PROBABILISTIC ROBOTICS: A SECONDARY EDUCATION PRESENTATION ALIGNED WITH THE UNDERSTANDING BY DESIGN MODEL

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by

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Certification of Approval

I certify that I have read Probabilistic Robotics: A Secondary Education Presentation Aligned with the Understanding by Design Model by Marwa Ahmad, and that in my opinion this work meets the criteria for approving a creative work project submitted in partial fulfillment of the requirement for the degree Master of Arts in Education: Instructional Technologies at San Francisco State University.

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Abstract

With a remarkable annual growth rate of 13.63 percent in the AI Robotics industry worldwide (McKinsey & Company, 2023), the demand for skilled labor is surpassing the available labor force capacity. Recognizing this gap, SuperTech FT (STFT) seeks to encourage more students to study and work in the field by demystifying misconceptions about the academic, professional, and training requirements in such an interdisciplinary field. The goal is to help develop a talented workforce in the AI Robotics field accessible to any high school (HS) graduate. The 3 years old startup aims to share knowledge, hone a network of eager professionals dedicated to supporting aspiring students and welcoming them into the field, while facilitating their entry into the industry by enabling students to explore multiple adjacent career tracks that they could be working in within the growing field. This ambitious endeavor is carried out by developing a condensed six week online program that delivers AI Robotics education, drawing from Massive Open Online Courses (MOOC), industry professionals and academic lectures, as well as carefully curated media clips available from open source outlets.

Part of this initiative, the AI Robotics Youth Program 2023 is collaborating with two instructional designers (ID) to evaluate students' needs and assess the lecture styles and distributed material drawing insights from a survey conducted during this year's summer camp. As a result of this is collaboration, a lecture on Probabilistic Robotics has been redesigned following the Understanding by Design (UbD) Model (Wiggins & McTighe, 2005). It serves to exemplify how other lectures in the program could undergo a similar redesign to enhance overall effectiveness of the summer program. The result is a more engaging lecture, not only facilitating better recall and boosting students' performance, but most importantly, fostering the development of practical, problem-solving, and critical thinking skills, which are considered prerequisites in navigating the complexities of such a rapidly evolving field like AI Robotics.

Moreover, the overarching objective of this project is to initiate the development and implementation of an action plan to ensure that this curricular improvement aligns with the UbD framework while adhering to The Next Generation Science Standards (NGSS Lead States, 2013), as industry standards of quality benchmarks for online teaching in Engineering, Science and Mathematics.

Acknowledgements

This humble work is dedicated to everyone who is a life-long learner, who sees beauty in the little things around them, who doesn't give up to circumstances, who works on crafting their own story with their bare hands, whom I wish for Yusuf to grow up to be. And thank you, Abu Yusuf, for surviving my stress.

Also, this work wouldn't have been possible without the supportive Education Team at SuperTech FT. Dr. Hu and Ioanna, I owe you all the hours that I was working on my thesis while you were chasing competition deadlines and running discovery meetings with multiple stakeholders. Thank you for relieving some of my stress by always being understanding and not really expecting much from me for the past semester ^^

And last but not least, Dr. Beatty.. I get it now. I see why so many of my senior colleagues dreaded the day of their graduation from the ITEC graduate program. I'm feeling it too. I now realize that I will miss your patience with us, I will miss those inquisitive questions in class to get us to challenge our own beliefs, and I will definitely miss your insightful input to the many ideas running in my head about a potential career path. Thank you for always making us feel welcome and understood, and for always being just one click away.

Table of Contents

List of Tables

List of Figures

List of Appendices

Section 1: Background

Introduction

In its "Technology Trends Outlook 2023" annual report, the globally recognized management consultancy McKinsey & Company highlighted a concerning trend: only one in ten job openings has the necessary skilled labor to meet the demand in the field of Applied AI.[1] Applied AI requires expertise in Machine Learning (ML), Computer Vision, and Natural-Language Processing (NLP). These skills are crucial for automating processes and maximizing the potential of big data, leading to increased profits, efficiency, and innovation.

Aspiring Vision

Boasting an impressive annual growth rate of 13.63 percent globally, the AI Robotics market has garnered significant attention. SuperTech FT (STFT), a startup with three years under its belt, has taken on the mission of enlightening high school (HS) students about the vast opportunities in this field. Positioned as one of the pioneering online teaching initiatives addressing the labor shortage in AI Robotics, STFT developed a curriculum from scratch for its summer program, titled "AI Robotics Youth Program 2023." [Appended Flyer] This program is

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[1] Including: Aerospace and defense; Agriculture; Automotive and assembly; Aviation, travel, and logistics; Chemicals; Construction and building materials; Consumer packaged goods; Education; Electric power, natural gas, and utilities; Financial services; Healthcare systems and services; Information technology and electronics; Media and entertainment; Metals and mining; Oil and gas; Pharmaceuticals and medical products; Public and social sectors; Real estate; Retail. (McKinsey & Company, 2023, p. 12)

meticulously crafted to cater to 90 percent of the US population with a high school diploma. The program's promotional material pledged the following:

> "Our AI Robotics Education Program is future-ready and socially-responsible. Our program prepares future leaders for fast-growing and life-changing AI and robotics fields, and the ensuing ethical and legal decisions the society has to make. We use cutting edge technology to deepen the understanding of the foundations in mathematics, probability and statistics, physical science, computer technology; and moral philosophy. Our curriculum covers the interdisciplinary nature of AI Robotics: mechanical, electronic, and computer engineering; the industries need talents from all these disciplines. Our teaching team of experts follow and set national and international standards on STEM education and for AI and robotics industries."

Guided by the mission to "educate all, inspire all, and enable all," according to its president, STFT embodies a forward-thinking vision. This vision emphasizes the crucial role of providing the future workforce with the skills and education needed to solve tomorrow's challenges, all delivered by leaders in the field.

Industry Professional Speakers

Since the summer of 2021, the startup has been proactive in engaging numerous C-level executives working and researching the field of AI and Machine Learning. It has welcomed industry speakers from major multinational firms such as Nvidia, Google, Microsoft, Apple, and IBM to introduce students to AI Robotics, which has also been instrumental in shaping the curriculum. Moreover, speakers' sequence and replacement for the following year's program has also been an integral internal evaluation mechanism conducted on an annual basis. In fact, it's noteworthy that the summer program has embedded 15 graded assignments in total, for students to submit to their G-Classroom account, in clear evidence of STFT's commitment to self-improvement. [see Appended Built-in Assessments]

The invited experts are seasoned professionals in various subfields and adjacent areas within the interdisciplinary realm of AI Robotics, with a special focus this year on AI's ethical considerations and its social responsibility. Recently completing its third 6-week online summer camp, STFT remains committed to demystifying AI Robotics for HS students, providing them with opportunity to entertain the idea of a potential careers in the field.

Objectives & Expected Outcomes – in brief

For that purpose and because I attended the program as a student, myself, and identified its merits, challenges, and potentials, I chose for my creative work to consider how I could help enhance students' learning outcomes through the application of a series of instructional amendments to the one lecture that scored the lowest on students' post-lecture survey. The redesign involves adopting the UbD model (Wiggins & McTighe, 2005) while aligning its content material with the Next Generation Science Standards (NGSS) as established by the Board of Education of the National Academies of Science, Engineering, and Medicine (NASEM)— more on this later.

This is pivotal to STFT's aspirations for growth and will positively impact its reputation as a distinguished educational program: By embracing these industry-standard frameworks, students' practical application of the material would automatically improve along with the program's overall quality in a ripple effect. Recognized by its practical approach to teaching an interdisciplinary field that is in demand, when STFT succeeds in fulfilling its mission of more effectively inspiring students to enter the field of AI Robotics would ultimately open avenues to attract additional funding opportunities, enabling the program to scale and benefit an even larger number of students in the future.

