 

# Integrated Project Delivery Games for the Classroom

**David Martin, CPC, PSP, P. Warren Plugge, Ph.D., and William Bender, PE, Ph.D., LEED AP**
Central Washington University
Ellensburg, WA

Integrated Project Delivery (IPD) is a collaborative approach to project delivery that takes teamwork from different project participants. Students in an undergraduate construction management program learn about and participate in IPD through classroom lectures and active learning. This paper presents three classroom games students played to learn basic fundamentals of IPD. Learning outcome assessments were performed and the results are presented.

**Key Words:** Integrated Project Delivery, Active Learning, Classroom Games

## Introduction

The purpose of this paper is to provide educators insight into classroom games that reinforce IPD principles. Due to the fragmented and unique nature of construction projects and the heavy reliance on contracts to define specific individual roles and responsibilities of the project participants (i.e. Owner, General Contractor, Architect/Engineer, subcontractor, etc.), construction project managers face unique challenges. These challenges include managing multiple inter-related yet separate organizations to construct a single product that is custom built within a fixed budget and time frame. When the phases involved in the realization of a construction project are considered and the fact that different organizations are involved at different stages, it is easy to understand how coordination problems arise between project participants and collaboration becomes sporadic.

Collaboration requires participants to more broadly understand each other with regard to specific technologies, finances, and operations of the respective participants (Ibbs, Kwak, Ng, Odabasi 2003). Sharing this information demands a significant level of trust among the project participants. Unfortunately, many relationships within the construction industry are not been built on trust. Consequently, distrust among project participants leads to poor communication, conflict, and reduced performance. The extent of litigation in the construction industry illustrates this level of distrust. Many in the construction industry understand this dilemma and attribute the problem to unwillingness on the part of the project participants to behave in a collaborative manner (Rowings, Federle, Birkland 1996).

At the same time however, market forces within the industry are demanding significant performance improvements, which in turn, require increasingly collaborative delivery environments. Construction Management at Risk, Design – Build, Partnering, Build – Operate – Transfer, and more recently and much more collaborative are Lean Construction and IPD now account for nearly 50% of all construction projects as compared to 10-15% thirty years ago. However, these increasingly collaborative project delivery systems do not ensure long term, sustainable collaboration. Lean Construction has had its successes and continues to grow but failures do exist. In fact, several opponents dubbed Lean Construction as "Mean Construction" as evidenced by the November 21, 2007 cover story of Engineering News Record entitled "Lean Without Mean." The reasons are varied and vast but, one of the more common reasons cited is that the project managers or superintendents selected for these projects had difficulty adjusting their mindsets to operate within a collaborative environment. Many had been very successful, in the past, on more traditional contracts but their respective mode of operation was to act from a more competitive position verses collaborative position. As these mindsets started to reveal themselves, expectations were dashed and distrust ensued.

It could then be argued that adjusting these mindsets could solve the "Mean" problem. However, these personality traits are not easily altered. These traits are often embedded into the individual's psyche and likely are how that individual makes sense of his world around himself. In order to bring about change in the way an individual operates, an epiphany or an awakening needs to take place. In an effort to bring this about, several active learning

exercises were employed at CWU's Construction Management Program encouraging construction management students to reconsider the values associated with collaboration, negotiation, and work flow variability.

## *Active Learning*

In construction education, active learning has been performed in several different forms to expose students to various subjects in construction. The idea of active learning was first established through the works of Kurt Lewin, John Dewey and Jean Piaget, where they defined experiential learning through "adaptive modes of concrete experiences and abstract conceptualizations and the modes of active experimentation and reflective observation characteristically resolved in different fields of inquiry" (Kolb, 1984). In construction education it is very difficult to take experiences commonly found in the construction field and simulate them in a classroom setting. Gier and Hurd (2004) investigated different approaches to active student learning to enhance student engagement in the classroom. They suggested when students were engaged in real world scenarios they were more actively engaged in learning the concepts being taught. Similarly, Simms (1995), stated that an experiential learning approach or active learning provides a solution to three challenges in diversity education, "providing a holistic education, addressing the dilemma of individualism and equality in the classroom and providing a safe climate for learning. The dual knowledge theory of experiential learning theory depicts learning as a holistic and integrated process that attends to what learners think as well as what they feel, perceive, and do."

