International Journal *of* Designs for Learning

2021 | Volume 12, Issue 2 | Pages 1-14

PEDAGOGY + REFLECTION: A PROBLEM-BASED LEARNING CASE IN INTERIOR DESIGN

Abimbola O. Asojo & Hoa Vo, *University of Minnesota*

Interior design education aims to provide students with real learning experiences. The authors, hence, combined problem-based learning (PBL) and design thinking to design a seven-week studio project in the Interior design program at a land-grant Midwest university. Thirty-two sophomores were engaged in different stages of the design process for the education wing of Minnesota's official natural history museum in collaboration with Perkins+ Will, a global architecture and design firm.

Students explored design thinking via interactions with stakeholders and practitioners who participated in the creation of the Museum. This approach allowed students to gain insights about the design-challenge plus the pros and cons of their solutions. For seven weeks, students in teams of three immersed themselves in a diverse and real design environment. They learned how to communicate, collaborate, and compromise to accomplish the common goal of finding the most relevant solution for the design problem at hand. The authors collected students' reflections on their learning experiences at the end of the project. This paper discusses the lessons we learned from this interior design PBL case.

Abimbola Asojo is a Professor in the Interior Design program and the Associate Dean for Research, Creative Scholarship and Engagement at the College of Design, University of Minnesota. Her research focuses on cross-cultural design issues, African architecture, computing and design, architectural lighting design, K-12 design and post-occupancy evaluation.

Hoa Vo is a Ph.D. candidate in Interior Design at the University of Minnesota. Her research focuses on the notion of creativity, feedback as a tool to foster creativity in design-educational and professional contexts, and human well-being in the built environment.

INTRODUCTION

Translating learning experiences to real-life design problems remains a challenge for interior design students (Hook et al., 2013). A common practice in design education is to have students propose solutions for open-ended problems through hand sketches and digital renderings. Most of the problems are interior design challenges for existing buildings with theorized clients. Students hardly have the opportunity to examine their solutions with real clients and actual contexts of use. Therefore, they might misinterpret clients' needs and encounter difficulties in framing problems and predicting potential obstacles. Although the solutions are visually appealing and code compliant, they are not necessarily sufficient in reflecting the needs of real clients and adapting to actual contexts of use.

The authors respond to this challenge by combining problem-based learning (PBL) and design thinking to create a pedagogy that offers students real learning experiences. PBL provides the pedagogical structure of problem-solving that helps students develop reasoning skills and construct knowledge (Barrows, 1986). Design thinking, whereas, is the pedagogical tool that guides students to successful problem-solving solutions (Chamberlain & Mendoza, 2017). Domains with ill-defined and complex problems (e.g., interior design) benefit the most from the educational applications of PBL and design thinking (Galford, Hawkins & Hertweck, 2015; Huber, Waxman & Clemons, 2017; Jonassen & Hung, 2008). The authors, therefore, exposed students to an open-ended problem-solving project that required flexible decision-making in considerations of multiple factors. For seven weeks, students interpreted the problem,

https://doi.org/10.14434/ijdl.v12i2.25372

researched, and constructed knowledge to develop successful solutions. The process, learning outcomes, and reflections are discussed in this paper.

THEORETICAL BACKGROUND

This section presents the theoretical background which shaped the authors' pedagogical approach and reflection on lessons learned in this PBL case. PBL is prominent in design education with team-based projects. This approach focuses on discussions and collaborations between team members to analyze and solve open-ended problems (Svihla et al., 2016). For instance, interior design instructors from Kansas State University applied PBL to the project of re-envisioning the Manhattan Catholic School (MCS) (Kaup, Kim & Dudek, 2013, pp.42—55). The instructors provided students with a professional team-based environment, site visits, and research (a case study and interviews of stakeholders such as teachers and students of MCS). Using the gathered information, the teams established tables of *Problem* and *Analysis*. This step helped them to frame the problems at hand and placed the foundation for initial solutions. The teams then wrote their programming proposal for the innovative learning environment for the pre-K to 3rd-grade students at MCS. The principal of MCS also coached the teams in determining and specifying functional spaces needed for this grade school. The outcomes of this project were satisfying with the mutual understanding between design teams and stakeholders (MCS teachers and students). The MCS teachers confirmed that the teams' solutions accurately reflect their expectations. The teams' feedback, likewise, conveyed excitement and motivation toward the project's structure and pedagogical tools (Kaup, Kim & Dudek, 2013).

Another example is the Chatham University's PBL fellowship program. Interior design instructors created a series of PBL projects for Lighting—Acoustic and Residential Design courses (Galford, Hawkins & Hertweck, 2015). The problems were two real client profiles: a senior female Type II diabetes patient with her assisted living facility and a retired couple with their art gallery renovation. Students from each class worked in groups (6 to 10 members) to address either of the provided problems. Instructors acted as facilitators guiding students to (1) envision the scope of problems, (2) generate ideas, (3) gather relevant information, (4) conduct team-based research, (5) develop and review proposed solutions. Invited practitioners and institutional educators serve as jurors to evaluate the groups' outcomes. Students' self-reflections showed sufficient understanding of clients' needs among the groups. They looked into relevant concepts on senior living and Type II diabetes, codes, and regulations of each building type, specifications of applicable materials. Giving and receiving feedback between members of the groups also improved students' ability to work in future collaborative environments (Galford, Hawkins & Hertweck, 2015). Overall, the PBL project's structure and pedagogical tools provided interior design students with a variable of skills they hardly obtained in traditional studio formats.

A similar PBL project is the Fraser clinic for children with autism took place in the Interior design (ID) program at University of Minnesota (Asojo & Patel, 2017, pp.157–163). The sophomore students worked in teams to solve the problem of providing positive learning experiences for children with Autism spectrum disorder (ASD). A tour of the existing site, group readings and discussions on research journals and book chapters, solution presentation, and feedback sessions with Fraser personnel and practitioners of Perkins + Will were activities students engaged in. These activities built a sound theoretical and practical foundation for the group to address the problem at hand. The groups also used the WELL Building Standard as a guideline to promote occupants' health and well-being in their design solutions. Both the Fraser personnel and invited practitioners were pleased with the students' research-based and context-related solutions. The PBL nature of the project successfully informed students with new insights on approaching and solving a typical design challenge in a real-life scenario (Asojo & Patel, 2017).

