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Development/Process Integration with Dobot with the University of Southern Indiana

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ABSTRACT

With the number of people choosing to go to college decreasing, USI must increase the percentage of students that attend. Without increasing the number of students attending the University of Southern Indiana’s engineering program, the college will suffer due to a decrease in enrollment. To complete this task, a new type of recruitment device is required, enter the University of Southern Indiana’s Engineering Recruitment Robot (USIERR). USIERR is a miniature robotic cell designed to be taken anywhere. The demonstration will be taken to college fairs and other science and engineering events as a showcase for potential students. To accomplish this, a robot was selected with the mindset of usability, sizing, user-friendliness, and cost. After selection of the robot, programming and the development of standard operating procedures were created. To ensure the ease of operation by any USI faculty, a pack-n-go cell was created. The cell includes multiple variations of the Milwaukee Packout where the robotic system rests. The demonstrations that will take place at the college fairs include using pneumatic suction cups/grippers to pick and place objects. For on-campus tours, another demonstration that can be conducted is laser engraving on medallions.

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1 INTRODUCTION

Often, it has been shown that items that seem more attractive, flashy, innovative catch people's attention. The same can be said for universities recruiting potential students. (USI Factbook) A problem that the University of Southern Indiana is facing is that they do not attract as much attention as some of the larger engineering schools. At the recruiting fairs, larger engineering universities, such as Purdue University, Rose-Hulman Institute of Technology, University of Louisville, attract more attention than the smaller universities such as USI. (EduRank) Almost all students will hear about the great engineering schools that are around while growing up, for many of the engineering students at USI, the University of Southern Indiana was not part of the discussion. According to College Factual, USI is the ninth rated engineering school in Indiana. (College Factual) USI will always be a step behind these schools because of the lack of engineering reputation. To combat this, USI must find a "wow factor" to intrigue students, something that USI can take to college fairs to pull students away from other schools; where every student can interact with and create a memorable interaction with USI. The answer to USI's problem is the Dobot.

1.1 What is a Dobot?

A Dobot is a brand of robotic arms that can show many different robotic applications as well as some automated functions, while being relatively small. (Dobot) One of the human features that the Dobot can perform is being used to pick up parts either from a conveyor belt or from a cart, and then place the part in a machine or a fixture. Robots are usually used in areas where a task is very repetitive or dangerous. Robots can complete tasks in the same amount of time or faster than a human. Using a robot allows you to reduce human error and reduce the number of work-related injuries. (ToolingU). The Dobot that we are looking at embodies all these features while staying relatively small. Dobot makes many distinct types of these robots. The robot that we are looking at has a conventional robotic arm with four axis of motion and can be applied to several applications based on the tooling that is equipped to the end of the arm. With the Dobot we can show the basic robotic properties as well as involve the students at college fairs.

1.2 Versatility of Dobot

The robot that we will be using is the Dobot Magician for Advanced Education. The overall reason that we were given this robot by the stakeholders is because of the wide variety of functions. One of the functions that it offers is that it can hold a pen or writing utensil that is 10mm (about 0.39 in) in diameter. The Dobot then uses text input from a user and uses it to write on paper. The Dobot also comes with a vacuum gripper/end tool, allowing for a variety of other tasks. There is a wide variety of things that we can do with the grippers. An advanced idea that we have is to pair the grippers with the AI (Artificial Intelligence) software package. This then allows us to incorporate a vision system and control the robot by voice commands. For example, the operator can tell the robot to pick up a blue box out of an assortment of colored boxes, and it will navigate to the blue one using the vision system. From here the vision system will find which block is blue and correlate the position with the grippers. The robot will then move into the correct position and pick it up and move it to a different location.

1.3 *Relatability to Engineering Curriculum*

According to the Harvard Business Review, “Too many hiring managers avoid telling candidates the truth about a job. Their logic is that if applicants find out how hard they will work or how boring the core of the open jobs are, they will walk away.” (Tarki, Weiss) Many current students believe that the same misconception is related when being recruited for college. One student states that he believes that “When recruiting students, many colleges will stretch the truth of what their programs entail. They will show overly exciting/intriguing things, that have nothing to do with their program. This makes us students feel they were lied to.” (Koch) With the Dobot, USI can show potential students a lot of intriguing things, along with how they directly correlate with our engineering programs. As of now, there are 4 courses where students would directly interact with these types of programs. The newest concentration in Manufacturing Engineering Technology is Automation, which includes a series of seven courses over the four-year program which will use this robot's various functions. While interacting with the Dobot, the advisor could explain USI coursework, and how they will physically interact with them in class. With this demonstration, USI could show the captivated student what they will be using.

