Humorous Improvisation Tailored for Technical Innovation

***Peter Ludovice*[1], *Lew Lefton*[2], *Richard Catrambone*[3]**

Abstract – Enhancing creativity among U.S. engineers has been labeled a high priority by government, industry and educational institutions. We applied humorous improvisation to various engineering design classes by using the creative energy derived from humor as the stochastic fluctuations in a Monte Carlo search of idea space. Analysis of the initial results of various innovation workshops using improvisation allowed the development of a three step process ideally suited for technical innovation. While humorous improvisation has been used successfully for decades in generating business and marketing ideas, it has not been successfully applied to engineering innovation. This lack of success is due to a significant difference in the shape of idea space between technical and non-technical fields. Technical idea space is more constrained than its non-technical counterpart, and therefore requires a systematic procedure that reflects this fact. Our three step approach to engineering innovation uses humorous improvisation in an initial divergent step to traverse idea space. This is followed by a convergent and emergent step that is required to address the constrained nature of this idea space. This three step procedure was applied to engineering design in various academic and professional groups. We present an analysis of this method and how it effectively addresses technical innovation. How it can be applied to engineering design classes is also discussed. Analysis of these applications indicates that this three step approach is superior to humorous improvisation alone. Other tests indicate that this method can also be applied in a video conference format.

Keywords: innovation, design, improvisation, humor, creativity, divergent thinking

INTRODUCTION

The use of humor in innovation is by no means new. Arthur Koestler wrote extensively on the equivalence of humor and innovation [1]. Both humor and innovation require the incongruity of shifting from one train of thought to another that is significantly different. Edward de Bono suggested a similar approach in his work on lateral thinking [2]. This incongruity in both humor and innovation is illustrated schematically in Figure 1. Humorous approaches have been applied to generating innovative ideas in business and marketing for decades. This approach has been recently described by John Sweeney of the Brave New Workshop improvisation troupe of Minneapolis, who uses humorous improvisation to generate innovative ideas [3]. While approaches similar to that of Sweeney may be effective in generating innovative business and marketing ideas, they are not effective for technical innovation because of the inherent difference between the shape of technical and non-technical idea space.

Idea space is an N+1 dimensional variable space defined by the complete set of N variables required to define a design, and one variable that describes the feasibility of the design. In designing a container these N dimensions would include variables such as the geometry of the container, the wall thickness, the method for joining seams and the materials of construction. Many design approaches sample idea space only in the relatively feasible space of this last dimension so as to avoid consideration of infeasible designs. However, it is our contention that exploring the

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infeasible domain of this last dimension will suggest other ideas that may be superior designs, once the infeasibility is addressed. We describe such forays into infeasible space as divergent thinking which attempts to produce a crazy, silly, wacky, idea that is infeasible. An example would be to suggest peanut butter as the material of construction for the aforementioned container. The inferior thermal, tactile and mechanical properties of peanut butter make it an infeasible material choice for a container. However, this infeasible idea, when one attempts to apply it, may conjure up thoughts of making the container edible or biodegradable. This is the convergent step we discuss below. The third, or emergent step, occurs when the group considers this convergent step of making an edible or biodegradable container. At this point more traditional design or brain storming might produce biodegradable container applications such as re-absorbable scaffolds for tissue engineering, or a controlled-release pharmaceutical tablet, which is essentially an edible container that slow releases a pharmaceutical agent.

Like Sweeney, we utilize humorous improvisation as an exercise in divergent thought to sample idea space. However, we also add a convergent and emergent component to the approach to direct the divergent thought back from infeasible space to more feasible space that is physically realistic. Because a marketing idea for a new advertising campaign is not constrained by the laws of nature, it can be infeasible (i.e. advertisements may employ any fantastic idea). In contrast, technical innovation must produce a final design idea that is severely constrained by physical laws, and therefore requires a fundamentally different approach than marketing applications of humorous improvisation (i.e. the addition of the convergent and emergent steps described above).