PROJECT DESIGN

The project took place in spring 2018, in the interior design program at a land-grant Midwest university. The authors structured the project based on the PBL process of (1) problem-introduction, (2) critical thinking-operation, (3) learning-need-identification, (4) knowledge-application, and (5) learning-reflection (Albanese & Dast, 2013, p. 63). These steps were reflected in the seven-week schedule of the project. The given problem was designing the education wing of Minnesota's official natural history museum. The authors used the first week to (1) introduce the problem to 32 students. We designated weeks two, three, and four for students to (2) critically investigate the problem, (3) identify and acquire problem-relevant knowledge, and (4) applying new learnings to draft initial solutions for the problem. We also dedicated weeks five and six for students to (5) reflect on their initial solutions and (4) apply new reflections to the final solutions. Week seven was a chance for students to (5) review their final solutions in terms of real clients' needs and actual contexts of use.

The authors, furthermore, tailored PBL to the design thinking process of the project to facilitate interior design students' learning. Students were guided to follow specific design steps to tackle the assigned project with desired responses (i.e., relevant and creative). Hence, we combined PBL and Huber et al.'s *backward design* model (2017) (i.e., *situational factors*, *learning goals*, *teaching and learning activities*, *feedback and assessments*) (see Figure 1) to build pedagogical tools such as research binder, mentoring, peer debriefing, desk critiques and juror reviews. The Research binder was a research- and writing-intensive assignment that helped

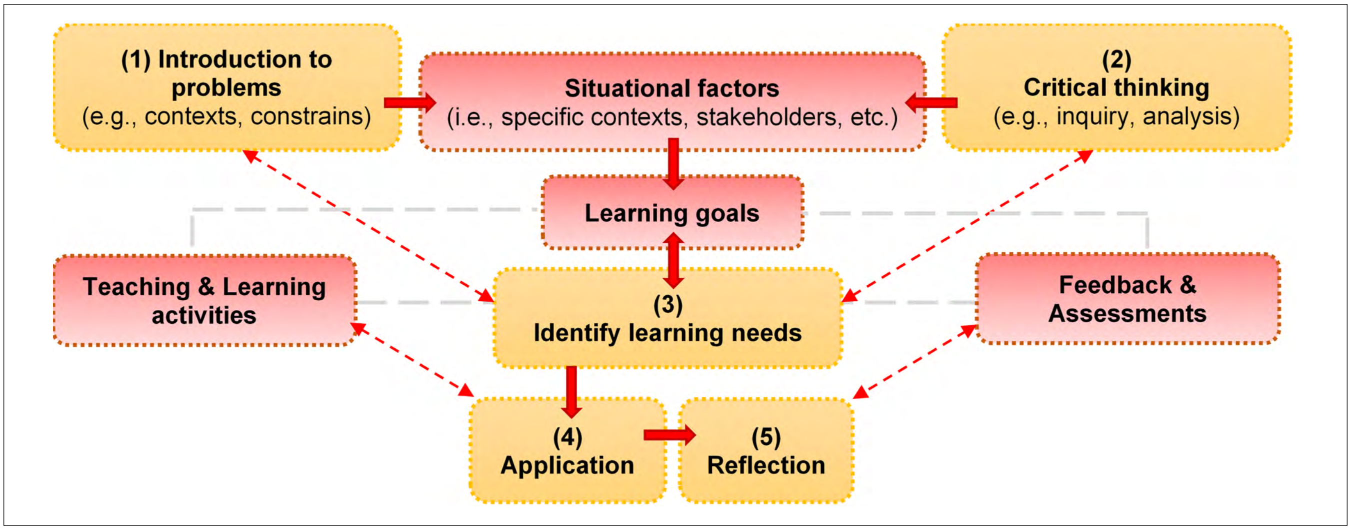

FIGURE 1. The combination of PBL and the Backward Design model (modified and developed from Huber, Waxman & Clemons, 2017).

students critically investigate the problem (2) and identify the scope of problem-relevant knowledge (3). Students first collected *situational factors* (i.e., clients' background and needs, building conditions, historical and social contexts, etc.). They then defined *learning goals* (i.e., the problem-solving directions, relevant knowledge and skills to achieve the determined directions). At the same time, students used research articles and design precedents to support the problem's scope and solution's directions (i.e., goals). In week one, students improved in critical thinking by actively analyzing the problem, identifying directions for solutions, and motivated themselves in accumulating knowledge and skills to execute their goals.

Mentoring and peer debriefing were also teaching and learning activities that helped students apply their learned knowledge and skills to form potential solutions for the given problems (4). Mentoring referred to discussions between students with Bell museum personnel and Perkins + Will's architects and designers. Peer debriefing referred to students summarizing and discussing their directions and progresses toward the solutions between peers. The authors, as instructors, gave desk critiques (i.e., feedback) to help students reflect on their learnings (i.e., whether they acquired the relevant knowledge or reached the desirable skill levels). These activities took place within week two, three, and four.

Juror reviews, likewise, provided assessments and improvements for students' learnings. Bell museum personnel, Perkins + Will's architects and designers served as jurors to (5) guide students' reflections on their goals, solutions with respect to the given problem (i.e., clients' needs, actual contexts of uses), and (4) encouraged them to revise and improve the solutions. The reviews took place in weeks three (schematic presentation), five (design development presentation), and seven (final presentation). Details of the reviews are available in the following project schedule.

In week one, students were introduced to the project and context by the instructors and Perkins + Will. At the end of the first class day, students were assigned to teams of three. There were 11 teams in total. The teams spent time researching and familiarizing themselves with the project requirements and building systems. In week two, the teams worked on their preliminary concepts and designs. In week three, the teams presented their preliminary concepts to the instructors, architects, interior designers from Perkins + Will, and a Bell Museum representative. Based on comments they received, the teams developed their concepts into design solutions. This process spanned through the second half of week three and the whole of week four. At the beginning of week five, the teams pitched their proposals with the floor plan, experience plan, RCP, and sketched perspectives. The jurors consisted of the instructors, the architects, and designers from Perkins + Will. This stage served as a middle point when students had materials for the jurors to provide critiques, yet they were still in the process of changing and refining their designs. The purpose was to allow sufficient time for the teams to revise their designs before the final presentation. Students used the rest of week five and the whole week six to enhance their designs based on the received critiques. After revisions, the teams presented their final solutions to the instructors and Perkins + Will practitioners in week seven. During week one, three, and four instructors gave lectures on rendering, technical drawings, K-12 design principles, and desk critiques to the class.

