ARDUINO HANDS-ON AND DESIGN RESOURCES/TOOLS FOR DESIGNERS [PHASE 2]

DESIGN DOCUMENT

Team Number: sddec23-07

Client: College of Industrial Design/Mani Mina

Advisor: Mani Mina & Rachel Shannon

Team Members/Roles:

Kyle Thompson: Researcher

Chin-Yen Liang: Project Lead

Mark Sandstrom: Researcher

MohamedElbashir Eltigani: Communications

Team Email: sddec23-07@iastate.edu

Team Website: http://sddec23-07.sd.ece.iastate.edu/

Executive Summary

Development Standards & Practices Used

List all standard circuit, hardware, software practices used in this project. List all the Engineering standards that apply to this project that were considered.

Arduino microcontrollers, breadboards, LEDs, servo motors and various sensors.

Summary of Requirements

- The projects created are limited by the constraints of the Arduino platform.
- Projects ideally should last about 2 to 3 weeks.
- We are also constrained by the mental and learning capacity for technical information by the students.
- Industrial Design students should have a basic understanding of programming and circuit design by the end of our course.
- Projects must be attractive to design students and reinforce design thinking and process.
- Projects must be simple and intuitive for non-technical students.
- Projects must be able to adhere to studio time.

Applicable Courses from Iowa State University Curriculum

CPRE 185, EE 285, EE 201, EE230, CPRE 288, ENGL 314, CPRE 388, CPRE 281

New Skills/Knowledge acquired that was not taught in courses

- Design Thinking
- Empathy Mapping
- Sketch Booking
- Data Visualization

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Team

1.1 Team Members

Chin-Yen Liang

Kyle Thompson

Mohamedelbashir Eltigani

Mark Sandstrom

1.2 Required Skill Sets for Your Project

Patience, Empathy, Critical Thinking, Problem Solving, Communications, Pressure Management, Teamwork, Creativity, Attention to Detail, Leadership, Enthusiasm, coding, working with Arduino.

1.3 Skill Sets covered by the Team

Chin-yen exemplifies patience and leadership within our group.

Kyle brings empathy, critical thinking, problem solving and attention to detail to the group.

Mark shows technical skills, communication, and is detail oriented.

Bashir demonstrates communication, attention to detail and pressure management

1.4 Project Management Style Adopted by the team

Agile + Waterfall

1.5 Initial Project Management Roles

Kyle Thompson: Researcher

Chin-Yen Liang: Project Lead

Mark Sandstrom: Researcher

Mohamedelbashir Eltigani: Communications

2 Introduction

2.1 Problem Statement

We will be creating Arduino projects for industrial design students. By working with the industrial design students and faculty. We will be bridging the gap between INDD and engineering. Throughout the process, we will look at the way technical content and information is delivered to the student to enhance their grasp of technical information and learning. This will bring a better understanding of technical restraints in the design world. We aim to grasp a deep understanding of culture and the Industrial Design student's mindset, to cater to design projects and technical information for them specifically.

2.2 Requirements & Constraints

Constraints
The projects created are limited by the constraints of the Arduino platform.
Projects ideally should last about 2 to 3 weeks.
We are also constrained by the mental and learning capacity for technical information by the students.
Requirements
Industrial Design students should have a basic understanding of programming and circuit design by the end of our course.
Projects must be attractive to design students and reinforce design thinking and process.
Projects must be simple and intuitive for non-technical students.
Projects must be able to adhere to studio time.

2.3 Engineering Standards

Software and Systems – Students will be coding in C++ and utilizing the Arduino IDE to create logic for their projects.
I**nstrumentation and Measurement** – Students will be using sensor technology along with the Arduino kits to learn more about possible applications.
Wired and Wireless Communication – Students will be using wired connections to send information to the Arduino board and the Arduino board will use other wired connections to send signals and power to the project

2.4 Intended Users and Uses

The projects created are intended for students of Industrial Design. Educators and students will benefit from the projects which we create to help further their understanding of Arduino. They may use the device to help prototype future projects or help demonstrate their designs. Our end goal for the project is to bridge the gap between industrial designers and engineers.

3 Project Plan

3.1 Project Management/Tracking Procedures

Our project has taken on the agile approach for the flexibility in which it gives us. Due to the nature of our project, being more focused on the human side of learning, we need to be able to make quick decisions and changes to our direction. Having a primary plan in place will lock us in and make other methods not viable.