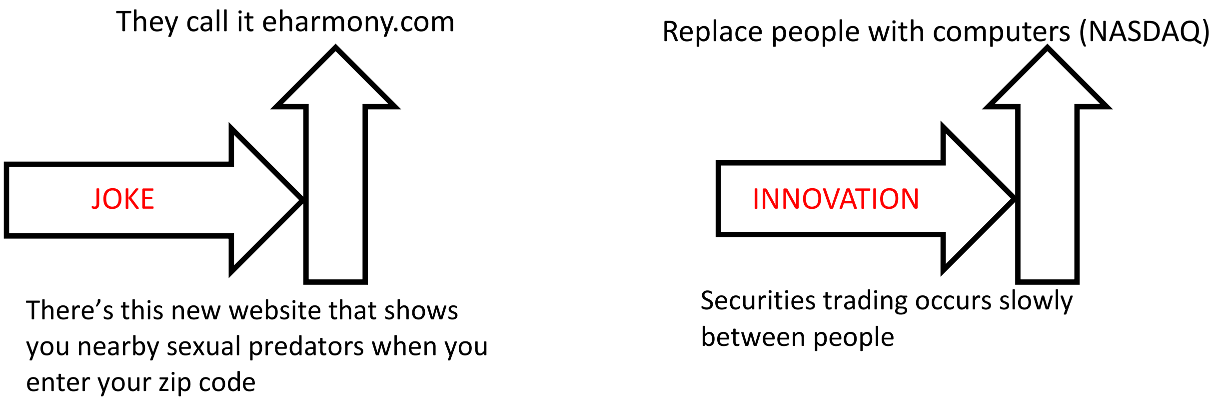

FIGURE 1. Schematic of the incongruity that exists in both humor and the creativity of innovation. Examples include a joke from comedian Nikki Glaser [4], and the hypothetical thought process behind the formulation of the NASDAQ stock exchange.

Technical innovation consists of two basic components: (i) design, and (ii) creativity. This is a distinction important in technical fields that was not made in the equivalence of innovation and humor discussed by Koestler and de Bono. These two components work in concert to produce technical innovation. The design component consists of various frameworks that organize the relevant N design variables, characterize tradeoffs and conflicts between various objective functions (e.g. economics, performance and robustness) and their associated independent variables, and means to find optimal combinations of these independent variables. A commonly used design approach that organizes such variables is the TRIZ method [5]. The design component is well understood in engineering and numerous approaches to design have been developed. However, creativity is typically lacking in engineering fields because it requires engineers to use divergent thinking. A study comparing university music students with engineering students found that the music students had significantly more artistic creativity, while there was no statistically significant difference in technical creativity between the two groups [6].

Given this creativity deficit among engineers, our work focuses on the creative, rather than the design component of innovation. We will apply the same divergent thinking to this creative process that Koestler and de Bono discuss. However, we will draw an analogy between the shape of idea space and the shape of energy space for a molecular system to illustrate the optimal approach to applying humor to technical creativity. The field of statistical mechanics provides the best framework for describing the search through idea space via the analogy of idea space and molecular energy space. Here conformation is defined by the N dimensions (i.e. bond length, bond angle etc.) and energy is the last of the N+1 dimensions in this space. This framework was used to develop an approach to catalyze creativity in engineering design, and this approach was used in workshops with engineering students to examine the effectiveness of this method.

APPROACH TO IMPROVING TECHNICAL CREATIVITY

Our approach to improve technical creativity uses humorous improvisation to increase the sampling of idea space. The fundamentals of this approach can be better understood by examining the use of statistical mechanics to describe the manner in which molecular conformations are sampled at a constant temperature. For a molecular conformation to traverse conformation space, its kinetic energy, which is proportional to the system temperature, must be sufficiently high to allow it to overcome local barriers in energy as seen in Figure 1. In the computer simulation of molecular structures, the simulation begins with an initial guess which is then allowed to equilibrate via algorithms such as molecular dynamics (MD). This algorithm adds a specified amount of kinetic energy to the system that is proportional to the system temperature in accordance with the equipartition theorem. For a system at constant temperature and volume, the probability P of sampling a particular state at energy E is given by the Boltzmann factor $P=e^{-E/kT}$ where k is Boltzmann’s constant, and T is the absolute temperature. If the temperature T is relatively low, the sampling of high energy states is limited. Typically, molecular simulations begin with an initial guess far from the equilibrium conformation (which is not usually known). Then MD or similar algorithms are used to sample molecular conformation space until the molecular systems finds a low equilibrium energy as seen in Figure 2. However, many bulk molecular systems, especially those that contain significant entanglements such as polymer melts or solids, are too viscous and cannot overcome the significant barriers seen in Figure 2. In such cases, MD simply oscillates about a local energy minimum near the initial conformation as seen in Figure 2.

