The Use of LEGO® SERIOUS PLAY™ in the Engineering Design Classroom

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Abstract

With the belief that teaching design, innovation and entrepreneurship studies requires methods and techniques that are themselves innovative and entrepreneurial in nature, LEGO® SERIOUS PLAY™ (LSP) has been used within the Technology Management and Entrepreneurship (TME) Program at the University of New Brunswick, Faculty of Engineering, as a complementary instructional technique since 2005.

LSP is a creative and experiential process that can facilitate strategic planning, problem solving, team building, and innovation mining through the use of specialized LEGO® brick kits. Designed for the corporate environment, it made its formal debut in 2002. Since then, over 250 global organizations, in 27 countries have used this facilitated thinking technique. Example companies that offer enthusiastic testimonials for the methodology include Daimler/Chrysler, Verizon Wireless, Ikea, and Pfizer.

LSP is now emerging in the educational environment. The current generation of students, before becoming gripped to electronics, was encouraged by parents to use their hands and imaginations to construct models using LEGO® bricks. They were at one time 'Imagineers'. In addition, engineering students tend to work hard and play harder. Thus it became desirable to test how introducing the element of play [1][2] with purpose into the Entrepreneurship and Design classrooms could awaken students' creative energies that spur innovation.

"Constructivism" [3] has been increasingly emphasized as an effective approach to learning. Also, the related "Constructionist" theory suggests that by using our hands and 3D modeling to explore ideas we can surface more information, past experience, intuition and understanding than we can effectively express through speech alone.

Based on the promising LSP initial TME pilot results in 2006, it was predicted that Engineering students as a whole could further benefit from the LSP experience and use this form of concrete thinking to solve design/innovation challenges and teaming issues. The LSP pilot action research was extended in collaboration with graduating Civil Engineering students in their Team Capstone Design Course winter 2008.

Lego based (LSP) workshops subsequently conducted demonstrated a positive impact on the design teams with respect to their views on team responsibility and accountability, ability to collaborate and cooperate as well as their awareness of team risks and responsibilities over those teams with no LSP workshop experience.

1 Introduction

Change has become a constant pattern that we must embrace. Government reports raise concern regarding declining growth rates in national productivity [4]. Work is underway to foster Canadian Science, Technology and Innovation Advantages [5]. Engineering educational reform studies conclude that a different kind of engineer is needed for the future than what is being produced now [6].

At the Symposium for Learning 2009 Conference held at Wharton, University of Pennsylvania, the National Science Board was quoted in the opening proceedings as reporting that, "In addition to analytic skills, which are well provided by the current education system, companies want engineers with passion, some systems thinking, an ability to innovate, an ability to work in multicultural environments, an ability to understand the business context of engineering, interdisciplinary skills, communication skills, leadership skills, an ability to adapt to changing conditions, and an eagerness for lifelong learning" [6].

We have all heard it before - you cannot expect different results if you keep doing the same things. In 2006, the University of New Brunswick introduced a

new technique in its quest to better exercise the passion, innovation and teamwork skills of its senior engineering students.

LEGO® SERIOUS PLAY™ (LSP) is a creative and experiential process that facilitates strategic planning, team building, innovation mining, and leadership development through the use of specialized LEGO® brick kits. The LSP technique provides users with multi colored Lego® bricks to help team members browse their integrated intelligence and build simple representative models in response to a question posed by the facilitator. Upon discussing the models, participants are also communicating valuable aspects of themselves, exploring team dynamics and simplifying project complexities. In short, the technique is intended to ‘give the brain a hand’ in a playful and relaxed setting. The in depth science attached to LSP is well documented [7].

Based on promising LSP results in engineering entrepreneurship classes in 2006-07, it was predicted that core engineering students could also benefit from the LSP experience to solve innovation challenges and team-building issues.

It was successfully proposed to the UNB Teaching and Learning Priority Fund to conduct further action research into the question “How effectively does the use of LEGO® SERIOUS PLAY facilitate and enhance team development?”

The plan was to repeat the use of LSP within the Technology Management and Entrepreneurship Class of Winter 08 but also extend the LSP research in collaboration with graduating Civil Engineering students in their Team Design Project Course (CE 4973). This course was created and first offered in the 2005 Fall Term in response to the Canadian Engineering Accreditation Board, (CEAB Report on the Accreditation Visit to UNB, Civil Engineering, November 2003), where the need for increased support of teamwork and design opportunities was highlighted.