The PBL (combined with Backward design) framework (including research binder, mentoring, peer debriefing, desk critiques and juror reviews) is also applicable for different project types (the complexity varies with studio levels). One of the authors, as the lead faculty of the PBL sophomore design studio, reached out to local (architecture and interior) practitioners, firms, and prospective clients (e.g., business owners) to find real-life project opportunities. For instance, while this paper presents the PBL implementation in a K-12 Museum design project, the authors have conducted similar projects such as a clinic and a youth career training center. The project, thus, changes annually. The applicability-prospect of this framework to other disciplines, however, requires further pilot studies which are beyond the scope of this paper.

PROJECT CONTEXT

In this PBL experience, 32 sophomores were engaged in different stages of the design process with hands-on experiences designing Minnesota official natural history museum in collaboration with Perkins+ Will, a global architecture and design firm. The new museum features a digital planetarium, high-tech exhibits, famous wildlife dioramas, and outdoor learning gardens for K-12 students (Bell Museum, 2018).

FIGURE 2. Aerial landscape of the new Bell Museum with the 10-degree line (Retrieved from Perkins + Will's presentation, 2018).

Bell Museum Background

The Old Facility

The Bell Museum is State-funded and operated by the University of Minnesota College of Food, Agriculture and Natural Sciences. It is Minnesota's official natural history museum. It was formerly called James Ford Bell Museum of Natural History, this facility held numerous of dioramas made by Frances L. Jacques from the mid-20th century and animal specimens of Minnesota wildlife (Bell Museum, 2018). The first facility was a 75-year-old art deco building in University of Minnesota's Minneapolis campus. Its typical layout of box-like rooms led to daylighting insufficiency and ADA inaccessibility. The academic classrooms and auditorium-style spaces were also no longer able to serve the demands of an interactive museum, and this led to the need for a new facility.

The New Facility

For that purpose, a 12-acre site on the University of Minnesota's St. Paul campus became the context for the new facility. This location provided ample views toward Minneapolis and Saint Paul downtowns. Thus, it served as a connection between the two cities that make up the Twin Cities area of Minnesota. With the new Planetarium added, the new Bell Museum was about 10,000 square feet larger than the old one. It tripled the facility's capacity to serve general visitors and school groups. The new facility size is 90,000 square feet and it houses a 120-seat digitalized planetarium (Minn post, 2015; Joel Hoekstra, 2018).

Surrounded by the University's soccer field, retired housing, and the main avenues of the two cities, the site provided the new Bell Museum with promising footages. The 10-degree geological diagonal edge between the soccer field and University Grove Housing defined the overall architecture (See Figure 2). The whole structure is a living diorama with abundant glass façade for strong interior and exterior visual relationship. The low reflective nature of the glass panels is meant to reduce the collision incidents for the local bird population (Perkins + Will, 2018).

The new Bell Museum provides an innovative programming for diverse educational opportunities. A new digital theater offers immersive earth and space experiences, which represents the University's reputation for innovative research, education and public engagement. The North wing contains the Planetarium, Earth and Plants explorations, a story box and a web-based area. The South wing houses the Touch and See area, human interactions, and seminar activities. For outdoor experiences, multiple story boxes accompany geological grounds and a pollinator garden (See Figure 3).

Sustainability is a main theme throughout the exterior, site, and integrated systems. Local materials such as Eastern white cedar texture and thermal-modified white pine play an important part in delivering the environment-friendly message of the Bell Museum (See Figure 4 for the exterior of the new Bell Museum). The interior spaces also reflect the use of local materials. These materials in addition to photovoltaic panels and LED lighting are integrated such that the new Bell Museum meets the Minnesota B3 Standards, an equivalent guideline of LEED Gold (Perkins + Will, 2018).

Project Description

Students designed the South education wing of the first level of the new building taking into consideration the fixed elements such as the shell, structure, and vertical circulation. This South education wing included the K-12 education area and hands-on exhibition. A description of the spaces included in the design brief are as follow: the Student Education

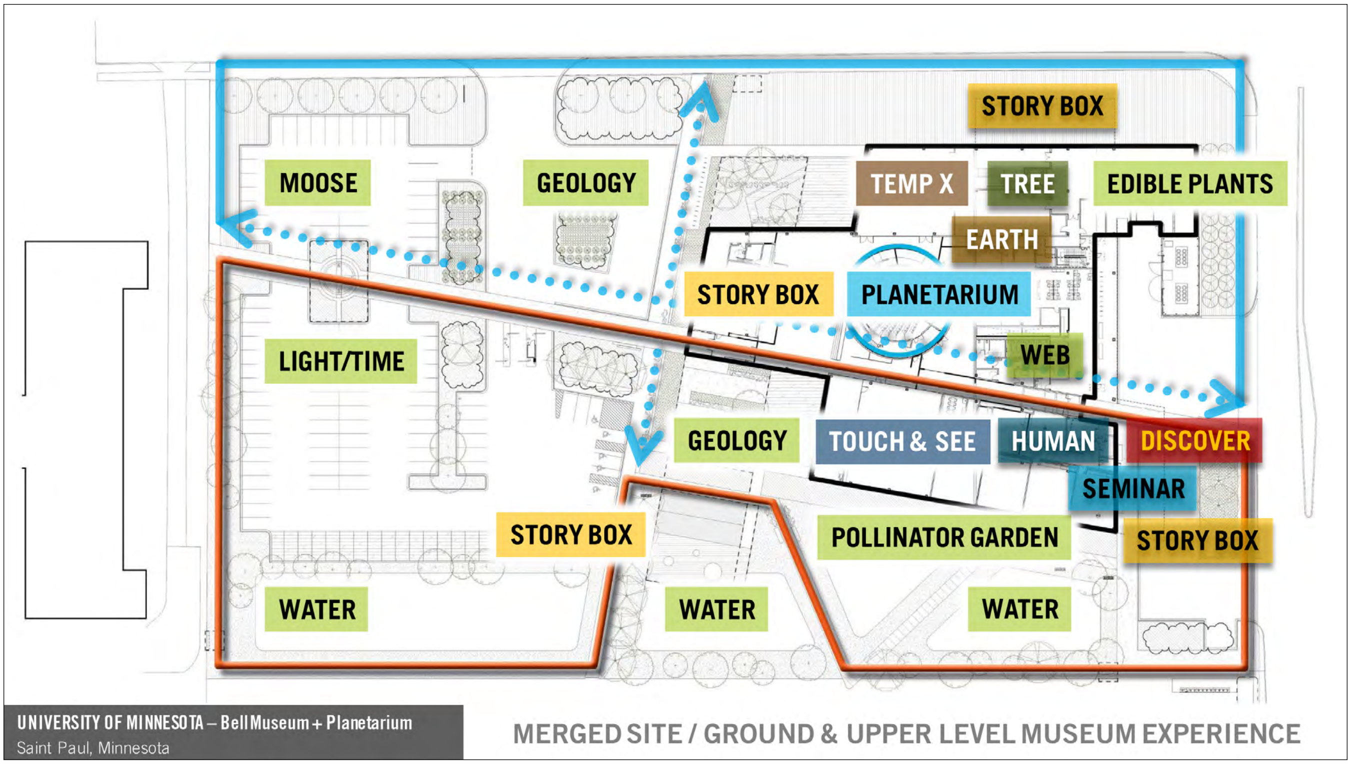

FIGURE 3. Bell Museum experiences (Retrieved from Perkins + Will's presentation, 2018).