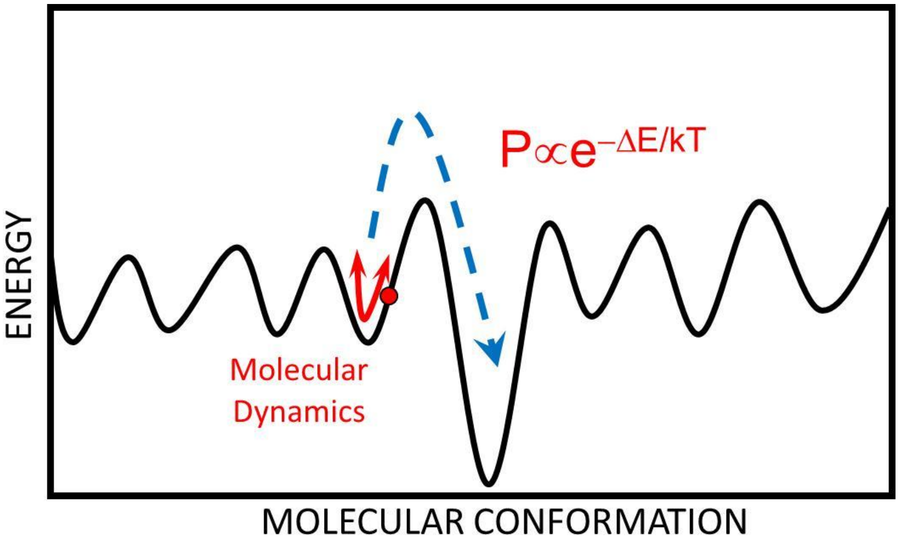

FIGURE 2. Representative energy landscape of a typical molecular system. For energetically constrained or viscous systems, traditional molecular dynamics (MD) is unable to broadly traverse conformation space and move an initial starting conformation (dot above) to a lower energy equilibrium conformation. This can be overcome by adding additional kinetic energy (T) to reduce the Boltzmann probability ($P \propto e^{-\Delta E/kT}$) of accessing the higher energy states of the barriers in the energy landscape.

Many strategies can be used to overcome energy barriers to broadly search conformation space and increase the chances of achieving a low energy equilibrium conformation. Such strategies are an active area of research because the simulation of viscous polymer systems is important in the design of new polymers. These strategies can include simply increasing the temperature of the system (annealing), making random conformation changes (Monte Carlo models) or increasing local fluctuations (various stochastic models). All of these approaches sample higher energy states to allow for a broader sampling of molecular conformation space. An analogy to sampling idea space can be made by replacing the horizontal axis in Figure 1 with idea space and the vertical axis with idea infeasibility. This produces Figure 3, which frames our technical creativity challenge. As with molecular simulation, technical design begins in the vicinity of some initial design. While this initial state may not be stated explicitly, designers are inherently biased by prior knowledge in the field. The goal of sampling idea space is to find a design idea that is far from the initial state (novel solution), but is also a feasible solution to the design challenge. Failure to broadly sample idea space will simply explore known solutions to the design challenge. This is what Osborne's traditional brainstorming accomplishes, making it the creativity equivalent of molecular dynamics [7]. Osborne's traditional brainstorming approach has been shown to be less effective at broadly sampling idea space [12].