With the agile approach, we can give individual members of the group a sense of ownership by working directly with the project team throughout. Since our project has many solutions, each stage of our design process requires input from our customers in order for us to have a final product.
Our project will be using Discord to help manage, document and communicate.

3.2 Task Decomposition

Due to our project's nature, our progression and time frame will depend on the time schedules of industrial design students. Given this constraint, we have decided to decompose our tasks into individual sections on the timeline and schedule. Those will naturally take a lot of time. We will meet with industrial students to interview several times and test our ideas with them later. This will be done in a 2-to-3-man group where one is interviewing, and the remaining group members are taking notes. Once the data has been gathered, we can build our project based upon the needs of our client.

Task 1: Conduct basic secondary research on the College of Industrial Design to gain a strong foundation and direction.

Task 2: Conduct primary research by interviewing/surveying INDD students to gain understanding on how they learn and what kind of process they go through to learn and troubleshoot new things.

Task 3: Reflect on the primary and secondary research and create a presentation to communicate our findings.

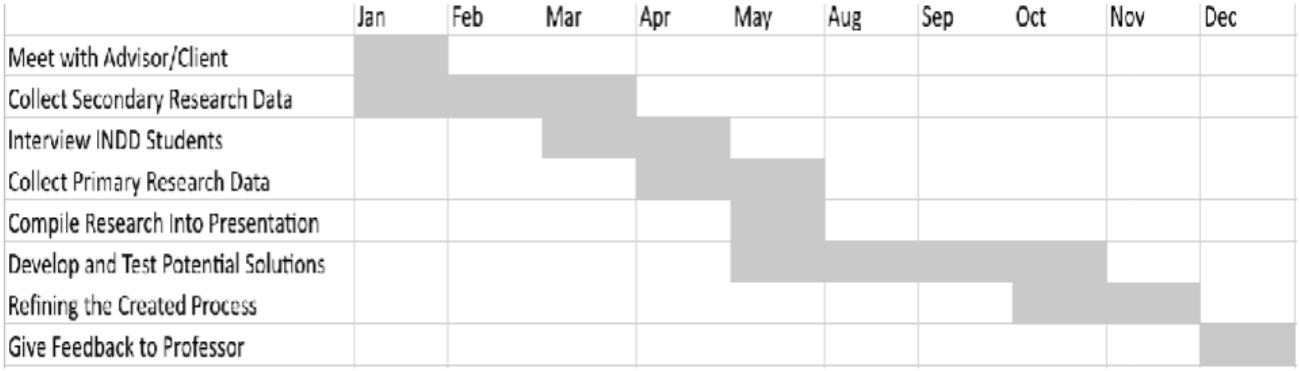
Task 4: Create a prototype to test with INDD students.

Task 5: Using feedback from our prototype and the previous group's work, refine our solution.

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

Meet With Client/Advisor:
Collect Secondary Research Data and Present to Advisor:
Interview INDD Students:
Collect Primary Research Data:
Compile Research into Presentable Data:
Develop and Test Potential Teaching Solutions:
Refine the Process We Create Iteratively:
Give Final Feedback to Professor:

3.4 Project Timeline/Schedule



3.5 Risks and Risk Management/Mitigation

This project involves exceptionally minimal risk due to the heavy research element of our research.
Meet with Advisor/Client .1
Collect Secondary Reasearch Data .6
Interview INDD students .6
Collect Primary Reasearch Data .6
Compile Research into Presentation .2
Develop and Test Potential Solutions .5
Refining the Created process .2
Give Feedback to Professor .1

3.6 Personnel Effort Requirements

	Kyle	Bashir	Mark	Chin
Meet with Advisor/Client	2	2	2	2
Collect Secondary Research Data	10	10	10	10
Interview INDD Students	10	10	10	10
Collect Primary Research Data	10	10	10	10
Compile Research Into Presentation	3	3	3	3
Develop and Test Potential Solutions	20	20	20	20
Refining the Created Process	5	5	5	5
Give Feedback to Professor	1	1	1	1

3.7 Other Resource Requirements

Industrial Design Students that are willing to give advice and experiences.
Input from professors of INDD

Arduino kits with whatever sensors and add-ons that the INDD students see could be used in a project of theirs.

An INDD studio that can supply the Arduino kits and information packets that we created.