Construction management researchers have explored the ideas of active learning in different forms including hands-on models or interactive games to demonstrate construction management concepts. It has been found that construction management students learn differently than other disciplines. Stein and Gotts (2001) found through a Meyers Briggs survey questionnaire of 73 undergraduate construction management students, mostly juniors and seniors that 75% of the students have a sensing/judging temperament and students like to reach conclusions through a step-by-step process and like to put what they have learned to use. Most importantly, it was found that 67% of the students preferred hands on or activity based learning. Researchers have also found that construction management students are kinesthetic learners, who prefer to learn by doing, as opposed to listening to a lecture (Carns and Plugge, 2010, Gier and Hurd, 2004). Active learning models have been used to teach many concepts in construction management. Bray and Manry (2007) used a hands-on model to demonstrate active learning in a concrete design class. They found students "enjoyed the opportunity to do a hands on project and were more willing to concentrate on design issues presented in a construction management context." Carns and Plugge (2010) used a working model of a heat pump to demonstrate the refrigeration cycle commonly found in most homes or businesses. Their statistics showed through the use of a hands-on active learning model there was some association between perceived knowledge and actual knowledge when the model was used. Furthermore, the use of the model "demonstrated that construction management students are active learners who gain comprehension of more complex concepts, such as mechanical systems, as visual hands-on learners". In plan reading Hubbard and Hubbard (2009) provided an example of how a steel structure could be used as a model to teach students about the various connections and steel commonly found in most structures. The problem they found was though questions in class students invariably did not know basic concepts of steel construction. What they found was through using the steel structure model was that it provided a "hands on" experience for the students and provided a more meaningful experience when learning about steel and steel connections.

Although models are commonly used in construction management courses to demonstrate concepts within the construction curriculum, games are also an effective active learning tool to teach concepts in construction management. Gier and Hurd (2004) used games to teach concepts in team building and leadership in construction management. The purpose of their activity based learning exercise was to teach students about their own strengths, weaknesses and leadership styles. They found CM students prefer getting actively involved since they will be "expected to act, make decisions, solve problems, manage people and build projects (Gier and Hurd, 1984). Leathem and Tatum (2012) used a Jeopardy style game show as an active learning tool to teach concepts in building science, materials and methods, and mechanical, electrical and plumbing (MEP) courses. Their research showed that this type of game delivery reached the millennial type of student and created a greater interest in the courses. Lee (2010) took a more critical look at the design issues related to games and simulation exercises in construction management. As Lee (2010) suggests, although there are many games used as an educational tool they provide a platform for "interactive, participatory and contextually rich environments" for construction education. He also theorizes that game and simulation based learning provides "context specific-knowledge and awareness which leads to improve students' understanding of concepts and their interrelations".

 

## Methodology

Professors at CWU used three activity based games to demonstrate concepts in collaboration, negotiation, and work flow variability which is common problems found in construction management. The games, Prisoners Dilemma, $20 Negotiation Game and Parade of Trades Game were deployed in a project management course where students participated in the activity based learning exercises. At the end of each game students were provided a survey questionnaire to assess their experiences while playing the games.

### *Prisoners Dilemma*

The first activity based game that was introduced to the students was Prisoner's Dilemma. This game theory was originally framed by Merrill Flood and Melvin Dresher in 1950 and was formalized by Albert W Tucker in 1992 (Poundstone, 1992). Prisoner's Dilemma illustrates why two individuals might not cooperate, even if it appears that it is in their best interest to do so. The purpose of the game is to show that purely rational self-interested persons will betray another if it appears that betrayal yields a greater reward than cooperation even if the risk is greater. Equally important is to reveal the construction students' own propensity to betray and take a competitive stance against another.

