EDUCATION FOR THE NEW ERA

A TRACK-BASED APPROACH WITHIN AN EXISTING PROGRAM

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PAPER ABSTRACT: The magnitude of the upcoming social, economic, and technological changes is expected to be unprecedentedly massive. As the term "the fourth Industrial Revolution" implies, the tectonic changes will thoroughly reshape today's industry and subsequently require industrial design programs at academic institutions around the world to review and revamp the existing curricula and offerings. As a response, a track-based approach with a focus on empirical learning and real-world impact was planned within an existing industrial design program at a university to introduce elements of emerging areas across materials, sustainability, and technology. Key findings from its implementation suggest the approach is applicable to established industrial design programs. Details of the approach and recent outputs are discussed with evidence.

Keywords: Design education, Track approach, Sustainability, Technology, 4th Industrial Revolution

1. INTRODUCTION

Industrial design, as the name denotes, has been closely associated with industry since its inception. As a discipline, it has been inevitably but advantageously inspired and influenced by desires and expectations from industry and, in return, initiated innovations and advancements towards real world implementation through industry's adoption. Although the complementary tie has driven numerous technological, economic, and social changes, the ongoing tectonic shift that has been reshaping the industrial landscape, often collectively referred to as the 4th Industrial Revolution (Schwab, 2015), makes it imperative for industrial design to rethink and redefine its position and role for the new era (Deloitte, 2018). It also pushes education of industrial design to accommodate, propound, and more importantly, originate changes (Pitsis et al., 2020). Opportunely, a few academic institutes have paved the way for pioneering research and education by opening design centers or departments that specialize in emerging areas such as material science, sustainable technology, smart mobility, and virtual experience (Winston, 2015; BBC, 2019). While the approaches are ideal and expected to produce remarkable outputs, setting up such a new entity may still be a costly and time-consuming option to many industrial design programs across the world, and therefore there will be an urgent need for more accessible and applicable approaches.

2. STRUCTURE

A track-based approach has been planned and practiced towards embracing key emerging areas in industrial design education as part of attempts to update an existing academic program nested within a design school that belongs to a large university. Among the undergraduate and graduate degrees that the program offers, the 3-year bachelor's degree was selected for the track-based approach because i) it has a sufficient number of students (the average course consists of 30-60 students); ii) students' intellectual growth and gained skills can be observed over the years; and iii) findings could be applied to master's and PhD levels for extended impact. Within the program, most major-related topics are introduced in the second and third years of study that build on foundation courses offered in the first year where general design principles and skills such as drawing and 2D and 3D model making are taught. The new track was designed to introduce students to a set of emerging areas across three courses, one each year, and each course consists of three stages spanning a 12-week semester. Topics for the courses (Table 1) were selected through an analysis of emerging areas and have been updated each year to be closely aligned with the six principles of education (Hubka & Eder, 2003). Compared to previous attempts made to provide knowledge and experience in relevant areas (Hu et al., 2021), the approach placed a specific emphasis on empirical learning and practice-focused study.

Year	Themes	Topics	Stages and topics included
1	- Materials - Techniques - Expression	a. Materials for design b. Model-making techniques c. 3D composition d. Photography e. Biological relationship f. Basic circuit and components g. Interactive design h. Emotive expression	1. Material deformation (25%, 3 weeks) a, b, d 2. Material symbiosis (35%, 4 weeks) a, b, c, d, e, h 3. Material composition (40%, 5 weeks) a, b, c, d, f, g, h
2	- Sustainability - Perspectives - Intervention	a. Critical analysis of precedents b. Preparation of criteria c. Application of criteria d. Design in context e. Sustainability f. Materials for design g. Model-making techniques h. Real-world intervention i. Independent design philosophy	1. Criteria-based analysis (25%, 3 weeks) a, b, e, h 2. Criteria-based critical synthesis (30%, 4 weeks) a, c, d, e, f, g, i 3. Sustainable design intervention (45%, 5 weeks) a, c, d, e, f, g, h, i
3	- Innovation - Problem solving - Impact	a. Research skills b. Prediction and realization of future c. Technology (Sensors, coding, electronics, mechatronics, IoT, AI, etc.) d. Design for problem solving e. Selling ideas f. Project management g. Team-based work h. Real-world intervention i. Entrepreneurship j. Intellectual property	1. Research and proposal (15%, 2 weeks) a, b, d, h 2. Proof-of-concept model and pitch (40%, 4 weeks) a, c, d, e 3. Full-fledged model (45%, 6 weeks) a, b, c, d, f, g, h, i, j

Table 1. Details of the track approach.