Sampling infeasible space in Figure 3 is analogous to sampling high energy space in Figure 2, and is the approach used here to produce a novel design solution. This sampling begins with a divergent step that broadly samples idea space far from the known solutions to find a novel idea. We use humorous improvisation to produce this divergent step. The humor in the humorous improvisation generates a number of divergent infeasible (silly) ideas. Humor is the equivalent of the kinetic energy (or temperature) in molecular systems. Instead of kinetic energy to help sample high energy states, humor provides the creative energy that samples infeasible idea space. One can define a new Boltzmann-like factor where the probability of sampling infeasible states is a similar function of the barrier to idea space sampling and the amount of humor in the humorous improvisation exercise as seen in Figure 3. This is a useful metaphor to describe how humor increases the sampling of idea space. However, an equivalent metaphor is that humor randomly generates novel infeasible ideas in the context of a Monte Carlo model[8]. Regardless of the metaphor, humor samples infeasible idea space as seen in Figure 3. Humor and humorous improvisation has been used to produce creative ideas in business and marketing for decades. Sweeney recommends capturing these divergent ideas from a humorous improvisation exercise in a large list for later evaluation. Such a list approach was shown to be ineffective in a 2007 Purdue study [9]. However, Sweeny's approach may be effective because of the difference in the shape of idea space for technical and non-technical idea space.

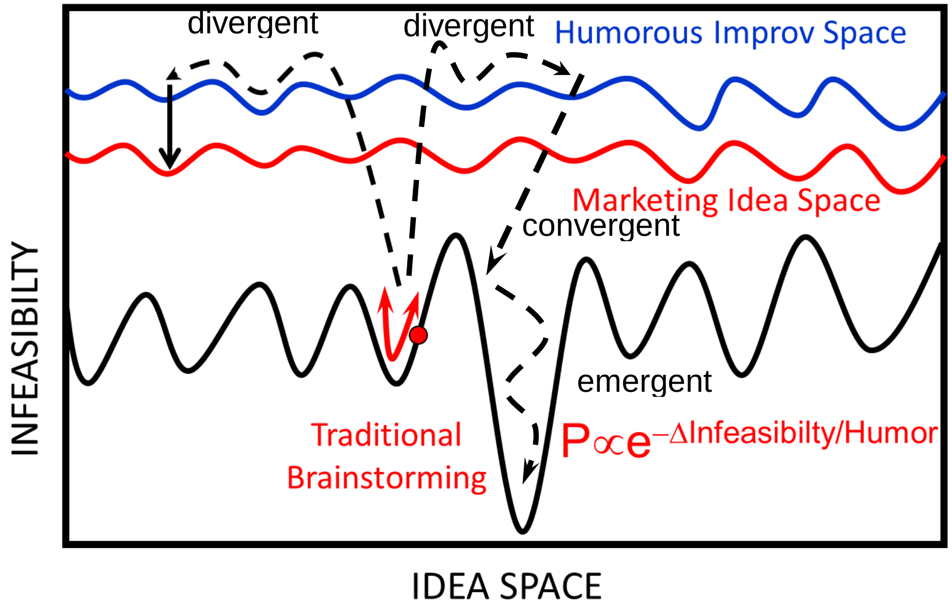

FIGURE 3. Equivalent landscape in Figure 2, but for idea space instead of molecular conformation space. Here, the vertical axis is the infeasibility of a particular idea, and humor is the energy that produces infeasible ideas. Traditional brainstorming often fails to broadly sample idea space because it does not probe sufficiently infeasible ideas to overcome the barriers to novel and creative solutions. A single divergent step uses humor to probe infeasible idea space for business and marketing. However, additional convergent and emergent steps are added to navigate to the more constrained technical idea space.

