The Charrette Design Model Provides a Means to Promote Collaborative Design in Higher Education

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ABSTRACT

Higher education is typically compartmentalized by field and expertise level leading to a lack of collaboration across disciplines and reduced interaction among students of the same discipline that possess varying levels of expertise. The divisions between disciplines and expertise levels can be perforated through the use of a concentrated, short-term design problem called a charrette. The charrette is commonly used in architecture and interior design, and applications in other disciplines are possible. The use of the charrette in an educational context provides design students the opportunity to collaborate in teams where members have varying levels of expertise and consult with experts in allied disciplines in preparation for a profession that will expect the same.

In the context of a competitive charrette, this study examines the effectiveness of forming teams of design students that possess a diversity of expertise. This study also looks at the effectiveness of integrating input from professional experts in design-allied disciplines (urban planning, architecture, mechanical and electrical engineering) and a design-scenario-specific discipline (medicine) into the students' design process. Using a chi-square test of goodness-of-fit, it is possible to determine student preferences in terms of the team configurations as well as their preferences on the experts.

In this charrette context, the students indicated that the cross-expertise student team make-up had a positive effect for both the more experienced students and the less experienced students. Overall, the students placed high value on the input from experts in design-allied fields for the charrette. They also perceived a preference of input from external experts that had an immediate and practical implication to their design process. This article will also show student work examples as additional evidence of the successful cross-expertise collaboration among the design students and evidence of the integration of information from the experts into the design results.

Keywords: charrette, interior design, interior architecture, design process, cross-expertise collaboration, consultation

1. INTRODUCTION

Many interior design students enter a university which follows a compartmentalized organizational model which relies on silos - colleges, schools, and departments. This silo model can often result in a lack of interaction between students in separate disciplines and even those within the same discipline at differing levels of expertise (Tran, A. L., et al., 2012; Buchbinder, 2005; Denton, 1997). By contrast, it has been noted that cross-disciplinary collaboration has been a growing trend in the architecture, engineering, and construction industries, but the educational process is lacking in its support of this professional trend (Tran, A. L., et al., 2012; O'Brien, 2003). Various disciplines also look for evidence of students working in team settings as a factor in employment (Riebe, L., et al., 2013; Teijeiro, M., et al., 2013; Denton, 1997). Because interior design is so closely related to the AEC fields, the same can easily be said of interior design in both cases. Interior design is a profession that relies heavily upon consultation from allied professions such as architecture, engineering, and construction. Multi-disciplinary consultation and cross-level expertise collaboration is needed to bring designs and ideas on paper into built form. Depending on the type of project, the overseer of the information exchange in this design and building process is the architect or interior designer. The designer manages the process of design with the consultation of a variety of allied disciplines.

It would appear by observing the state of the interior design and architecture practice over the last several decades that this issue of cross-disciplinary interaction is becoming more important. For quite some time now, firms have been utilizing a team-based approach to solving design problems. Professionals are finding that in order to accomplish basic milestones in the design process and arrive at creative solutions requires significant interaction among individuals of varying disciplines (Gibson, M. R., & Owens, K. M., 2014; Zeiler, W., et al., 2009; Sonnenwald, 1997). Achieving expertise within a discipline while utilizing the knowledge base of other disciplines is necessary for reaching an innovative solution to a design challenge (Kennedy, B., et al., 2015; Sonnenwald, 1997).

In addition to building skills integrating multi-disciplinary input into the design process, successful development of the young designer requires mentorship (CIDQ, 2015). Mentorship is not something that is required for accreditation, but it has been a recognized method to accelerate the transfer of knowledge from knowledge holders to knowledge seekers (Bonner, B. L., & Baumann, M. R., 2012; Tamer, 2003). In the education context, mentorship occurs from professor to student, but not as often from student to student. Building mentorship relationships between students could be leveraged to benefit all students on both sides of the mentorship relationship. Cultivating a setting for this to take place can prove challenging.

Within this compartmentalized higher education setting, United States interior design programs are accredited by the Council for Interior Design Accreditation. A portion of the accreditation process specifically looks at cross-disciplinary collaboration between students of interior design and individuals in other disciplines (CIDA, 2010). The requirements of accreditation and the state of the higher education environment are directly at odds with one another. This conflict has placed the design educator in a unique position to prepare their students for a highly collaborative profession and accelerate knowledge transfer between students. One possible solution resides in an underutilized design process methodology – the design charrette.

