Engineering Service Learning at Children’s Museum: A Decade of Empowering the STEM Education Pipeline

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Abstract

One of the most effective techniques to teach engineering in higher education is service learning, in which student learning objectives are combined with community service to provide a real-life, progressive learning experience. A significant part of engineering introductory courses are team projects, which are effectively facilitated through service learning. This paper describes a 10-year service-learning project at San Antonio College (SAC) done in close collaboration with The DoSeum, formerly the San Antonio Children’s Museum [1]. It presents the development, implementation, and results of this project, which is included as a component of a freshman-level Introduction to Engineering course. Initially, the museum’s Education Coordinator requested our help to develop thematic toys and games to teach visiting children various physics concepts. This evolved to align with the re-development of The DoSeum into a STEM center during the past decade. The project starts with the museum education team, the “customer,” presenting to engineering students the physics concepts they need addressed as well as the aesthetic, technical, and safety requirements of the project. Each student engineering team chooses a physics concept to design and build a toy or game “exhibit” that meets all requirements, using recycled and repurposed materials as much as possible. The teams present their prototypes to the engineering course instructor and The DoSeum team for inspection, feedback, and approval. After final modifications, a product test with the “customers” (children and their families) is conducted at The DoSeum. On a busy Saturday afternoon, hundreds of children and their families play with the exhibited toys and games and indicate their preferences on a ballot to decide the “Top-3” exhibits. At the same time, The DoSeum’s education team has the option to select projects that are suitable to be donated and become exhibits in the museum. The project concludes with detailed team written reports that describe how the multi-step engineering design process was used to design, build, and test a new product. The final activity is a class discussion where students exchange observations and lessons learned. Feedback on this project has been almost universally positive since its inception. This paper also provides conclusions and suggestions to help other schools start a service-learning component in their “Introduction to Engineering”
course that will not only benefit students, but also help their communities learn more about engineering.

**Literature Review**

Two previous papers, one in 2008 [2] and one in 2011 [3], documented our constant efforts to integrate service-learning projects in our “Introduction to Engineering” course in order to expose our students to real-life problems and show them how engineering can address those problems. This paper presents the broad analysis of our ten-year experience with this project.

The project fits under multiple definitions such as a service-learning project, an experiential learning project, project-based learning, or an active learning project designed to help students become familiar with real-life engineering activities. A very brief literature review provides support for every definition mentioned here.

Service learning has been considered to be a highly effective teaching tactic in higher education for many years. According to Bringle and Hatcher [4], service-learning is defined as a “course-based, credit bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs, and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of personal values and civic responsibility” (p. 112). Service-learning has been found to enhance students’ collaboration skills [5], civic engagement, interpersonal skills [6], [7], and their ability to apply knowledge to problem-solving [8].

There is a large variety of service-learning projects developed at other institutions of higher learning [9] – [11] such as EPICS (Engineering Projects in Community Service), PROCEED (PROGRAM FOR COMMUNITY ENGAGEMENT IN ENGINEERING DESIGN), Public Service Design Seminars (PSDS), and IDEAS (Innovation, Design, Enterprise, Action, and Service) Competition. All demonstrate the powerful effects of involving engineering students in solving problems for their communities and their results compare very well with the results of our project. The continuous partnership between our institutions provided a stable relationship that allowed our project to evolve and expand. This added another valuable example of the expanding list of engineering projects that serve their communities across the country.

Experiential learning means learning from experience or learning by doing. Experiential education proposes first to immerse learners in a specific experience. Then, they are encouraged
to reflect on the experience they had. This helps them develop new skills, new attitudes, and new ways of thinking that will broaden their expertise [12] – [15].

Project-based learning is a way to train students to apply directly what they have learned and broaden the scope of their knowledge [16] – [18]. Having the opportunity to use critical thinking to solve challenging problems, students are able to take their learning to a higher level. The real-world application demonstrates the mastery of material since it goes beyond just basic recall understanding. Students design and build the whole solution based on their analysis and research of the problem and needs of the “customer”.

Active learning is a technique where students get actively involved in the learning process rather than just simply listening to a lecture. They are doing work that includes researching, discovering, processing and applying the information they found to solve a problem [19], [20]. An added benefit of all these methods is that besides helping students achieve the desired outcomes, they also improve student retention and graduation rates [21]. All these learning models are clearly present in our ongoing project and the ten years of partnership with the San Antonio Children’s Museum, which has become The DoSeum, a center of STEM excellence that has served to validate the long-lasting positive outcomes of this project.