2 BACKGROUND

2.1 *Statement of Problem*

As of now USI does not attract as many students’ attention as other schools do. This means that not as many students know about the possibilities that USI has to offer for engineering. This puts USI at a disadvantage due to the loss of possible revenue. If USI does not gain some of these students, the engineering program cannot continue to grow.

Table 1. Engineering Degree Comparison
2022 Data Undergraduates Degrees Awarded

School	Purdue	Rose-Hulman	Louisville	WKU	Murry State	USI
Tuition	$ 9,718.00	$ 49,479.00	$ 28,520.00	$ 27,000.00	$ 17,316.00	$ 8,691.00
Mechanical	395	133	111	50	0	27
Industrial	264	0	36	0	0	0
Electrical	190	46	48	27	20	12
Civil	157	35	51	35	30	8
MET	177	0	0	26	16	14
Engineering	0	1	0	0	0	19
Total	1183	215	246	138	66	80

As seen above in the table the data has been arranged to where the cost of tuition is below the university's name followed by how many undergraduate degrees were awarded. Following the number of degrees is the total amount awarded. It is important to note that Purdue has the largest number of degrees awarded at 1183. Following Purdue is the University of Louisville with 246 degrees. Then, it is Rose-Hulman with 215 degrees, Western Kentucky University falls behind Rose Hulman with 138 degrees awarded. Next, is University of Southern Indiana with 80 degrees awarded, and finally is Murry State with 66 degrees awarded however they only have technology degrees. (EduRank) With Purdue having the largest number of degrees awarded we can rule them out because it is a widely known school for engineering and would be hard for USI to compete against. However, USI is only 165 degrees away from being at the same level as WKU which in the grand scheme is not hard to achieve the same number or more degrees awarded. This can be achieved by improving the college recruitment materials such as incorporating this robot. While finding this data, Dr. Ely the director of the Technology Programs stated, “While at college fairs I hear from students that universities such as WKU, Murray, and Louisville are the schools that recruit students harder for their programs”. Most of these schools can be two or more hours away from a student causing them to choose schools that are not as close to them as like USI. This is due to many students not knowing that USI has engineering programs, but with this new recruitment tool it will help increase the number of incoming students into the USI program.

2.2 EXISTING SOLUTIONS

When starting this project, after determining what stakeholders wanted the next step was to see what products are on the market. The robotic technologies that are currently on the market are vast. There are large robots, small robots, medium sized robots, robots that spray paint, tighten bolts, assemble parts, robots that co-work with humans, fully automated robots, as well as many other types[1]. For this project, the most important features that we are looking into are the overall size, and the useability of the robot.

The first robot that caught the eye of our group was the Dobots. Dobot has a wide variety of robots including teaching and industrial. The benefit that Dobot has over many robots is the price of the teaching robot models. Most teaching robots scale down on added torque and other forces to make them safer for students. Also teaching robots usually costs less than industrial, which is a benefit to us. These robots can be controlled using a teach pendant, normal programming, AI extensions, and other controller types. The Dobot also comes with many end effectors that can be used for instruction or actual use. (Dobot)

The next set of robots that our group looked at was the ones that USI already owns. These include the Kawasaki SO3N- R Series, and the Mitsubishi MELFA RV-2AJ. Both robots are industrial robots that the university has had for a long time. The Kawasaki's were previously used in Tech 272, and other classes. The Mitsubishi currently sits in the AEC unused. Both robots have many different functions that can be completed with them. They are mainly controlled by teach pendant/ offline programming. The only concern is that if a program was to be messed up away from USI it would be very difficult to fix. An additional concern that these robots have are the overall size and the power requirements.