Program Background

Merits of an Ambitious Program

In January 2023, Dr. Albert Hu, the president, and chairperson of the Board of the three-year-old startup, reached out to me on LinkedIn. Since then, I've been volunteering as a researcher. The AI Robotics Youth Program is an exceptional pre-college initiative introducing secondary education students to AI Robotics, and its various applications.

The program provides a comprehensive exposure to various subfields within AI robotics within a limited timeframe. It establishes a strong foundation in Mechanical and Mechatronics, Electrical and Electronics (e.g., mobile robots), and Computer Engineering (e.g., AI, autonomous vehicles), with each discipline covered over a two-week period. It also addresses critical topics such as Ethical AI, Responsible use of AI, Social responsibility, and adjacent fields. And covers concepts like Robotics-as-a-Service (RaaS), Internet of Things (IoT), Fleet control/Swarm robotics, Brainwave device control, Robotic simulation (WeBot), Forward and Inverse Kinematics, Automation, Humanoid locomotion, Cloud-IoT robotic fleet control, probability, statistics, Prompt engineering, and Generative and Applied AI in robotics (for coding and other applications). [see Appended Outline and brief description of the program]

Program Design

Each lecture lasted one hours with remainder of time, up to thirty minutes extra, was dedicated to students' questions, with some presenters openly allowing to be interrupted during their presentation. The program starts off with two weeks covering Mechanical Engineering topics (including coordinate systems like Cartesian and polar, rotational motion, linear motion, force, etc.). This is followed by two weeks of Electrical Engineering content, and the final two weeks addressing the Computer Engineering discipline, including computer vision, "computer in (robotic) motion," AI, and ML. All shared materials and presentations gradually build students' knowledge to reach a final practical training in controlling a mobile robot (mBot)—later covered in more detail.

Program Schedule

I participated in STFT's 3rd summer camp, conducted between June 26, 2023, and August 3rd, using Google Classroom as the learning management system (LMS) and Zoom for online sessions. Weekday classes occurred between 1 p.m. and 4 p.m., with a shorter and earlier Friday lecture series for guest speakers—those are volunteering to present once and may be approached to present every summer, or they may not be reinvited next year.

Following the presentation and Q&A, a 10-minute break was provided between 2:20 p.m. and 2:30 p.m. After that, a 30-minute lab session or "fellow-led activity" starts covering various live teachings—not necessarily related to the application of that particular lecture—including mBot assembly, mBot programming (on robot movement and the use of sensors), Dobot control (remote robot movement), and instructions on Robots Operating Systems, among others (more details in Appendix document A, Curriculum and Program Schedule). The day concluded between 3:00 p.m. and 4:00 p.m. with students reconnecting for a final lecture on soft skills and the importance of having a growth mindset, which is especially pertinent in a rapidly changing field of innovation not mature systems. It's noteworthy that this final instructional program on soft skills operates independently of STFT's curriculum.

Hands-on Activities

The program embeds two hands-on projects: one at the beginning and another towards the end, each involving two different types of commercial robots. At the program's start, the simpler mBots are distributed for students to take home as part of a San Francisco government and non-profit initiative. Students are required to collect their devices from the Code Tenderloin offices at 55 Taylor Street in downtown San Francisco. Then, over a number of those dedicated 30-minute lab sessions, STFT's Teaching Assistants (TA) would guide students live on how to assemble these gadget robots at home. Those sessions always start off with an icebreaker game (see Appendix) to get participants comfortable and ready to collaborate.

To avoid confusion and maintain consistency, lab sessions utilize the same universal Zoom link shared for all other STFT-run sessions. And the language used to program those mBots is a beginner-friendly, low-tech coding language called Google Blockly or mBlock. Throughout these lab sessions, students learn hands-on, in real-time, how to program their mBot to complete simple tasks such as line tracking and obstacle avoidance, essentially engaging with a real AI Robot.

Towards the end of the program, a different type of robot is used: a Dobot. This miniature industrial robot is safe to use in classrooms but requires a more advanced set of skills for students to operate. Valued at around $1000 each, STFT owns 6 Dobots that can be access remotely by the program participants. To control this robot, students need knowledge of Python programming on a Single Board Computer, like the Raspberry Pi 4. But since this prerequisite surpasses the technical capabilities of the recruited program participants, STFT's Assistants would guide the coding aspect then grant students remote access to the Dobot via a STFT-developed platform called: RETA.

Essentially, the purpose of this series of lab sessions is twofold: first, it provides students with a tangible example of how they could use Dobot's intelligent algorithm to "program" a robot to perform a task, in this case "color sorting" or "shape sorting," using its computer vision capability. Second, "to teach students what an industry robot looks like and functions like," as per Dr. Hu (personal communication over Slack, October 23, 2023). Surely, by that time in the program, students had been already introduced to the relevant concepts necessary to successfully complete this task remotely. As stated by the STFT president:

> "We do not replace math directly; instead we deepen the understanding of math with students' hands-on activities moving a robotic arm across the coordinate system; "Math in (Robotics) Motion." [and] Likewise, with "Physics in (Robotic) Motion.""

Site Visit

Lastly, another exemplary activity that underscores STFT's commitment to providing a comprehensive and hands-on learning experience on-site, in the AI Robotics field stems from its partnership with InOrbit, a "cloud robot management platform" (InOrbit, 2023). Where on the fourth week of the program, students are invited to participate in a site visit dedicated to teaching them what cloud-IoT control system is and how it functions, by means of a TurtleBot as a tool and in collaboration with InOrbit.

This not only provides an opportunity for students to learn about this technology but also creates an opportunity for in-person interactions with their peers and STFT staff during a casual pizza and coke event. Noteworthy, the site visit hosts a friendly competition to get students excited about operating a simple-service robot on-site, thus, further enhancing their learning experience and fostering enthusiasm for learning. This collaborative in-person initiative solidifies STFT's position as a remarkable provider of structured knowledge-sharing programs in the AI Robotics domain.

Beyond the Program

For these reasons, I found the program to be exceptionally informative, providing valuable resources in terms of lectures, information, and networking opportunities for high schoolers. It is particularly crucial at a pivotal time in their lives when they are making decisions about joining university/college or exploring potential fields of specialization. Most importantly, the program exposes them to the numerous potentials within the field of AI Robotics, showcasing various job opportunities that don't necessarily require advanced proficiency in math or having to study computer, mechanical, or electrical engineering. This approach allows students to envision their future roles not only as part of the workforce but also as consumers whose lives and product experiences will be profoundly influenced by AI Robotics. It empowers them to approach a field of rapid technological improvement as partners in its creation.

Purpose

To serve the mission of STFT, the primary instructional goal of this creative project is to provide recommendations for the redesign of the lecture that scored the lowest points in students' post-lecture survey. The redesign will then serve as an exemplary template for the later improvement of other presentations within the program to follow a uniform, structured outline backed by industry standards criteria for quality assurance. The objective is to identify the most suitable learning theory and effective methods for the delivery of engaging online learning experience, particularly for the instruction of technical material. Ultimately, it would allow STFT to deliver more effective learning experiences for its student participants next year.

From a technical perspective, I will revise the lecture, analyze students' survey, and utilize the extrapolated insights to guide the redesign process, which ensures the delivery of an amended lecture that is more attuned to students' needs and expectations of next year's content material. Simultaneously, I will work towards ensuring that the presentation complies with NGSS as the benchmark for quality.

Justification

The NGSS framework, collectively developed by 30 states, emphasizes the *application* of knowledge beyond mere *understanding*, a central prerequisite for a future workforce in the field. It is widely adopted in most K-12 schools and complemented by California's Career Technical Education (CTE) vocational training standards, as integral to major robotics programs, including online Massive Open Online Courses (MOOCs), and Science, Technology, Engineering, and Mathematics (STEM) summer camps. Additionally, it is prevalent in various physical science, life science, and engineering camps, as well as online learning platforms like Khan Academy.