The following describes the method of research taken and the associated results.

2 Workshops Performed

The LSP workshops were designed in detail using the following four step format.

- Workshop Objectives
- Workshop Overview
- LSP Participation Principles
- LSP Workshop Detail Plan

Objectives for each workshop are detailed below. More detailed workshop descriptions can be supplied upon request to the author.

2.1 TME Entrepreneurship Classroom Application

Within TME 3113 Business Planning and Strategy in an Entrepreneurial Environment a “Team Building and Imagination Style Discovery” workshop was performed in 2007, 2008 and again in 2009. Objectives set for this workshop were to:

1. Provide team members a new approach to solution focused innovation and idea generation.
2. Increase the level of overall participation and contribution that each team member outwardly demonstrates.
3. Increase their capability to communicate clearly and honestly to each other.
4. Increase team members’ confidence in their ability to improvise, be creative and tap into their unique ability to imagine. Creativity requires right brain thinking (imagination and intuition) as well as left brain thinking (logic, analytics and pattern recognition)
5. Have team members develop an understanding of their own ‘Imagination Style’
6. Have students experience the value of physical model building and/or prototyping in the entrepreneurial process.

2.2 CE 4973 Team Design Classroom Application

Within CE 4973 Team Design, two workshops were performed in January and February 2008: Team Discovery and Building; and Imagination Style and Innovation Mining.

Objectives for the Team Discovery and Building workshop were to:

1. Increase the level of overall participation and contribution that each team member outwardly demonstrates.
2. Increase the awareness level, honest appreciation and trust of team members for each other.
3. Increase the level of collaboration, co-labour, working together in an interconnected way.
4. Increase their capability to communicate clearly and honestly to each other.
5. Increase the individual team members’ feeling of responsibility and accountability for the team achievements.

Objectives for the Imagination Style and Innovation Mining workshop were to:

1. Increase the level of overall participation and contribution that each team member outwardly demonstrates.
2. Increase team members' confidence in their ability to improvise, be creative and tap into their unique ability to imagine. Creativity requires right brain thinking (imagination and intuition) as well as left brain thinking (logic, analytics and pattern recognition)
3. Have team members develop an understanding of their own 'Imagination Style'
4. Provide team members a new approach to solution focused innovation and idea generation.
5. Unleash team member creativity to encourage more team based creative problem solving.

3 Survey Instruments Used

Following each Lego workshop, participants filled out an evaluation survey consisting of seven questions (10 point Likert scale) as well as open-ended questions to allow descriptions of their concerns and experiences. In the case of the CE Team Discovery and Building workshop, a similar Pre-Questionnaire was also conducted with the entire class (both Lego and non-Lego teams) in order to establish the newly formed team baseline for comparison.

The CE participants completed the Comprehensive Assessment of Team Member Effectiveness (CATME) instrument two times throughout the term: one at the midway point and a second at the end of the term. The CATME instrument [8] was developed at Purdue University to use peer evaluations and self evaluations to assess how effectively each team member contributes to the team. It assesses team member contribution in the following five areas:

1. Contributing to the team's work
2. Interacting with teammates
3. Keeping the team on track
4. Expecting quality
5. Having relevant knowledge skills and abilities

4 TME-Engineering Entrepreneurship Student Results

The post workshop survey was administered to the three different TME classes run in Winter 07, Winter 08 and Winter 09. The following results were averaged for the 70 total participants that took part:

- 98% agreed or strongly agreed that the Lego Serious Play method created a playful and relaxed environment to interact with their team.
- 85% agreed or strongly agreed that the Lego Serious Play workshop was helpful to discover more about others' knowledge, insight and perceptions.
- 71% agreed or strongly agreed that the Lego Serious Play workshop was helpful to discover more about their own knowledge, insight and perception.
- 92% agreed or strongly agreed that building the models and telling the stories added to the ease and the breadth of their communication with their team.
- 89% agreed or strongly agreed that their imagination ability was exercised and heightened during the exercises.
- 77% agreed or strongly agreed that building the models and telling the stories added to their resulting understanding of the challenges presented.
- 76% agreed or strongly agreed that the Lego Serious Play activities changed their attitude towards the value of building physical models or prototypes in the innovation/product development cycle. (33% were neutral)

Students were also asked to make open comments regarding what they liked and what they disliked. The most frequent comment regarding what they liked focused on the interactive, creative and relaxing environment that helped to "break the ice" allowing them to better communicate with and learn about their teammates. The most frequent comment regarding what they did not like focused on the limited time to build the models and the limited amount of Lego that they worked with. (Note: TME students only received the LSP Fiddlebags to keep class cost reasonable. These are very fundamental Lego kits with approximately 50 pieces at a cost of 9\$/student.)