To play the game, the class was divided into two groups (approximately 12 students to each group) and placed in separate rooms and completely shut off from each other. Each group was then advised that the goal of the game was to earn the most points possible for their group. There was significant effort to avoid presenting this game as a competition. For example, groups were identified as groups and the word team was never mentioned. Also, it was repeated numerous times that the goal was to earn the most points possible for their respective groups with no mention of the other group's results. Each group was then tasked to choose either the letter "X" or "Y" over a series of ten frames. Each frame acted separately from the next but the values earned or lost were cumulative. If both groups 1 & 2 chose "X", then both teams received -1 points. If both groups chose "Y", then both groups received +1 points. If group 1 chose "X" and group 2 chose "Y", then group 1 received +3 points and group 2 received -3 points and then vice versa.

### *$20 Negotiation Game*

The $20 Negotiation Game is an adaptation to the $2 Game that was first developed by Rowe (2001) as a simulation game to demonstrate win/lose bargaining and negotiation and conflict management. The game was changed from negotiating $2 to $20 to increase the importance of the dollar amount. The purpose of the game is to get students to develop their skills in negotiation and conflict management. Through playing the game students take time through the activity to negotiate the process of getting $20 from their fellow classmate given a set of instructions. The importance of the game is that it illustrates the basic tools that are necessary in negotiation theory. Topics which the game demonstrates are the nature of competition and concepts in bargaining range. In playing the game students begin to understand strategies typically used in negotiation which include competition, collaboration, avoidance, compromise, accommodation, and revenge.

To play the game the students were divided into pairs. The general instruction for both players at the start is to divide the $20 in half and this was to be a pure win-lose situation with no side deals, all or nothing. After this session the instructor facilitated a debriefing session. Without telling the students in the beginning, the game is then played two more times. In the second round students change partners with another student in the class. At this point the students are provided "Secret Instructions". Secret instructions are meant to tilt each player toward competition, accommodation or compromise. The secret instructions will also change students attitudes on intangible and tangible items typically found in construction negotiation. In the third round the students are then told they will go back to their original partner they started the game with. At the end of each round there is a debriefing session to discuss the concepts of negotiation. In addition to the debriefing sessions, students are then provided a questionnaire which allows the students to answer some specific questions about the game and reflect on what they have learned in the process. The central point of the $20 game is to illustrate the basic concepts and applications of collaboration and negotiation in an activity based demonstration.

 

## *Parade of Trades Game*

Lean construction is a part of IPD in that many of the practices have a common thread. In Lean Construction, as in IPD, there is an emphasis on reducing waste, decentralizing decision making, involving the constructors in the design process and increasing productivity. A major theme of increasing productivity is through increasing the reliability or reducing variability in the construction process. This is fostered in the field with IPD by reducing work stoppages due to changes, lack of trust, and general and subcontractors working together. The Parade of Trades game was originally developed as a way to demonstrate the impact to production based on work flow variability (Tommelein, et al 1999). Enhancements to the game are discussed by Bolivar (2011) to include computers and software for a better demonstration of the true statistical behavior of variability in work flow.

The Parade of Trades activity demonstrates a lean concept of limiting variability in work flow to improve production. In construction, a "parade of trades", otherwise known as subcontractors typically follow each other. For example, walls are framed followed by rough electrical, followed by insulation, followed by the drywall, then wall coatings, etc. In the field, these trades depend on work upstream to be completed before they start. If there is variability in work flow then trades will either wait for work or become a bottle neck. This variability will lead to an increase in time for a series of tasks and make some trades less productive.

Students are set up as a production line and pass bolts based on dice thrown. Some dice represent high variability, they only have a 2 or 12 and some dice represent consistent flow and are all fives. As dice are thrown and bolts pass through the production line the length of time it takes to move the bolts through the line is recorded. The number of bolts passed and the number of rolls are recorded. These results are plotted on view graphs to show the effects of variability. A series of questions to consider the data and similarities to real construction are poised for student's consideration.

## *Survey Questionnaire for Project Delivery Games*

Experiences in the classroom were observed and documented through a simple questionnaire provided to the students at the conclusion of the active learning exercises. Shown in Table 1 is the survey questionnaire used by the professors to gain insight to what students were learning in the exercises. A Likert scale ranging from strongly agree to strongly disagree was used to measure whether students felt their understanding of the topic was enhanced, identify whether the topic helped in their professional development as a construction manager, changed their views on the subject, identify whether the exercise would help the student become a more effective construction manager and make recommendations to whether the exercise should be performed in future classes.