Research Questions

This study seeks to answer four questions. The first two questions address the effectiveness of placing students in teams that span expertise divides:

RQ1: In terms of growing design-related knowledge and skills, do interior design students perceive a benefit to the less experienced students in working in cross-level expertise teams?

RQ2: In terms of growing leadership skills, do interior design students perceive a benefit to the more experienced students in working in cross-level expertise teams?

The second two questions address the effectiveness of professionals offering their expertise to design students that would be useful to them on a design project:

RQ3: Did the students value the input to their design process on this charrette from experts outside of the interior design profession?

RQ4: What characteristics of a lecture/discussion given from a multi-disciplinary expert are viewed as helpful by interior design students?

Charrette: Providing a Rich Context for Cross-Disciplinary Interaction and Cross-expertise Collaboration

The word "charrette" is French for "cart". The idea of a charrette embodies the mindset of interior design students when project deadlines approach. Apparently, in 19th century French architecture schools, a cart with a bell would be pushed through the studios to collect the students' drawings and artwork at the close of the project deadline. Upon hearing the bell of the approaching cart they were expected to deposit their presentation drawings and art works on the cart. As the deadline came to a close and the sound of the cart grew nearer, student work would accelerate with the students sometimes jumping onto the cart with their drawings in an effort to finish their work in the closing moments (Kelbaugh, 1997). This process resulted in a tremendous amount of progress being made in those closing moments leading up to the deadline. In design education today, the charrette seeks to capture the heightened productivity of the closing moments prior to a deadline by placing a very short amount of time on a design effort and instilling a sense of urgency in the students. The charrette tends to streamline the design process and can produce multiple solutions, some viable and others not, that can later inform a final solution synthesized from the myriad of ideas.

Outside of the higher education context, a charrette can be used in many ways. One of the more common ways is in an architectural, landscaping, or urban development project where community input is needed. The charrette methodology brings a variety of project stakeholders together to brainstorm ideas for a challenging design problem. In Sutton and Kemp's reflection on three different community-based design charrettes, they explain why the charrette was such an enticing methodology to achieve their goals:

> *"The significance of the methodology we describe is twofold. First, design charrettes offer a promising tool for engaging local residents in community problem solving, while providing them with tangible outcomes. Second, it offers insights into a notion of community research and action, currently rooted in the social sciences, that embraces design as a method of inquiry, defined as systematic investigation, on par with widely accepted social science methods."*

A design professional along with local government officials direct the meeting between members of the community, public officials, and other members of the design team (engineers, construction manager, etc.). The charrette is used to generate input and uncover design preferences of all parties involved. Illustrated brainstorming, or visual inquiry, is one of the common activities by designers (Sutton and Kemp, 2006). By using the charrette in an academic context, students can be better prepared for professional situations such as those described in the example above.

Charrettes within an academic context can serve to bring diverse disciplines together in an effort to address a complex and messy theoretical problem. Because a charrette methodology significantly alters the typical design process and challenges peoples' default thinking modes, innovation is more likely to occur (Sutton and Kemp, 2002). As an academic exercise, the charrette can offer design students the opportunity to interact with professionals or students in other disciplines within a "safe zone" where a student can develop skills in interacting with individuals in other disciplines, and expand their knowledge base regarding these allied disciplines, without the pressure that comes with "real world" projects and community stakeholders. The charrette methodology allows students to "get out of the classroom" by collaborating with one another across expertise levels, interacting with professionals in other disciplines, and seeking innovative solutions to an unusual design challenge (Sutton and Kemp, 2002). Depending on how the design teams are arranged, this author theorizes that the students can also learn to collaborate more fully in a cross-expertise fashion as the more experienced design students lead the less experienced ones. The charrette described in this study takes this approach.