Within this framework, students are not only expected to acquire factual knowledge but also to develop additional essential skills to succeed in their careers. The emphasis extends beyond strict STEM education to encompass practical abilities such as collaboration, problem identification, problem-solving, and the engineering of innovative solutions. Therefore, the program should not only aim to share technical knowledge but also to foster these broader skills as fundamental targets in its curriculum.

The STFT board of directors is well-aware of these missing fundamentals and has taken proactive steps to embody these standards in its curriculum. Its commitment and insightful vision are reflected in its integration of daily 30-minute lab sessions and self-assessment mechanisms, underscoring the program's robust methodology. That's why, it is no surprise, how the program has gathered the dedicated involvement of AI proponents, industry professionals, researchers, and C-Suite executives volunteering their time and expertise to further reinforce its noble mission.

Aim and Expected Outcomes

To achieve this, my goal is to enrich the learning experience of our students by proposing modifications to the curriculum that fosters more *application* of the material, thus, aligning it more closely with the NGSS and the Common Core State Standards (CCSS) for Mathematics and Computer Science. If successful, I believe that this project will increase high school students' likelihood of entering the field of AI Robotics that is steadily gaining professional traction due to recent media on Generative AI, ChatGPT, etc. Despite extensive interest in the field, there remains a shortage of professionals due to the industry's fast-paced work environment, fierce competition for entry, and widespread misconceptions portraying it as overly technical and suitable only for high academic achievers.

Significance

I believe that implementing the above changes would significantly enhance STFT's credibility and recognition by adhering to a recognized standard for delivering online instructional programs. This not only differentiates it from competitors, but also ensures better service to learners, as a student-centered approach to the needed endeavor. Despite this year's low dropout rate and an overall 4.3 out of 5-star rating from participants, as reported by Dr. Hu, refining the curriculum presents an opportunity for more students to seize the unexplored opportunities in the field with more engagement to the wealth of material and network at their fingertips.

In fact, implementing more strategies to better engage students with the material and enhance their interaction with their peers and instructors would automatically result in a higher-quality learning experience. As it would encourage more collaboration among participants, potentially translating the shared knowledge at students' disposal into action, thus, inviting innovation and further advancing the industry.

Personally, this project introduces me to an intriguing field related to technology and the AI hype. Applying my knowledge from my graduate ITEC program would be worthwhile, especially considering the potential advantages of working in the AI Robotics industry, revealed to me through my participation in the summer camp. The experience has highlighted the growing demand for skilled talent in the field, providing valuable insights for an instructional designer like myself.

Regarding the design principle, I plan to apply the UbD model outlined by Grant Wiggins and Jay McTighe as being: "a way of thinking more purposefully and carefully about the nature of any design that has understanding as the goal." (Wiggins & McTighe, 2005, p.8). Especially since our learners are at the crucial phase of building foundational knowledge on topics they could explore before entering university or joining the job market right after high school.

In terms of learning objectives, my focus will be on advancing students' *comprehension* of the material, as originally defined in Bloom's 1956 *Taxonomy of Educational Objectives* as being: "a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications." (Armstrong, 2010). Representing learners' ability to effectively work with the knowledge shared by: Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing, and Explaining concepts they'd encounter throughout the summer program. For that purpose, I aim to enhance the students' learning experience and work towards solidifying their acquired knowledge in their long-term memory.

Scope

For this project, I opted to develop a Lesson Plan for a single lecture using the Understanding by Design framework. The selected topic, "Probabilistic Robotics," is highly abstract, and redesigning it serves as a model to showcase how other instructional presentations can be revamped, restructured, and delivered to enhance the learning experience and instructional outcomes for our online learners.

Furthermore, it is imperative to align this lecture with STFT's core mission of inspiring students to enter the AI Robotics field rather than intimidating them. The goal is to demystify misconceptions about the field and present the diverse career prospects associated with it. To achieve this, I simplified the lecture content to maintain their excitement about the subject and reduce the likelihood of some feeling intimidated or discouraged from exploring the vast potentials of the sector.

This was made possible by integrating proven, effective learning theories and tools that have been tested in the online instruction of technical material, as outlined in the following task items. The instructional analysis starts with:

- Analyzing the standards to turn them into Learning Objectives [See UbD doc.]

- Develop 2 examples of Mr. B's lesson objective targeting the level of *Understanding*, as per Blooms' taxonomy.
    - Write them following the ABCD format for a more effective teaching/learning outcome.

- Developing Assessment: 2 formative assessment tools for this 1 lecture. [See PPT redesign]
- Identifying strategies to redesign the lecture: [Also part of the PPT]
    - Redesigning the presentation to follow the UbD model Enhancing, replacing and or completely removing specific elements from the existing lecture materials.
    - Suggesting supportive instructional material where needed.
    - Proposing recommendation on the presenter's teaching style, to support a more engaging experience to his approach. [Under lecture Evaluation & Quality Assurance and within PPT Notes]

Out of scope:

Develop new or enhanced learning material and media from scratch for that 1 chosen presentation.

Section 2: Front-End Analysis

Introduction

Summary of the Why and How

The AI Robotics industry is experiencing rapid growth leading to a shortage of skilled labor to fulfill the increasing demand. In response to this, SuperTech FT has crafted a 6-week online program led by subject-matter experts, to introduce students with only a high school diploma to next-generation skills essential for the evolving landscape of AI Robotics. The program combines MOOC resources, industry professional lectures, and open-source media clips, offering a carefully curated selection that targets specific skill development as industry prerequisites. According to its president, this approach addresses the gap in preparing students for what "need to know to succeed ten to fifteen years from now" (personal communication over Slack, August 14, 2023).

SuperTech FT aims to demystify misconceptions about the field and contribute to building a talented workforce in AI Robotics. The effectiveness of the program's curriculum is under evaluation by two volunteer instructional designers, utilizing students' surveys collected during this year's summer camp to guide their instructional enhancement lecture-by-lecture. The ultimate goal to this endeavor is to unify presentations and align them with the UbD framework and NGSS, to ultimately enhance students' engagement in the program for the upcoming year.

Rationale Behind the UbD Model

Choosing to apply the UbD framework for this endeavor is driven by the diverse and multidisciplinary nature of the material covered in the program. Encompassing Mechanical, Electrical, and Computer engineering, along with ethical considerations and philosophy, surrounding socially responsible AI, ethical AI, and their embedded legal complexities. Additionally, the program is delivered by 12 C-suite level executives coming from different geographical locations, cultural backgrounds (Germany, Japan, Switzerland, India, the US), and professional experiences, which contributes to the varied teaching styles and expectations from attendants, therefore, adding another layer of complexity to students' teaching experience.

Therefore, the UbD model was chosen as an effective framework of reference due to its capacity to break down complex subjects into more manageable concepts, fostering students' understanding through a structured inquiry-based teaching approach. This method promotes curiosity and active thinking, essential qualities for individuals entering the dynamic field of AI robotics.

Furthermore, UbD's practical and pedagogical structure allows for a "reverse engineering" of lessons. Starting with the identification of the clear intended goal for each lecture, followed by pinpointing the need to precisely demonstrate students' comprehension, instructors can systematically plan instructions and learning experiences following its guidelines. This approach also helps minimize individual teaching styles, emphasizing cumulative students' understanding as the utmost focus. Finally, aligned with state instructional standards, the framework facilitates the development of focused activities that enhance student engagement and encourage "self-directed, life-long learning" (Roth, 2017).

This is made possible because the framework targets six facets of understanding: Explanation, interpretation, application, perspective, empathy, and self-knowledge. All of which should be considered by the lecturers not only to help unify the program pedagogy, but also because they serve the student as the center of the program's instructional objective. Moreover, following its process will also help us develop specific needs statements in relation to the online program deliverables.