2.3 SYSTEM HIERARCHY

With the USIERR, there are multiple system hierarchies just like any other system. We have broken our system down into four major components: packaging, controller, robot, and the end effector. Without each of these major components the robotic cell would not perform correctly. The packaging consists of what the robot and its accessories will be transported in. This would include the individual carrying cases, as well as the pack-n-go roller that the cases rest on. We have designed the individual carrying cases custom to the robot itself. When the user packs the system up, every unit has a specific place that it must go in to ensure that the robot is safely packed. Each individual case will not exceed 15lbs, while fitting onto the pack-n-go roller for easy transportation. The sections are light enough for any normal user to be able to move them without struggling.

The next system in our hierarchy is the controller. Every robotic controller is broken down into two categories, the software and the hardware[2]. For our system, the software is the different programs that the robot will use during the demonstrations. Overall, this is one of the most important subjects in our entire system. This is why we allotted significant project time for troubleshooting programs. While the robot's movement comes directly from the software, without the controller the robot could not execute what it was being told to do. The major hardware component that our robot uses is the controller. The controller itself handles relaying what the software commands into actual movement. This robot has multiple controllers in use; that is why it is especially important for each one of them to be set up with the corresponding software.

The next system in our hierarchy is the actual robot. The Dobot has two categories of physical properties, electrical and mechanical. Both properties are equally important and require maintenance to ensure proper operation. The electrical systems involved are the overall connections from each component and the power supply. The most important connections would be the ones connected to the controller and the ones connected to the different motors. The mechanical systems that are the most important are the individual motors. These motors are what controls the overall movement of the robot, if a single motor would not be working the robot would lose an entire degree of motion and would not be able to do many normal tasks[3].

The last system in our overall Dobot hierarchy is the many end effectors. An end effector is, "any of various tools that can be mounted at the end of a robotic arm and that are used to interact with or manipulate objects” (Merriam Webster) The end effectors that are used for the Dobot have two different areas of interest, the physical end effector, and the various inputs the end effector requires. The inputs can be electrical, pneumatic, or both. For our robotic cell, we have several types of end effectors such as a suction gripper, pen holder, clamp gripper, and others. Each of these end effectors have a different purpose, and thereof require a different program to operate it. It is particularly important that the user has selected the corresponding program that relates to the end effector they are choosing to use.

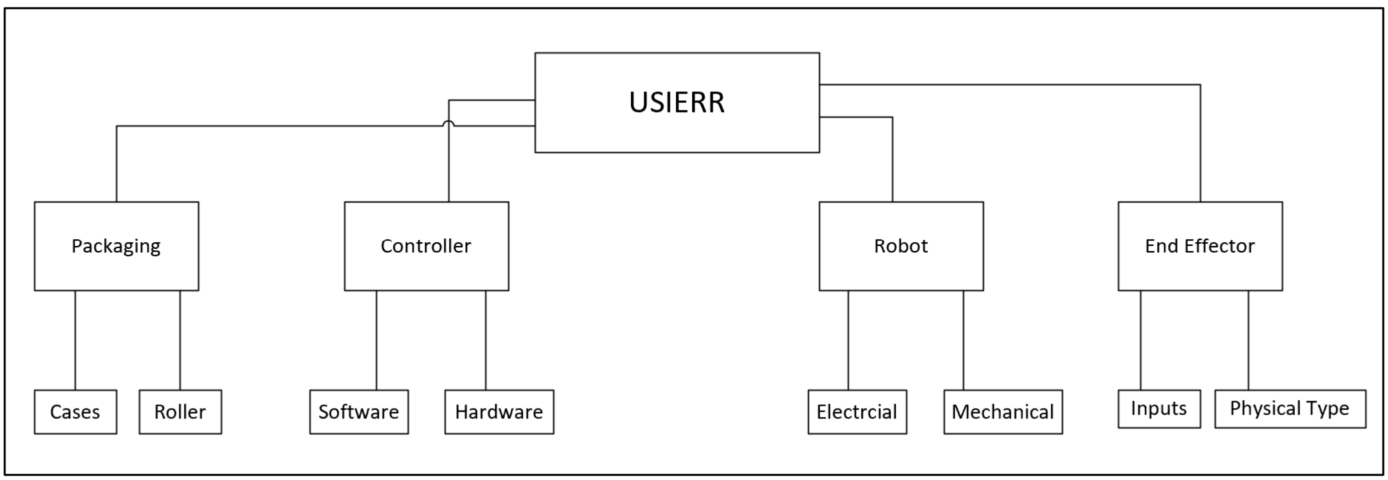

Figure 1. System Hierarchy

2.4 CONCEPTUAL DESIGN

We are creating an easily moveable package for the recruitment robot that will be used at college fairs. The robot must meet the requirements that were given to us such as easily transportable, ability to store multiple programs that could be changed while at the fairs and use of standard electrical connections. Additional constraints are being able to be interacted with by curious students and having a step-by-step procedure that outlines how to set up robot and other working parameters.