The charrette methodology allows for students of varying levels of expertise to participate and contribute in meaningful ways (Sutton and Kemp, 2002). For the charrette in this study, the student teams were organized vertically, sophomore, junior, and senior levels in this case, to provide the structure for a student-to-student knowledge transfer. In these types of team situations, specific instances of interaction can take on a non-hierarchical structure where any student can be the "teacher" or "pupil" (Frederick, 2008). In situations like these, successful teams often "generate knowledge together without a clear differentiation of roles" (Frederick, 2008) while engaging in collaborative sequences during their design process. Team roles were not assigned by the faculty due to research that shows that participants feel leadership should be flexible to the situation at hand rather than an assigned title (Denton, 1997). It was anticipated, however, that students would naturally identify situation-specific leadership based upon skill and expertise level. In most cases, this would likely be the senior member of the team, but would not have to be this way as each student naturally has different strengths and weaknesses. Due to the generally high-level expertise of the seniors, the faculty anticipated they would serve their less experienced team members in a leadership role by establishing a method of communication among the team members that would acquaint them socially and uncover individuals' strengths and weaknesses, and that the seniors would help them more fully understand how the more technical aspects of the design scenario would fit into the design process. Establishing close ties between team members in collaborative settings has been shown to accelerate knowledge transference between individuals (Tamer Cavusgil, 2003) and make the knowledge application process beneficial to all of those involved in the team (Grant, 1996). These observations in other disciplines can be applied in design education to accelerate student learning.

Fundamentally, each of these issues fit into the "forming, storming, norming, and performing" process pioneered by Bruce Tuckman (1965). "Forming" consists of establishing relationships of dependency with team members, "storming" involves conflict and polarization of the team members, and the "norming" stage serves to bring the team into a sense of cohesiveness where a largely unified direction is established to eventually complete the work at hand (Tuckman, 1965). The ability of the team to navigate through the second stage of "storming" and successfully complete the third stage of "norming" will greatly impact the final stage of "performing" (Russ, 1999) which is largely how student work is judged – based upon the presentation results.

2. METHODOLOGY

Project Z: Cross-Expertise Student Participants and Multi-disciplinary Interaction

The design charrette in this study, Project Z, provided an opportunity for students of varying levels of expertise to collaborate on a design project with one another. Students were arranged into teams of four or five students each. Team size was determined based upon the number of participants spanning the three levels of expertise (sophomore, junior, and senior) and also on Denton's (1997) research which places the minimum team size at three persons and the top end at five to six for teams at this approximate expertise level. Team members were distributed by faculty based upon design course performance in order to create a "fair" situation for the teams, and expertise level, but a perfectly even distribution of sophomores, juniors and seniors was not possible. Each team did have at least one sophomore and senior, but juniors were in short supply. This resulted in a total participation of 82 undergraduate students formed into 20 teams with a population breakdown as follows: 39 sophomores, 19 juniors, and 24 seniors. The charrette teams were publicized to the students ahead of the charrette kick-off in an effort to allow the students to get to know one another, but the scenario was kept secret until the kick-off event. A survey following the completion of the charrette was used to assess the student perceptions of the effectiveness of the varying levels of expertise in the team arrangements.

Project Z also provided the opportunity for interaction between professionals of allied disciplines and design students. Professional experts in the disciplines of urban planning, architecture, mechanical engineering, electrical engineering, and medicine (specific to the design scenario) participated in the charrette kick-off to provide break-out session lectures and question and answer time for the students. Due to time constraints, several break-out sessions were run concurrently. This resulted in each student not being able to attend every session, so students were provided with guided note-taking sheets which they were then expected to share within their individual teams. The first four experts (urban planning, architecture, electrical engineering, and mechanical engineering) provided key information on building systems and security. The fifth expert, in medicine, provided a lecture/discussion on the spread of pathogens, placing the medical content in context with the fictitious Solanum virus as described in "The Zombie Survival Guide, Complete Protection from the Living Dead" by Max Brooks (2003). A survey following the completion of the charrette was used to assess the student perceptions of the multi-disciplinary consultation that occurred during the break-out sessions.

Project Z: Design Scenario and Charrette Format Rationale

The students were called upon to design a safe house for 50 human survivors of a Class 2 zombie outbreak (500+ zombies) in Florida, USA for two weeks. Included in the 50 users (25 male/25 female), the design was required to accommodate 10 people with significant injuries: two people on crutches, two people with an amputated arm, three people with an amputated leg, and three people with a head injury. In addition, the students were required to design for five dogs - 2 German Shepherds, 1 Labrador Retriever, 1 Golden Retriever, and a Springer Spaniel. A building with a variety of architectural styles and a storied history was selected for the project. The building has tight corridors, high ceilings and a natural grit that provides the perfect atmosphere for the project (see Figures 1 - 6). The design scenario was kept hidden from the student participants until a kick-off event.