**Background**

After a less than successful initial attempt [2] to incorporate service-learning projects in our Introduction to Engineering course, the San Antonio Children’s Museum became the natural community partner for the service-learning project. It was selected from a list of potential community partners provided by the service-learning office at our college. The selection was based on the alignment between their needs for volunteer work in the area of education and the learning objectives of the course project. The original Children’s Museum provided a list of science topics that were considered to be difficult to convey to their visitors without a physical demonstration involving educational toys or games. This list has evolved to focus on various age-appropriate physics concepts. The list was developed into an engineering-like specification (Appendix 1, 2). Throughout the years, the project was very well received by the media, parents, students, and the community. The project evolved from use in one course to all “Introduction to Engineering” courses and from a grant- supported project that provided $50 per team for materials, to a more sustainable project where primarily recycled, reused, or repurposed
materials are used. This concept also fits well with the new DoSeum’s own initiative to practice environmentalism.

The DoSeum seeks to build on partnerships with institutions that are willing to work through the design process to innovate and evolve educational programs for maximum impact. The DoSeum has benefitted greatly from this project by increasing the museum’s capacity to fulfill its mission to engage children in joyful STEM learning during the product testing event and beyond. Through this project, The DoSeum extends its educational impact to include college students while positioning these college students as role models for children, particularly the students in The DoSeum’s after school programs. The primary service provided to The DoSeum by this partnership with the Engineering Section at San Antonio College is to allow The DoSeum to fulfill the four dimensions of children’s museums as defined by the Association of Children’s Museums (ACM) [22], [23]. According to the ACM, “all children’s museums function across four dimensions, as local destinations, educational laboratories, community resources, and advocates for children. They are experts in designing learning spaces that elevate naturalistic and child-centered learning.” By sharing and testing their expertise with college engineering students through the service-learning project, museum staff from multiple departments have the opportunity to practice communicating about the museum and guiding a design process. Through the years, The DoSeum exhibits, education, guest service, and operations departments have supported this project. The DoSeum staff have participated as part of the team that goes to the college to pitch the opportunity to the students and test their proposals and prototypes, as part of the staff that works with the college faculty and students to produce the product testing event, and as part of the team who judges and recognizes the best student projects.

Children’s museums can “act as incubators and innovators, testing and developing child-centered and play-based pedagogies for engaging children in learning.” The partnership with our college provides opportunities for The DoSeum staff to observe children’s reactions to a range of ways to teach a STEM idea through play – from very basic and traditional to innovative and unique. The service-learning project itself has undergone a process of incubation, testing, and innovation. As the project has evolved, it has provided a model for other service-learning projects the museum has engaged in with college and university partners including a version of this project in which students from the University of Texas at San Antonio compete to be selected by The DoSeum exhibits and education team to design or re-design an exhibit. The San
Antonio College project served as a lab and prototype for this expanded, multi-year partnership project.

“Children’s museums are an important part of the social service fabric of their communities…” according to the ACM statement; they are “symbols of how a community treats and respects children.” The partnership with San Antonio College positions The DoSeum as a community hub for multiple family types. Families with young children become part of a college class experience, ideally establishing a desire to go to college in young children, thereby strengthening the school to college pipeline. Focusing college student’s efforts on serving children as their clients and allowing children to react honestly to the college student’s projects during the product testing event models for the community at large how to respect and value contributions from children.

Finally, this engineering service-learning project has set the stage for multiple opportunities for The DoSeum to work with other partners, such as Communities in Schools and local elementary schools and school districts, to engage elementary school students in STEM learning. Students from The DoSeum’s after school programs engage in the engineering design process. As such, these students have been the primary target audience for the San Antonio College engineering service-learning project for the last three years. This interaction provides meaningful ways for the elementary age students to identify with the college students as professional colleagues – engineers. In connecting the after-school students with the college students for this project, The DoSeum fulfills the fourth dimension of children’s museum to “cultivate deep and wide-ranging relationships with partners from all sectors to best serve all children and families in their communities.”

Goals

Since the beginning of the Fall 2008 semester, this service-learning project has been consistently implemented in the “Introduction to Engineering” courses at San Antonio College. The course has been designed to addresses six primary goals:

- attract students to the engineering profession
- provide an orientation to the engineering field and curriculum
- teach academic success strategies
- develop team-building skills
- involve students in community activities
- provide personal and professional development
It is the only course that has the ability to expose the students to the variety of engineering fields and explain the differences between engineering functions. This is often the earliest source of information to help them decide which engineering career/job to pursue and motivates them to withstand the rigors of an engineering education in order to succeed and graduate. The toy/game project contributes significantly to the achievement of the six primary course goals detailed above.