FIGURE 4. Bell Museum exterior, © Peter J. Sieger (Retrieved from Perkins + Will's presentation, 2018).

and Museum Visitor Interactive Touch and See experience on the first floor. This area is located at the South with two entrances from East (bus drop-off) and West (parking lot, learning gardens) sides. Students were responsible for all the spaces enclosed in this wing:

- Touch & See
- Collection lab
- Supplies and Maintenance room
- Field Biology
- Physics
- Bee Hive
- Learning Lodge classrooms
- Education Materials
- Table/ Chair storages
- Guide Greenroom K-12 Staging area.

Students needed to keep the staircase and elevator as is. Restrooms were north of the elevator and out of the scope of design. Another requirement was adding another exit door in the South for faculty/ staff-led groups to access the site learning elements.

STUDENT PROJECT OUTCOMES

All teams provided rich-in-context and insightful solutions that met all project requirements. They were able to incorporate the State B3 sustainable design guidelines into the specifications of materials and furniture and fixtures. The key themes that emerged from all the teams' solutions were a sense of place, connection to nature, sustainability, universal design and interactive technology.

Sense of Place

Approaching the space from emotional standpoints was one of the strengths of the student teams. Besides fulfilling the functional aspect of the designs, most teams aimed to create an atmosphere that inspired education, exploration, and enjoyment. For example, since people perceive space based on physical characteristics such as size, volume, and objects (Miller et al., 2001), student created fluid experiential spaces. Having the spatial fluidity allows the K-12 audience to engage with the educational wing based on their age groups. One team noted:

> *"The free flowing space of the touch and see lab coupled with the structure of the collections area will provide a safe yet enjoyable atmosphere for discovery."*

Their design concept, derived from the flow of a river, focused on arranging display cases in an open-ended order. Three large free-form-stands defined the main circulation while the small-stand-alone ones provided explorative points (Figure 5, 6). With this flexible arrangement, visitors were free to choose their paths and thus creating personalized experiences and attachment to the space. Thus, the team's solution successfully demonstrated the *place attachment* theory with tangible design elements (Giuliani, 2003).

Another team proposed:

> *"Fostering learning through offering a variety of interactive opportunities and open adaptable spaces where young students feel comfortable and safe."*

The team used moveable furniture to create semi-private corners inside the classrooms. Reasoning that large spaces in comparison with children' bodies might cause anxiety and

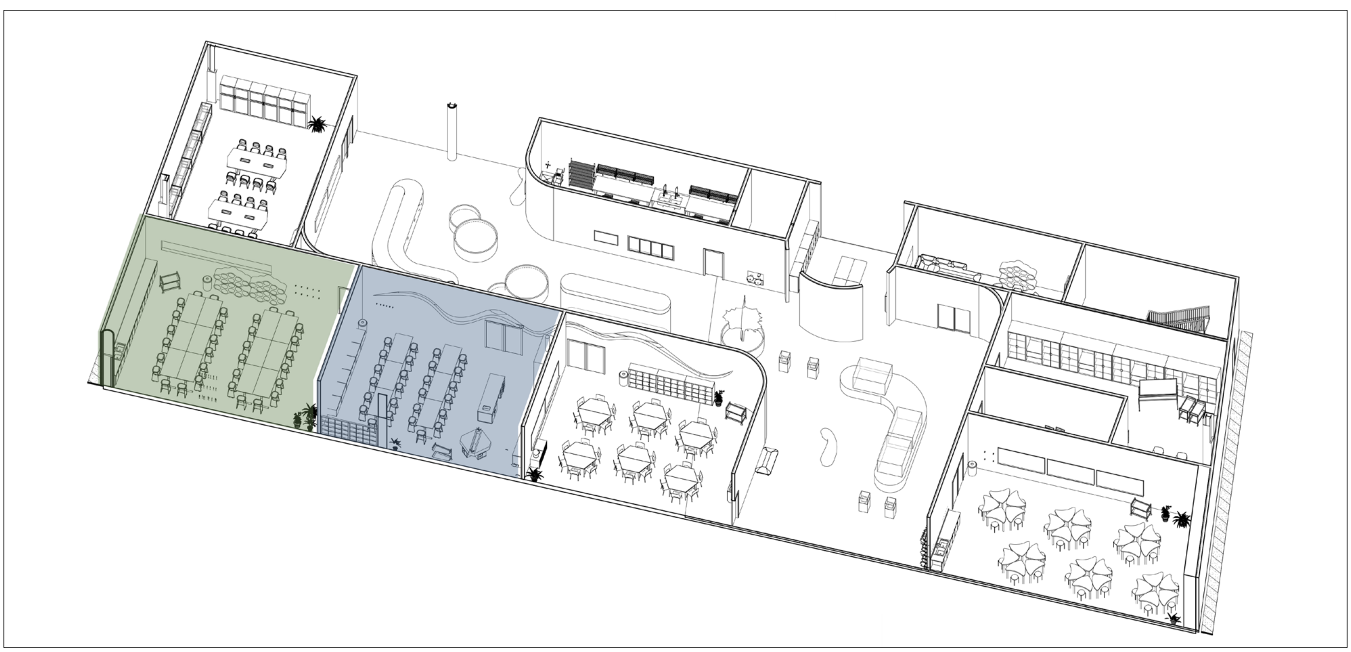

FIGURE 5. Axonometric rendering of a free flowing space (Source: Watanabe K., Geevie W., Olson C., 2018).

FIGURE 6. Proposed design for Touch and See area in the educational wing of the new Bell Museum (Source: Watanabe K., Geevie W., Olson C., 2018).

FIGURE 7. Semi-private corners in Lodge learning classroom for smaller children within K-12 age groups (Source: Hartman A., Kutschera L., 2018).

hinder their learning experiences. The team intentionally reduced the height and width of the classrooms into a child friendly environment of wooden house-like shelter and bright-colored beanbags (Figure 7).