Because ideas for marketing campaigns may violate numerous physical laws of time, thermodynamics, kinetics, material properties, they are not far from the silly ideas that occur in humorous improvisation space (see Figure 3). This allows a list of these divergent ideas to be collected and used to inspire a marketing campaign. Because the original divergent ideas generated are adjacent to potential marketing ideas in idea space, little or no convergent step is required to produce the marketing idea. The best illustration of this is the annual crop of Super bowl commercials that are usually humorous and based on silly ideas. It is easy to imagine that the popular marketing campaign for the Geico® Insurance Corporation might have come from an improvisation exercise that involved a talking animal. The talking animal itself is almost the same as the ultimate marketing idea it produces. In contrast, this divergent step is far from a typical design solution in technical idea space. Therefore we apply a convergent step that uses the original divergent idea to inspire a potential solution to the technical design challenge at hand. This design solution then undergoes a final emergent step, in which the group collaboratively evaluates the feasibility of this potential solution. The emergent step addresses the requirement of satisfying various physical laws inherent in technical solutions that does not commonly exist in non-technical design challenges.

In practice, this three step approach consisting of a divergent, convergent, and emergent step is accomplished by writing down ideas in a two column list. Humorous improvisation generates divergent ideas that are recorded in the left column of the list. Simultaneously, ideas related to the technical design challenge are recorded in a neighboring column. This second set of ideas are part of a convergent step in which the initial divergent ideas inspire an idea related to the design challenge by associated thinking. The divergent idea is a catalyst for the convergent idea via associative thinking. Mednick suggested that associative thinking could produce creative ideas [10,11]. Koestler referred to the use of such thinking to connect disparate ideas as bisociation [1]. Since associative thinking connects the divergent idea with the design challenge, it is useful to include participants who are experts in the relevant technical field that understand the design challenge. This allows the divergent idea to catalyze an associated idea in the mind of an expert that may be quite feasible given the expert's knowledge of possible technical solutions. Previously, it was thought that experts were too constrained in their thinking to engage in divergent thinking. However, Sawyer suggests that experts are important to the innovation process [12]. This list of convergent ideas associated with the design challenge is produced by all the participants, except those who are involved in the actual improvisation. The combined list of convergent ideas is then discussed by the group and evaluated with regard to its feasibility as a design solution. This is a collaborative discussion that allows a feasible design solution to emerge. This emergent step produces a solution that is in the well of feasibility in Figure 3.

As with most improvisation sessions, we begin with a number of warm-up exercises to get the participants in the appropriate frame of mind. These often include exercises such as "Pass the clap," and "Free Association" [13]. Information on typical improvisation exercises are readily available from a variety of sources [13-15]. While most engineers in our participant samples have heard of humorous improvisation, thanks to the popularity of television programs like "Whose line is it anyway," few of them have ever participated in humorous improvisation. For this reason, we often use improvisation exercises (called games among the improvisation community) that require minimal effort in the performing arts. This is designed to mediate any cultural barrier that may exist among our target demographic with regard to such a free-form performance genre. Typically, our first exercise used is "Snapshot," in which the participants pose as though they are in a vacation snapshot while one of the facilitators that are leading the exercise improvises a narration to the accompanying slide show.

RESULTS & DISCUSSION

The innovation protocol described above was applied to various engineering students and educators under human subjects research protocol number H08340 approved by the Institute Review Board of the Georgia Institute of Technology. An initial workshop was carried out with a sophomore mechanical engineering design class at Georgia Tech (ME2110) in 2009. This workshop showed encouraging results in the form of a correlation between those that thought the exercise was fun, and those that thought it was potentially beneficial for technical creativity [8]. Subsequent to this initial workshop that simply used humorous improvisation, we added the two additional convergent and emergent steps. Figure 4 illustrates such a workshop in progress at the 2011 national meeting of the American Society of Engineering Education (ASEE). As with most of our public workshops, there is no specific design focus similar to those presented in an engineering class. Random suggestions are typically taken from the audience. For example, this ASEE session resulted in the design of a new barbeque process for cooking pork barbeque. The divergent idea was derived from a humorous improvisation about the Spanx® brand shaping undergarment. This lead to applying a band or wrap during the slow-cooking of the barbeque. This idea for wrapping the cooking barbeque in a mesh was the convergent idea associated with Spanx®. This is recorded in a two column list seen in Figure 4.What emerged from the discussion is the application of a metal mesh that compresses the cooking barbeque to squeeze excess fat from the meat thereby resulting in a leaner product.