The DoSeum has coordinated this project as a culminating public program every semester. Since the first iteration of this project, the museum’s program goals have been implicit in the request to create interactive exhibits to teach difficult physics concepts to children younger than 12 years of age using toys and games. The primary goal for this project is to engage college students as co-educators along with The DoSeum staff. This follows from the museum’s mission to “transform communities through joyful learning,” in this case by empowering engineering students to understand the impact they can have on the community through educational experiences that connect families. When the college students successfully create projects that teach physics through play, they enhance the learning experience of The DoSeum, and they observe for their own edification how learning happens.

The DoSeum’s goals for the service-learning project have evolved along with The DoSeum’s growth and development. The secondary and emerging goal is to engage students from The DoSeum’s after school programs in engineering design-based activities with college students to present the possible future to these elementary students – a college education. The college students are briefed and informally coached to deepen their engagement with the children. They are encouraged to explain to the children that they are from the local college, that in most cases were raised in the local area, and that they have also utilized the engineering design process in their class for this project. The DoSeum after school programs strive to foster growth mindsets that promote lifelong learning; the college students embody these mindsets.

**Student Learning Outcomes**

From the beginning, the specific learning objectives for the course in general and this project in particular, were tailored to support ABET-required outcomes [24], particularly Criterion 3: Student Outcomes. Effective with the 2019-2020 accreditation cycle, the new ABET Engineering Accreditation Commission Criterion 3: Student Outcomes states the following:
Students must demonstrate:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Project Guidelines and Requirements

The toy/game service-learning project assignment is given to the students as the second design project of the semester in the Introduction to Engineering course. The student teams are provided the project guidelines along with administrative, logistical, safety and technical requirements by the course instructor and a member of The DoSeum education team. Each semester the detailed specifications with guidelines/requirements are updated and provided by The DoSeum staff and course instructor to the student teams as handouts on the first day of the project (Appendix 1, 2), and are summarized below:

The goal of the project is to design, construct, document, and demonstrate a toy or game for The DoSeum that is safe, fun, spark’s a child’s curiosity, and helps it understand the basics of a physics concept. Students are informed that there is no funding for this project, and students are
encouraged to re-use materials in alignment with “the Green initiatives taken by The DoSeum and the Alamo Colleges District.” The primary requirements of the toy/game project are:

- Must be safe and easy for small children to use either on the floor or on a tabletop
- Must be an original design or novel modification of an existing design
- Length/width/height cannot exceed 60”/30”/48”
- Must use recycled or repurposed materials as much as possible
- Must submit a final team written report of 8 – 12 pages

Physics concepts students can choose from are specified on the project request handout. Students can suggest a different physics concept, but this must be approved by The DoSeum team. The DoSeum aligns exhibit and program activities to state and national educational standards and best practices in informal education, and the college student projects are required to uphold the same alignment. Students are instructed to determine the specific age range their project will target. Although children are not restricted from interacting with projects not intended for their age level, project designs are more intentional and effective when a target age level is determined. Projects are required to be accessible for use by children ages 3-11.

Project Implementation Process

The toy/game service-learning project covers a 9-week period involving a process of multiple steps as shown in Figure 1. The DoSeum staff engages with the students over the course of four interactions. These interactions correlate to the engineering design process as the course instructor and The DoSeum staff present the problem/need, review and approve ideas, and prototype the student’s projects prior to the product testing to provide feedback to improve the designs. Each step of the process is described in the following paragraphs.

Project Assignment (week 1) – The DoSeum Education Team staff and the course instructor present the goal, guidelines, and administrative, logistical, safety and technical requirements of
the toy/game service-learning project both orally and in writing (Appendix 1, 2). To build understanding of their “client”, The DoSeum representative provides The DoSeum organizational history, target audience, mission, vision, guiding educational beliefs, exhibit gallery descriptions, and program descriptions. Students are invited to ask questions to better understand The DoSeum or the assignment. They are also provided the timeline and goals of the upcoming interactions with The DoSeum staff, and they are informed of the product testing, child voting process, and The DoSeum staff awards. In addition, the course instructor shows photos and videos of some previous toy/game projects to help motivate the student teams. The student teams consist of three to four students per team, one of which is assigned as team leader. The course instructor also explains how this project will allow the student teams to go through the entire engineering design process from the initial identification of the customer’s (The DoSeum) needs to the design, construction, delivery and documentation of a product to satisfy the customer’s needs. Students are encouraged to continue asking questions of The DoSeum staff or instructor at any time (in person, by phone, or email). Also, student teams are invited to visit The DoSeum to view and interact with the exhibits to help formulate ideas for their toy/game.

**Brainstorm and Evaluate Ideas (week 2)** – After the project is assigned, student teams may visit The DoSeum and/or do research online to brainstorm ideas for their toy/game. Students receive free admission to The DoSeum for the duration of the project. The course instructor reviews ideas with the student teams as they are developed. The student teams evaluate different alternative ideas to determine the pros and cons. They are also required to use an evaluation matrix to help them select the best idea by comparing and scoring each alternative in relation to key properties such as safety, durability, fun factor, cost, educational value, and complexity.