The team applied the *prospect refuge* theory (Dosen & Ostwald, 2013) to their design, which indicates the human need of exploring the surroundings while keeping themselves safe. Overall, the teams showed an awareness of how the end users perceive the designed spaces, especially the K-12 audience and the classrooms. At the end of the project, a student reflected:

> *"Children's learning classroom environments need to be specifically designed for children and teachers to have the most successful use and interactions."*

The teams focused on understanding the personal experiences of the end users and they integrated that understanding into the proposed solutions to create a built environment that occupants can relate to.

Connection to Nature

Several of the student teams proposed design solution with strong connections to nature. One team noted:

> *"Patterns found in nature often form twin spirals called phyllotaxis in Fibonacci's Sequence, creating a centralized point that flows out in spiral pattern. These patterns in nature inspired the centralized form and bringing together students of various ages and educational levels to the educational wing of the Bell Museum."*

This team represented the *Fibonacci's Sequence*, or the natural spiral of living organisms, in the centralized cylindrical aquarium in the Touch and See area and classrooms and other facilities were organized around it (Figure 8). To create multiple dynamic views of the aquarium, students added glass walls/ partitions/ windows to the surrounding enclosed spaces. They intended to provide visitors with dynamic views of the aquarium (i.e., water—the core of life) to create a connection to nature.

Another team took a different approach and derived their concept from Perkins + Will 10-degree geological diagonal edge design parti. The students created their floor plan for the educational wing using 10-degree geographical angle also relating the angle to leaf veins (Figure 9). The team related the systematic order of leaf veins to the strong diagonal lines of the building exterior. They implemented the 10-degree axis in their interior space plan to separate the Touch and See on one side and the other facilities on the other. The 10-degree angle was reinforced throughout the interior.

The team noted:

> *"The 10 degree angle will be implemented into the construction of walls and finishes to create a visually interesting and aesthetically pleasing space."*

This team also provided multiple chances for visitors (especially the target K-12 audience) to be exposed to local plant

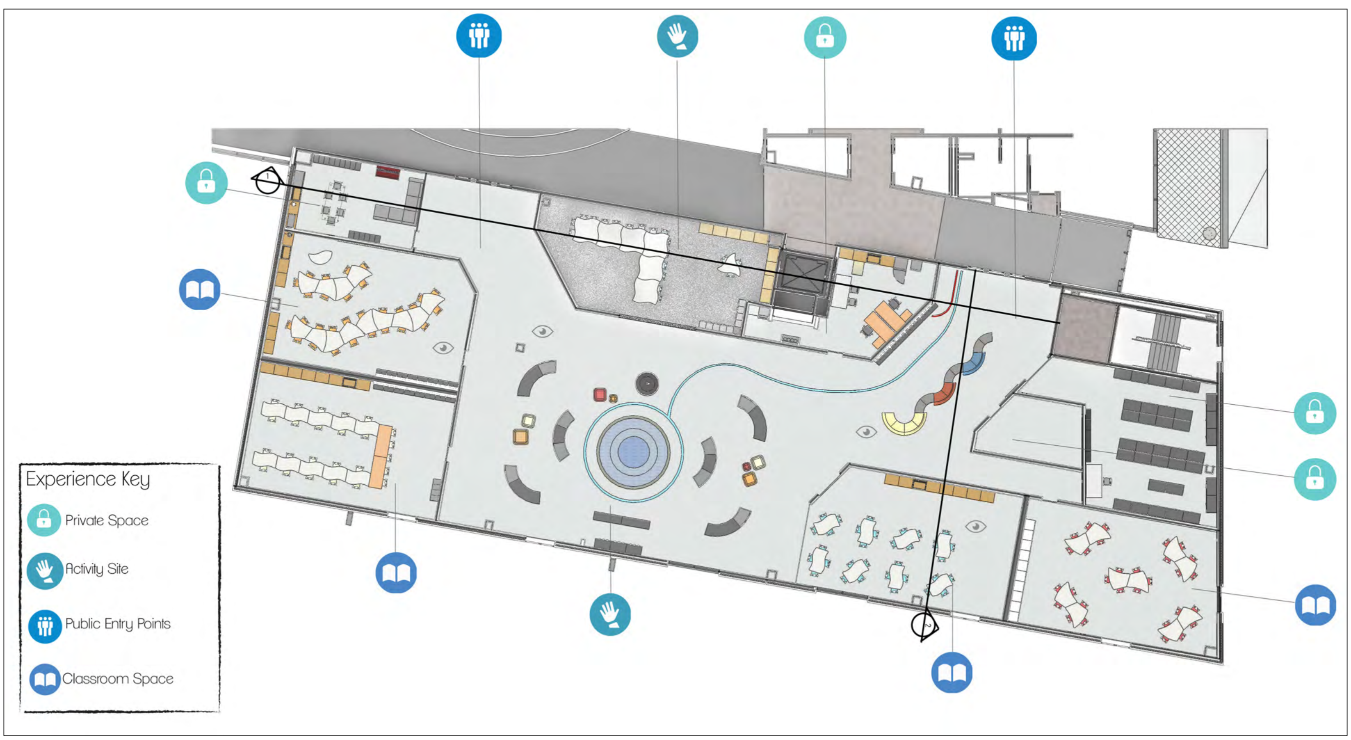

FIGURE 8. The Fibonacci's-sequence-inspired floorplan (Source: Ritter L., Maholik C., Rastall A., 2018).

FIGURE 9. The 10-degree-leaf-vein-inspired floorplan (Source: Li P., Newland K., Courington S., 2018).

FIGURE 10. The feature wall in Touch and See area covered with pictorial information of local species (Source: Li P., Newland K., Courington S., 2018).

and animal species. Pictorial information boards covered the entire main wall of the Touch and See area (see Figure 10). Hence, visitors can gain knowledge of local species via experiencing the space.

Some teams highlighted the importance of connection to nature by emphasizing a strong visual connection between the indoors and outdoors.

One team noted:

> *"The community puts a lot of emphasis on nature as well as the connection from the inside to the outside."*

Another team noted:

> *"We emphasize the transparency between indoor and outdoor space. This connection will allow visitors to explore historical pieces through way of connecting corridors, and subconsciously entice them to interact and reflect on nature and the universe."*

The teams, therefore, incorporated nature and the outdoor into their design solutions. Overall, the teams' design decisions were derived logically from not only the existing site and architecture but also the contextual conditions of the community.