For students, this approach would reduce students' cognitive load and minimize their confusion when reintroduced daily to a new instructor with their own teaching style and content material. On this point, Dr. Hu suggests that we may need to develop two versions of guidelines "one for teachers (weekdays), the other for guest speakers (typically Fridays)." [See Guideline for STFT Leader-Teachers in Appendix]

Needs Assessment

Goal

In the face of the considerable material to cover within a limited timeframe of 6 weeks, the success of the summer program depends on the precise delivery of content tailored to specific learning outcomes addressing the unique needs in AI Robotics. Choosing the most effective learning principles for online delivery of scientific material, such as math and physics, becomes crucial. Additionally, ensuring continuous quality improvement through annual evaluation and iteration is vital for the program's improvement and adaptation to the ever-changing educational landscape in this rapidly evolving field.

To effectively navigate these challenges through the lens of Instructional Design, two instructional designers were purposefully brought on board. My senior colleague, Ioanna Kravariti, and I were granted full access to the six-week-long Google Classroom. Where we attended lectures and voluntarily created an assessment document (see Appended under Program Implementation Guidelines[2]) to evaluate the program's various aspects, including each lectures' content material, the effectiveness of used resources and media clips, and presenters' teaching skills.

Subsequently, an education department was established to propose guidance on each lecturer's teaching style and offer more recommendations on the effectiveness of their instructional pedagogy and content sequence. The overarching objective is to elevate students' engagement levels and enhance their learning outcomes while maintaining a curriculum closely aligned with STFT's core mission of reducing barriers to entry into the field of AI Robotics.

Identified Discrepancies

The current state of certain highly technical lectures is undermining STFT's fundamental mission of reducing barriers to entry into the AI Robotics field. Prolonged presentations coupled with a nonuniform teaching approach and lecture style are hampering students' engagement and hindering their targeted learning objectives. The repetition of most fundamental concepts in AI

[2] The initial document was populated only with titles of the standards we were going to be using, I then completed all the rest for this creative project.

Robotics among different lecturers is fostering a sense of boredom among students, particularly towards the program's conclusion.

Furthermore, there is a critical need to cultivate an environment that encourages students to pose inquisitive questions, contrary to the traditional education model that overly prioritizes test scores for securing school district funding. The importance of adopting a dialogue-driven teaching approach, to explore underlying beliefs that shape students' views and opinions, is one that Socrates used with his pupils, according to Dr. Hu, as he wrote on Slack once: "the Socratic Method is a dialogue between teacher and students, instigated by the continual probing questions of the teacher, in a concerted effort to explore the underlying beliefs that shape the students' views and opinions." (personal communication, October 13, 2023)

Therefore, it is essential, particularly in this dynamic industry, to prepare students for an unconventional, fast evolving job market. Equipping them with essential skills such as problem-solving, critical thinking, adaptability, and interdisciplinary collaboration should be a top priority in the curriculum. These skills are crucial for navigating an industry with significant growth potential and innovative applications yet to be conceived. As our learners' innovative thinking will be instrumental in driving change and pushing the boundaries of their respective chosen domains in the field of AI Robotics.

Additionally, the absence of effective short media clips to succinctly grasp key concepts and the lack of an assessment mechanism to evaluate both students' understanding and satisfaction in the program—not only of each lecture—as well as the systematic evaluation of speakers' teaching styles, are critical gaps currently compromising the program's quality.

Addressing these shortcomings is not only essential for student retention but also vital for sustaining STFT's reputation and viability in the long run.

Proposed Solutions

To enhance students' learning experience, boost their engagement, and consequently improve the program's effectiveness and quality, the following solutions should be considered:

1. **Align Lecture Content with NGSS:** To gain accreditation and distinguish the program, aligning lecture content with NGSS is crucial. The standard provides recognized instructional guidelines tailored for teaching science online. This alignment ensures that the program meets established pedagogical benchmarks and elevates its standing in the industry.

2. **Yearly Evaluation Process:** Establish a systematic yearly evaluation process to continually assess the content delivery and materials through participants' experience. Regular assessments enable the program to adapt to evolving educational landscapes, ensuring that it stays current, effective, and competitive within the dynamic field of AI Robotics. [See Appended "Program Implementation Guidelines," including the standards based on which we evaluated lectures]

3. Surveys for Learner Satisfaction: Implement regular surveys to gauge students' satisfaction in meeting learning outcomes, engagement with the materials, and overall comprehension, preferable to the point of them feeling comfortable discussing it. Whereby, at the end of the program, students will be able to properly use the new jargon that they were repeatedly exposed to in multiple lessons pertaining to the AI Robotics space. This feedback loop provides valuable insights into the effectiveness of the program and helps in tailoring future content to better suit students' needs.

4. More Insights from Post-Lecture Surveys: Leverage post-lecture questions as an opportunity for follow-up for a deeper analysis of participants' needs. Moreover, in the 2024 program, we could seamlessly integrate students' answers as a segway into the start of next day's lecture. This approach not only reinforces positive behavior but also creates a more interactive and participatory learning environment while conferring an element of continuity to the program.

5. In-Lecture Assessment Tools: Develop and incorporate more in-lecture assessment tools to regularly evaluate students' understanding and grasp of the material. These assessments can provide real-time feedback, allowing instructors to adjust their teaching approach based on participants' comprehension levels. This proactive approach ensures that students are consistently engaged and comprehending the material effectively. [See Guideline for STFT Leader-Teachers in Appendix]

6. Guidelines for Teachers: Provide clear guidelines to teachers to minimize cross-lecture repetition. Encourage them to be aware of concepts covered in previous lectures and utilize these instances for student engagement rather than reteaching. For example, instructors could pose questions related to previously covered material to foster interaction. Especially among recurring speakers, as we aim to unify the delivery of material following UbD principles.

7. Leverage Repetition for Recall: Work with lecturers to use repetition strategically as an opportunity for recall and engagement. Instead of reteaching basic concepts, encourage instructors to engage students by posing questions that prompt recall, reinforcing their understanding. This approach not only prevents redundancy but also actively involves students in the learning process.

8. Interactive Class Model: Offering feedback on the performance of students on their formative assignments, coupled with praise for those who excelled, serves as positive reinforcement. This approach not only recognizes the efforts of attentive students but also motivates those who may not have been as focused in the previous lecture to become more engaged, thereby fostering a more inclusive and participative learning environment.

9. Data Analysis from Surveys: Analyze survey data to identify specific subjects or content areas where students, particularly younger ones, may be facing challenges. Tailor additional explanations or supplementary materials for these identified concepts. This targeted support ensures that students receive the necessary assistance without causing information fatigue for others, fostering a more inclusive learning environment.

environment.

Desired Goals

Dr. Albert Hu, the visionary president of SuperTech FT, recognized the growing demand for skilled talent in the rapidly evolving field of AI Robotics. Established in collaboration with fellow members of the Board of Directors, including senior executives and professors from major technology firms and venture-capital-funded startups, the AI Robotics Youth Program aims to bridge the skills gap and provide students with a solid foundation in the AI Robotics field.

Dr. Hu, along with his Board of Directors, ensure the integration of NGSS principles into the program's curriculum, given their solid foundation in the field with decades of training and experience, as well as commitment to a high-quality interdisciplinary education. Still, each year, Dr. Hu shuffles between recurring teachers and guest speakers to cover most effectively the highly interdisciplinary material of the AI Robotics Youth Program.

Identifying opportunities for growth and funding, Dr. Hu embarked on a mission to enhance the program's scientific recognition and increase student engagement. With the goal of creating the STFT Science curriculum standard aligned with NGSS, he aspires to secure ACHIEVE's credentials for non-profits (personal communication over Slack, September 05, 2023). This strategic move aims to not only make the program accessible to high school STEM teachers but also to position STFT as a pioneer in AI Robotics education, globally.

Seeking industry-standard accreditation and planning international expansion reflect his foresight and ambition. Driven by a mission to lower barriers to entry into the field, he envisions a curriculum that would gain widespread recognition and contribute to the development of a talented workforce in AI Robotics, while offering all that as close to being free to learners as possible. Dr. Hu's visionary approach leads him to onboard 2 volunteer instructional designers for the 2024 program, showcasing a commitment to the program's continuous improvement.