**Project Proposal (week 3)** – The student teams prepare a project proposal (Appendix 3) that includes a brief description, sketches, pros/cons, and a materials list for their primary and secondary toy-game alternatives. The proposal is presented to The DoSeum staff and the course instructor for review in class. The DoSeum staff gauges their feedback against the Scoring Rubric presented on the project request handout (Appendix 1), challenging the groups to elevate their design ideas to meet the “Exceptional” criteria standard. Particular attention is given to the Educational and Play Value and Originality of Design criteria. Based on the feedback provided at the project proposal review, students make a final decision on which alternative toy-game idea to implement and what modifications will be needed to their initial design. This project proposal
interaction with The DoSeum staff is a recent development that proved beneficial to the students by providing more extensive feedback early in the process allowing more time for the students to improve and customize their designs to The DoSeum’s needs and desires. It is also more reflective of the way that The DoSeum works with exhibit designers, engineers, and fabricators.

Construct Toy/Game Prototype (week 4, 5) – After completing the design of their toy/game, student teams acquire the materials for the project. Most of the materials should be “green” (i.e., recyclable or repurposed items) such as used or excess cardboard, wood, plastic, tubing, balls, etc. The San Antonio College Math Engineering Science Achievement (MESA) Center lab has a large supply of “green” materials to donate or loan to student teams for this project. When the timing of this project has aligned with The DoSeum’s exhibit and education inventory clean-out, students have also been invited to The DoSeum to acquire free materials. The teams then build their toy/game prototype either off-campus (such as at a student’s garage) or often in the MESA Center lab using materials and tools there and getting assistance from the lab technician.

Prototype Review (week 6) – Student teams demonstrate their toy/game prototypes to The DoSeum staff and instructor in the classroom and obtain important feedback and recommendations to improve their project as well as to ensure all project requirements are met. The prototypes demonstrated are at a stage where functionality can be shown; however, their appearance is often quite plain since final cosmetic improvements such as painting, illustration, and decoration have not been added yet. During this interactive review of the prototypes, special attention is given to the play value and the durability, ergonomics, and safety criteria; primarily to ensure that the projects are safe and fun. Admittedly, the element of fun is the most subjective aspect of the criteria; but, The DoSeum team’s experience working with and observing children provide a framework by which to judge the potential of a toy or game to engage children in play and learning. The DoSeum staff also reviews the schedule and logistical requirements for the upcoming “live” demonstration and testing of the toy/game projects at The DoSeum. Simultaneously, The DoSeum staff prepares for the public program event, briefing the event staff and the after-school students and school site partners on the goals of the project and how the live testing will be executed.

Complete Toy/Game Construction (week 6, 7) – The student teams make final design changes, acquire any additional materials, and complete construction of their projects to include aesthetic improvements as well as making any required or suggested modifications to improve safety (e.g.,
sanding rough edges), functionality, and child engagement. Throughout the process students are able to ask questions and get feedback from The DoSeum staff and the course instructor. The after-school students are reminded of the opportunity they will have to preview and test the projects, are provided with some prompting questions and encouraged to engage in conversation with the college students about the process of designing and building.

**Toy/Game Demonstration at The DoSeum (week 7)** – The demonstration and “testing” of the toy/game projects occurs on a Saturday afternoon at The DoSeum, its busiest time of the week. SAC students are invited to arrive at 11 am, prior to their set-up time, to engage in guided STEM activities with the children and families from the after-school program. Student teams set up their projects between noon and 1 pm at various exhibit areas throughout The DoSeum. All students are highly encouraged to be at the Saturday event with a minimum of two students per team required to be there. Each team is assigned a letter which identifies their team and posts it at their toy/game location. Students from the after-school program have the privilege of being the first to try out (“test”) the projects, then the projects are made available to all The DoSeum guests. On that Saturday, from 1:00 pm to 3:00 pm, hundreds of families with children that are visiting The DoSeum try out the various toys/games presented by our students. Student teams often bring hand tools and extra supplies/repair parts with them, knowing some components of their toy/game may fail from repeated and vigorous use by children. Children are given a simple ballot (Appendix 4) where they can indicate how much they like each particular toy/game. The ballots are collected from the children after they have tried out all or most of the toys/games. At the end of the toy/game demonstration/test, the ballots are counted and the student teams achieving the three highest positive scores are designated as the “People’s Choice” award winners. In addition, The DoSeum education team staff serve as judges and select the top toy/game project in each of four categories based on the criteria shown in the scoring rubric (Appendix 1):

- Educational Value – the extent to which the project inspired curiosity
- Play Value – the extent to which the projected inspired play
- Originality of Design – the extent to which the project innovated an existing design or presented a novel design
- Durability, Ergonomics, and Safety – the absence of hazards, the extent to which the project is safe and easy to use for children, with reduced maintenance and repairs.
In the most recent program event, The DoSeum presented five project awards – one for each of the criteria strands above and a “best of show,” which best met all the standards. They have the option to select for donation whichever exhibits suit their educational needs. This will become the new protocol for The DoSeum project awards.