5 CE 4973 Team Design – Engineering Core Student Results

5.1 Team Building and Discovery Workshop

A total of six teams were formed in the core CE Design course using a common average GPA method to balance the team make-up. Three teams were given the opportunity to work with Lego in an alternate evening class time at 7:00-10:00 pm while the other

members attended the regular afternoon scheduled class from 2:30-5:20 pm. It should be noted that responses to voluntarily participate in the research indicated an initial reluctance to go to the evening class instead of the afternoon class lecture. When students were told the evening class would involve Lego, teams became receptive to the option.

All three Lego teams received the initial “Team Discovery and Building” workshop using the LSP format, and the “Window Lego Kit” (a more extensive box of Lego, approximately 200 pieces at \$50/student). The remaining teams attended an in class lecture, with their regular course professor, which discussed team development concepts toward the team objectives listed prior. As stated earlier, both Lego and Non Lego teams were surveyed the first week of class as teams were freshly formed and then again by the third week of class to evaluate their progress as a team.

The results on the pre- and post-questionnaire Likert scale questions were tallied and the average differences between the two surveys for each group was determined (delta scores). When comparing the before and after survey results (administered in first and third class weeks), Lego teams showed an improved performance, by a factor of approximately 2 times to 10 times greater than the Non Lego Teams in the areas summarized in Table 1.

From this data and the comprehensive statistical analysis performed on the raw data, the LEGO workshop demonstrated a clear and significant positive impact on the teams with respect to their feelings on team responsibility and accountability, their ability to collaborate and cooperate as well as their awareness of team risks and responsibilities.

Table 1. Evaluation Survey Comparison

Question	Lego delta	Non Lego delta	Improvement Factor
How aware are you of the qualities, strengths and weaknesses that each team member brings to the team?	2.65	1.26	2.1
How clearly and honestly do you feel you can communicate within this team?	0.30	0.16	1.9
*How responsible and accountable do you feel for the success of this team?	0.65	-.05	10+
How well do you trust the members of this team?	0.91	0.47	1.9

*How well do you feel you can collaborate, cooperate and work together in this team?	0.57	0.05	10+
*How aware are you of the risks and opportunities that can impact the success of this team?	1.57	0.16	10

All students, whether they received the Lego workshop or not were asked on the second questionnaire, administered approximately three weeks after their teams were formulated, if their perception of the team had changed during this period. Eighty-three (83%) percent of the Lego workshop participants agreed that their perception of the team had changed where as only thirty-seven (37%) of the non-Lego workshop participants perceived change.

The CATME Instrument was also used with Lego and non Lego teams and administered in Course Week 5 and then again at the course end. In the CATME, each team member is asked to rate (out of 5) themselves and each team mate in five assessed areas. The average ratings for each team, in each area, were used for team comparisons.

With respect to the average change between these two survey results, a similar difference was observed in three out of five CATME categories whether the teams received a Lego experience or not. Table 2 shows however that Lego teams reported a statistically significant functionality increase in their average scores (deltas) during the team life cycle whereas the Non Lego teams reported a decrease in team functionality.

Table 2. Team Functionality Comparison

CATME Category	Lego delta	Non Lego delta
Keeping the Team on Track <ul style="list-style-type: none"> - Watches conditions affecting the team and monitors the team's progress - Makes sure the teammates are making appropriate progress - Gives teammates specific, timely and constructive feedback 	0.29	(-0.08)
Having relevant knowledge, skills and abilities <ul style="list-style-type: none"> - Demonstrates the knowledge, skills, and abilities to do excellent work - Acquires new knowledge or skills to improve the team's performance - Able to perform the role of any team member 	0.27	(-0.17)

5.2 Imagination Style Discovery and Innovation Mining Workshop

An additional Lego workshop experience was offered to two of the three teams who participated in the Lego Team Building and Discovery workshop. This entailed showing up again during an evening timeslot of 7:00 to 10:00 pm. Each team participated in privacy on separate evenings to avoid compromising any competitive advantage or leaking confidential design information.