3. IMPLEMENTATION

3.1 YEAR 1: MATERIALS, TECHNIQUES, AND EXPRESSION

The three stages of the first-year course were planned to help students empirically gain an insight of design-focused adoption of basic concepts of biology, psychology, and interaction, in addition to materials and techniques. Students learn a set of relevant techniques each week and discuss their experiments and outputs in class. Instant feedback from instructor and peer students suggests possible improvement and each stage concludes with presentations of their final compositions using physical models, digital visualizations, and a progress report. The weekly cycle of introduction of specific techniques and experimentation followed by a class review repeats throughout the semester and the evolutionary short turnaround allows adoption of constructive alignment (Biggs, 2014) and task-oriented assessment (Cain et al., 2018).

In the first stage students explore permutations of a wide variety of materials and techniques, including physical, thermal, and chemical methods, through hands-on experiments, and their discoveries are refined into esthetic compositions via iterative development. Selected works from the first stage (Figure 1) demonstrate that students developed early serendipitous findings into their own methods and purposefully utilized them for creation.

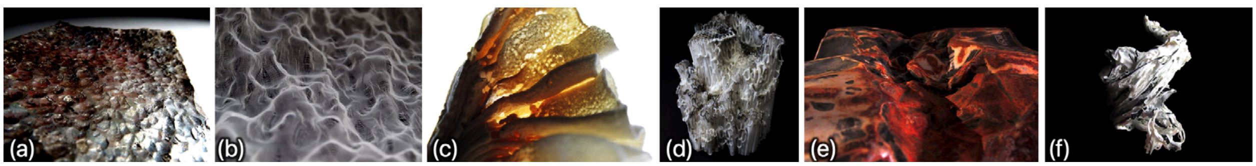

Figure 1. Examples of permutations of materials and techniques: (a) Hammering on metal (by Nikolai Scott), (b) Pushing on mesh fabric (by Ella Murphy), (c) Heating on foam (by Nicole Hone), (d) Heating on straws (by Kayla Crossman), (e) Rusting on steel (by Hamish Morgan), and (f) Acetone on plastic (by Emily Martin).

Building on gained knowledge and skills, students integrate two distinctive materials to form a unique symbiotic relationship, either mutualistic or parasitic, in the second stage. Advanced techniques such as molding, casting, soldering, and basic machining are introduced to help students produce more sophisticated compositions. The examples of emotive material symbiosis (Figure 2) show students' dramatic growth in their capability to choose and combine materials and techniques to express concepts seemingly distant from common design practices, which, in this case, is borrowed from biology.

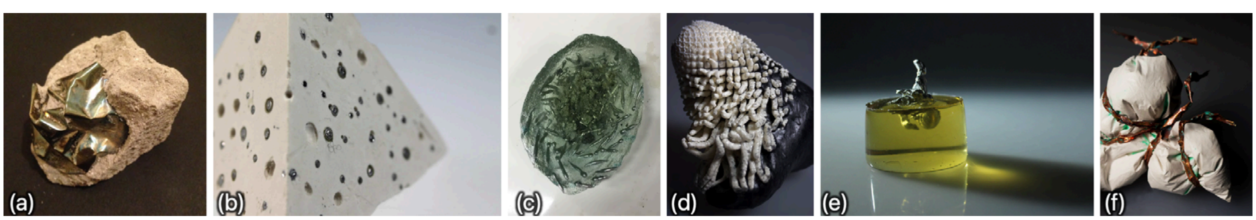

Figure 2. Examples of material symbiosis: Mutualistic: (a) Cement and metal (by Ruby Parkinson), (b) Plaster and solder (by Maddy Hazelton) and (c) Resin and solder (by Luke Poulsen). Parasitic: (d) Expanding foam and mesh (by Eilish Marra), (e) Gelatin and solder (by Kirsty McRae), and (f) Plaster and copper (by Izzy Robb).

In the final stage students construct an interactive composition using three contextually attached materials to represent two of their personality traits identified in class activities such as peer observation. While the first trait is symbolized by the form and material qualities of the composition, the second is hidden at first and revealed by an intended physical action. Technically, an electrical circuit that consists of a DC motor, a pushbutton or slide switch and a battery is embedded in the composition and the specific action such as a push, pull or tilt activates the motor, often connected to additional materials placed inside. Integration of materials, surface treatment, basic circuits and video production are introduced to extend students' knowledge; however, specifics of product design are deliberately excluded to allow first year students to liberally develop and express their ideas.