The relentless pursuit of partnerships in India, Europe, and the Middle East, coupled with plans for incorporating cutting-edge topics like self-learning robots and the simultaneous localization and mapping (SLAM) method in next year's program, highlights Dr. Hu's dedication to staying ahead of the AI hype. His forward-thinking vision aims not only to meet the current demand for skilled professionals but also to shape the future landscape of AI education. Ultimately, Dr. Hu’s strategic initiatives not only aims to establish STFT as a credible and competitive service provider but also to scale the program’s impact worldwide.

Present Conditions

The Youth AI Robotics program, sponsored by the San Francisco government and various nonprofit agencies, provide participants with a scholarship promoting STEM education among the disadvantaged and minorities enabling select students to attend the program free of charge. The curriculum includes STFT technical lectures focusing on AI Robotics, complemented by presentations on soft skills, growth mindset, and interview preparation delivered by Code Tenderloin, the recruiting and operational branch of STFT.

Students, ranging from high schoolers to early college students with no prior knowledge of AI Robotics, but possessing middle school STEM prerequisite skills, are encouraged to actively participate in the online sessions held between 1 p.m. and 4 p.m. throughout the week. The use of mBots for practical learning added a hands-on component to their experience. While opening video was optional though frequently encouraged, 27 students signed up to explore AI Robotics over 2 alternative introductory tracks in Web Development and Lab Research.

Therefore we know that students are intrinsically motivated in the AI Robotics since all 3 tracks paid students the same symbolic stipend to attend 1 program during the summer, and offered the same opportunity for them to gain new skills to advance their resume and have a higher chance of employment as they had not yet accumulated experience by their age.

Among the 27 students, only 2 discontinued attendances. 1 stopped attending after the first day, which may mean that they chose to attend other tracks offered simultaneously by Code Tenderloin. 1 stopped attending after the first week without reporting the reason. 1 was a returning HS student who thought last summer's 2022 program to be "interesting" and "fun" for him, enough to make him repeat it. And then, among the remaining 21 participants, 13 took the time to express the reasons why they were interested in joining the program. Their reasons were mostly concentrated on their curiosity about an "interesting" field they weren't familiar with to "learn about AI, [that they] don't know much" about, as well as the applications of AI in their life, particularly naming: driverless cars and the medical field. And 1 pointed that it was an "important thing in the future" while 2 thought they'd be exposed to "more coding languages, ai/robotics in general."

Potential Solution

UbD as a Universal Solution

Redesigning the entire program using the UbD framework is the perfect opportunity to address the program's irregular structure for being delivered by various presenters of multiple background. It supports its growth and ambition from targeting beginners only to serving intermediate and proficient AI Robotics enthusiasts in the future. This approach also ensures a uniform design across lectures, allowing IDs to develop a curriculum that progressively advances through Bloom's taxonomy, moving beyond *comprehension* to higher-order thinking skills like *creation*. This shift fundamentally aligns better with the program's goal of fostering students' *application* of their acquired knowledge, a crucial objective in a field that demands practical understanding and problem-solving skills.

NGSS and AI4K12 as Industry Standard Frameworks

Recognizing the dynamic and interdisciplinary nature of the Robotics field, aligning the program's learning goals with NGSS involves leveraging students' existing skills and knowledge from other subjects into the learning of new concepts. And encouraging them to participate more proactively in distilling information and developing their critical thinking to ask question and test their own hypotheses, in preparation for working in the fast-changing industry.

While NGSS may not comprehensively cover all topics taught in the program, another standard, AI4K12, is introduced to support the breadth of disciplines covered. The combination of both standards, closely connected with the CCSS, enhances the instructional design, maximizing students' learning with measurable outcomes and practical applications from each lecture. This approach ensures a more effective instructional experience tailored to the complex and interconnected nature of the program's curriculum.

Learning Beyond Lecture

Incorporating NGSS and AI4K12 standards enables the program to address varying interest levels and prerequisite knowledge among students. To cater to diverse needs, additional materials beyond fundamental concepts can be offered to students eager to expand their knowledge beyond the fundamental concepts shared during lectures. Simultaneously, learners lacking essential prerequisite knowledge despite STEM exposure in high school can benefit from supportive materials too. These supplementary learning opportunities, aligned with NGSS and

AI4K12, can be presented in a designated section slide at the end of a presentation linking additional Practice Exercises, Disciplinary Core Ideas, and Crosscutting Concepts for those who need it. This approach enhances inclusivity and allows for a more personalized learning experience.

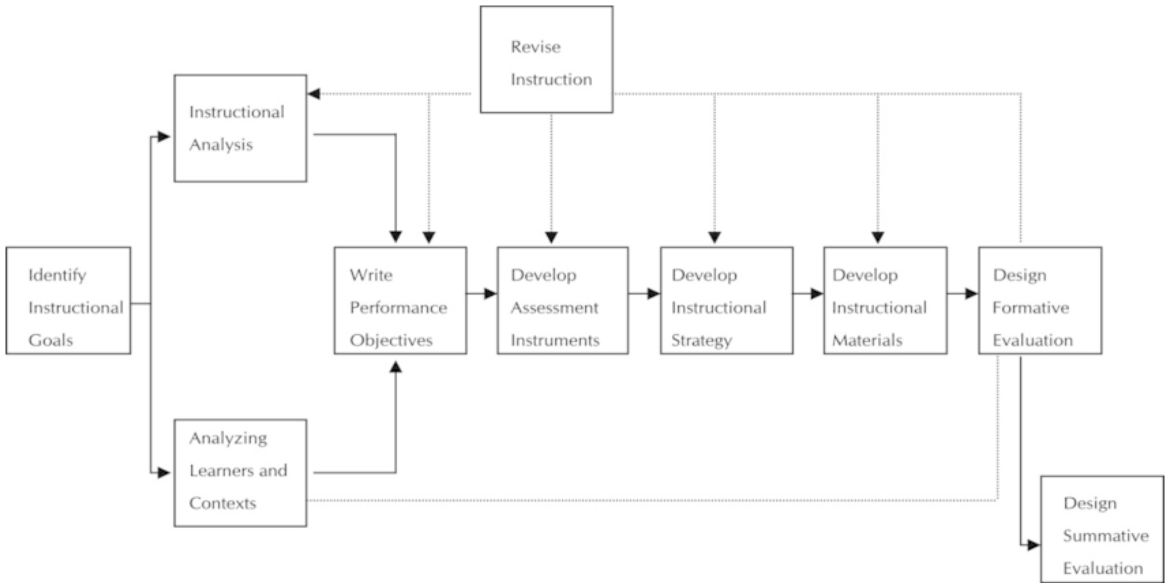
Yearly Assessment

The program should establish a commitment to a structured, systematic, and iterative approach to its design through an annual process encompassing program evaluation, redesign, development, and implementation (detailed below). This cyclical process, led by in-house instructional design experts, ensures continuous improvement and alignment with evolving educational standards and industry practices. The recommendation section below will provide further details on implementing this strategic approach for sustained program enhancement.

Recommendation

Creating a well-thought-out learning experience design for the AI Robotics Youth Program 2024 involves following a step-by-step, systematic process. The Action Plan outlined below includes developing a detailed Design Document, in line with the instructional design cycle: Analyze, Design, Develop, Implement, and (re-)Evaluate. This process is based on the Dick and Carey Model from 1996, as shown in Figure 1.

Figure 1: Instructional Design following the Dick and Carey Model (1996)



Dick and Carey's systematic model of Instructional Design

I. ANALYZE

1. Identify needs (i.e., instructional goals)

    a. Analyze the Learners (goals, interests, skills, etc.) & Context (educational background, motivation for registering in the program, using laptop or mobile, family social status, if possible)

    b. Instructional Analysis (i.e., Goal analysis)

        1. Evaluate speakers

        2. Lectures revision – One by one

            a) Make titles less intimidating.

            b) Label lectures

            c) Check that each lecture covers only a few major skills

            d) Coordinate the introduction of basic concepts between presenters.

e) Remove the lectures that are too technical or reduce the concepts they'll be covering if they must be taught in the first place.