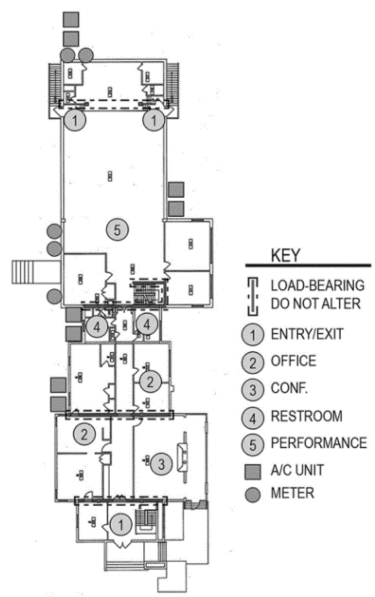

Fig. 1: Fine Arts Annex: Main Level/2nd Floor Plan showing existing uses.

Fig. 2: Fine Arts Annex facing west: the largely open exposure along east façade at Copeland St. and the sloping site creates multiple points of entry and defensible challenges.

Fig. 3: Fine Arts Annex facing north: the tight confines along the western exposure with the neighboring property create a challenge when seeking to design a defensible zone around the building perimeter.

Fig. 4: Fine Arts Annex: stairway at main entry of 2nd/primary level; large glazing exposure at this stair creates both opportunities and challenges in the design scenario.

Fig. 5: The existing performance space provided a large, versatile two-story volume.

Fig. 6: In large part, the interior consists of relatively narrow corridors and tall ceilings creating a vertical scale that contributes to a feeling of confinement.

In order for this charrette to be successful, four basic logistical characteristics were deemed necessary. First, the design content and presentation requirements were created to be too broad and deep for one person to achieve individually. Second, the design duration was kept short, only four-and-a-half days. Third, individuals received a grade for the quality of the design outcomes and their individual performance which would be based upon student peer-to-peer evaluations. Fourth, the charrette was made into a competition where faculty in the department served as judges of the student work in a double-blind review format. The first three characteristics were all necessary to make this charrette scenario worthwhile and successful. Change any one of these characteristics and the situation could become unproductive (possibly through design requirements that were too easy, or a duration that was too short/long), lack incentive to do well (through grading), or allow some students to not contribute to their team's efforts. The fourth characteristic, making the charrette into a competition, was mostly done to make the whole situation more fun, but to also increase the incentive to be more creative and earn the recognition of being a top team in the charrette.

Assessing Student Perceptions

Following Institutional Review Board approval, students were surveyed to gauge their perceptions regarding the team formation and the consultation input from the external experts. Students' enrollment status (sophomore, junior, or senior) in the department were also collected for deeper analysis. The survey was distributed online and results were recorded electronically.

Cross-expertise Team Effectiveness

In an effort to assess the design students' perception of the team arrangements, a five-point scale (5 = extremely effective; 4 = very effective; 3 = somewhat effective; 2 = minimally effective; 1 = not at all effective) was used to evaluate students' perceptions regarding the following two questions:

Q1: How would you rate the effectiveness of the team make-up in terms of enhancing the learning experience for the less experienced design students?

Q2: How would you rate the effectiveness of the team make-up in terms of helping the more experienced students develop leadership skills?

For question one, a chi-square test of goodness-of-fit was performed to determine if students perceived the team make-up to be effective, or not effective, at enhancing the learning experience for the less experienced students (sophomores and possibly juniors) compared to what would be expected by chance. For question two, a chi-square test of goodness-of-fit was performed to determine if students viewed the team make-up as highly effective, or not effective, at helping the more experienced students (seniors) develop leadership skills compared to what would be expected by chance. If the p-value was too high (above .05) then the student responses do not give an indication whether the resulting perceptions were high or low with any statistical certainty.

Multi-disciplinary Expert Effectiveness in the Design Process

Next, student perceptions regarding the usefulness of the information presented by each of the five multi-disciplinary experts were measured. A five-point scale ("5 = extremely useful; 4 = very useful; 3 = somewhat useful; 2 = minimally useful; 1 = not at all useful; x = I did not attend this session") was used to evaluate students' perceptions regarding the following question:

Q3: Please rate the usefulness of each expert to your design solution that was provided to you for this project.