Sustainability

All the teams addressed sustainability in their choices of materials and Furniture, Fixture and Equipment (FF&E). One team utilized the LEED (Leadership in Energy and Environmental Design) and NGBS (National Green Building Standard) guidelines in their materials selection. The team used ezoBoard, reWall, Green Living Wall, and Cork Rubber Flooring Expanko XCR4 for ceilings, walls, decorative partitions, and floors. The materials were either vegetable-originated or material-reclaimed. The team's decisions focused on reducing the carbon footprints of the building while maintaining the aesthetic of the design (Figure 11).

Another team employed the C2C certification (Cradle to Cradle), a guideline focused on eliminating of waste (see Figure 12). It calls for designs, products, and materials that embrace natural resources with innovative and responsible productions (Epea, 2018). A C2C certified material needs not contain harmful substances, can be recycled, produced by fair labor and sustain the sanity of nearby resources (i.e., water, land, etc.). By using a C2C certified carpet for the entire Touch and See area, the team ensured the lowest carbon footprint for the largest surface. Acoustic ceiling tiles (ACT) with recycled content, LEED-certified paint, and recycled woods for decoration (see Figure 13) completed the team's material palette.

Despite the use of different sustainable guidelines, this general theme was the most prominent in the teams' reflections at the end of the projects. One student expressed:

> *"I learned that Perkins + Will designed the new Bell museum following the State B3 Sustainable guidelines. Both clients and designers supported the use of local materials"*

FIGURE 11. A classroom-demonstration of using sustainable materials (Source: Watanabe K., Geevie W., Olson C., 2018).

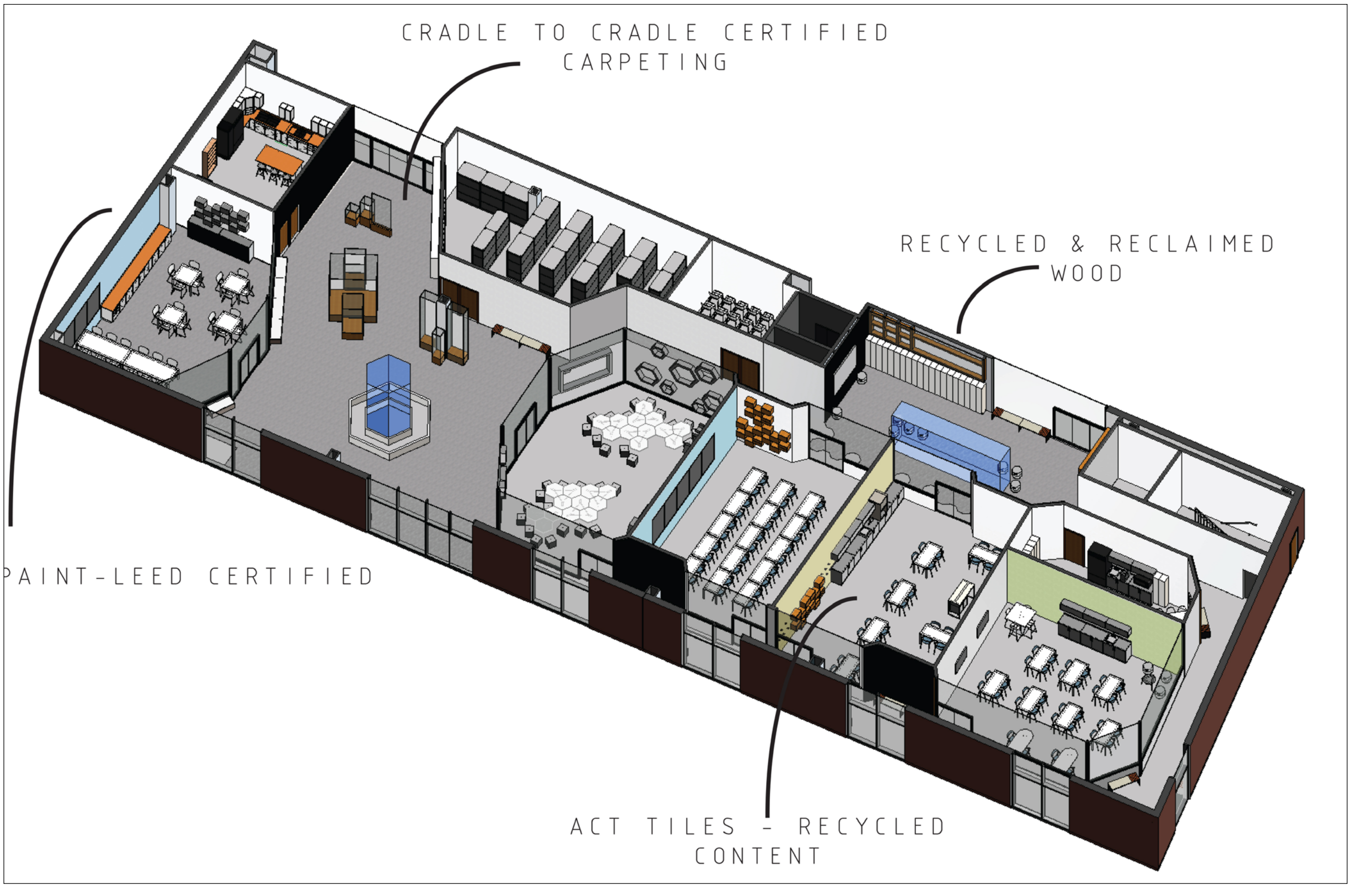

FIGURE 12. Demonstration of sustainable materials in the entire educational wing (Source: Blaney B., Burroughs M., Rueger E., 2018).

FIGURE 13. Touch and See entrance with reclaimed wood panels (Source: Blaney B., Burroughs M., Rueger E., 2018).

Another student stressed on the importance of the project's requirement on sustainability:

"I appreciated the University's effort in informing and training students about sustainable design which will benefit us in the long term."

These reflections showed the commitment of the teams to achieving design solutions that were not only visually pleasing but also environmentally friendly.

Universal Design

Using universal design principles, the teams took into account the diversity of the target audience, K-12 students with a wide range of ages and sizes. In their design solutions, students focused on using furniture with different anthropometric proportions to support the wide range of sizes of the children. One of the groups explained their strategy.

"A variety of moveable and flexible height furniture in the classrooms will allow ample exploration of creative ideas."