It was noted that the teams receiving two Lego workshops increased team functionality noticeably over the Non Lego in one additional category and were slightly more improved in the two above stated categories (Table 3).

Table 3. Team Functionality Comparison

CATME Category	Two Lego delta	Non Lego delta
Contribution to the Team's Work - Does more or high quality work than expected - Makes important contributions that improves the team's work - Helps to complete the work of teammates who are having difficulty	0.23	0.08
Keeping the Team on Track - Watches conditions affecting the team and monitors the team's progress - Makes sure the teammates are making appropriate progress - Gives teammates specific, timely and constructive feedback	0.41	(-.08)
Having relevant knowledge, skills and abilities - Demonstrates the knowledge, skills, and abilities to do excellent work - Acquires new knowledge or skills to improve the team's performance - Able to perform the role of any team member	0.36	(-0.17)

Table 4 shows the responses to the open question that was asked of both teams upon completing the Innovation Mining workshop:

- How, if at all, did the LSP help with the enhancement of the performance of your team?

Table 4. Open Question Responses

Help with Performance Enhancement
allowed the team to get together outside of a formal meeting and interact
definitely helps build a team whose members are comfortable with one another. This will no doubt increase our performance, particularly by helping quieter members come out of their shell and contribute.
yes, helped us understand what each member brings to the table.
improved group communication - eliminated any hesitation to speak up in the group
It is too soon to tell if it enhanced our team performance.
fun activities help the group function more effectively both socially and technically.
It allowed me to become more familiar with my team mates. I learned more about their personalities.
I think it helped - again a bit late, some of us have been working together for four years now.
got us to know each other better
Became much more open, friendly and got to know people better.
team bonding
Maybe brought us closer
keep things light; working together

When comments are reviewed, participants in general accepted that the LSP experience did enhance the performance of their team in terms of team bonding, raised comfort levels, understanding each other, heightened communication levels and encouraged full team participation.

6 Conclusions

From the statistical analysis performed, summary data presented, personal observations, and observations of others associated with the workshops, it is concluded that:

- Engineering students are very receptive to the use of LSP within the classroom context. They demonstrate respectful behaviour, are seriously/thoughtfully engaged in the exercises, and demonstrate characteristics of enjoyment such as frequent smiles, and full laughter.
- The LSP workshops create a playful environment that encourages full participation, creative contribution and communication across team members.
- The LSP workshops effectively encourage self discovery as well as team member discovery.
- No preventative cultural or gender barriers were observed when applying the technique.

- The LSP workshops demonstrated a statistically significant positive impact on the teams with respect to their feelings on team responsibility and accountability, their ability to collaborate and cooperate as well as their awareness of team risks and responsibilities over teams with no Lego experience.
- The greater majority of students that participate in LSP workshops would readily agree that the workshops helped build team member awareness and communication comfort.
- The "Fiddlebag" or fundamental Lego kit is adequate for a single team building and discovery workshop lasting two to three hours.
- When more than one workshop is planned with the same group and/or customized idea generation/problem solving is a workshop objective, a more complex Lego package is recommended such as the "Window Kit" or better.
- The investment in LSP can be justifiable in senior engineering courses when team function development and project design creativity are primary course objectives.
- Play can be taken seriously in the core engineering classroom and have purpose.

7 Recommendations

With four years of experience with applying Lego® Serious Play™ with senior engineering students it is recommended that:

- LSP be considered a useful complementary teaching and learning technique to keep engineering students engaged, facilitate team discovery and reinforce team building. This will require students or faculty to purchase "Fiddlebag" Lego kits at the minimum. To deliver the LSP workshop, the faculty member must be LSP Certified [9].
- LSP workshops should be performed during regularly scheduled class time as part of the course content and with the entire class cohort. This will alleviate the need for special schedule planning from the student as well as relieve any doubts or worries students may have that some teams have an advantage over the others.

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9 References

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