4 Design

4.1 Design Context

4.1.1 Broader Context

Our project focuses on bridging the gap between Industrial design students and their technical knowledge surrounding electronics. The INDD community does not have many resources when it comes to educating their students on electronics. Many students want to incorporate electronics into their design projects many of the times but find issues when trying to do such implementations. By arming the students with a better knowledge of electronics through Arduino, we hope this will impact future projects they might do and not be limited by their technical knowledge.

Area	**Description**	**Examples**
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	Our project might affect the professors running the studios, as they can assign different projects than in the past.
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	We hope our created labs and tools will follow the values of INDD professors and students. As it gives them opportunity to create new things while not forcing them
Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	The electronics and tools we teach the INDD students to use could one day help them create cleaner and more efficient environmental projects
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	The economic cost will be mainly on the INDD. Since all electronic components and Arduino kits will be expensive on a large scale.

4.1.2 User Needs

Industrial Design Students: This group needs a way to practice working with electronics because this will enable them to build better and more complex products and designs.

4.1.3 Prior Work/Solutions

There was an earlier attempt at a class that would educate INDD students on the Arduino and how it could improve their projects, this was the first INDD 370X. Our group was given admittance into the canvas page of this class, upon further research and discussion with Mani, we learned that this class was not successful as the students thought the labs were too technical as they were not given enough freedom. SD-May23-48 was the previous senior design group; they are working on their second half semester.
According to their documents and discussions with them and Mani, we have learned that the process of communicating with the INDD students has been much more of a focus than creating labs. The previous group had begun lab work as they created an Arduino controlled car. This car was the correct amount of creativity but was forcing each student to create a car, INDD are in a design major to be able to create fresh unique ideas.

Pros of our improved design:
• Freedom to use Arduino in many ways
• Less step-by-step work
• "Toolbox" of different codes used by Arduino
• Explanation of how codes are used on real projects

Cons of old designs:
• Forced learning
• Limited creativity
• No real-world applications
• All students working on the same project

4.1.4 Technical Complexity

1. The design consists of various complicated electrical systems that will be monitored and controlled by the Arduino system (lighting, motors, sensors, etc.). Designing these systems to be educational and complex involves many engineering principles in order to optimize our deliverable. We will need to design many system level diagrams to walk students through their process, as well as provide debugging insight to help them gain experience. This will require us to understand the technology and electronics we are using at a very deep level.
2. The problem scope contains multiple challenging requirements that challenge our group to collect a lot of primary and secondary research in order to help us to create projects that retain the student's attention and enhance their learning.

4.2 Design Exploration

4.2.1 Design Decisions

Although we have not reached that point in the design phase. Due to progress with our research and conversations had with clients and advisor. We have chosen to leave projects in an open-ended fashion, in which the delivery at the end of the projects is not set from the start. This will allow students to learn at their own pace, with guidance from materials that we will provide them with.

We have also made decisions regarding the deliverables at the end of semester. We have chosen to go down towards more inquiry-based material compared to assigned or guided material for learning. Something like a guidebook or website in which the design student can look at for step-by-step guidance on how they want to implement their design. We know students will be working with Arduino and we believe Arduino is still the simplest solution to teaching students and having them implement electronics into design.

4.2.2 Ideation

1. Design premade projects for the students
2. Design a resource for students to use while creating their own projects with specific parts
3. Design a sort of "Arduino playground" that could be used for multiple projects and experimentation

4. Videos to help students walk through the process and debugging/troubleshooting.

4.2.3 Decision-Making and Trade-Off

Below is our weighted decision matrix:

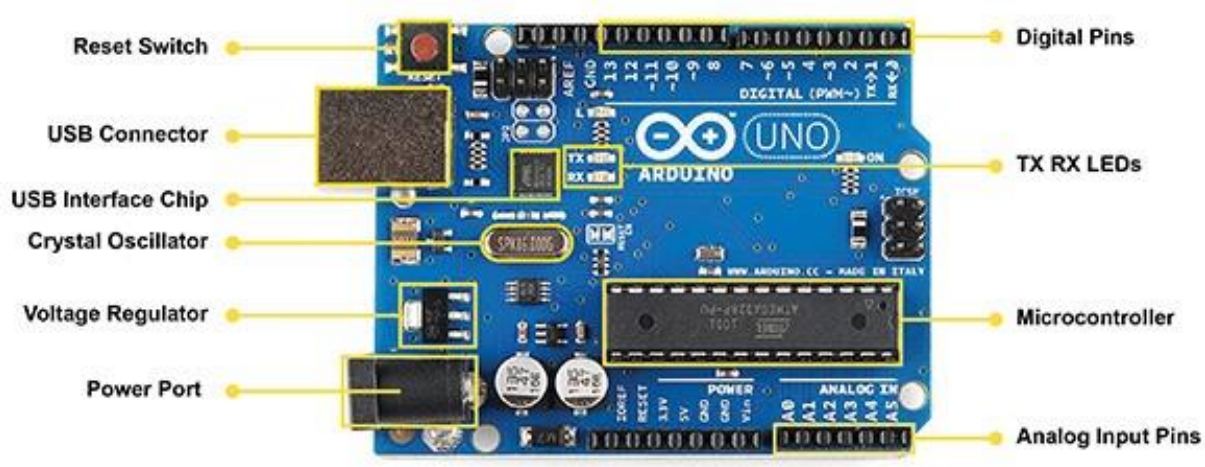
Criteria	Weight	Premade Projects	Online Resource	Arduino Playground	Video Examples
Cost	2	2	5	2	5
Technical Difficulty	4	3	4	2	2
Time Required	3	2	3	1	4
Usefulness of Final Product	5	3	5	2	5
Total Score		37	60	25	55

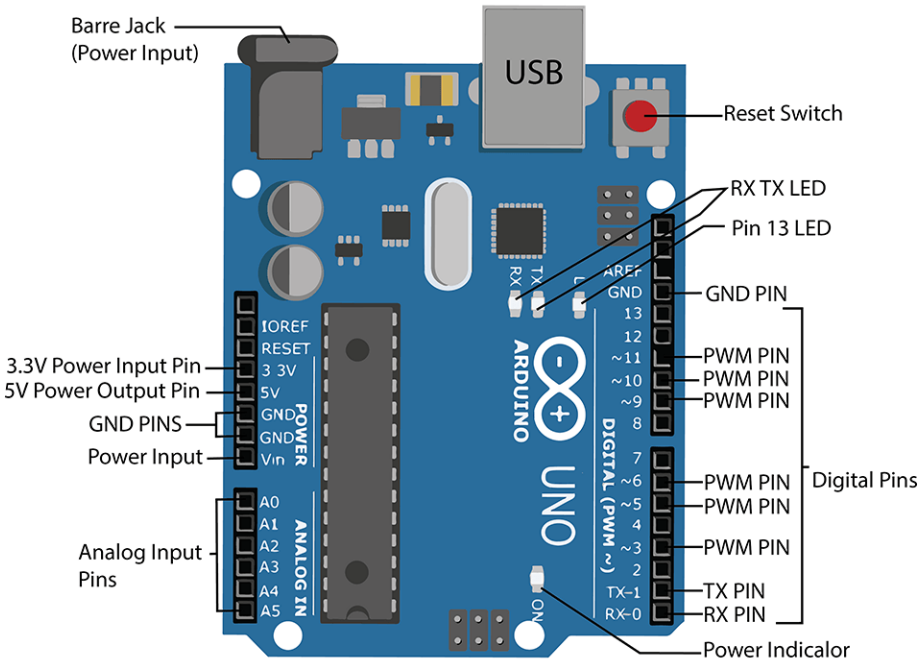
4.3 PROPOSED DESIGN

4.3.1 Design Visual and Description

Due to the focus on research this semester, our group does not yet have a design visual and description. Our focus has been on the non-technical aspects of our goal in order to improve our product and results. However, each project we create will make use of the Arduino Microcontroller seen below. Our goal will be to utilize many aspects of the two diagrams below in order to expose the INDD students to as much as possible. Our group will also be making use of empathy mapping to describe those we have interviewed to help visualize our findings.

Empathy Mapping Example: https://www.figma.com/file/Ov89QIhzhgJgJB8AEuDK4X/Discover-%7C-Empathize-%7C-Research-%5BTeam-07%5D?node-id=1-4857





Our plan will be to include some sort of web page or documentation that will have lots of resources we create that students will be able to use with these boards as well.

4.3.2 Functionality

Our design is still undergoing constant changes; therefore, we don't have an exact intention in its behavior and functionality. Our goal will be to have some sort of resource (likely online), that will provide students with a wealth of information about the open-ended projects they're assigned, and possible resources that they can use to help them along in their process. We also hope to create some kind of real example that INDD students can reference.