All the teams acknowledged the fact that K-12 denoted more than one specific age group. Ranging from kindergarten (4-6 year-olds) to twelfth grade (17-18 year-olds), these visitors have very different physical characteristics which demand different sizes of furniture. Using adjustable chairs and tables, one of the teams introduced an effective strategy to rearrange the classrooms to serve smaller children or teenagers. The modular tables allowed multiple arrangements depended on the educational purposes at hands. Most classroom-furniture incorporated wheels to allow for flexibility (see Figure 14).

FIGURE 14. Adjustable, modular, and wheeled chairs and tables (Source: Maholik C., Ritter L., Rastall A., 2018).

The teams' furniture specifications were the results of the in-depth research about K-12 student behaviors and their age groups. Knowing that physical explorations of surrounding environments stimulate the development of the brain, the teams used furniture to provide the end users with physical safety and intellectual development. As one student reflected:

> *"Function in education sometimes needs to follow form because of children's safety and I am 100% okay with that if more children are safe."*

Without solely favoring aesthetic, the teams prioritized the relevancy and efficiency of their solutions to multiple user groups. One team kept the classroom design minimal with geometrical shapes and structures (see Figure 15).

A student stated:

> *"I have learned that there is a diverse makeup in this regional area of students who often don't feel represented and I hope we accomplished representing them in a space with the design solution."*

This point of view reflected in the inclusive design solutions of the teams. They paid attention to anthropometrics, especially in the size of furniture and interior openings. Besides the adjustable tables and chairs previously mentioned, the teams made their spaces ADA accessible. Since this was the main problem of the old Bell Museum, for the new designs, it was important for students make their solutions accessible.

Interactive Technology

Besides design elements, the teams also incorporated technology into their solutions on different levels. A student recalled:

> *"I learned that the community cares a lot about educating children and collaborative learning."*

To assist that community-based requirement, the teams looked for means to deliver information of artifacts to the visitors. Unlike adult visitors, the K-12 audience need a more dynamic and direct approach to the museum exhibitions. One student recalled:

> *"A lot of the jurors' feedback I will remember and take note of on future projects and in practice, For example, it was particularly important to focus on the client and their user group and creating both a 2d and 3d design experience for the K-12 audience."*

The strategy of using interactive technology became prominent among others as it allowed real-time interactions between the displayed information and the audience. From touchscreens embodied in display cases to interactive surfaces monitored by projectors, the applications varied on a team basis. One team noted the following:

> *"We reflected Minnesota's Natural Environment using design elements that balance the space with the rest of the museum. We created an immersive and interactive learning experience for visitors of all ages."*

Bringing in multiple design features might detach the educational wing from the rest of the new Bell Museum. With that in mind, the team minimized the material palette, simplified the floor plan, and presented information using technology instead of tangible signs and boards. For instance, the team intentionally left blank walls across the hallway of their new design for the educational wing. As visitors moved along the walls, projectors automatically showed relevant images and texts on those vertical surfaces (see Figure 16). With this strategy, the team created multiple makeovers for their space without excessive needs of materials and constructions. Since visitors could interact with the projected information, their learning and exploring experiences were unique and personalized.

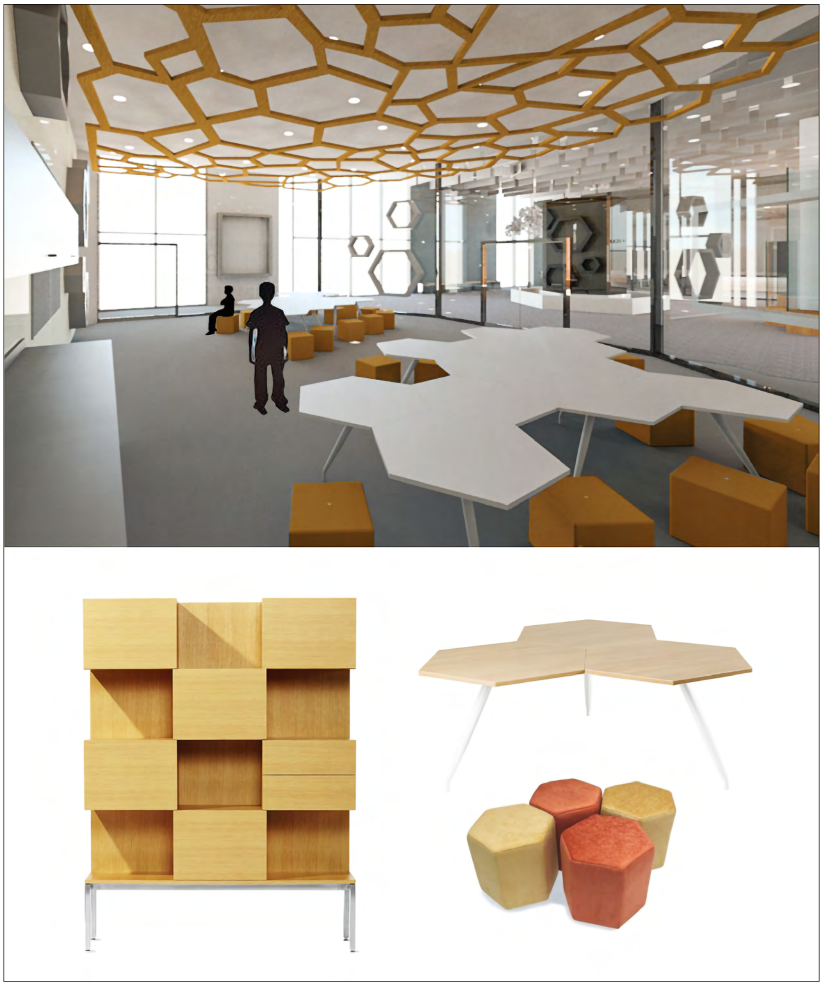

FIGURE 15. A geometrical and modular classroom with furniture specification (Source: Blaney B., Burroughs M., Rueger E., 2018).

CONCLUSION

The stakeholders (Bell Museum personnel, Perkins + Will architects and designers) and the instructors were pleased with the in-depth research and design solutions of the student teams. Through the teams' reflections of their design solutions and process, they expressed ample understanding of the site, the existing building, constructional structures, the community, and target audience (K-12 students). The common themes that emerged from the teams were sense of place, connection to nature, sustainability, universal design, and interactive technology.

