	(10 / 47)	(6 / 23)
	Valuable Ideas	(4 / 46)	(1 / 25)
	Wow Ideas	(0 / 1)	(0 / 2)
	General Creativity	(3 / 48)	(0 / 25)

It can be observed that the students in Group A were more prolific in idea generation on both days. It also appears that both the generic traditional brainstorming and the IdeaKeg sessions produced “creative ideas” regarding the posed problem. Comparing Groups A and B, Group A outperformed Group B on all categories on both days. Comparing Day 1 versus Day 2 for the two groups illustrates that Group A was equally productive in idea generation and Group B produced much less on the day without the IdeaKeg activity. It is important to reiterate, that the ideation timeline during the IdeaKeg session was only 15 minutes as compared to the full 40 minutes in the session without instruction. While the full class period was utilized for the complete experience, one could argue that the two groups were **much** more prolific when using the IdeaKeg tool on all criteria.

This sentiment is confirmed by the transcripts of the observers for each of the two groups. The observer in the IdeaKeg session commented consistently that the entire class was “highly attentive and engaged in the activity and problem at hand.” The observer in the classroom without instruction consistently noted that student work tended to “get off track” and that students were “not consistently engaged” in the activity.

As a final assessment of the idea generation comparison. The Problem Owner from Day 2 was asked to evaluate the ideas generated from Group A and Group B. The Problem Owner was asked to identify any ideas that were new and worth pursing in addressing their wish. For Group A, with the IdeaKeg Intervention, the Problem owner identified 27 ideas that were worth pursuing. For Group B, without any intervention, the Problem Owner identified 18 ideas worth pursuing. While the next big innovation often comes down to just one new idea, it could be argued again that the IdeaKeg activity was more effective than the traditional unguided brainstorming at idea generation.

Conclusions and Recommendations

A group of faculty have engaged RHIT with the implementation of a creative problem solving tool called IdeaKeg. The tool, founded on principles of the Osborn-Parnes CPS model, engages participants in forced object association and mash-up thinking in an attempt to develop better problem frames. The tool has been used with both faculty and students in several undergraduate course and department retreats. Additionally, the team performed an investigation comparing the effectiveness of the IdeaKeg tool versus that of traditional unstructured brainstorming.

Based on the implementations and experimental investigations, the investigators have made the following conclusions and recommendations:

- The IdeaKeg tool appears to be more effective at idea generation than traditional unstructured brainstorming.
- Simply providing space for students to brainstorm without guidance can result in creative idea generation.
- The IdeaKeg tool provides a functional structure to fully engage students in the classroom.
- Students generally enjoy the IdeaKeg experience.
- For successfully ideation, it is crucial, when implementing a new CPS tool in the classroom, to promote participant buy-in and a positive mindset toward the activity.
- Student/Participants struggle to see the impact of the IdeaKeg interventions, but Problem Owners/Instructor see the merit of using the tool.

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