3 CONCEPTUAL DESIGN

3.1 REQUIREMENT SPECIFICATIONS

The stakeholders have given us user-stated requirements that must be met for this project to be successful. The most important requirement for this project is that the robot must attract attention at college fairs. This will then allow the spread of USI's engineering program and entice potential students to learn more about the USI engineering programs. The Dobot must be easily transportable; this includes being lightweight and easily packaged. At most of the college fairs USI provides only one representative; because of this, our robot must be able to be set up and taken down by one person, with no struggles. Staff members usually only have between 20 and 30 minutes to set up at college fairs, this once again relates to ease of transportation/packaging. When traveling to fairs, professors usually use their personal vehicle. This leads us to another reason that it needs to be easily transportable, so that the faculty can fit it in any of their personal vehicles. This means that the Dobot's traveling case must not exceed a certain size or else it will not fit in a sedan car style. An added requirement is that the robot must use a standard 120-volt plugin. This is due to the college fair booths giving extension cords and power strips to use which both use 120-volts, which is an operating standard in most buildings.

3.2 DESIGN FRAMEWORK AND EVALUATION CRITERIA

To decide if our project is successful, we must set standards for our work. The project sponsor provided goals, including: the project stayed under $3,000, overall weight of each compartment was under 15lbs, visually appealing to customer, unique user involvement, and having anyone who has never used the robot be able to set it up using the directions. Meeting these requirements will determine the project's success.

Unlike the usual senior design project, this project was funded for the instructors at the University of Southern Indiana. This leads us to a much larger than normal budget. After all, this project will be displayed for all potential college students to see. If it looks sub-par, it will never draw the attention that USI is looking for.

When looking at the overall weight of each project we know that it must be kept low. It has been one of the major stipulations for the project from the beginning. As stated earlier, we want anyone to be able to set up and use this robot. A normal woman can lift to 16kg safely while a man can lift to 25kg safely according to legal manual handling guidelines. (H&S Lifting Solutions). To make it even easier for the users, we want to lower the weight to less than 15lbs.

Going along with this same idea, there must be very detailed directions so that anyone can set it up. We will test the ease of use of our instructions with the current faculty, engineering students, and normal students at USI. We chose engineering students at first to see if they can do it, then take their suggestions and move on to an ordinary student. The deciding factor for if they directions are successful would be a score of 4/5 ordinary students getting it correct.

3.3 EVALUATION OF ALTERNATIVES

Once this project was given to us it was our responsibility to determine what device would best fit our user's requirements. To determine this, we wrote down each of the requirements and any preferences into a decision matrix. Our decision matrix included multiple factors that had their own weighted scale. The factors included sizing, capability, user friendliness, and cost. We then ranked the possible devices on a scale of 1-5, 5 being most appropriate and 1 least appropriate. Sizing wise, we wanted a robot that was not extremely big but also was not small; the robot must be able to be transportable as well. When looking at capability, the scale is based strongly on how many programs the robot can run/store. The biggest factor is cost of course, the University of Southern Indiana has an extremely specific budget that we must stay below.

Decision Matrix

Requirements	Specifics
I. Robotic Cell	Must be a type of robot to fit robotic cell with common power/space.
II. Programmability	Must be able to be programmed by USI students.
III. Applicable to courses	Must be able to be involved into engineering courses.

Criteria	Specifics
I. Sizing	Must fit on normal conference type table, without being too large/small. Easily transportable.
II. Capability	The more programs the better.
III. User-Friendliness	Interactions with robot are easy.
IV. Cost	Entire Robotic System Cost.