As shown in the reflections, these themes derived directly from the specific contexts of the new Bell Museum and its surrounding. The input from stakeholders also played an important role in informing the student teams of the successful criteria for their designs. The instructors' provided necessary introductory and complementary information regarding the south educational wing (i.e., programming requirements, codes and regulations, technical helps, etc.). Whereas, the teams' critical thinking guided them to specific solutions for the general challenge. All the mentioned factors contributed to the achievement in learning goals of each team. The teams compared the objective criteria of the project and their subjective interpretations to define the paths they want to follow and what ideas they should pursue along the way. For instance, with sense of place, the teams borrowed several theories (e.g., prospect refugee, place attachment) to ground their solutions. To create the connection to nature, the teams looked into the natural conditions of the site as well as the artifacts of the old Bell Museum. For sustainability, the teams presented broad understanding of a variety of design guidelines. Some started with the local state-level B3 building guideline, others inclined toward national wide standards like LEED, C2C, and WELL. The teams also studied the anthropometrics data for different K-12 age groups and ADA requirements to ensure accessibility of their designs. With the community in mind, the teams' design solutions actually tied to the contextual, social, and historical contexts of the site. The interactive technology in the teams' design

FIGURE 16. Interactive wall with projectors (Source: Li P., Newland K., Courington S., 2018).

solutions was the evidence of their sense of current trends in the profession.

The design challenge (i.e., the south educational wing of the new Bell Museum) was at the center of this PBL experience. Desk critiques and formal presentations were class activities that helped the teams question their own assumptions and advance their progress. The instructors and stakeholders guided the student teams. They were reliable resources that the teams needed to ensure their learning experience thrived properly. The teams continuously and selectively applied the feedback they received into their design solutions. In other words, the cycle of reflection and application remained during the whole project. Overall, through this PBL experience, the teams were able to bridge the gap between their educational and practical experiences. Above all, they learned how to appreciate the contexts and community as the core of a successful design while working with stakeholders.

One concern regarding the implementation of this PBL experience was the stress students experienced from the workload and time constraints. While developing their projects, students expressed the needs for more research time outside and work time inside the studio, plus flexible deadlines to the instructors/authors. These concerns are not within the focus of this paper and thus, were not measured or discussed. Overall, students perceived workload as a struggle. However, they needed to accomplish the project in a limited time (7 weeks) because it was only one of three projects in the spring semester. Every class period, therefore, was designated to a specific task and students had to work continuously to meet the deadline. The authors, nevertheless, propose that flipped classroom strategies, as a future research direction, can mitigate students' stress and even advance the positive effects of PBL.

REFERENCES

Albanese, M. A., & Dast, L. C. (2013). *Problem-Based Learning*. In Understanding Medical Education: Evidence, Theory and Practice: Second Edition (pp.61-79). Wiley Blackwell. https://doi.org/10.1007/978-94-017-9066-6_5

Asojo, A. & Patel, T. (2017). Community Participatory Design Process for an Autism Clinic: Role + Pedagogy + Reflection. In Shin, J., Narayan, M., Dennis, S. (Ed.). *Proceedings of the 48th Annual Conference of the Environmental Design Research Association* (pp.157—163).

Barrows, H. (1986). A taxonomy of problem-based learning methods. *Medical Education*, 20(6), 481-6. https://doi.org/10.1111/j.1365-2923.1986.tb01386.x

Bell Museum. (2018). *Bell Museum*. https://www.bellmuseum.umn.edu/

Chamberlain, L., & Mendoza, S. (2017). Design thinking as research pedagogy for undergraduates: Project-based learning with impact. *Council on Undergraduate Research Quarterly*, *37*(4), 18-23.

Dosen, A. S. & Ostwald, M. J. (2013), Prospect and refuge theory: constructing a critical definition for architecture and design. *Common Ground: Archeology and Ethnography in the Public Interest*. https://doi.org/10.18848/2325-1328/CGP/v06i01/38559

Epea. (2018, July 12). *Cradle to Cradle®. Innovation, quality and good design*. https://www.epea.com/cradle-to-cradle/

https://doi.org/10.7771/1541-5015.1527

Galford, G., Hawkins, S., & Hertweck, M. (2015). Problem-based learning as a model for the Interior Design classroom: bridging the skills divide between academia and practice. *Interdisciplinary Journal of Problem-Based Learning*, *9*(2), 8. https://doi.org/10.7771/1541-5015.1527

Giuliani, M. V. (2003). Theory of attachment and place attachment. In M. Bonnes, T. Lee, and M. Bonaiuto (Eds.), *Psychological theories for environmental issues* (pp. 137-170). Aldershot: Ashgate.

Huber, A. M., Waxman, L. K., & Clemons, S. (2017). Students as Researchers, Collaborators, & End-users: Informing Campus Design. *International Journal of Designs for Learning*, *8*(2). Association for Educational Communications & Technology / Indiana University Bloomington. Retrieved March 9, 2021 from https://www.learntechlib.org/p/209604/.

Hook, J., Hjermitslev, T., Iversen, O. S., & Olivier, P. (2013, September). The ReflecTable: bridging the gap between theory and practice in design education. In *IFIP Conference on Human-Computer Interaction* (pp. 624-641). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-40480-1_44

Jonassen, D. H., & Hung, W. (2008). All problems are not equal: Implications for problem-based learning. *Interdisciplinary Journal of Problem-Based Learning*, *2*(2), 4. https://doi.org/10.7771/1541-5015.1080

Kaup, M. L., Kim, H. C., & Dudek, M. (2013). Planning to learn: The role of interior design in educational settings. *International Journal of Designs for Learning*, *4*(2). Association for Educational Communications & Technology / Indiana University Bloomington. Retrieved March 9, 2021 from https://www.learntechlib.org/p/209657/.

Joel H. (2018). Hands-on learning at the new Bell Museum. *MN Architecture*, 20—25.

Minn Post. (2015, September 23). *One of Minnesota's most beloved museums is finally getting a new building. Will that ruin its old-school charm?*. https://www.minnpost.com/politics-policy/2015/09/one-minnesotas-most-beloved-museums-finally-getting-new-building-will-ruin-i

Miller, N., Erickson, A., & Yust, B. (2001). Sense of Place in the Workplace: The Relationship Between Personal Objects and Job Satisfaction and Motivation. *Journal of Interior Design*, *27*(1), 35-44. https://doi.org/10.1111/j.1939-1668.2001.tb00364.x.

Perkins + Will. (2018, March). *Bell Museum + Planetarium*. Presentation for Interior Design program, University of Minnesota.

Svihla, V., Reeve, R., Field, J., Lane, W., Collins, J., & Stiles, A. (2016). Framing, Reframing, and Teaching: Design Decisions Before, During and Within a Project-based Unit. *International Journal of Designs for Learning*, *7*(1). Association for Educational Communications & Technology / Indiana University Bloomington. Retrieved March 9, 2021 from https://www.learntechlib.org/p/209616/.