This question was asked regarding each of the multi-disciplinary professional experts (urban planning, architecture, mechanical engineering, electrical engineering, and medicine) individually. It is important to recall that each student was not able to attend every break out session due to time constraints of the kick-off event, but at least one student from each team was required to attend each session in an effort to expose each team to the knowledge of the experts. For the purposes of data analysis, the answer "I did not attend this session" was omitted from the pool. Respondents of the survey were not evenly distributed across the five break-out sessions, so response numbers for this portion of the research show a variation in quantity. To analyze the results of Question 3 for each expert, a chi-square test of goodness-of-fit was performed to determine if students viewed the information presented as useful in the design process, or not, compared to what would be expected by chance. If the p-value was too high (above .05) then the student responses do not give an indication whether the resulting perceptions were high or low with any statistical certainty.

3. FINDINGS AND DISCUSSION

Cross-expertise Team Effectiveness

Q1: For question one, "How would you rate the effectiveness of the team make-up in terms of enhancing the learning experience for the less experienced design students?" 32 students responded to the survey out of the 82 that participated in the charrette for a response rate of 39%. Students rated the team make-up with high marks overall ($n = 32$; median = 4/"very effective"; IQR = 2.5 – 5; $X^2_{(4)} = 24.27$, $p = 0.0001$). These results indicate that the students perceived the team configurations to be effective in enhancing the learning experience of the lower expertise students.

This observation is important when educators consider creating team-based learning situations where the team members possess varying levels of expertise. If students view the cross-expertise configuration of the teams as having a strong purpose with the potential for positive learning outcomes, then the level of effort may increase which could then positively influence the design results. Examples of design outcomes are shown later in this paper.

Additionally, the team make-up in this charrette reflects what goes on in the professional world of design, and many other professions as well. Each team member possesses strengths and weaknesses in a variety of areas. Whether in an academic or professional setting, the strategy is the same: identify those strengths and weaknesses, leverage the strengths, and improve upon areas of weakness. One possible way to accelerate the learning process is by placing students with less experience in teams with those students who have more. The student perceptions shown here appear to indicate that this indeed happened.

Q2: For question two, "How would you rate the effectiveness of the team make-up in terms of helping the more experienced students develop leadership skills?" 31 students responded to the survey out of the 82 that participated in the charrette for a response rate of 37.8%. Overall, students rated the team make-up with high marks in terms of question two ($n = 31$; median = 4/"very effective"; IQR = 3 – 5; $X^2_{(4)} = 21.73$, $p = 0.0002$). These results indicate that the students perceive the team configurations were effective in helping the more experienced students develop leadership skills.

But, what do the senior students think? They are the ones who stand to benefit the most in terms of leadership, but they would arguably also be expected to contribute more time and effort to the team because of their higher expertise level. Due to this tension, it would be particularly helpful to understand the perceptions of the seniors in this case, but the number of participants is not high enough yet to draw conclusions about this particular subset on this issue. This gap in the data provides an opportunity for additional future research.

While the data is not conclusive for seniors, the views of those seniors who did participate show high marks ($n = 13$; median = 4/" very effective"; IQR = 3 – 5; $X^2_{(4)} = 9.7$, $p = 0.0458$). Effort was made on the part of the faculty to communicate the benefits of being the senior member of the team and having the opportunity to practice some leadership skills prior to entering the charrette. This may have made a positive difference. Other educators seeking to create a collaborative cross-expertise learning experience may want to do the same. The experience of the senior design student in this charrette to some degree mimics stepping foot in the professional world where leadership skills are valued in design teams. The training the charrette can provide in developing leadership skills could prove valuable in professional practice.

Multi-disciplinary Expert Effectiveness in the Design Process

Q3: In total, 30 survey respondents (36.6% response rate) provided 60 responses to the survey questions that supported question 3 ("Please rate the usefulness of each expert to your design solution that was provided to you for this project."). Looking at all 60 responses to the five experts, the students rated them highly (n = 60; median = 4/"very effective"; IQR = 2 – 5; $X^2_{(4)} = 26.67$; $p = 0.00002$). This finding supports the inclusion of professionals from design-allied disciplines during the information gathering phase of design in the context of a student design charrette.

The following findings are limited by the low participation numbers (particularly the juniors), so no conclusive findings can be determined at this time, but are still interesting as they relate to future lines of research. Looking at the results by expertise level, the sophomores and juniors rated the experts "very useful" (4) and "extremely useful" (5) (sophomores: n = 30; median = 4; IQR = 2 – 5; $X^2_{(4)} = 16.35$; $p = 0.0029$) (juniors: n = 8; median = 5; IQR = 3 – 5; $X^2_{(4)} = 15.76$; $p = 0.0034$). The results for the seniors are inconclusive as their ratings do not statistically deviate from what would be expected (n=22; median = 4/"very useful"; IQR = 2 – 5; $X^2_{(4)} = 6.19$; $p = 0.1854$). One potential reason for the inconclusive results in the seniors as compared to the sophomores could very well be their knowledge base. At this point in the curriculum, sophomores had not taken courses in construction-related topics such as plumbing and electricity while the seniors had completed courses related to these topics. It is possible that this could be the reason behind the potential variation in the students' perceptions. For now, however, the results are inconclusive, but it is still worth keeping in mind when creating cross-expertise learning situations such as this charrette.

