25TH INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
7-8 SEPTEMBER 2023, ELISAVA UNIVERSITY SCHOOL OF DESIGN AND ENGINEERING, BARCELONA, SPAIN

MULTIDISCIPLINARY DAIRY MILK PACKAGING COLLABORATION

Bryan F HOWELL, Kanae S LEE, Rebecca N HOLBROOK, Sophie J HOUGHTON, Linda REYNOLDS and Laura K JEFFERIES
Brigham Young University, United States of America

ABSTRACT
There is a growing trend fostering interdisciplinary projects at universities, as scholars and students from different fields unite to tackle complex problems to real-world challenges. This research explores how 25 students from food science, industrial design and graphic design and three instructors from the same disciplines collaborated to address declining dairy milk consumption in the United States. The project had three phases (P): research, design, and innovation. In P1, student teams studied the dairy industry and packaging-related topics, including regulatory constraints, farm management, market and brand analysis, packaging technologies, and environmental impacts. In P2, individual students designed dairy labels for a 1-gallon US plastic jug and a ½ gallon US paperboard container. P2 designs were evaluated in a 100-person consumer sensory panel and a national survey reaching 619 people. In P3, student teams designed new environmentally responsible milk packaging forms and purchasing experiences. Results in P1 indicate that students working in multidisciplinary teams developed a comprehensive understanding of milk. P2 packaging results showed some difference between the sensory panel and the national survey, but a few designs performed well in both. P3 designs were not surveyed for this study. Educationally, students reported a mixed learning experience. Some embraced the challenges of a research-driven class project, while others found the disciplinary and cultural differences chaotic and emotionally challenging. The two-year difference between graphic and industrial students exposed professionalism differences. Instructors reported a positive educational experience but would train future classes on private vs public feedback, personal vs user-driven design narratives, and consumer-driven design ranking.

Keywords: Interdisciplinary design, multidisciplinary design, innovative milk packaging, multidisciplinary collaboration, multidisciplinary educational experience

1 INTRODUCTION
There is a growing trend fostering interdisciplinary projects at universities, as scholars and students from different fields unite to tackle complex problems and find creative solutions to real-world challenges in healthcare, law, and technology [1][2]. Design professionals and academics have demonstrated that multidisciplinary teams create increasingly robust solutions over individual disciplines [3][4]. Throughout the interdisciplinary process, students apply the methods of their domains, exercise critical thinking and rationality, operate technology used in the industry, and work in cohesion with cross-functional teams [5]. The greater the interaction students have with other disciplines, the more likely they will think critically from different perspectives, which can be channelled to create unconventional solutions to obstacles in their industry [5]. This design study presented students with an exigent challenge in the dairy industry — a 52% decline in fluid milk sales since 1970 in the United States [6]. Food science students introduced the design class to this issue because the former hypothesized that leveraging the packaging of dairy milk cartons and jugs could increase the product's attractiveness to consumers. The interdisciplinary nature of this study stemmed from the research and evaluation of packaging designs created in the class. Food science students shared their knowledge of consumer sensory science, the dairy industry, food regulations and laws, and statistics to understand the interaction between consumer attitudes and purchase intentions of proposed packaging. Designers shared their knowledge of narrative development, visual communication, and experience design.

Food science researchers analyzed the effects of packaging design on consumers through a consumer sensory panel and a national survey and presented statistical outcomes to the design class. Through all project phases, including the creation and feedback stages, it was discovered that several factors could facilitate or impede the interdisciplinary learning process to influence its potential value. These factors determine how enriching a multidisciplinary education is to students, including their level of motivation and interaction with the other disciplines before the class, personality, academic stress, and the learning environment [7]. This paper illustrates how disciplinary education and an interdisciplinary research project are undertaken in the classroom and represents the findings of the educational outcomes for the design and food science students and instructors.

2 METHOD

2.1 Participants

Participants included twenty-five students, twenty females and five males. Eighteen were second-year graphic designers, four were fourth-year industrial designers, and three were third-year food scientists. Designers were informed that their design work would be evaluated via a consumer sensory panel and a national survey and that designs and results would be presented to an actual client. All participants were undergraduate students at Brigham Young University. No students received extra credit or other forms of compensation.

2.2 Procedure

All twenty-five students and three instructors collaborated on the one-semester, three-phase (P) project: research, design, and innovation. The students periodically presented their work to the client, BUILD Dairy, a private enterprise that supports dairy research.

2.2.1 Phase One (P1): Research the Dairy Industry

Students were assigned to conduct research in teams of four to five, covering specific aspects of the milk production process. Groups thoroughly researched topics such as legal requirements for dairy milk labelling, Food and Drug Administration (FDA) and National Dairy Council nutrition facts, local dairy farm operation, dairy plant production, types of packaging, consumer trend analysis and experience mappings, and the environmental impact and sustainability of the industry. Miro, a visual collaboration platform, was implemented as a repository for data and to collaborate effectively, see Fig. 1. Students presented their experiential learning findings to the class.