Robots	Req I	Req II	Req III	
Kawasaki SO3N- R-Series	-	X	X	*** "X"- met
DoBot Magician Lite	X	X	X	*** "-" not met
DoBot Magician	X	X	X	
Mitsibushi MELFA RV-2AJ	-	X	X	

	Sizing		Capability		User-Friendliness		Cost		
Robots	Score	Weight	Score	Weight	Score	Weight	Score	Weight	Total Score
DoBot Magician Lite	3	0.2	3	0.35	4	0.35	3	0.1	3.35
DoBot Magician	5		5		4		2		4.35

Best Selection:
DoBot Magician

Figure 2. Decision Matrix

The first robot on the matrix is the Kawasaki SO3N- R Series. The Kawasaki robot is by far the largest and the heaviest out of the four, which will cause many problems for transportation. Overall, the capability of the robot is fine, it can do any feature that a normal manufacturing robot can do. The only setback would be that many of the programs would have to be made from scratch and then transformed for the Kawasaki to be able to complete. User-friendliness is also a large issue with this robot. The Kawasaki is great for someone who has been trained on how to use it very specifically, for someone who has never seen this robot before it would be impossible to use. The most promising thing about this robot is that it is already owned by the University, this would mean that the overall costs would be mostly for programming and packaging for moving. The next robot that our group evaluated was the Mitsubishi RV-2AJ. Overall, this robot is much like the Kawasaki. It was graded almost identical and has the exact same problems as the

Kawasaki. The major issues that both robots possess are the power hook-ups and the safety concerns. Each of these robots can severely hurt someone if not used properly. This is a major concern for a project that will be utilized around youth that have never seen such a machine. Regardless of the safety concerns, these robots do not run on standard 120V power, so they could not be used at events.

The next robot that our group graded was the Dobot Magician Lite. The cost of the Magician Lite is too large in respect to the overall size of the robot. After everything is purchased, we should sit between $1,000-$2,000. If this robot was larger the pricing would not be as concerning. The Lite has many different programs already built into it, ready to be used. This is a major upside to the Kawasaki due to not having to manually install multiple programs. The user friendliness also is an exceptionally good score, the robot is designed to be used in a school setting with students with no previous knowledge. The only setback that the Magician Lite has is its overall size. The overall size of the robot is not very large, we believe that it would even look small on a normal sized conference table.

The final robot that our group investigated was the Dobot Magician. This robot is almost identical to the Magician Lite, just bigger in every way. With the increase in size, it allows more room for the programming sections. Due to this, the robot can run many more functions and connect to more systems than the Lite version. The overall cost of this robot is more than the Lite version but is not unreasonable; we believe that the total costs will be around $2,500 after everything is purchased. The sizing is much more reasonable than the Lite version, it is much bigger but not too large to where it would be hard to move. This should allow the user to be able to see things much more easily as well as be able to have more students view it at the same time.

4 SYSTEM DESIGN

4.1 SUBSYSTEM HIERARCHY

The most important subsystem hierarchy in our Dobot is the controller. The controller consists of two sections, the software, and the hardware. Software is the overall programming that the robot follows. In many cases the software is known as the brain of the robot[4]. The second half to this subsystem hierarchy is the hardware used the robot. The hardware is the overall unit that tells the robot what to do. This basically reads what the code is saying and forces the robot to follow that command. Without the hardware, the robot would not be able to read the code or do anything.

Another subsystem in the Dobot is the packaging used to transport the robot with all its accessories. The packaging is broken down into three main categories, overall sizing, material type, and pack-n-go. The overall sizing category consists of two separate designs, these are the overall size of the package, and the inside size where the robot will sit. We would like the outside size of the package to not be too large, but still large enough to where we do not require many packages. The inside of the package is yet to be determined. This section will likely be cut to the exact size of the robot or accessory it will hold. This section is equally important because we want everything to fit while also not being too large to where things can move around and possibly break.

Looking further into the material type of the packaging we break this down into the outer shell of the package and the packing media inside the crate. For the outer shell we want a material that is exceptionally durable and has a high yield strength. The outside shell is what will be making the most contact with floors, cars, tables, so it must be able to withstand the normal beating. For the packing media, we want a material that is both durable and cushioning. The material needs to be able to hold the robot and its accessories in place. If the robot moves around too much parts can easily be damaged. The material also needs to be cushioned for the same reason. When the package is being moved around, we do not want the robot to be hitting something that is rough/hard. For this material, we were thinking about a type of foam, whether that be the pick and pluck or regular.