4.3.3 Areas of Concern and Development

Our concerns currently involve resources and educator availability. Due to the nature of INDD classes/studios resources and educator availability (no TAs), we worry about the reinforcement that these students will receive in their process. Educators here will likely also have restricted technical knowledge.

To address these concerns, we will need to flesh out our constraints with client/advisor and gather primary research to see if students will be able to find a work around on their own.

4.4 Technology Considerations

Strengths: Arduino is open source and supports various sensors lcds and servo motors.

Weaknesses: There is a limited number of ports, and it requires a breadboard. Also does not support Bluetooth or Wi-Fi.

4.5 Design Analysis

We have pitched our design ideas to varying INDD faculty and students and have received positive feedback with respect to our direction. Considering this feedback, we have chosen to keep moving forward with it, with the goal of narrowing down a final deliverable that perfectly fits our desired puzzle. We think this has been well received because INDD students prefer their tasks to be open ended and non-prescriptive, leaving them with resources to help with their process and helps them when they're stuck on a problem.

4.6 Design Plan

INDD students will use an online resource catered to working with Arduino's on the specific project that may work with something like LEDs, servo motors, or even sensors. Along with this online resource, they will also have access to an example project we made. Along with these things students will also hopefully be able to work with some qualified staff who may be able to help them with their design and project.

5 Testing

Our testing will move through the following 5 steps in order.

5.1 User acceptance testing

- Conduct UAT with a group of non-technical students to determine if the Arduino project is appealing to them.
- Observe how the students interact with the project and gather feedback on their experience.
- Record the feedback to identify common themes and areas of improvement.

5.2 Usability testing

- Conduct usability testing to identify any usability issues that could affect the appeal of the project to non-technical students.
- Observe how the students interact with the project and identify any usability issues that arise.

- Make note of any difficulties or confusion that the students experience.

5.3 FOCUS GROUPS

- Conduct focus groups with non-technical students to gather feedback on the project's appeal.
- Encourage students to share their thoughts on the project's concept, usability, and aesthetics.
- Identify any common themes or issues that arise and make note of them for future improvements.

5.4 SURVEYS

- Create a survey to gather feedback on the project's appeal.
- Ask questions about the project's concept, usability, aesthetics, and overall appeal.
- Analyze the survey results to identify areas of improvement.

5.5 ITERATIVE TESTING

- Use the feedback gathered from UAT, usability testing, aesthetics testing, focus groups, and surveys to make iterative improvements to the project.
- Test each iteration with a new group of non-technical students to determine if the changes have improved the project's appeal.
- Continue making iterative improvements until the project has high appeal to non-technical students.

6 Implementation

Next semester we plan to regroup and not only review our own research, but to also incorporate the previous Arduino Hands-On Teams findings from their projects built this semester (Spring 2023). Our goal is to build a resource or project then, depending on our combined findings, as soon as a prototype is created, we will begin our testing process and iteratively update as needed!

7 Professionalism

This discussion is with respect to the paper titled "Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 AREAS OF RESPONSIBILITY

Table 1. The seven areas of professional responsibility in the assessment instrument

Area of responsibility	Definition	NSPE Canon
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence.	Perform services only in areas of their competence; Avoid deceptive acts.
Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.
Health, Safety, Well-Being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public.
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.
Sustainability	Protect environment and natural resources locally and globally.	
Social Responsibility	Produce products and services that benefit society and communities.	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

Area of Responsibility	IEEE Code of Ethics Canon
Work Competence	No. 7 of the code of ethics describes this, since our ability to seek and accept honest criticism of our work and acknowledge our errors is part of being a professional in the work environment. NSPE has much more specifics when it comes to work competence, as both number 8 and 9 for their code of ethics describe work competence. IEEE is much more general and broader when it comes to describing Work competence.
Financial Responsibility	No. 3 describes how we need to make sure that our financial estimates and claims are honest and built on a foundation that is backed by available data. IEEE is a little different than the NSPE version because, the NSPE version mentions how the costs must specifically be reasonable while IEEE says that it must more specifically be backed up by “data”.
Communication Honesty	No. 3 and No. 7 show us to be honest and realistic in stating our claims, which is part of reporting work truthfully. No.7 tells us to