3. Enhance *cognitive engagement* (concept maps, presentation slides that implement multimedia learning principles, etc.) and embed *motivational strategies* such as relevance, attention, etc.

c. Write performance objectives

1. In line with the essential NGSS, Mathematics, AI4K12, and Computer Science standards that are currently missing from the program.

II. DESIGN

1. Create a Lesson Plan for any 1 lecture following the UbD framework

2. Analyze the standards into its instructional goals
   → Select materials based on the intended instructional goal(s) only.
   a. Set the standards as instructional goals following the UbD framework.
      Identify one instructional goal for each presentation (NO OVERLAP).
      1. Give examples of learning objectives

   b. Based on identifying the concepts and essential skills, you would like the students to acquire
      MUST MAKE IT CLEAR: What the students/learners will be able to do by the end of the camp in real life in the professional context.

3. Convert the instructional goals/learning objectives that must be covered into *terminal* (i.e., what learners must master before they complete the course) and *subordinate* objectives (i.e., number of prerequisite skills, enabling students to perform the intended learning goal), following the ABCD format specific to: *Understanding*
   CLEARLY: What the students will be able to do in the learning environment, and what prerequisite skills are required to accomplish these behaviors, but make sure they align with the instructional and terminal objectives.

4. Identify the most effective Instructional Strategy for the support of students' online learning of scientific material.

III. DEVELOP – *Now, as per UbD principles, I should work backward to implement the above, element by element.*

1. Develop instructional materials

a. Visuals, videos, printable, and activities etc. to support the learning process.

b. Insert additional websites, videos, and curated PDF links to maximize learning efficacy and concepts' retention.

2. Create Assessment tools to assess students' learning, and instructional evaluation

    a. Teaching performance through daily post-lecture survey questions (our evaluation of students' reaction to presenters' teaching style and material)

    b. Learning performance through *formative assessment* (our evaluation of what the students have grasped from each lecture)

    c. *Summative* knowledge assessment to measure that they're actively learning and retaining concepts, to be illustrated by a final project: The hands-on mBot and Dobot exercises.
    → PS: Make sure those are in alignment with the terminal objectives and the instructional goals.

3. Create a collaborative online Learning Environment

    a. Create opportunities for student-to-student engagement, interaction, and collaboration.

    b. Ideally, subject-matter experts can put extra efforts in

        1. Recording videos

        2. Delivering their presentation in person at Code Tenderloin to be more approachable to the students whom are physically attending from there– though not required to, and

        3. Offer to converse personally with interested students who show curiousness and eagerness to be given more guidance or mentoring.

IV. IMPLEMENT amended program

1. The best learning principle/instructional strategies that will help the learners meet the terminal goals set forth.

V. EVALUATE

1. Evaluate

2. Reiterate.

While elements of the roadmap outlined above have been completed for this creative project, the remaining stages will be executed step-by-step by the instructional designers and relevant departments at STFT. The process will be carried out progressively until the program runs again in late July 2024. Once implemented, the enhanced program will be in turn reassessed through students' surveys to gather feedback and repeat the design cycle again, continually.

Data Collection Method

Students' feedback is gathered through a daily survey comprising 5 questions that assess the presenter, the content, the shared resources, and effectiveness of media used in each lecture (refer to the Post-Lecture Surveys in the Appendix). The surveys provide ample feedback on students' experience with the covered lecture material and their preference for the teaching style of each guest speaker over the 6-week period, which I aim to utilize to gather data on students' satisfaction and instructional needs.

Simultaneously, 2 IDs carried out daily observational assessments (see Appended snapshot of the entire "Program Implementation Evaluation") of the presentations, using a scientific approach aligned with Gagne's instructional principles (detailed below). The evaluation rubric covers the effectiveness of students' understanding of the material, the relevance and complexity of content, the identification of LO, the use of illustrations and examples to facilitate learning, the opportunities provided for participants' interaction, collaboration, and assessment, etc... Additionally, it includes notes on the accessibility and adherence of the lectures to Universal Design principles, which prioritizes flexibility to accommodate all types of learners (Bruff, 2019).

Task Analysis

The first round of evaluation was conducted during the summer of 2023 program by means of a daily students' survey, dispatched at the end of each lecture and lab session [see both survey in Appendix] to gather students' assessment of the presenters' teaching style and presented material. As previously mentioned, 2 IDs also registered observational notes in assessing lectures throughout the summer camp (under Program Implementation Evaluation in Appendix).

As they listened to speakers, the IDs suggested improvements in line with scientific guidelines for teaching science online that are based on 4 quality assurance rubrics [See Appended, Mr. B's Quality Assurance document] used specifically for hybrid and online learning environments, including:

- The Quality Online Learning and Teaching (QOLT) framework created by the University of California;
- The Quality Matters (QM) standards, K-12 rubric;
- The OSCQR -SUNY Online Course Quality Review rubric;
- The NGSS EQuIP rubric

In collaboration with my colleague, Mrs. Ioanna Kravariti, I crafted the roadmap shard above to guide our efforts in systematically improving the program and its associated lecture series. The roadmap is also informed by discussions with Dr. Albert Hu, STFT's president and CEO, during various Department of Education meetings and Slack discussions.

In this project, my focus is on elements within the *analyze*, *design*, and *develop* stages of the design roadmap outlined earlier. While the *implement* and re-*evaluate* stages will occur during the next summer program when the camp runs again between end of July and beginning August.

I decided to concentrate on specific elements from the various stages of the learning design because I believe that these particular aspects would effectively showcase the positive impact that the program could derive from implementing the proposed instructional principles, strategies, and recommendations.

Content Analysis

In terms of content analysis, starting with only one lecture for the ongoing creative work project, which will serve as a model for subsequent redesign efforts across the entire program, I would ultimately need to review around 30 lecture materials, constituting a 50+ hours curriculum.

This involves gaining knowledge of the NGSS standards that STFT intends to incorporate into next year's program, in order for me to develop recommendations to: a) enhance students' online engagement, b) align NGSS with the program lecture standards and LOs, and c) streamline the program pedagogy to provide a more structured learning experience. Therefore, mitigating the currently unstructured content delivery that is taxing students' cognitive workload for having to adapt daily to the multiple speakers' teaching styles, which will be accomplished by adopting the UbD framework.

Learner Analysis

STFT's operational partner in outreach and soft skill development, Code Tenderloin, managed the program's advertising and recruitment efforts. The camp's participants range from 16 to 24 years old, including mostly high school students, 1 college student, 1 graduate student, and 1 young professional. Although the information about the participants was originally managed by a terminated volunteer, I reached out to Dr. Hu and another TA to provide some details about the program participants. The prerequisite for enrollment was only a middle school-level knowledge of STEM course material, without any additional prerequisites to the selection process.

To better understand participants' motivations and effectively tailor our instructional strategy to meet their needs as clients, I reflected on my personal experience with Code Tenderloin (CT). CT is a nonprofit dedicated to assisting struggling individuals facing challenges, whether for being from a non-traditional background, a minority, or overcoming other impeding obstacles in life. This includes those facing challenges like former incarceration, homelessness, or substance abuse. CT would help them, for instance, secure a high-paying job in the tech industry by teaching them essential coding skills and then partnering with businesses to facilitate their entry into a job placement program.

Reflecting on my own experience with CT's Code Ramp program, I consider that the students applying to the STFT summer program through CT are likely to come from non-affluent school districts. Especially as these applicants were accepted into the program free of charge when the cost per student would otherwise be 4000 USD, as per Dr. Hu. Hence. They must have either sought out CT themselves or were identified by the non-profit for being eligible for the available scholarship by the San Francisco government and other non-profits agencies supporting STEM and local initiatives aimed at fostering a more equitable society and reducing the opportunity gap among specific communities in the US.