The final aspect of the packaging is the pack-n-go category. The overall concept of this is that the packages can be stacked on top of each other and then rolled around. This gives us our two categories, the dolly and the actual cases. When looking at the dolly aspect we break this down into two types, built in and separate. As of now we do not know which type will be more beneficial to this project. The important thing when looking at the cases is how they connect to one another. Whether that be a built-in feature or a device that wraps around everything to secure it. No matter which type is chosen, it must be able to secure each and every package.

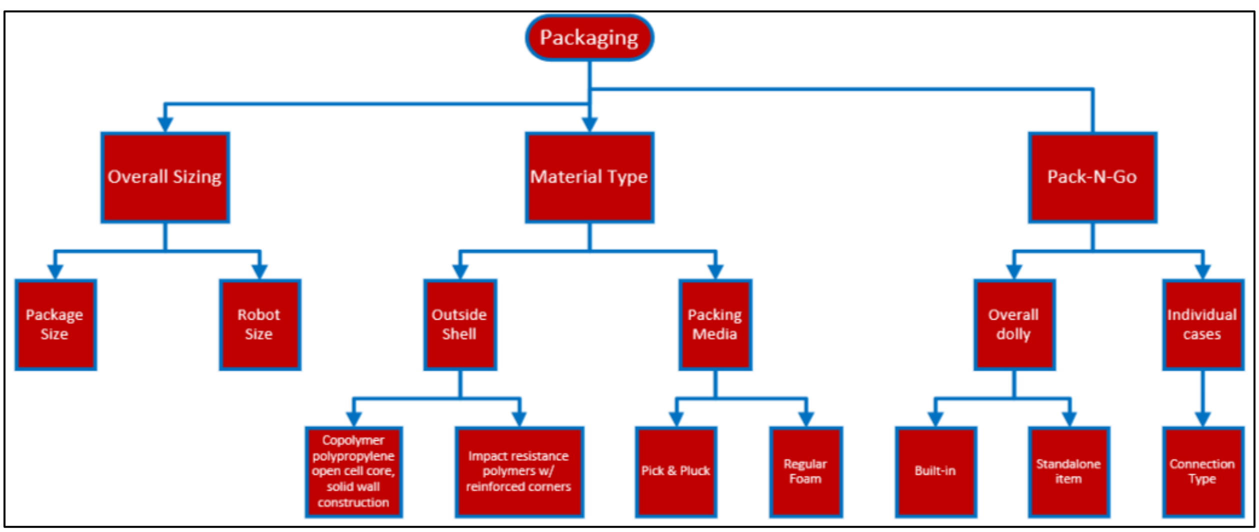

Figure 3. Subsystem Hierarchy

5 CONCLUSION

To increase the percentage of students attending the University of Southern Indiana for engineering, we need a new recruitment tool. The University of Southern Indiana requires something they can take to any event like a college fair. The device needs to help draw attention towards our university's booth and entices students to attend USI. The requirements of the device include easy transportation, normal power requirements, fits on a standard table, and can be easily set up by anyone.

The USIERR fits all these requirements while remaining in the University of Southern Indiana's budget. The robot cell includes the Dobot magician, pack-n-go carrying case, and multiple end effectors.

5.1 CURRENT PROGRESS

Project information such as the preliminary project schedule and bill of materials can be found in appendix A and B. We have created a Pick and Place program that can utilize the vacuum gripper or the mechanical gripper. Along with standard operating procedures that have been tested by students and faculty of USI. Creation of a 3-D printed putter head along with the supporting green have been modeled along with supporting standard operating procedures. Laser engraving has been worked on to allow for future students who are touring USI to take a medallion with them that has both their name and USI eagle engraved on. Fixtures have been assembled to keep the medallion in the same spot every time when the program is running. A carrying case has been chosen and setup to house the end effectors using poka-yoke to create user friendliness when retrieving and returning end effectors to their compartment along with the cutouts being labeled.