	credit properly and acknowledge our errors which is part of not being deceitful. IEEE and NSPE both state that anything must be released in a nondeceptive way, IEEE also states that any criticisms must be accepted in a professional manner.
Health, Safety, Well-Being	No. 1 code of IEEE ethics fits this description, as every decision and process should put the Health, Safety and Well-being of the public first. IEEE is similar, but they also include that any dangerous factors must be released to the public.
Property Ownership	No 9 is the closest one; by avoiding injuring other's property, reputation, or employment by false or malicious action. The ACM code of ethics has more details about the Honors property rights, which include copyrights and patents.
Sustainability	No 1 is also great for describing how our designs need to show concern for safety, health, and the welfare of the public. This is turn means that things must be sustainable and reduce risk to the public. IEEE addresses sustainability broadly to also cover Health, safety and well-being. There is no specific section for it.
Social Responsibility	No. 8 fits well as it states that there should be no prejudice and to treat all people fairly and honestly. IEEE is focused on how to treat others in this category, while NSPE focuses on how the products produced must be beneficial to the public and consumers of the product.

7.2 Project Specific Professional Responsibility Areas

Area of Responsibility	Application to Project
Work Competence	Yes, work competence is an intrinsic analysis of the quality of our work. It is a baseline by which we judge all work. Our team is at a medium level, since we are still awaiting more outlets for primary research.
Financial Responsibility	Yes, our team is operating at a high level with this regard. We are keeping financial risk at a minimum especially with our project being educational as an end goal.
Communication Honesty	Yes, we are communicating well with everyone we have interacted with thus far, the group is performing at a high level.
Health, Safety, Well-Being	No, this does not apply to our project, unless there is potential for abuse on Arduino projects, we do not anticipate this being an issue.
Property Ownership	Yes, since our project and resources are funded by Iowa State University, we must be respectful to the tools we're given. In this regard we're performing at a high level.
Sustainability	No, since our project is mostly educational, our impact on the environment is quite low.
Social Responsibility	Yes. This greatly applies to our project since our end goal is to educate industrial design students and improve their overall community and interaction with electrical engineers and the work EE's do. In this regard we're doing very well (high level).

7.3 Most Applicable Professional Responsibility Area

Our team demonstrates a high level of social responsibility and proficiency. We hold this to this to the highest standard considering that our project is focused on education and bridging the gap between communities. We spend a lot of time discussing how we can approach doing so and being

empathetic and considerate of each of the communities involved. Our team has spent time in the industrial design environment along with researching the industrial design student and their processes. This is perhaps the biggest impact on our project since gaining understanding of different cultures and communities is imperative to the success of our projects.

8 Closing Material

8.1 Discussion

Discuss the main results of your project – for a product discuss if the requirements are met, for experiments-oriented project – what are the results of the experiment, if you were validating a hypothesis – did it work?

The main findings from our research this semester show a few things.

1) INDD students despise prescriptive assignments, meaning they do not like being handed a lab or project that walks you through step by step how to solve the problem being given. They prefer to explore the issue and find a solution that they are confident in.

2) INDD students that would like to learn Arduino wish they had been exposed to it earlier in their academic career.

3) INDD students wish they had more resources or people to reference when working with Arduino.

4) INDD students are much more social in their work and will often work together when people are stuck on similar issues. They are not punished for this; they are instead encouraged.

5) INDD students reflect much deeper upon their work and must worry about whether they are creating something useful or just wasting time.

6) INDD students spend a lot more time discussing the visual appeal of their work in not only the physical project sense but in their project books.

8.2 Conclusion

Summarize the work you have done so far. Briefly reiterate your goals. Then, reiterate the best plan of action (or solution) to achieving your goals. What constrained you from achieving these goals (if something did)? What could be done differently in a future design/implementation iteration to achieve these goals?