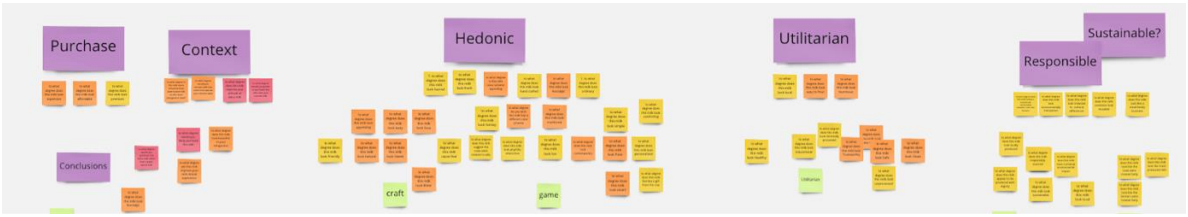

Figure 1. Miro Board Research

2.2.2 Phase Two (P2): Design Labels on Existing U.S.A. Standard Milk Packaging

Designers were given two weeks to create matching labels for the front and back of a 3.79-litre (1-gallon US) plastic jug and all four sides of a 1.89-litre (½ gallon US) paperboard container. Labels were based on newly designed narratives rooted in research from P1. All labels used the same company name, "Milkhaus", corporate address, nutritional facts panel, and identical digital form assets, see Fig. 2.

Figure 2. Control Assets

For the sensory study, 100 panellists viewed 21 unique graphic designs. Panellists evaluated seven randomly-assigned images in each of the three sessions on separate days. Only the front panel images of each jug and carton pair were presented to simulate what a consumer would see first in a retail setting. Questions were presented, and data was collected by Compusense software. Image pairs were presented one at a time, with all questions being answered before continuing to the next one. Each jug and carton pair were presented side by side on the computer screen, with the jug always on the left, and were identified by a 3-digit code. Questions were categorized by theme and shown below the images. After completing the questions for all labels, all seven label pairs were presented on a single computer screen; panellists were asked to choose a label design from which they could taste the milk of their desired fat content (skim, 1%, 2%, whole), see Fig. 3. Samples were delivered to participants through a sliding window in a private booth, without interaction with the administrators of the panel. The university Institutional Review Board approved the sensory panel and the survey, and subjects were paid for participation. The panel and survey concluded a week after the final designs' completion.
Survey questions were divided into five categories with a total of 21 questions: purchase (4), hedonic (6), utilitarian (3), consumer behaviour (4), and responsibility (4). Participants rated the designs in sub-categories such as; level of environmental transparency, inclusivity of cultural differences, reusability, and the consensual relationship between cows and humans. Designs were presented to the client a week after completing the sensory panel and national survey. The success of a given packaging design was determined by comparing the significance of statistical means to the control.

Figure 3. Sensory Panel

2.2.3 Phase Three (P3): Designing a New Milk Experience

Students were divided into teams of four to five students to develop a new container and experience surrounding dairy milk. Each group collectively designed a unique packaging form and digitally generated 3D model in CAD. Students created their own dairy brand, reimagined the milk consumption experience, and designed the packaging based on the team's common new packaging form. Students relied on points of research from P1 and P2 to inform their designs, and Miro was again used as a tool for group ideation, see Fig. 4. A national survey was planned to measure the results of P3 but has not yet been administered.

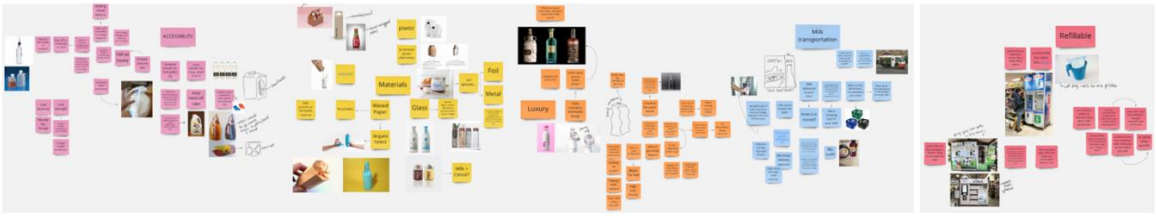

Figure 4. Group ideation for P3 direction

2.3 Data Analysis

The sensory panel results and national surveys from P2 were statistically analyzed using SAS. Student educational experiences were derived from personal interviews, class documents posted on Miro, and student course rating reports.

3 RESULTS

3.1 P1 Results

At the close of P1, student groups gave 20-minute presentations of their findings to the class, see Fig. 5. This allowed students to share gathered knowledge and gain an understanding of the domain. Industrial Design students offered information on packaging materials and manufacturing processes and mapped consumer experiences. Food Science students presented on dairy milk production, laws, and regulations. Graphic Design students discussed packaging trends and evaluated the environmental impacts of dairy milk production and consumption. Knowledge sharing was formative and vital to the study's process, as it took the inputs of all disciplines to gain a full view of the milk industry ecosystem.

Figure 5. Excerpts from P1 research presentations

3.2 P2 Results

In P2, each student created a design for two standard package forms and a standard brand name. Images of these designs were submitted to the local sensory panel and the nationwide survey.