Dr. Hu also confirmed that each student received a stipend for their participation, a take-home mBot for the summative hands-on projects, and were even reimbursed for their commute fare to InOrbit, for a site study visit activity in Mountain View.

In an effort to increase student engagement and get them motivated to actively participate during lecture, the STFT president promised to select 2 or 3 candidates from the program's participants to be hired as operational assistants during next year program. The selected students would receive a stipend for their efforts as well, and this time it would come from STFT, as pledged by Dr. Hu. His attempt aimed not only to increase students' involvement in the program, but also to kindle their interest in what it could potentially offer.

Program Evaluation and Challenges

The program is conducted through a recurring Zoom meeting link, with students receiving daily prompts to join the meeting through Google Calendar. They could log in through their laptops or mobile phones without any restrictions. Google Classroom serves as the primary platform for posting materials, updates, questions, and submitting the final mBot project, offering an effective means of communication.

Except for 2 or 3 presenters who did not use a PowerPoint presentation and offered an apology with a valid explanation to the inconvenience, the lecturers typically used a PowerPoint deck often including embedded graphs and video links in their presentations to illustrate abstract or complex concepts.

Occasionally, I detected the video clips serving more of an entertainment purpose than an explanation. I believe this is acceptable, because these instances facilitated students' engagement with the highly technical concepts they were being taught. They offered a cognitive break from a heavily "dry" or "informational dump" lecture style or from a presenter's disengaging presentation and monotonous voice.

And while most videos served their intended purpose, Ioanna and I identified a few instances where some were either too long or not aligned with the intended learning goal or the specific concept in question. In these instances, I recommend either playing only the relevant part in the videos or substituting them completely with a representative visual element (illustration, table, graph, pie chart, bullet points, etc.…). These visuals can be sourced from open-source media outlets. It is critical, however, to keep the length of any video clip between one to three minutes maximum, in order to optimize the use of lecture time.

One significant observation during daily evaluations was the limited interaction between presenters and students, as well as among students themselves, except during Q & A. The proposal is to create a Slack channel for each cohort, providing a space for ongoing connections and professional networking beyond the program. This would foster collaboration, question-sharing, and the development of a supportive community.

This could even turn into a space for students to connect and potentially initiate a network of professional relationships that originated during STFT's summer program but ended up fostering a lasting community of participants interested in the field. This is especially important since encouraging students to actively participate, ask questions, and collaborate is crucial, as it effectively trains them as prospective engineers and professionals in any field they choose to pursue.

Moreover, encouraging interaction during lectures is crucial, and tools like Mentimeter polls and Zoom's "breakout room" feature can enhance engagement and foster group work. These interactive instances enable immediate feedback on students' comprehension and facilitates peer-to-peer learning. They also provide an opportunity for presenters without a PPT presentation to tailor their presentations based on students' understanding and interests, leveraging students' interaction for a positive learning outcome.

Addressing online etiquette, the challenge of camera use is serious. However, encouraging presenters to be interactive in engaging the learner can contribute to students' overcoming their reluctance to turn on their cameras. What's more important is in students answering speaker's questions and prompts, as a sign of their active engagement and comfort with the level of difficulty of the material discussed. Therefore, perhaps emphasizing the value of thinking about answers as a way to reinforce the learning process, even if not shared, should be vocalized. Similar it is vital for the lecturer to establish a supportive and approachable atmosphere from the beginning.

Finally, in tackling the issue of motivation, it is critical to better understand the learners' perspectives and explore means to engage them. Presenters, IDs and the STFT administrators must allocate a bigger time on figuring out learners' goals, even if it means there could be necessity in resorting to offering monetary incentives like Amazon gift cards for competition winners through tools like Mentimeter. This proactive approach can ultimately contribute to a more dynamic and participatory learning environment.

Section 3: Design and Development

Instructional Contexts

Analysis Instrument

I chose to address one of the lectures that received the most feedback of being too technical from the surveys collected daily from students after the lecture (See appended Post-Lecture Survey Results). The reason being that I believe it compromised STFT's intended core mission of demystifying the field and making it more approachable to HS students with various cognitive aptitude, skill potentials, and academic capacities to consider joining the promising field for their study or work. In fact, Dr. Hu concurs with me that although "On paper, it is organized, however, that was too difficult for students, from some student feedback I read." (personal communication on Slack, November 10, 2023).

Survey Analysis

The quantitative survey of a 3 Likert scale questions and 2 open-ended questions was sent daily to capture students' learning assessment and attitude with regard to presenters' instruction, resources, and pedagogy. Only 12 students replied out of the program's 25 attendants (<48%), rendering the average score of the 3 scaled questions inconclusive of the lecture's need for improvement. However, what did uncover students' dissatisfaction with the lecture, is having the majority of students recording in their open-ended answers that the lecture confused them or was too fast considering the number of equations explained. As one participant puts it:

> "I wasn't sure how a lot of probability was connected to generative AI and how to apply those concepts - it would help to make that connection more clearly next time. Also to perhaps include more engagement with the interns, like asking mini test questions to the interns, or small games such as how we guessed which face was real or AI generated." (Anonymous participant to the post-lecture survey form)

Having said that, other students appreciated the presenter's passion and his easy-to-understand examples, while one even went on praising the lecture's high level of difficulty. However, spanning 2 surveys assessing the same presenter who delivered 2 distinct lectures on 2separate days, the open-ended questions asking students to suggest improvements to the lecture and what they thought that the presenter did well in his presentation, still revealed the necessity for the 1st lecture's redesign.

Moreover, to avoid personal bias, I reached out to one of the program's Teaching Assistant (TA) to inquire about their opinion about the level of technicality of the lecture, if it were appropriate to HS students having just graduated from HS themselves, and they replied:

> "I do think that the statistics lecture was a bit too technical. I think most students were being polite and uncritical in their survey responses (despite Alivia [another TA] insisting that they put more substance in them). There was a significant minority of students who had not reached the grade level at which statistics or basic calculus are taught (11th-12th grade). The technical details must have intimidated them." (personal communication on Slack, November 15, 2023)

For all the above reasons, I decided to keep the name of the lecturer, and the presentation's date and title anonymous, as a way to respect that presenter's privacy and instead, focus the attention on how to increase the learning outcome for our students.

The Instructional Rationale

The reason why that lecture scored low, is because it was too technical for our participants to follow. In the sense that, while freshmen students would have been genuinely interested in the topic to choose to enroll a lecture in it, our program participants, on the other hand, have a more generalist interest in the topic of AI Robotics when they signed up for the program. Particularly as the majority of our audience are high schoolers whom are yet to zoom in on their interest, both in academia and in terms of their respective professional career choices.

Having said that, the lecture should not be completely deleted because of the importance of the topics it discusses, including common mathematical concepts that are typically taught in high schools, like probability, statistics, and basic regression analysis. In fact, according to Dr. Hu, "AI and ML's foundation is statistics" (personal communication on Slack, September 4th, 2023).

Lecture Initial Structure

The lecture was delivered through a PowerPoint presentation (PPT).

It consisted of 44 slides divided as such:

- 1 Title slide
- *Agenda* made up of 2 "Content" slides

2 slides to state the Agenda of the lecture with the subfields enumerated (from the lecture in question).

***<u>Context</u>*:**

- 1 Introductory slide of the major topic: "Robotics"
- 1 brief explanation is made on the reason why students are being exposed to this lecture on"Probabilistic Robotics," in the broader context. As the presenter puts it:

> "Always exact measurements while taking actions are not possible. Hence the internal algorithm is dependent on probabilistic calculations in some way."

***<u>Content</u>*:**

- 18 slides on the 1st major concept addressed: Basics of Probability
- 19 slides on the 2nd major concept presented: Robotic Environment Interactions
    - 1 slide assigned as "Homework" relevant to the last slide in the last section of the presentation that the lecturer couldn't even reach due to lack of time.
- 1 slide on the 3rd major concept discussed: Basics of Localization that was never explained.