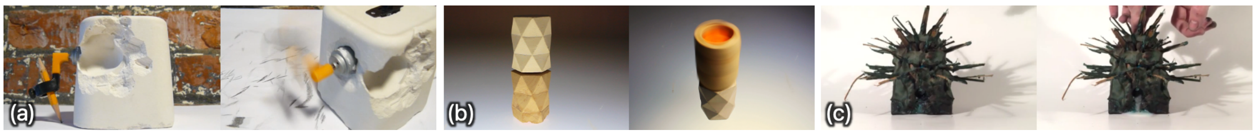

Figure 3. Examples of representation and interactive revelation of personality traits: (a) Offbeat and staggering (by Jack Kemp), (b) Organized and energetic (by Jack MacIntyre), and (c) Tough and nervous (by Matt O'Hagan).

The examples in Figure 3 show that students skillfully integrated the technological components with their multi-material compositions for interactive expression of their personality traits: an arm on the side of a plaster body (a) spins to make the composition stagger and leave traces on the floor, a multi-faceted composition (b) stays static while the heavy plaster half is on top but starts spinning when turned over to place the light wooden half on top, and the motor action (c) tears a sachet inside a spiky structure and squirts a liquid out.

3.2 YEAR 2: SUSTAINABILITY, PERSPECTIVES, AND INTERVENTION

While virtually every industrial design program offers courses on sustainability, the course on design-led sustainability requires students to investigate and challenge practices they take for granted, propose radical design interventions towards sustainability and argue for their proposals. In common with post-sustainability education (Jickling & Sterling, 2017), the unconventional notion was based on findings that most of existing waste management and recycling schemes are not effective and new approaches should be developed (Geyer et al., 2017). The premise that argumentation supports learning, engagement, conceptual change, and problem solving (Jonassen, 2010) formed the theoretical basis of the course's framework of investigation, proposal, and argumentation.

Figure 4. Examples of visual summaries: (a) David Trubridge's Kōura lampshade (by Kate Rowland), (b) Kikkoman soy sauce bottle (by Catherine Parkinson), (c) Issey Miyake's A.P.O.C. (by Madi Juriss), and (d) Formway Design Studio's Noho Move chair (by Andre Ryan).

In the first stage of the course, students identify an exemplar of "good design" through comparative analysis of artifacts using a variety of online and offline resources. After extracting an initial set of criteria from the identified artifact for good design with a focus on sustainability, they develop the criteria into more comprehensive versions applicable to a wide range of artifacts. Figure 4 shows visual summaries students prepared to present exemplary artifacts and defend their criteria for good design. After students advocate an exemplar, often in admiration, in association with their own design criteria, the second stage asks them to audaciously respond to the "good" design. A critical review of the artifact from a contemporary perspective makes students research up-to-date knowledge, advanced technology, and perceptual changes with a focus on sustainability, which lays the foundation for a bold reimagination as "great" design along with a revised set of criteria. Although the challenge intentionally brings some confusion and a feeling of self-contradiction to students at first, it stimulates their critical thinking and empirical learning as evidenced by the examples of students' responses (Figure 5). Part of the approach was adopted from the principle of disruptive learning (Tillmanns et al., 2017).

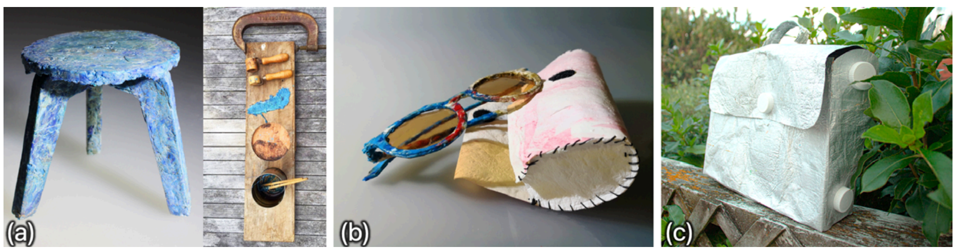

Figure 5. Examples of reimagination: (a) Salve stool from Stool 60 (by Jack MacIntyre), (b) Beach waste sunglasses from Ray-Ban (by Patrick Lennox), and (c) Tetra Bag briefcase from Tetra Pak (by Kelly Chang).