Prepare Written Report (week 8) – Student teams prepare an 8 to 12-page formal written project report to include drawings, a project timeline (Gantt chart), evaluation matrix of alternatives, patent search, list of materials, and a description of the results of the toy/game demonstration/test at The DoSeum. The report must be structured in accordance with steps of the engineering design process. Detailed requirements for the report are shown in Appendix 2.

Present Written Report, Provide Oral Feedback, Complete Survey (week 9) – Student teams submit their final written project report to the instructor. The teams are encouraged to have their report reviewed by the SAC Writing Center before submittal to the instructor. The grading rubric for the written report and overall project grade is detailed in Appendix 5. Students are also asked to complete a survey as well as provide oral feedback during a discussion in the classroom about this service-learning project to include their overall impression of the project, what they most liked, what was most challenging, and their recommendations.

Results

The project has provided numerous benefits to all parties, most notably the following:

For faculty:

• It provided the satisfaction of directly engaging students in real engineering activities.
• It helped them contribute to community improvement.
• It helped them develop improved relationships between faculty and students.
• It helped them promote the engineering program to the community and other students.

For students:

Note: The following statements are based on observations and feedback over the 10-year history of this service-learning project as well as the results of a recent survey given to students after completion of the toy-game project (Appendix 6).

• The effort put into the project was worth it. Since this project is the most challenging and complex project given to the students, it does require considerably more time and effort than
other engineering projects in the Introduction to Engineering course. Nevertheless, only four of 30 students surveyed (13%) felt the effort put in was not worth it.

- It helped improve self-esteem by giving back to the community. Survey results showed that 25 of 30 students (83%) felt good about doing something for the community. Asked what the best part of the project was, 12 students (40%) responded that it was presenting the project at The DoSeum and seeing the kids enjoying it and having fun.
- It helped them contribute to community improvement. Students felt strongly (i.e., 25 out of 30 or 83%) that service-learning projects should continue in the future.
- It showed them that engineering, along with being challenging, is satisfying and can be fun. Only two of 30 students (7%) did not enjoy the project.
- It helped them gain a better understanding of the engineering profession. Of the 30 students surveyed, only five (17%) disagreed with the statement that the project strengthened their interest in an engineering career. Also, only two (7%) felt the project did not help them connect engineering course topics to real life.
- It provided invaluable hands-on experience. Eleven students (37%) responded that building the toy/game into a finished produce was the best part of the project.
- It helped them understand the complex process of bringing ideas to reality. Only three students (10%) of those surveyed disagreed with the statement that the project increased their understanding of the engineering design process.
- It helped them develop teamwork skills. Student feedback in this area was the most positive; i.e., 28 of 30 students (93%) agreed (with two students being neutral) that teamwork was important to the success of the project.
- It provided a first-hand, direct experience observing the public reception of their creation.
- It helped improve communications and interpersonal skills.

For The DoSeum:

- This service-learning project has provided a model for service learning at The DoSeum that has been replicated with other institutions of higher learning.
- It has provided the opportunity to activate the STEM education pipeline, providing opportunities to understand more about college engineering curriculum which can be aligned to The DoSeum after-school program content.
• The project has allowed The DoSeum to sharpen its ability to empower and guide people to facilitate learning activities with children.
• The student projects have been a source of ideas for The DoSeum education and exhibits teams for future innovations of exhibits and education programs.

Lessons Learned

As a result of conducting this project, some valuable lessons were learned and some new practices were successfully adopted. For faculty that may be considering the implementation of service-learning projects in their freshman engineering courses, the following points should be addressed to ensure successful outcomes:

• Academic rigor - The project must support the objectives and learning outcomes the course is used in and not offer a grade just for serving the community.
• Faculty training in service-learning – Formal training in conducting service-learning projects is very beneficial in setting up and implementing service-learning projects and also provides the opportunity to network with likeminded faculty.
• Student Commitment – Faculty need to get strong student commitment to the project by emphasizing from the outset the importance of the project as a real-life engineering design experience. Students should clearly understand the benefits of the project, both to themselves and to the community, and know the amount of effort and teamwork required for success.
• Cost, Complexity, and Time – To minimize costs, students are encouraged to use “green” materials as much as possible to include materials/equipment that are going to be recycled or disposed of. A previous grant provided $50 per student team to purchase materials in the early years of this program, but no longer does. Six (20%) of students surveyed commented that acquiring materials (especially for free) was the most difficult aspect of the project. Students were encouraged to go to the MESA Center lab supply for free “green” materials, use discarded/surplus items from home, or ask for donations from local home improvement stores. Four students (13%) stated that finding solutions was the most difficult part of the project and three students (10%) felt that the amount of time required posed the greatest difficulty. Faculty should discourage students from spending any significant amount of money on materials/equipment or attempting to create a very elaborate toy/game. Instead, they should keep it simple and use their ingenuity to minimize complexity, time and cost.
• Safety and quality - Emphasis should always be placed on safety and quality at every step.
• Administrative support – Administrative support such as scheduling activities with collaborators and preparing/recording results of surveys/ballots is key to success of service-learning projects.
• Recognition - All participants (faculty, staff, and students) should be prominently recognized.
• Publicity – It is very important to raise awareness of the program within the community by informing PR staffs and by using all available means (TV, newspapers, social media).
• Flexibility - Unexpected developments are inevitable; so, all involved need to be flexible and adaptable to change and be ready to correct problems as they come up.

Conclusion

Both San Antonio College and The DoSeum are committed to continue this partnership as an aspect of strengthening the Pre-K to university pipeline. After ten very successful years, this service-learning project will be retained in the “Introduction to Engineering” course based on the substantial value/benefits it provides to SAC engineering faculty and students, The DoSeum, and the community at large. We highly recommend other engineering schools to consider implementing this type of service-learning project in their basic introductory engineering course.

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References

[1].  https://www.thedoseum.org/


[22] https://www.childrensmuseums.org/about/about-acm


Appendix 1 - DoSeum Exhibit/Project Handout for the spring 2020 Project

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**Project:** Children’s Museum Educational Exhibit – Physics

**Project Client:** The DoSeum, 2800 Broadway, San Antonio, TX 78209

**Description:** The DoSeum requests an interactive exhibit that teaches concept(s) from physics to children younger than twelve years of age. All exhibits at The DoSeum must be educational, playful, and safe.

**Project Assignment:** Participating Alamo Colleges campus to provide details about the project assignment.

**Proposal Deadline:** 03.18.2020. Representatives from The DoSeum will visit the participating Alamo Colleges campus to provide feedback on project proposals.

**Prototype Deadline:** 04.08.2020. Representatives from The DoSeum will visit the participating Alamo Colleges campus to provide feedback on project prototypes.

**Project Deadline:** 04.18.2020. Saturday. Alamo Colleges student engineers will transport their final products to The DoSeum for a product demonstration/test with DoSeum guests aged 3 years and up.

**Project Budget:** The DoSeum is a non-profit organization. Thus, there is no funding from The DoSeum for this project.

**Research Opportunity:** Participating Alamo Colleges Engineering students are granted free admission to The DoSeum for the duration of the project. Students will need a student ID and to pass a background check administered at the front desk. This benefit does not extend to family or friends. Contact Clint Taylor with any questions regarding this opportunity.

**Special Requirements:** Project must use recycled/recovered materials as parts to align with the Green initiatives taken by The DoSeum and the Alamo Colleges District. Exhibits must be original work to avoid copyright and patent infringement disputes.

**Content Requirements:** The exhibit must teach one or more concept(s) from physics:

- Acoustics
- Aerodynamics
- Buoyancy
- Electricity
- Friction
- Gravity
- Hydraulics/pneumatics
- Light
- Magnetism
- Measurement
- Potential/kinetic energy
- Power
- Pressure
- Recycling/Upcycling
- Simple machines
- Tension
- Thermodynamics
- Time

*Confirm with a DoSeum representative before proceeding with a concept not listed above.*
### Additional Information
The DoSeum is designed to serve children 0-11 years of age. Design your product for a specific age audience. We suggest your team chooses either 3-5 years (preliterate), 5-7 years (in between), or 7-11 years (critical thinkers). The target age audience should inform the exhibit’s design from the educational goals to the physical construction.

The guiding principle for program and exhibition design at The DoSeum: Joyful learning experiences allow children to explore, create, and discover through intentional play.