3.2.1 Sensory Panel Results

Results from this panel distinguished designs #914 and #189, as top performers overall and in the "likelihood to purchase" category, see Fig. 6. Despite these designs' top scores, they were not leaders across all categories. Specific designs performed better than others in different categories, often dependent on the narrative which inspired the design. This finding suggests that graphic designs must reflect the initial brand goal or primary message of a company to be successful in communicating with consumers. This finding suggests that packaging designs must reflect strong messaging derived from brand values to establish effective communication with consumers.

Figure 6. P2 Top Performing Milk Packaging Designs in Sensory Panel

Following the collection and analysis of sensory panel results, findings were reported to the class. Statistics were explained to students, and results were presented using blinding numbers, allowing students to recognize only their ranking. Despite these efforts, graphic design students reacted negatively to this presentation. Student rating comments mentioned that reviewing the results "wasn't helpful and felt discouraging." Another student commented that the results created a "hierarchy" in the classroom.

3.2.2 National Survey Results

Top performers in the national survey were designs #914 and #459, see Fig. 7. Again, these ratings were the highest overall, but the survey results support the previous finding that targeted messages outrank overall performers in specific, relevant questions.

Figure 7. P2 Top Performing Milk Packaging Designs in National Survey

3.3 P3 Results

The four team concepts were: 1) a paper carton containing edible pods of milk made of seaweed-based plastic. 2) A rectangular reusable glass form, in conjunction with a milk-refill station in local supermarkets. 3) A compostable moulded paper pulp container lined with seaweed-based plastic. 4) A plastic carton with interlocking stacking abilities, allowing unique reuse in the home, see Fig. 8. These designs have not been publically assessed yet.

Figure 8. P2 New Milk Packaging Forms

3.4 Student Course Ratings

Student course ratings were mixed. The course scored 4.1 / 5 in student ratings, below university and department averages and a decrease in the course-specific historical rating of 4.6. Trends in student ratings mentioned feeling the emphasis on research (P1) took too much of the course's time. Incorporating research into the design process was new for many graphic design students. The sensory panel debrief negatively impacted student confidence and course social dynamics. Students excused the course as "experimental," commenting on unclear communication between instructors and students and disappointment over the efficacy of collaboration.

Despite these unflatering comments, several students praised the course's interdisciplinary nature and hoped for similar opportunities in the future. Many said it enhanced their learning by pushing them to think in a new way, such as a comment stating they "never thought about forms before" the course.

4 DISCUSSION

4.1 Connections

Students in graphic design, industrial design, and food science had the opportunity to cooperate on this research. Being in the same class enabled students to learn different disciplinary methodologies. The food science students brought a crucial understanding of the regulations and processes of the dairy industry. Despite students' working proximity in the class, some remained siloed in their discipline, while others formed lasting interdisciplinary friendships.

4.2 Collaborations

Collaboration was particularly strong at two points throughout the design process. In the P1 research phase, students worked together in multidisciplinary teams. Shared expertise at this stage made for a more comprehensive and informative research base. The second point of pronounced collaboration was in P3 where designers from mixed disciplines worked together to design a new milk packaging form.

4.3 Differences

Throughout the course, some graphic design and industrial design students felt tension when their approaches to design clashed. Graphic design students were accustomed to a personal aesthetic approach versus a user research-based approach by industrial design students. This difference in values and methodology was, at times, used to the team's advantage, pulling the best from each discipline. While other times a lack of respect for disciplinary differences led to a drought of energy and care for the project. The experience difference between second-year graphic and fourth-year industrial students was apparent. The older students demonstrated more professionalism and accountability about deadlines and disciplinary differences than the younger students, and when collaborating, the workloads between students were often lopsided.

4.4 Instructor Refinement

Instructors reflected on their experiences as an overall positive one. The food science instructor opined that this first attempt at multidisciplinary research was a fast and efficient way to introducing students to it. She stated that she would modify aspects of the class to address some adverse student outcomes. The graphic design instructor agreed that she found the study to be a valuable educational experience, but the cultures of the multidisciplinary students would have to be reconciled next time. Feedback communication styles proved to be a fundamental difference between the disciplines. The graphic design students were forced outside their comfort zone after the sensory panel results were discussed in class. The industrial design students were more accustomed to public project ranking and feedback. To better prepare students for the emotional toll of feedback, the graphic design instructor suggested that she would train students in ranking and deconstructing consumer feedback. Meanwhile, the industrial design instructor noted that the students' differences in knowledge, academic maturity, and professionalism were too extreme. Consequently, he would oversee this multidisciplinary research course again with students with similar academic maturity.

Concerning the client's interactions with the students, the instructors agreed that students would have benefitted if the client had a more significant presence in each project phase.

5 CONCLUSIONS

Despite the course's intent to provide a holistic education with a real-world challenge, the students, and instructors, experienced varying levels of success. Many students had little prior understanding of the dairy industry, and some were reluctant to work on a project they perceived as environmentally and humanely unethical. On the instructors' end, the different pedagogical cultures resulted in disruptions and impromptu changes during the semester, which caused stress to some students who preferred a set routine and fixed schedule.

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