Table 1

### *Quantitative survey questions*

| | Question | SA | A | N | D | SD |
|---|---|---|---|---|---|---|
| 1. | This exercise added to my understanding of topic X. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2. | This exercise helps in my professional development as a construction manager. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3. | The concepts acquired in this exercise have changed how I view topic X. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4. | This exercise will likely cause me to be a more effective future construction manager regarding production. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5. | I recommend that this exercise be continued for future students of this class. | ☐ | ☐ | ☐ | ☐ | ☐ |

Standard qualitative questions were also asked to assess what students learned from the games as they relate to construction project management:

 

6. What were the lessons that you learned from this game?
7. What implications does this game reveal about the construction industry?
8. How will these lessons affect how you will manage construction projects in the future?

## Results and Discussion

In addition to class discussions, students were also assessed through a survey instrument providing both quantitative and qualitative feedback to the authors on the activities that took place in class. For each exercise students were asked through a questionnaire to identify their understanding of the topic, determine if the topic added to their professional development, rate how the concepts added to their understanding of the topic, assess how the exercise would change their view as a professional construction manager and suggest whether the exercise should be continued for future students in the class. Qualitatively the authors were interested in discovering the specific lessons each student learned from the exercise, allowing students to reflect on the implications the exercise would reveal about the construction industry as a whole and identify how the lessons learned in the exercise would affect how the student would manage projects in the future. Although the number of survey responses was relatively low for each of the games, information on the effectiveness of using the games as an activity based learning tool could still identify trends within the games.

### *Prisoner's Dilemma*

Both groups started off aggressively in the first two frames. Each group chose "X" in the first two frames. Between frames 2 and 3, each group chose a representative from their group to negotiate each group's next move. In private, each representative agreed to chose "Y" in frame 3. However, as is evident, both groups ended up choosing "X" despite the agreement. Between frames 5 and 6, representatives again negotiated an agreement to choose "Y" which carried on through frames 6 and 7 but came to an end in frame 8 on through to the end of the game. Table 2 reflects the results of the game that was played.

Table 2

***Prisoner's dilemma tabulation results***

| **Frame** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Group1** | -1 | -1 | -1 | -1 | -1 | +1 | +1 | +3 | -1 | -1 | -2 |
| | X | X | X | X | X | Y | Y | X | X | X | |
| | X | X | X | X | X | Y | Y | Y | X | X | |
| **Group2** | -1 | -1 | -1 | -1 | -1 | +1 | +1 | -3 | -1 | -1 | -8 |

At the end of the game, the two groups were reassembled and discussions between the faculty members and the students ensued. In this case, students from both groups accused the other of playing "dirty" although it was evident that neither group was trustworthy. After students had a chance to vent their frustrations, the question was then posed, "Was it possible for both teams to earn +10 points?" The logic was undeniable to them and the students realized both teams could have earned +10 points. Then a profit/loss component was added to the discussion and this question was asked "Why then, did both teams end up in the red?" It was then suggested that construction management students tend to operate from a competitive position even when collaboration is the best option. This realization aided in helping the students to understand that acting competitively does not always yield the best result. It is then suggested that the construction industry experiences similar troubles and that IPD and Lean projects are not exempt from these problems.

Trust is the key component to foster collaboration and trust either increases or decreases based upon the actions of the other party. In this case, trust continued to deteriorate as the actions of each group increasingly bred distrust to the point that each group accused the other of playing dirty. The experiences gained from this game had an impact on some of the students. Several commented that competitors are not necessarily the enemy and that it is better to increase the size of the proverbial pie through collaboration than to get a bigger share of a smaller pie through competition. On one occasion, several students indicated that the results of this experience impacted how they approached the $20 Negotiation Game. They indicated that they approached the game from a much more

 

collaborative stance than they otherwise would have prior to this experience. Table 3 shows the responses to the survey questionnaire.

