Extend Course for Product Designer in Digital Mobile Era

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Abstract: Product design refers to a system of processes from confirming a product’s specifications to product’s structure. Form, technology, and needs must be considered simultaneously to ensure qualities. In recent years, with the advancement of smartphone technology, many products are connected with apps. Designers cannot exclude themselves from this new wave of the trend. In this article, household hydroponic products design is used as an example, to show the close relationship between digital mobile technology and product design in the contemporary world. Regularly measure the amount of liquid to be added is difficult for a consumer who has no professional experience. To facilitate the introduction of small-scale aquaculture systems into the home, we proposed sensor hardware combined with App software, measured EC and pH value and transmitted to the phone. The app can calculate and display the amount of added and control the amount of inserted through a Bluetooth connection. The physical design needs to take into account the connection between the electronic parts and the circuit board, and interface operation. Thus, not only the model of the product but also the user interface has to be integrated to show the product’s quality completely. Besides, authors made reflection upon the necessity for adjustments for interdisciplinary courses under the changing digital mobile era. Also, under the current curriculum structure, possible teaching approach is expressed for extending student’s feasibility.

1. Introduction

Product design which refers to a series of work from the product specifications to determine the product structure is an essential part of product development. Product designer must take into account the form, technology, and needs, through the appropriate product form to indicate a specific differentiated value. In recent years, the progress of mobile communication technology, product, and portable app combination; a designer in the front, must not be outside the wave. In addition to the shape of the product, the interface must be integrated to complete the quality of design. In this paper, the design of home-use water farming products is provided to show the design process today. To reflect the digital mobile product changes, cross-domain curriculum and the teaching content adjustment also offer to extend the existing curriculum structure.

MIT App Inventor is an informal online learning environment [1]. Xe (2016) analyzes the user skill; they can build complex applications with existing modules to enhance development capabilities [2]. Therefore, the computer science as the dominant learning approach will adjust in future. Teacher [3] explores the effectiveness of the high school student programming camp. Beginners can also build programs by dragging and dropping existing modules. The mobile application created from the student shows the smoothness of the teaching process.
A small program can also be useful; one can immediately feel the response. Learning fast is a high motivation for both new students and programmers. Students were challenged to evaluate a previously developed app and provide a suggestion for improvement. The achievements are very positive.

Microcontroller open-platforms have gained attention recently by educators and creative designer. Wide availability enriches the utilization of modern electronics and enables new possibilities in education [4, 5]. Related hardware (Arduino shields) can be plugged on top of the main Arduino board and extend its capabilities [6]. By combining electronic hardware, the designer had an opportunity to create and realized their concepts. A low-cost multi-meter and a digital temperature monitor designed and demonstrated in [7]. Arduino platform could combine with software and hardware in open-platforms, which provide teaching for the under-graduates industrial designer. Students have to master skills [8] associated with the Arduino include connecting Arduino circuit, learning Arduino IDE, and applying a variety of sensors (Figure 1). 3D printer technology was then introduced to support prototyping of hardware and design. Students acquired knowledge (programming, mechanical design, and electronic circuit) add to one's possessions extended their design abilities [9].

**Figure 1.** Apply Arduino to course of Industrial Design, making Hi-Fi concept models [8]

![Diagram](image1)

**Figure 2.** Digital mobile product and cross-domain associations

Refer to Figure 2; digital product design requires cross-link between structure (configuration), electronics (hardware), and information design (software and interface). In a digital mobile era, new generation designer need extend his knowledge. "cross-disciplinary" does not require the individual designer to complete the work alone, but understand system elements and their associations. App Inventor and Arduino (Figure 2) are building block based tools. The simplicity features enable designer in programming and electronic functional (mechanism) design. Designers can develop concepts firmly and realize ideas through cross-domain cooperation.
2. Case study: home-use hydroponics sensor module design

Growing plants in nutrient solutions without the use of soil is Hydroponics. The NFT system (Nutrient Film Technique) is quite popular with home hydroponic growers as well, because of its simplicity. NFT relies on a continuously running pump to deliver a low but continuous flow of nutrient over the plant roots. As with all re-circulating systems, the nutrient concentration will fall over time as the plants absorb the dissolved minerals [10] and transpiration from plant leaves. The electrical conductivity (EC) and pH of the solution need maintain by adding additional nutrients, and the whole solution will also change periodically.

Nutrient A and B contain different mineral ion. Nutrient A, B are required to be added separately according to the EC measured the concentration [10], and then look up table to add the appropriate amount of liquid. Evaporation also affects the pH balance. After a period of use, the user needs measured pH value to determine the amount of Phosphate to add to the target value.

2.1. Sensor module design: physical

Regularly estimate the amount of liquid to be added is difficult for the consumer who has no professional experience. People need a friendly procedure to facilitate the introduction of small-scale aquaculture systems into the home. The design proposal based on the sensor hardware combined with App software to transmit measured value to the phone. The sensor and the submersible motor placed in the tank with a bucket of pipe to control the amount of added (Figure 3).