5.2 FUTURE RECOMMENDATIONS

The following issues are left open for future engineering senior design students to improve upon the expansion and use of this project. Looking into the use of the 3-D printing end effector and how to keep the robot from burning it mainboard when switching from firmware's. Along with working with the software that they use to understand how it works and files needed to set the parameters for the printer head. We tried to do this with one of the robots, but unfortunately when changing the firmware to the printing one it caused the mainboard to go bad. Due to this we had to put a hold on the printing aspect of this project to avoid another malfunction with the other robot. Along with stopping the printing part we also had to put the AI extension on hold to prevent damage to operating robot.

The AI extension kit is a feature that would have been nice to set up and use, but there was no supporting documentation sent with it when we ordered it and no online material available either. If future students take on this project being able to get both the AI kit working along with the 3-D printing would be a big attraction to use at college fairs to help draw attention to USI. In addition to creating more programs that could be ran during the fairs that use different end effectors or show case different aspects that help showcase robotics, and how prospective students could look forward to using during classes that would be taught at USI.

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7 APPENDIX

7.1 *APPENDIX A: PRELIMINARY PROJECT SCHEDULE*

	Mode	Task Name	Duration	Start	Finish	Predecesso
1		DoBot Project	40 days	Mon 1/8/24	Fri 3/1/24	
2		Research Robot	3.5 days	Mon 1/8/24	Thu 1/11/:	
3		Look into robot manufactures	1 day	Mon 1/8/24	Tue 1/9/24	4
4		Sizing	0.5 days	Mon 1/8/24	Mon 1/8/24	
5		Compatibility	0.5 days	Tue 1/9/24	Tue 1/9/24	3
6		Capability	1 day	Wed 1/10/24	Wed 1/10/24	5
7		Requirements	0.5 days	Thu 1/11/24	Thu 1/11/24	6
8		Packaging	7 days	Thu 1/11/24	Mon 1/22/24	
9		Case type	3 days	Fri 1/12/24	Wed 1/17/24	10
10		Sizing	1 day	Thu 1/11/24	Fri 1/12/24	7
11		Useablility	2 days	Wed 1/17/24	Fri 1/19/24	9
12		Material Type	1 day	Fri 1/19/24	Mon 1/22/24	11
13		Coding	17 days	Mon 1/22/24	Wed 2/14/24	
14		PLC	10 days	Wed 1/24/24	Wed 2/7/24	15
15		Contoller setup	2 days	Mon 1/22/24	Wed 1/24/24	12
16		Separate Programs	5 days	Wed 2/7/24	Wed 2/14/24	14
17		Instructions	22 days	Mon 1/22/24	Wed 2/21/24	
18		Packaging	2 days	Mon 1/22/24	Wed 1/24/24	
21		Robot setup	5 days	Wed 2/14/24	Wed 2/21/24	
22		mechanical connections	2.5 days	Wed 2/14/24	Fri 2/16/24	13
23		electrical connections	2.5 days	Mon 2/19/24	Wed 2/21/24	22
24		Program selection	5 days	Wed 2/14/24	Wed 2/21/24	
26		Testing	5 days	Wed 2/21/24	Wed 2/28/24	
27		Professor Test	1 day	Wed 2/21/24	Thu 2/22/24	25
28		Updates	1 day	Wed 2/21/24	Thu 2/22/24	
29		Engineering Student Test	1 day	Thu 2/22/24	Fri 2/23/24	27
30		Updates	1 day	Thu 2/22/24	Fri 2/23/24	
31		General Student Test	1 day	Fri 2/23/24	Mon 2/26/24	29
32		Update	1 day	Fri 2/23/24	Mon 2/26/24	
33		Variety Panel Test	2 days	Mon 2/26/24	Wed 2/28/24	31
34		Update	2 days	Mon 2/26/24	Wed 2/28/24	
35		Review	2 days	Wed 2/28/24	Fri 3/1/24	33
36		Suggestions	2 days	Wed 2/28/24	Fri 3/1/24	
37		Documentation	2 days	Wed 2/28/24	Fri 3/1/24	