An interesting observation can be made when looking at the student perceptions of each individual expert. Again, the participation numbers are a bit low here (especially the medical expert), but still worth noting. The experts in urban planning, mechanical systems, electrical systems, and medicine all received high marks (urban planning: n = 15; median = 4/"very useful"; IQR = 3 – 5; $X^2_{(4)} = 13.00$; $p = 0.0113$) (mechanical systems: n = 11; median = 5/"extremely useful"; IQR = 4 – 0; $X^2_{(4)} = 10.35$; $p = 0.0349$) (electrical systems: n = 16; median = 4.5/"very useful – extremely useful"; IQR = 4 – 5; $X^2_{(4)} = 13.37$; $p = 0.0096$) (medicine: n = 6; median = 5/"extremely useful"; IQR = 4 – 0; $X^2_{(4)} = 10.66$; $p = 0.0307$). However, the architecture expert received low marks from the students (architecture: n = 12; median = 1.5/"not at all useful – minimally useful"; IQR = 1 – 2.5; $X^2_{(4)} = 11.51$; $p = 0.02$).

While not statistically conclusive, this observation regarding the architecture expert brings up an interesting inquiry: What happens if the student perceptions of the architecture expert are removed from the pool? This modification to the analysis resulted in 30 students (36.6% response rate) providing 48 responses to question 3. On the whole, these responses show very high marks for the four experts (n = 48; median = 5/"extremely useful"; IQR = 4 – 0; $X^2_{(4)} = 46.38$; $p < 0.0001$). Under this revised form of analysis, the perceived value of the multi-disciplinary expertise becomes even higher.

What could have caused this low perception by the students of the information presented by the architect? Prior to the break-out sessions, the author had the opportunity to see the digital presentation files that the experts were going to use in their sessions. Upon observation by the author and other faculty, the architect's presentation was weighted towards the theoretical rather than practical side of the spectrum while the other four experts appeared to take a more practical approach to describing their topics in relation to the zombie-outbreak design scenario. The exit survey also offered students the opportunity to write-in comments about their views on the break-out sessions. Several students' comments expressed dissatisfaction with the level of usefulness of the information provided by the architect. It is possible that had the architect taken a more practically-minded approach, or done a more thorough job describing the theoretical concepts and how they related to the design scenario, then students may have received the information in the break-out session more positively.

Student Work Outcomes

The design students created a variety of solutions to this outlandish design scenario. In the midst of the scenario, however, students demonstrated the ability to design for very practical human needs within the built environment including security, access to clean water and air, and the generation of electricity. The student work shown here is a sampling of the solutions generated by the 20 teams that took part in the charrette (see figures 7-10).

The work was judged by a group of interior architecture and design faculty. A clear set of judging criteria with point values was provided to the students at the beginning of the charrette which was then used to judge the work upon completion. The best projects were those that could answer the technical and practical needs of the hypothetical users in a creative and interesting manner and then communicate those ideas visually and in written form.

Many creative ideas were proposed by the student teams. Two examples include the use of photovoltaic panels and electric generators attached to treadmills to answer the need for electricity. To take this one step further, one group even conceived to capture a zombie, place them on an enclosed treadmill with an attached generator and use a dog as bait outside the enclosure to get the zombie to create a continuous supply of electricity. The group made it clear that no dogs were harmed in the making of the design project.

4. CONCLUSION

Design students value cross-expertise collaboration within their discipline and they value interaction with professional experts in allied disciplines. The higher education system, with all of its strengths, has some fundamental structural flaws that limit opportunities for students to collaborate across department and college lines, and also across levels of expertise. Design educators, however, have a profound responsibility and tremendous opportunity to overcome this silo-like system and provide the best possible education environment for their students so that they will be well prepared for a profession that demands the ability to integrate information from multiple disciplines. The charrette can be an invaluable tool in the hands of the design educator to address these multi-disciplinary and multi-expertise collaboration issues. Educators in other fields may very well see the opportunity to adopt the principles discussed here and adapt them to their discipline.