Table 3

***Descriptive statistics for prisoner's dilemma***

| Question | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|
| This exercise added to my understanding of collaboration. | 3 | 5 | 4.09 | 0.60 |
| This exercise helps in my professional development as a construction manager. | 3 | 5 | 3.83 | 0.58 |
| The concepts acquired in this exercise have changed how I view competition and competitiveness | 2 | 5 | 3.83 | 0.89 |
| This exercise will likely cause me to be more collaborative as a future construction manager. | 1 | 5 | 3.96 | 1.02 |
| I recommend that this exercise be continued for future students of this class. | 1 | 5 | 3.91 | 1.08 |

(N = 23)

From the responses of the self-evaluation questionnaire, students who participated in the prisoners dilemma felt the game added to their understanding of collaboration with a relatively high mean (M = 4.09, SD = 0.60). Likewise, they also felt the exercise helped change how they perceived collaboration as a future construction manager (M = 3.96, SD = 1.02)

## *$20 Game*

Through the experimentation of delivering the $20 Game it was observed that students commonly found themselves in various conflict modes. It was also observed that some students really engaged into the game and others did not necessarily take the game very seriously. The students that were involved were pretty creative in how they could negotiate their point and in many cases became emotionally involved in the game. This could be observed through the intense discussions between two students. In this class, many of the observations were similar to those observed by Rowe (2001) in that students were introduced to the ideas of reward, sanctions, force, threat of force, relationship, best alternative to a negotiated agreement, moral authority and commitment power. Students' responses to the survey instrument are shown below in Table 4.

Table 4

***Descriptive statistics for $20 game***

| Question | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|
| This exercise added to my understanding of negotiation. | 1 | 5 | 3.33 | 1.11 |
| This exercise helps in my professional development as a construction manager. | 1 | 5 | 3.13 | 1.18 |
| The concepts acquired in this exercise have changed how I view negotiation. | 1 | 5 | 3.04 | 1.13 |
| This exercise will likely cause me to be a more effective negotiator as a future construction manager. | 1 | 5 | 2.96 | 1.16 |
| I recommend that this exercise be continued for future students of this class. | 1 | 5 | 3.17 | 1.14 |

(N = 24)

 

The $20 game seemed to provide lower than expected results. Table 4 shows that students felt that the $20 game gave them an average level of understanding of negotiation as a construction manager (M = 3.33, SD = 1.11). Students also provided a somewhat average response to the fact that the exercise would cause them to be a more effective negotiator as a future construction manager.

### *Parade of Trades*

Initial discussions with students seem to think that the dice with higher variability but the same average value will produce better results. However the data showed that this is not the case since downstream trades are starved of bolts if the previous trade did not have enough waiting for them. The game also demonstrated the impact of production buffers and total impact on the integrated project by only focusing on the production of a single trade. Results of the student responses to the survey instrument are shown in Table 5.

Table 5

***Descriptive statistics for parade of trades***

| Question | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|
| This exercise added to my understanding of production variability. | 3 | 5 | 4.17 | .57 |
| This exercise helps in my professional development as a construction manager. | 2 | 5 | 3.74 | .75 |
| The concepts acquired in this exercise have changed how I view production. | 2 | 5 | 3.74 | .75 |
| This exercise will likely cause me to be a more effective future construction manager regarding production. | 3 | 5 | 3.91 | .67 |
| I recommend that this exercise be continued for future students of this class. | 2 | 5 | 4.04 | .71 |

(N = 23)

For the parade of trades game, the students were more confident in the fact that the game provided a high level of understanding of how production variability affects completion time (M = 4.17, SD = .57). They also felt their understanding of production as a construction manager was enhanced through the activity (M = 3.91, N = .67) and they recommended that this learning activity be continued in future classes (M = 4.04, N = .71).