Figure 4. Project Schedule

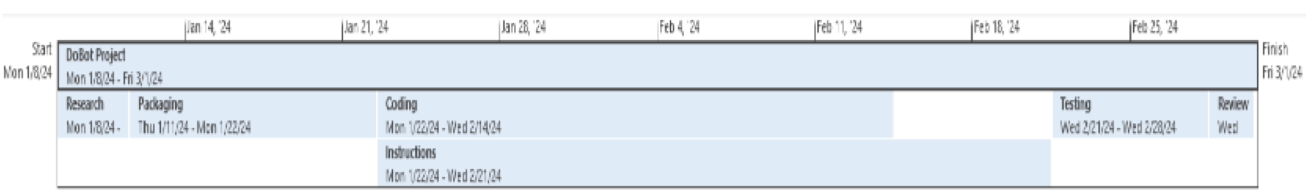

Figure 5. Project Timeline

For this project it was our intention to be fully completed with the project at the beginning of March. This allowed us to have additional room in case of delays. To determine this project's schedule, the first step was to list all the tasks that we will be completing with their respective timelines. This was important to us because it gave us the minimum amount of time required to complete the project. Luckily for us, this duration was less than the overall time that we have to complete this project. From here we included additional margin into the tasks that are crucial to being completed, starting with the most important tasks and continuing with the less important until the timeline reaches the beginning of March. This allowed room for change in our schedule, without it the schedule might become too hectic and exceed the desired timeline. After the schedule was finalized, it is important for us to monitor the paths on the critical path. If one of these was to go beyond its duration, it will increase the timeline and the project will fall behind. When this occurs, we will have no choice but to "crash" the overall timeline by reducing the amount of time for tasks on the critical path.

7.2 *Appendix B: Bill of Materials*

The Bill of Materials for this project is rather simple. It includes the overall robot (Dobot Magician), the added software package (artificial intelligence pack), the carrying device (Milwaukee pack out), and the overall work completed coding by ourselves. For the coding portion, we estimate that the total time it will take to code is 24 hours. If this time is not accurate, it will be changed too for the final Bill of Materials.

The Magician comes with many accessories from the supplier. These include the 3D printing set, a sensor calibration board, joystick controller kit, laser kit, pneumatic kit, writing/drawing kit, and the tooling package. Each of these packages entail everything that is needed for the Magician to function with them, as well as some additional safety devices. (Dobot)

The Artificial Intelligence extension will be paired with the Dobot. This extension includes a vision system, LED module controller, voice module, temperature/current sensors, and the software/hardware required. The reason this group felt so strongly about purchasing the AI extension was due to the teaching capabilities included. Students will be able to see firsthand how the AI software works.

Table 2. Bill of Materials

Bill of Materials		
Item	Cost	Link
Dobot magician	$ 1,999.00	Robot
AI Extension	$ 427.00	AI Kit
Carrying Cases	$ 588.94	Pack Out
Student Work	$ 480.00	$20/hr
Total	$ 3,494.94	

7.3 *APPENDIX C: FMEA FOR CHOSEN ALTERNATIVES*

For the USIERR there is nothing that we can imagine would cause major damage to the user. We believe that the most likely thing to occur that would be detrimental to the robot's functionality would be a connection coming loose inside the robot. To anyone that is not an expert on this robot this would be an impossible task to fix. This is due to the fact that there are tens of wires that all look the same. To combat this, our group went in, and color coded the wire types, as well as placed easy connect ends to help the user identify what needs to be plugged in. If the problem cannot be identified and solved at a quick glance, the user will then refer to the operations manual for the electrical system that we created. This manual has a section of steps to follow when troubleshooting electrical issues. The user should be able to follow these directions to figure out what the underlying problem is. We understand that the user will be under some type of time constraint due to being at a recruiting fair. If the problem cannot be identified before the recruiting fair begins, it would be in the best interest of the user to simply have the robot on display and talk about it. The creators would prefer this rather than trying to rush and fix it due to the complexity of the robot, as well as the increased possibility of messing something else up in the process. If the user cannot fix the problem, they must bring the robot to Professor Kicklighter, Doctor Ely, or Professor Nelson to be examined. As the creators, we have decided these three have full reins to complete what they think it necessary to fix the robot.

Another failure mode that the robotic device might conceive would be a system crash. We imagine that the device would be operating in normal condition and then stop suddenly. The user should refer to the manual once again and very closely follow the steps to restart the device. If all steps are completed and the robot still has not responded in the correct matter, then complete the steps one additional time. If this does not fix the robotic system once again present the robot to Professor Kicklighter, Doctor Ely, or Professor Nelson to be examined. As the creators, we have decided these three have full reins to complete what they think it necessary to fix the robot.