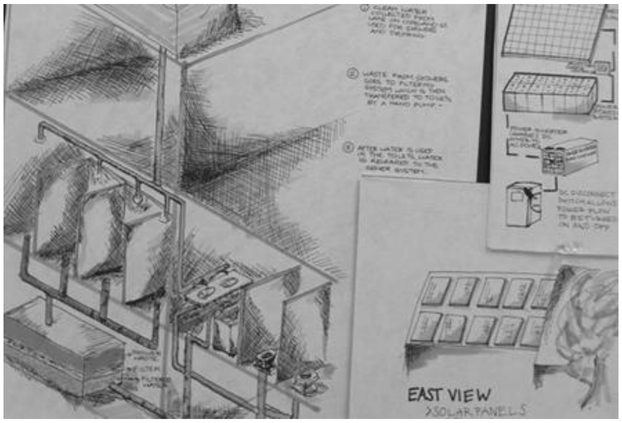

Figure 7: Project Z Student Work Sample: Detail of plumbing and electrical systems concept.

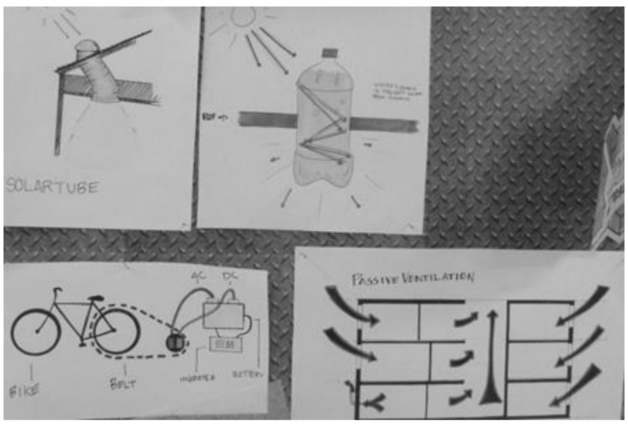

Figure 8: Project Z Student Work Sample: Detail of natural light, natural ventilation and electricity generation concepts.

Figure 9: Project Z Student Work Sample: Model of building with PV panels and water cisterns on the roof.

Figure 10: Project Z Student Work Sample: 1st Place Winner. 24" x 48" (approx. 60cm x 120cm). Each team had 4 or 5 students spanning the sophomore, junior, and senior levels.

The students in this study expressed a positive view of the cross-expertise team format in an effort to enhance the learning experience for the students with less design experience (Question 1). At this time, it could not be determined conclusively if any differences exist between each expertise level. Seeking a more nuanced answer to this question could be very telling. For example, do the sophomores perceive a greater benefit than the juniors and seniors? Larger participation numbers within each expertise level could provide an answer to this question.

Students in this study perceived the cross-expertise team format as providing an opportunity for the seniors to practice developing leadership skills (Question 2). Digging into the potential perception differences based upon expertise level presents an additional opportunity to expand on this research. Understanding how senior students view the opportunity to exercise leadership skills in the midst of an academic project is very helpful for educators as they seek to create learning situations similar in scope and format to this charrette. As leadership has been a growing focus within many academic disciplines, and specific courses have even been developed that focus on leadership, the cross-expertise team format could be a valuable context for advanced students to put leadership knowledge into practice prior to entering a professional setting. The findings expressed here regarding design students could also be transferable to other disciplines.

Overall, the students in this study perceived the experts as having a positive impact on their design solutions (Question 3). Four of the five experts were rated highly (median of 4 or 5 on a 5-point scale) by the students. The one who was rated low (median of 1.5 on a 5-point scale) provided a presentation that may not have connected to the needs of the project in the eyes of the students. The fast-paced context of the charrette may have influenced the students' views of the architectural presentation that was heavily steeped in theory. A presentation that did more to draw some practical applications of the material may have resulted in more positive perceptions by the students.

Overall, this charrette provided a strong learning opportunity for the students in a cross-expertise collaborative effort while integrating knowledge bases from multiple disciplines. The charrette can be a very valuable tool for educators as they prepare students for the professional world of design, architecture, engineering, and construction. While context is very important, two aspects of this study could be translated to other fields within academia: the cross-expertise team format and the integration of cross-disciplinary knowledge bases.

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