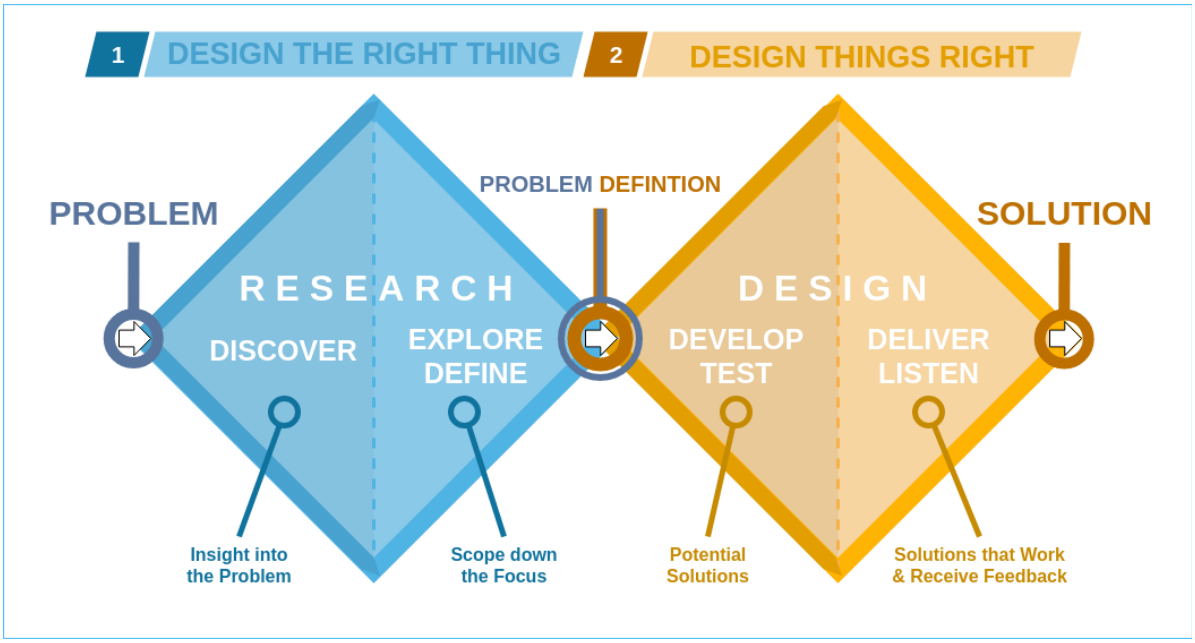
Our goal was to perform research on INDD students and to gather information about how we could teach them to work with Arduino microcontrollers so that they can have another tool to add to their toolbox. Our plan to do this will be to build an online resource for them to reference for help with Arduino projects. Some issues we ran into involved a lack of interview volunteers as well as low exposure to the non-Arduino interested side of INDD. Most students we interacted with

already had some sort of interest in the topic. In the future we plan to start earlier with student outreach and be more organized with our communication.

8.3 References

8.4 Appendices

Double diamond we used for reference in our planning.



8.4.1 Team Contract

Team Members:

1)Chin-yen Liang 2) Mark Sandstrom

3)Kyle Thompson 4) Mohamed Elbashir Eltigani

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:

Tuesdays: Face-to-face: 2:00pm – 5:00pm

Fridays: Virtual: 5:00pm – 6:30pm

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):

Face-to-face and virtual meetings

3. Decision-making policy (e.g., consensus, majority vote):

Majority vote

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):

Share a word document with information regarding record keeping

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

3. Expected level of communication with other team members:

4. Expected level of commitment to team decisions and tasks:

Leadership

1. Expected individual attendance, punctuality, and participation at all team meetings:

Everyone is expected unless there is prior communication on issue with attendance, punctuality +/- 10 minutes online, +/- 5 minutes in person.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

Equally shared responsibility with respect to project size.

3. Expected level of communication with other team members:

We expect full communication from each member at all times, except if there are pre-discussed exceptions.

4. Expected level of commitment to team decisions and tasks:

We expect full commitment from each member and are flexible if given early notice of absence/attendance.

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

See Part A.

2. Strategies for encouraging and support contributions and ideas from all team members:

Open communication, relaxed team dynamic and discussion!

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)
    1. Report any unresolvable issues of collaboration or inclusion to Project Lead
    2. Project lead will facilitate a group discussion in order to resolve said issue and hear perspectives from all members.
    3. Reach a consensus, if unresolvable we will seek outside help.

Goal setting, Planning, and Execution

1. Team goals for this semester:

Gain understanding in how design students think and how we can create useful Arduino projects to enhance their learning and give them more things to be creative with.

2. Strategies for planning and assigning individual and teamwork:

Assign things based off of how comfortable each person is with that respective task and what their current workload consists of.

3. Strategies for keeping on task:

Create deadlines and meetings to discuss progress made.

****

a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the

consequences as stated in this contract.

1)Kyle Thompson DATE 2/19/23

2)Chin-yen Liang DATE 2/19/23

3) Mark Sandstrom DATE 2/19/23

4) Mohamed Elbashir Eltigani DATE 2/19/23