The courage mustered by the reimagination propels students into radical real-world design interventions towards sustainability in the final stage. A specific focus is placed on producing the maximum output from the minimum input, which students are encouraged to interpret in a creative yet convincing way. The process of discovering opportunities from mundane materials or waste and developing interventions through iterative and painstaking experiments promotes empirical gaining of environmental awareness and practice of sustainable thinking, the main goal of sustainable design education (Deniz, 2016). As shown in Figure 6, various parts of bamboo (a) were processed into a tea canisters, strainers, clips and tea, rock waste collected from a local quarry (b) were ground and turned into a leather-like material flexible enough to stich, bend, and fold to make a bag, and an art set (c) made from milk bottles with a black protection layer displays an iconic marble-like pattern.

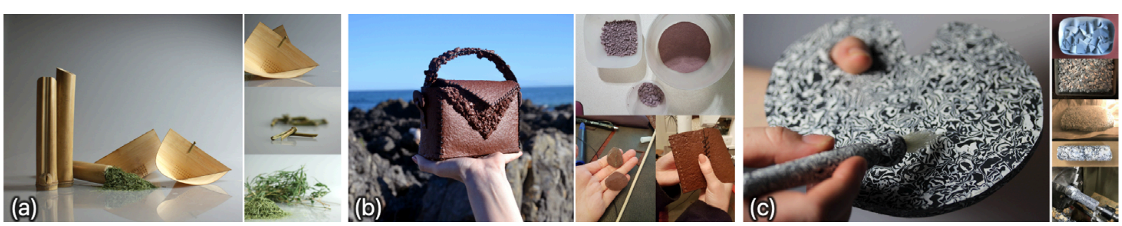

Figure 6. Examples of radical real-world design interventions: (a) Bamboo tea set (by Daniel van Polanen), (b) Rock bag (by Laura-Jane Douch), and (c) Milk bottle art set (by Huy Tim).

3.3 YEAR 3: INNOVATION, PROBLEM SOLVING, AND IMPACT

The third-year course asks students to design “creative creators” for near-future innovations. Following independent research on historical, ongoing, and forecasted changes in our society, economy, and lifestyle, students present an idea of innovation through purposeful integration of design and emerging technology. The first stage sets the direction of their design development throughout the semester and subsequent learning of elements of emerging technology, such as sensors, robotics, and coding, enables students to build a proof-of-concept model for an elevator pitch at the end of the second stage. The most popular and promising proposals selected by a class vote are assigned to teams for the final stage in which fully-fledged creative creators are constructed for real-world dissemination. Students within a team are supposed to work like members of a startup, and upon completion they are encouraged to promulgate their work by entering design competitions, registering IP, or pursuing entrepreneurial development. The course, as the culmination of the track, is intended to prepare students for professional practices through formulating and proposing a plan, working in a team, managing a project, dealing with challenges, and communicating their achievement to the audience.