FIGURE 4. Pete Ludovice (left), and Lew Lefton (right) improvising with a workshop participant (center) at the 2011 National Meeting of the American Society of Engineering Education. Divergent and Convergent ideas are recorded adjacent to each other by the workshop facilitators and the participants.

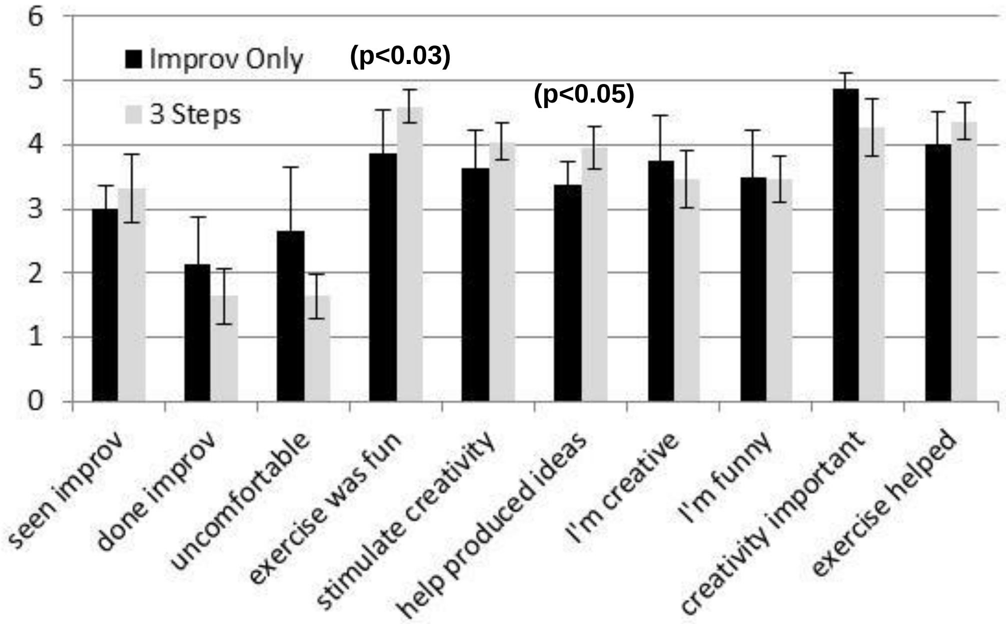

FIGURE 5. Response to questions (1= complete disagree, 5=completely agree) on the post workshop survey from a 2011 chemical engineering product design course (CHBE4535) N=22, and a mechanical engineering design course (ME2110) workshop. The CHBE4535 workshop used the three step process, and the ME2110 workshop used only humorous improvisation without a convergent and emergent step. The error bars are the 90% confidence intervals about the mean response and statistically significant differences are indicated above.

The first application of this three-step method to a more focused engineering design challenge occurred in a product design course in the Georgia Tech School of Chemical & Biomolecular Engineering (CHBE 4535). This is a course in which students design a product using chemical engineering skills. While examining one group's attempt to design a shoe deodorizer, we began with a divergent idea from a sophomoric bathroom humor joke [8]. One of the convergent ideas that resulted was the use of natural reeds in scented oils as a bathroom deodorizer. Capillary action in the channels of the natural reeds improves the mass transport of the scented oils to the room air. This convergent idea was produced by of one of the facilitators (P.J.L.) and reflects the importance of using the entire group to generate convergent ideas. A middle-aged college professor whose spouse places reed diffusers in bathrooms is much more likely to produce this idea than a typical college student. In contrast, college engineering students will likely produce vastly different ideas. After discussion with the group, the final emergent idea produced was the use of capillary channels in a shoe insole to distribute a liquid deodorizing chemical throughout the shoe. A comparison was made of the post-workshop surveys between this workshop (N=22) and the original ME2110 workshop (N=8) that utilized humorous improvisation, but not the subsequent convergent and emergent steps. This comparison is seen in Figure 5. Only two of the questions showed a statistically significant difference for $p<0.1$ from an ANOVA analysis. The difference in the degree to which the participants found the exercise fun ($p<0.03$) might have been attributed to the use of only a humorous improvisation step in the ME2110 case. However, the CHBE4535 course had a higher mean response for this question suggesting the association of the divergent and convergent ideas may be more humorous than the divergent ideas from the humorous improvisation. The examples provided above are consistent with this supposition. The difference between two classes for the answer to the question "The exercises done in this improvisational session might potentially help produce useful ideas for our classes design project," was also statistically significant ($p<0.05$). While the sample size of these workshops was relatively small, they do imply that the addition of the convergent and emergent steps may be effective.