### Scoring Rubric used by DoSeum staff:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Acceptable**</th>
<th>Notable</th>
<th>Exceptional</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Educational Value:</strong></td>
<td></td>
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<tr>
<td>Inspires Curiosity</td>
<td>Children engage in an activity that allows them to explore a concept in physics.</td>
<td>Presents children with an open-ended question to investigate.</td>
<td>Inspires children to develop and investigate their own questions. Designed for scaffolded learning. i.e., children practice increasingly complex understandings of the skill/concept as previous steps are mastered.</td>
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<tr>
<td><strong>Play Value:</strong></td>
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<tr>
<td>Inspires Play</td>
<td>Children will play after being invited.</td>
<td>Children want to play without an invitation. Exhibit can be used alone or in conjunction with other guests. Exhibit remains engaging after multiple play-throughs.</td>
<td>Onlookers enjoy observing someone else play with the exhibit. Encourages collaboration or friendly competition with peers or family.</td>
</tr>
<tr>
<td><strong>Originality of Design</strong></td>
<td>A version of an existing design.</td>
<td>An innovative version of an existing design. Utilizes appropriate, yet not overwhelming signage.</td>
<td>A novel design. The intended goal(s) of the exhibit are intuitive to the target audience without any outside facilitation.</td>
</tr>
<tr>
<td><strong>Durability, Ergonomics,</strong></td>
<td>Zero safety concerns. Wood parts are sanded smooth. Utilizes hygienic, non-hazardous materials.</td>
<td>Clearly designed for height and physical ability of target age audience. Requires minimal repair and maintenance.</td>
<td>Attention to detail. Polished finished product. Inevitable repair-needs are accounted for with maintenance access. MSDS of exhibit components are available upon request.</td>
</tr>
</tbody>
</table>

*Rubric is cumulative. To be considered Exceptional, the project must also meet the criteria of Acceptable and Notable.

**Any product deemed less than Acceptable in any of the categories will be refused entry into The DoSeum on the day of the event.
Appendix 2 - Toy/Game Project Guidelines for the fall 2019 Project

Team Project #2 – Engineering Design (Toy or Game) – Guidelines

Project Goal: Design, construct, document, and demonstrate a toy or game for The DoSeum (SA Children’s Museum) that is safe, fun, sparks a child’s curiosity, and helps it understand the basics of a physics concept

The DoSeum (Customer) Project Requirements: See separate The DoSeum handout

General Project Requirements:

- Must be safe for small children to use and not cause a cleanup mess when used or mishandled
- Must be an original design. It must not be a copy of someone else’s design or commercial product.
- Each team member must contribute equally to completion of the project.
- Maximum toy or game dimensions are: Width: 30” Length: 60” Height: 48”
- Must be capable of being easily used by children either on the floor or on a tabletop
- Must be a “green” project; i.e., must use recycled and recovered materials/parts
- Using GanttProject, develop a step-by-step project timeline (Gantt chart) for researching, designing, developing, constructing, testing, and documenting your design.

Written Report Requirements:

- 8 to 12 pages typed (double spaced) including title page and references page
- Title page includes title, team name/logo, date, course #, and teammate names and signatures
- Table of Contents page after the title page
- Annotate the name of the specific person that was responsible for each paragraph in the report
- Number the pages and use topic titles (chapter designators)
- Include separate introduction and conclusion paragraphs
- Describe in detail how the engineering design process was used to include:
  - Identification/description of the need being addressed, working criteria and goals/objectives
  - Gathering of needed information: describe results of your research including a patent search
  - Description of the method(s) used (Ex: brainstorming) to search for creative solutions, how the method was implemented, and what the results were
  - Description and preliminary design(s) of at least 2 alternative designs/ideas for your toy/game
  - Describe how the best solution from the alternatives was selected and include an Evaluation Matrix. Include a paragraph explaining the data in the evaluation matrix and the conclusions reached
  - Describe changes made to the toy/game based on the 6 November demonstration to The DoSeum representative.
- Final design including dimensions, drawings, parts list, description of operation, and limitations
- Describe the results of the demo and test of the toy/game at The DoSeum on Saturday, 16 November
  - Diagrams/sketches of your design must be embedded in the body of the report
  - Include a list of reputable references, use APA format and number the references
  - Staple this guidelines sheet at the end of the report and use it as a check sheet (√)

Toy/Game Presentation/Demonstration: On 6 November (in CAC 153) each team will present/demonstrate their toy/game to a DoSeum representative, who will provide observations/feedback on your design, which each team must document/record.

Toy/Game “Live” Demo/Test: On Saturday, 16 November each team will set up their toy/game at The DoSeum for use by children visiting the museum. Teams will observe and document the results of this “live” demo/test of their toy/game by children. Two team members (minimum) must attend. The DoSeum staff will select the Top-3 toys/games from all the classes participating. Bonus points will be provided if the project is a Top-3 or People’s Choice pick!

Toy/Game Top-3 Winners Presentation: The Top-3 teams may have to present their toys/games to The DoSeum board of directors and The DoSeum members in a media event. If so, details will be provided at a later date.