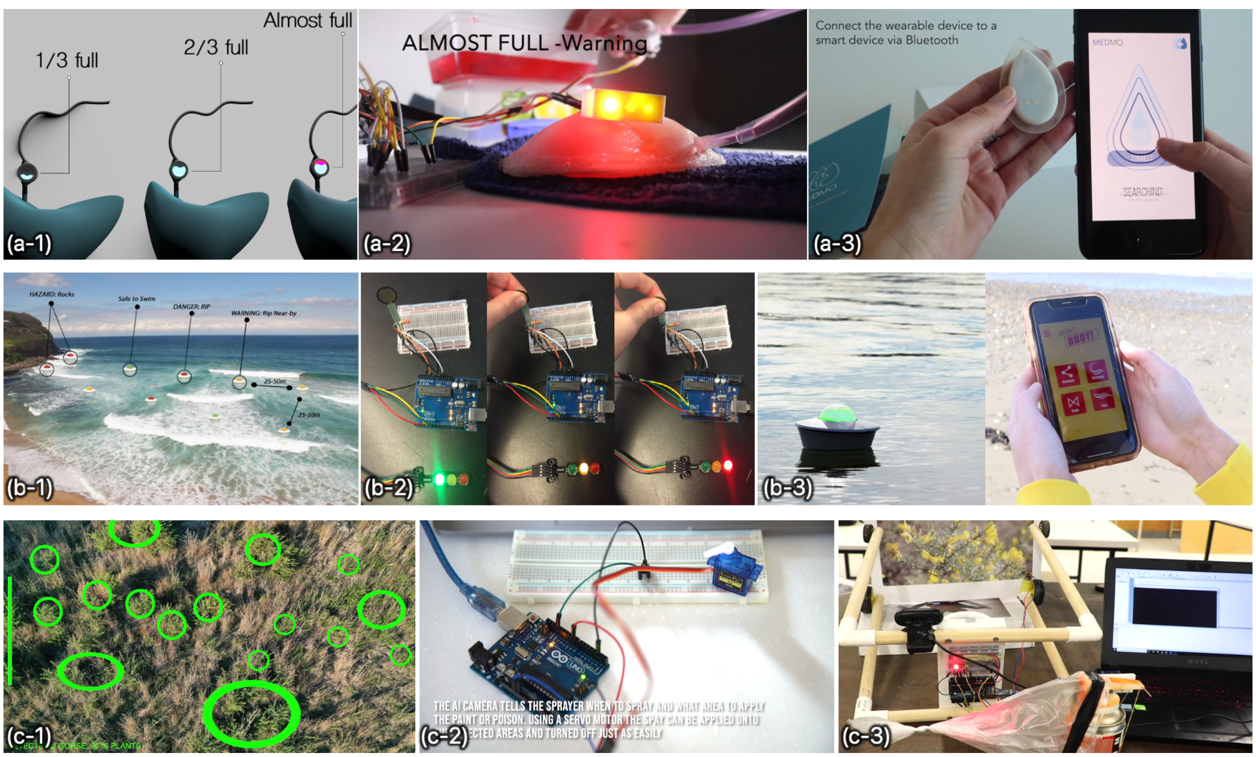

Figure 7. Examples of “creative creators”: (a) A postsurgical drain monitor MEDMO (proposed by Ana Morris, developed with Glen Askey and Courtney Naismith), (b) A rip current warning system Nah Yeah Buoy (proposed by Chamonix Stuart, developed with Hannah Tilsley, Conrad Vaka-Vivili, and Haina Yanghong), and (c) A detector-eradicator of invasive plants Invasive Inspector (proposed by Nathan Buckley, developed with Angus Harrison and Ziyu Zhou). Numbers denote the stages (1: initial idea, 2: proof-of-concept model, and 3: fully-fledged model by a team).

The growing number of ideas proposed across health, safety, and sustainability (Figure 7) shows which areas students are interested in and want to make an innovative contribution to in the context of the fourth Industrial Revolution (Penprase, 2018). A student proposed a wearable monitor that alerts the patient or caregiver when to empty their surgical drain (a) before it overflows to cause serious complications. The team developed a 3D printed flow sensor and a mobile app along with the model. The fact that a large number of people lost their lives each year due to rip currents stimulated another team (b) to develop a network of buoys that locates and warns rip currents. Machine learning and AI were utilized (c) to locate, mark, and eliminate invasive plants.

4. FINDINGS

4.1 RECEPTION AND OUTCOMES

The three courses have attracted an increasing number of students and the accumulated enrollments for the last 5 years exceeded 850, despite the severe influence of the pandemic including a noticeable decline in student numbers many universities are experiencing (Nadworny, 2022). While the steady quantitative growth is encouraging, the extending portion of students from other design programs such as graphic design as well as non-design disciplines such as science, psychology, engineering, architecture, and marketing shows the cross-disciplinary efficacy of the track approach. Student feedback collected from the university's standardized formal reviews as well as the courses' own surveys confirms a very high level of satisfaction with the course content, activities, and delivery. In addition, more students have continued their study at master's and PhD levels on relevant topics such as emotive products, sensing materials and design-led sustainability, which will be discussed in a separate article. Students in the courses have also achieved national and international recognition by winning several design and engineering competitions.

4.2 CHALLENGES AND RESPONSES

Like many other industrial design programs, the pandemic has significantly affected the courses, particularly the hands-on experimentation and physical modeling aspects. The school facilities were inaccessible during the lockdowns and as a result some course activities had to be simplified or modified. For example, students in the first year course were instructed to experiment with food ingredients and cooking utensils, and the reimagination of the second year course was replaced with CAD models. The challenges, however, offered a valuable opportunity to explore integration of physical and digital elements. New methods such as 3D scanning and printing will be introduced to the courses to empower students to produce a digital twin of their physical model for juxtaposition of the two realms.

5. CONCLUSION

The track-based approach was planned as practical preparation for the 4th Industrial Revolution and has been implemented within an existing industrial design program for about 6 years. The approach across the three courses has produced notable achievements including a much broader spectrum of student outputs, multidisciplinary design education and improved learning experience. Moreover, it has propagated a risk-taking culture, enriched graduate studies, and attracted students from outside the design school. As its course structure and components are highly accessible and applicable, similar approaches could be planned and attempted in existing industrial programs around the world.

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