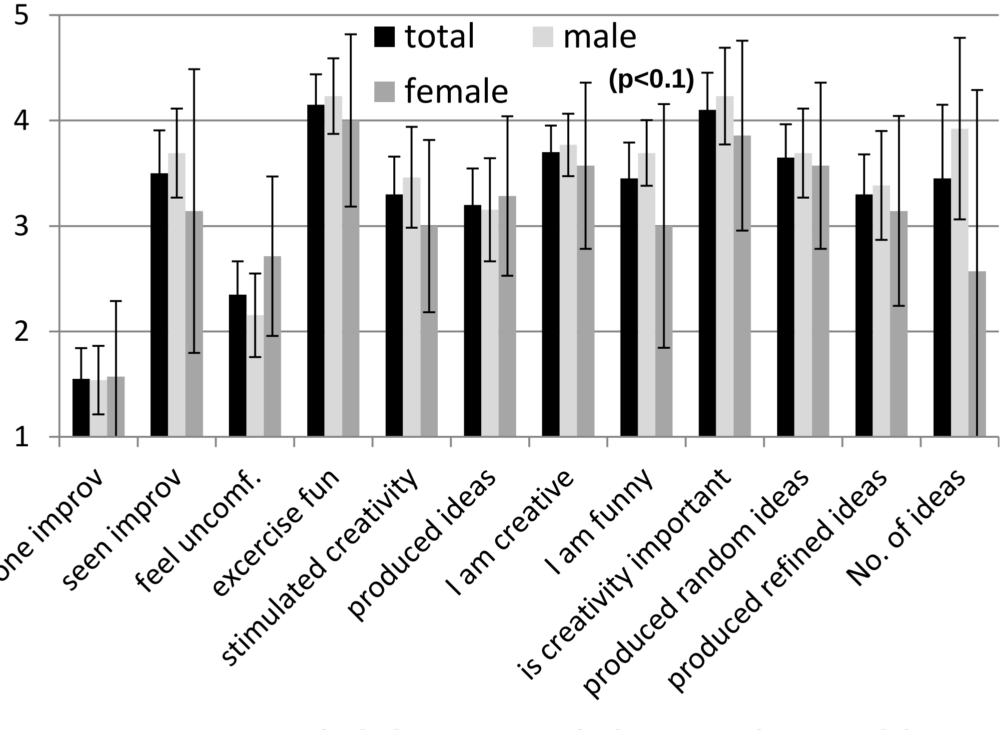

FIGURE 6. Response to questions (1= completely disagree, 5=completely agree) on the post workshop survey from a 2011 chemical engineering capstone plant design course (CHBE4505) N=19. The error bars are the 90% confidence intervals about the mean response and no responses were statistically different between genders at a 90% confidence level except for whether or not a participant considers themselves to be a funny person ("I am funny").

The three step process was applied to a traditional chemical process capstone design class at Georgia Tech (CHBE4505) in 2010. The students were tasked with designing a reactor to coat lead oxide particles with sulfuric acid to produce a paste for lead-acid batteries. This project was sponsored by a battery company who wished to redesign its existing acid coating reactor. Unlike the general design of the shoe deodorizer, this design challenge is more specific and addresses a conflict in design variables typical of many design approaches like TRIZ. The design variable conflict resided in the desire to scale up the size of the acid coating reactor, while this size increase limits transport in the reactor. Increasing the size of the reactor requires additional acid spray nozzles, but putting them in the middle of the reactor appeared to lead to clogging of the nozzles. Organizing such variable conflicts is the goal of many engineering design protocols such as TRIZ [5]. However, trying to circumvent this seemingly insurmountable conflict in variables is a matter of creativity as discussed above. Our three step improvisation approach addresses this creativity requirement.