Optional: (up to +5 pts) - Certification from SAC Writing Center of assistance obtained on the written report
Appendix 3 - Project Proposal

Toy/Game Project Proposal

Team Name: ___________________________ Date: ________________

Project Goal: Design, construct, document, and demonstrate a toy or game for The DoSeum that is safe, fun, sparks a child’s curiosity, and helps it understand the basics of a physics concept.

Toy/Game Idea #1 Description:

Toy/Game Idea #1 Sketch:

Pros of Toy/Game Idea #1:

Cons of Toy/Game Idea #1:

Toy/Game Idea #2 Description:

Toy/Game Idea #2 Sketch:

Pros of Toy/Game Idea #2:

Cons of Toy/Game Idea #2:

Materials Required:

<table>
<thead>
<tr>
<th>Idea #1</th>
<th>Idea #2</th>
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Appendix 4 – Toy/Game Children’s Ballot

To participate in our voting activity:

- Complete this survey with your child!
- Find all nine exhibit prototypes.
- Match the letter on the back of this sheet to the letter on the exhibit.
- Encourage honest reactions!
- Return the completed survey in before 2:40 PM.
- If all nine exhibits were visited, you will receive a gift!
- At 3:00 PM we will announce the recipient of the “Child’s Choice” award, among other categories.

Scoring Key:

<table>
<thead>
<tr>
<th></th>
<th>I felt sad or frustrated.</th>
<th>I was bored.</th>
<th>I had fun.</th>
<th>I had a blast!!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td>![Sad Face]</td>
<td>![Bored Face]</td>
<td>![Happy Face]</td>
<td>![Very Happy Face]</td>
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## Appendix 5 - Toy/Game Written Report and Project Grade Sheet for the fall 2019 Project

### Written Report and Project Grade Sheet

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Max. Points</th>
<th>Points Earned</th>
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<tbody>
<tr>
<td>Title page with title, team name/logo, date, course #, and teammate names and signatures</td>
<td>3</td>
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<tr>
<td>Table of Contents properly prepared and included after the title page</td>
<td>3</td>
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<tr>
<td>Report length of 8 to 12 pages typed (double spaced) including title page &amp; references page</td>
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<tr>
<td>Pages properly numbered and topic titles (chapter designators) used</td>
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<tr>
<td>Annotated name of the specific person responsible for each paragraph in the report</td>
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<tr>
<td>Included separate introduction and conclusion paragraphs that have appropriate information</td>
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<tr>
<td>Correct spelling, grammar, punctuation, and sentence structure</td>
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<td>List of references (include title, author, and date for each reference including websites, and number the references)</td>
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<tr>
<td>Identified/described the need being addressed, working criteria &amp; goals/objectives of project</td>
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<tr>
<td>Gathering of needed information: describe results of your research including a patent search</td>
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<tr>
<td>Description of the method(s) used (Ex: brainstorming) to search for creative solutions, how the method was implemented, and what the results were</td>
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<tr>
<td>Description and preliminary designs of at least 2 alternative designs/ideas for your toy/game</td>
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<td>Description of how the best solution from alternatives was selected – include Evaluation Matrix Include a paragraph explaining the data in the evaluation matrix and the conclusions reached</td>
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<tr>
<td>Documented customer (The DoSeum) observations/feedback at the 6 November demonstration and described changes made to the toy/game design based on the customer’s feedback</td>
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<td>Final design including dimensions, drawings, parts list, description of operation, and limitations</td>
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<td>Described results and lessons learned from the demo/live test at The DoSeum on 16 November</td>
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<tr>
<td>Step-by-step project timeline (Gantt chart)</td>
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<tr>
<td>Staple this guidelines sheet at the end of the report and use it as a check sheet (✓)</td>
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<tr>
<td>“Top-3” Pick by The DoSeum staff or “Top-3” People’s (kids) Choice ranking (10 points total maximum)</td>
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<tr>
<td>Writing Center certification of assistance provided in preparing the written report (optional)</td>
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<tr>
<td><strong>Overall Team Project Grade:</strong></td>
<td><strong>115</strong></td>
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Appendix 6 - Toy/Game Project Student Survey Results – Fall, 2019

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Question Score Key: 1 - Strongly Disagree 2 - Disagree 3 - Neutral 4 - Agree 5 - Strongly Agree

Q1. The toy/game project was enjoyable.
Q2. The effort put into this project was worth it.
Q3. I understand what is meant by service learning.
Q4. I felt good about doing something for the community.
Q5. Service-learning projects should continue in this course.
Q6. The project was well coordinated with The DoSeum!
Q7. The toy/game project strengthened my interest in an engineering career.
Q8. This project helped connect engineering course topics to real life.
Q9. This project increased my understanding of the engineering design process.
Q10. Teamwork was important to the success of this project.