Figure 3. Proposal of the sensors and app.

In physical design, one take account the connection between the electronic parts and the circuit board. Figure 4 shows the relative position of the LCD, sensor and functional elements. Ergonomic and aesthetic concerns will make the operation more user-friendly. There are four circuit boards, including Arduino main board, EC, pH and temperature circuit. First, determine the internal circuit and parts configuration. Large interior space results in chassis volume increases which is not suitable for applications. Final circuit placement (Figure 4) laid parts in series for reducing the total wiring length.

We used 3D CATIA tool to construct three-dimensional appearance model tool, and the 1:1 parts model with 3D-printing equipment. The surface of each parts model is repaired to improve the surface quality (Figure 5). Then, parts and circuit board assembled within the main chassis for functional testing.
2.2. Sensor module mobile app design
App design needs to proceed with user study, through the appropriate visual design and operation procedure; steps and configuration of three screens indicate in Figure 6. App Inventor programs blocks (Figure 7) represent sensing the measured value by Arduino through the Bluetooth connection. The interface layout was simplified to adapt the programming environment.

Figure 4. Internal component explosion diagram

Figure 5. Parts made by 3D-printing (before surface treatment)

Figure 6. App interface design of measure, display, and nutrition setting steps
3. Digital Mobile Product: Cross-Domain Curriculum and Experiences

Through the experience of hydroponics sensor module, we aware that digital mobile design needs close cooperation. To fulfill the lacking knowledge, we learn and communicate with programmer and circuit expert. While entering digital era, nevertheless, our design course had not been adopted. Understanding the relevance elements lead to inspiring through cross-domain collaboration. Therefore, designers require the extended cross-domain curriculum.

3.1. Current curriculum of Industrial Design

Industrial design needs digest different knowledge. There is separate focusing between various departments. Some emphasize on design method and inspiration of ideas, and some on engineering and practical skills. Design professional developments mostly are studio based core courses such as basic design, product design, and thematic design [11]. Writing programs are beyond student’s perspective at the moment. Programming learns systematic inference and teamwork, which used in all professions. The difficulty of learning leads low intention and willingness to provide such courses by the department.

3.2. Extend course for digital mobile product

Two extension course modules were proposed namely “introducing App Inventor” and “Arduino prototyping” for undergraduate junior level students each module spans 9-week period. Owing to the limited teaching hour available, For design students without the background in electronic and information technology, different materials and teaching methods are necessary. The teaching materials used in the courses are “Practice of App Inventor II” [12] and “Arduino prototyping projects.” In a typical programming class, students have different levels of expertise. Progressive learning [13, 14] removes the detail of programming syntax, encourage students to transform ideas into animated stories and art right away. It is used accordingly to reduce initial barriers.

In second module “Arduino prototyping," the purpose is familiar with some essential projects. A student can utilize or extend it in the concept stage so that they wouldn't be limited by knowledge or experience to increase the integrity of creation. The instructor used nine experimental examples to help the students understand necessary technology. Project implementations include automatic light sensing, notification of water temperature in coffee brewers, and wet diaper alarm system…etc. Students learned circuit diagram, electronic symbols and practiced wiring of circuits. Secondly, the instructor covered a conceptual description of programming, and students should be able to use them repeatedly in their project.

3.3. Preliminary feedback on extending course:
Each module spans only 9-week period; it wasn't possible to allocate enough time in the implementation so that just some of the students finished all the programming blocks. Students will have to reduce their conceptual ideas and focus on the most critical elements and achieve them through programming. For example, when the number of screens increases, the "Tiny DB" command will need to exchange parameters between screens, and this often was troublesome for the beginner-level user. Below is an excerpt from the feedback from students which reveal positive responses.

This time I learned a lot of exciting stuff! In the beginning, I was very unfamiliar with it and thought that the connections between each coding block to be confusing. I didn't quite know what coding block to put in what. Afterwards, I slowly became familiar with the relationships between different coding blocks. At the very end, as I use my phone to scan the QR code and see the finished product, I thought, "That was cool!" If I have time, I'd like to explore more!

You could create different sparks in creativity, and give a product a modified form of expression or way of use. Although I have only learned a rudimentary bit, I still found much interesting application through it. I can start creating my own program, and this is fairly challenging.

4. Conclusions

For students without a background in information technology, cross-discipline learning will require different teaching materials and methods, and this still has to be structured out. By introducing progressive education, students' difficulties, in the beginning, can be reduced. As students use prototype tools in the concept phase, they sense the concepts that realizable. In the implementation phase, cross-discipline collaboration is needed to increase the integrity of the design. Designers should experience the inner workings of technology, to collaborate with others. Programming and Arduino prototyping offer a way to learn to think and do systematic inference, as well as team collaboration. These are new skills in which designers in a digital age can capture.

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