Using the "Snapshot" improvisation exercise described above, a divergent idea resulted from a flatulence joke. While such an idea seems unusual for a design session, it is exactly this unusual nature that makes it more divergent than the ideas resulting from more traditional brainstorming sessions. This flatulence joke inspired a convergent idea regarding changing the phase of the coating reactor via association with a scene from the Warner Brothers feature film "The Bucket List." In a scene from this movie, Jack Nicholson reminds his young assistant played by Sean Hayes that incidents of flatulence are not to be trusted as one ages. This suggests that phases other than the gaseous phase might be involved, and this suggested the convergent idea of utilizing a phase change. In the ensuing discussion, a student suggested separating the acid from the water component of the aqueous solution. For sulfuric acid, this results in the separation of gaseous SO_3 from water. Using gaseous SO_3 mediates the aforementioned mass transfer limitation because gases have a higher diffusivity than liquids and a gas can continuously cover the reactor space. Four of the five finalists in the contest for best design sponsored by the battery company were inspired by the improvisation workshop. The winning design was a fluidized bed in which wetted lead oxide particles were contacted with gaseous SO_3 as the fluidizing agent, which was derived from the ideas described here.

The response to a post-session questionnaire asked participants a variety of questions regarding their disposition toward humor and improvisation as well as their impression of the improvisation exercise carried out in a subsequent CHBE4505 class in 2011 that included additional information such as age and gender. The results showed little difference due to gender, as the only result that was statistically different was for whether or not people considered themselves to be funny. The general results suggest the students found the exercise helpful, but the most telling results are the estimates of how many potential design ideas resulted from the exercise ("No. of Ideas"). Given the large variance in the answer to this question from female participants, the estimates were not statistically different between genders, but the average was between 3 and 4 ideas for the workshop. It is difficult to objectively estimate whether or not this numerical estimate is reasonable. This numerical question was not asked in the aforementioned CHBE4505 design of the acid coating reactor. However, the fact that four ideas generated from this improvisation exercise ended up as finalists in the design competition is qualitatively consistent with the average obtained here.

A similar exercise was carried out via remote teleconference with a mechanical engineering design class at California State University at Fresno in collaboration with Dr. J.S. Shelley, the course instructor. The facilitators of the workshop (P.J.L & L.L) interfaced with the Fresno class and Dr. Shelley via teleconference and carried out all the improvisation exercises in this manner. This class (N=9) was attempting to design a stand to test the performance of an airplane engine. The average results of the post-workshop survey where more encouraging than similar averages from a seminar in another product design class (CHBE4535) similar to the one described above, but carried out in 2012 (N=19). However none of these results were statistically different at a confidence level of 90%, with one notable exception. The only statistically significant difference was in the number of useful design ideas that participants believe were produced. The 90% confidence intervals for the chemical product design course and the mechanical engineering design class were 5.39 ± 0.98 and 10.28 ± 5.03 respectively, and these averages were statistically different ($p<0.004$). Given the small sample size of the mechanical engineering class this is not proof that the remote workshop is more effective, but it is compelling evidence that the remote delivery of this improvisation workshop will likely not hamper its effectiveness.

CONCLUSIONS

A three step process to enhance creativity in engineering design was developed. This method uses humor to induce divergent thinking in the first step of the process to create ideas that are far afield from traditional approaches to a particular engineering design process. To adapt this approach to technical design space, convergent and emergent steps were added to create a novel solution to real engineering challenges. In contrast, innovative ideas for business applications such as marketing campaigns do not require these additional steps because the difference between such divergent ideas and good marketing ideas is relatively small. The effectiveness of this method was illustrated with examples from engineering design classes at Georgia Tech. Data from these workshops at Georgia Tech indicate that there is little effect of gender on the results and that these workshops are also effective when carried out via remote teleconference.

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