## Conclusion and Future Work

Students generally commented favorably towards the concept of using the games to demonstrate the three areas discussed in this paper. In each case the students felt the games enhanced their understanding of project management as a future construction manager. One student even commented by writing "This game (Prisoner's Dilemma) has shown me… [that] it will probably have to be me to put my foot forward to begin developing trust between the companies. I hope to be a part of a company who trusts…" However, despite the students' positive responses, the measure by which students' knowledge of the three discussion areas was increased is primarily anecdotal and no empirical measures were employed to gauge the level of knowledge gained and/or propensities altered due to these experiences. In future work, it is planned to establish a baseline mechanism to determine the students' knowledge and negotiation propensities prior to the activity based games and then follow up with similar measure to compare with the baseline. In addition, this study was limited to between 23 to 24 students. To develop a statistically sound analysis, the sample size will need to increase. Finally, it was discussed that a transition between the games is necessary. In this case, there was no introduction to the students regarding the various types of negotiation tactics prior to participating in the $20 Game. Students armed with this knowledge will have a deeper arsenal from which to engage in effective negotiations.

Active learning games provide a good way to introduce and reinforce topics associated with construction project management. Initial results suggest games used in the construction management courses helped the authors to develop construction management students' knowledge of IPD skills. Future work in this area would suggest adding additional games to the project management courses to engage construction management students on the learning concepts necessary for project management and integrated project delivery.

## References

Bolivar, S. A. (2011). Enhancing the Construction Parade of Trades Game. *ASC Proceedings of the 47th Annual International Conference, University of Nebraska-Lincoln, Omaha, NE.*

Bray, H.G. & Manry D.W. (2007). Active Learning in a Reinforced Concrete Design Class Associated Schools of Construction Annual International Conference Proceedings. *ASC Proceedings of the 43rd Annual Conference, Northern Arizona University, Flagstaff, AZ.*

Carns, D & Plugge, P.W. (2010). Creating and Utilizing a "Working Model Heat Pump" to Enhance Student Learning in a Construction Management Program. *ASC Proceedings of the 46th Annual Conference, Wentworth Institute of Technology, Boston, MA.*

Gier, D.M. &Hurd, M.W. (2004). Increasing the Effectiveness of Active Learning Exercises in the Construction Management Classroom. *ASC Proceedings of the 40th Annual Conference, Brigham Young University, Provo, UT.*

Hubbard, B.J. & Hubbard, S.M. (2009). Utilization of AISC Steel Sculpture for an Introductory Construction Plan Reading Course. ASC Proceedings of the 45th Annual Conference, University of Florida, Gainesville, FL.

Ibbs, Kwak, Ng, Odabasi(2003) Project Delivery Systems and Project Change: Quantitative Analysis. *Journal of Construction Engineering and Management,* Vol. 129(4), Jul 2003.

Kolb, D.A. (1984). Experiential Learning: experience as the source of learning and development. Englewood Cliffs: Prentice Hall.

Leathem, T. & Tatum, M. (2012). Games as an Interactive Learning Tool: A case study of a Jeopardy style game show for construction classes. ASC Proceedings of the 48th Annual Conference Proceedings, Wentworth University, Boston, MA.

Lee, N. (2010). Design Issues and Implementation Strategies for Game and Simulation-Based Learning in Construction Education. ASC Proceedings of the 48th Annual Conference Proceedings, Wentworth University, Boston, MA.

Poundstone, W. (1992). *Prisoner's Dilemma*. New York: Doubleday.

Rowe, M.T. (2001). Negotiation and Conflict Management. MIT Open Courseware. URL http://ocw.mit.edu/courses/sloan-school-of-management/15-667-negotiation-and-conflict-management-spring-2001/lecture-notes/.

Rowings, James E., Federle, Mark O., Birkland, Sara A. (1996). Characteristics of the Craft Workforce. *Journal of Construction Engineering and Management,* Vol 83(8), March 1996.

Sims, R.R. & Serbrenia, J.S. (1995). The Importance of Learning Styles: Understanding the implications of learning, course design, and education. Westport, CT: Greenwood Press.

Stein, J. & Gotts, V. (2001). Analysis of Selected Learning Preferences of Construction Management Students. *ASC Proceedings of the 37th Annual Conference, University of Denver, Denver, CO*, 41-48.

Tommelein, I.D., Riley, D.R., Howell, G.A., (1999). Parade Game: Impact on Work Flow Variability on Trade Performance. *Journal of Construction Engineering Management*, Vol 125(5), Sept/Oct 1999.