***<u>Closure</u>*:**

- 1 Reference slide.

End of presentation

Lecture Initial Design

- Title page
  - In Black and White, hence, uninviting curiosity and attention.
  - Missing presenter's Name and Contact information

    At least the presenter's email should be mentioned, if not their LinkedIn.

    Note: LinkedIn was finally shared at the end in the Zoom chat.

- Missing presenter's dedicated Introduction slide

  Although the lecturer was briefly introduced by Dr. Hu, the presenter still had the chance to share both their academic background and current professional function. Adding a "contact-me" slide with the lecturer's social media handles would not only allow students to email the presenter when wanting to ask a question or followup on a point discussed during the presentation. But, could also, give students the opportunity to connect with them over LinkedIn for general interest in what they're doing or future referrals, etc. Could also be helpful in case students missed their name in full at the beginning of the presentation.

***<u>Context</u>*:**

- Missing Learning Objectives

  Must be stated clearly 2 or 3 measurable LO that they would come out of this lecture and which they could use in real life, preferably even skills.

- Missing lecture meta-purpose (as part of the entire prog.)

  It should clear why it's important for students to know more about this subfield in AI Robotics. And the reason must be relevant to their specific interest: be it professional, or to make them less prone to layoffs, or to receive a higher average salary as an entry level position, or there is high demand for this particular subfield, etc…

***Content*:**

- Slide 4 is an introduction to Robotics and should be titled as such.
  - Missing the Definition of "Robotic systems" and "Probabilistic Robotics"
  - Lecture could start with a general question to test students' level of knowledge of the general concept, especially at the beginning of the lecture before diving deeper into Probabilistic Robotics.
- Slide 5 exists in a vacuum

  It is placed before "Basics of Probability" slide and not made clear if it belongs to the introductory context of slide 4, especially since that slide already moves on to cover the basics of probability. At least move it one slide over to solve the confusion.
- Examples are not exactly deep enough to explain a mathematical concept.

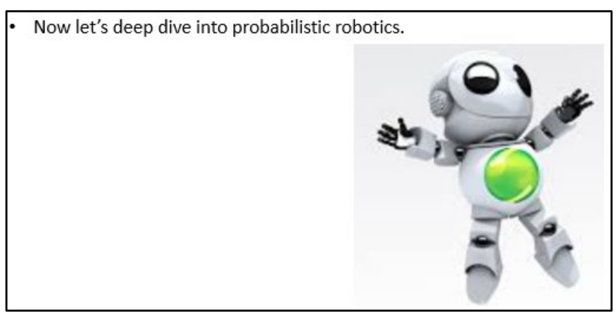
  Ex. "The exact mass of a random animal selected at the New Orleans Zoo." is given as an example to "Continuous Random Variable" but it doesn't explain the concept, it is incomplete.

- Not clear why concepts are covered in the order that they are.
- Not clear why they are relevant to the presentation's main topic to begin with.

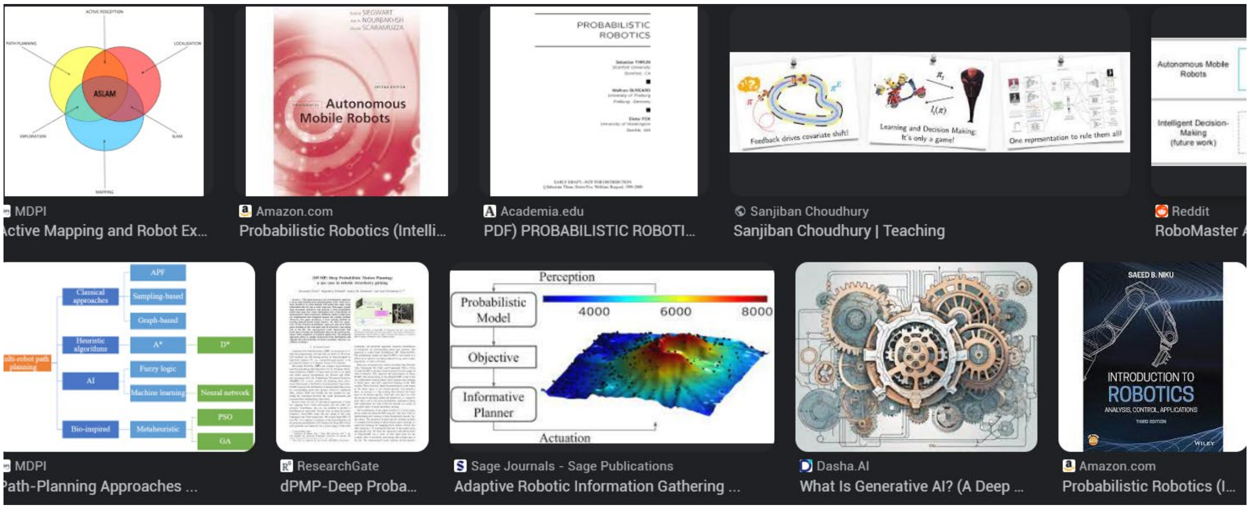
Abstract mathematical concepts and algorithm should be explained as part of an example and the example should be referred to over and over again to build on it new mathematical equations. This will make it much easier for students to follow, and build gradually on their knowledge instead of providing examples in a vacuum, only relevant to the discussed concept and moved on, which makes the lecture lose its logic and unity.

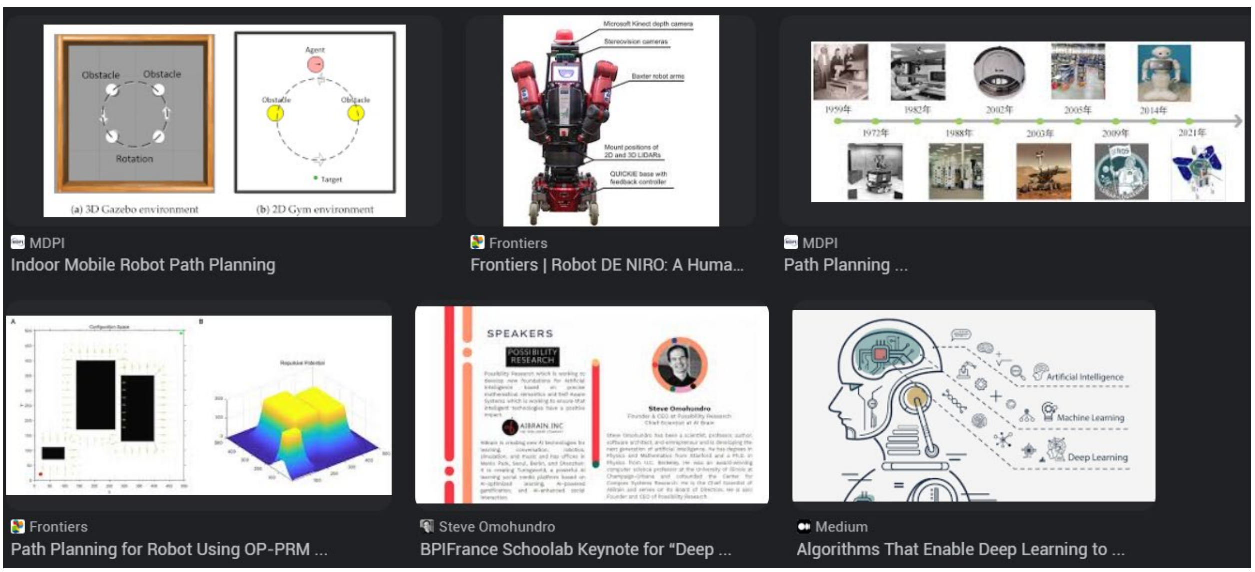
- Disproportionate distribution of major concepts with 18 slides covering Basics of Probability, 19 slides covering Robotic Environment Interactions, and only 1 slide discussing: Basics of Localization.
- Accompanying visual elements are irrelevant to the content of each slide.

Ex. From the lecture:

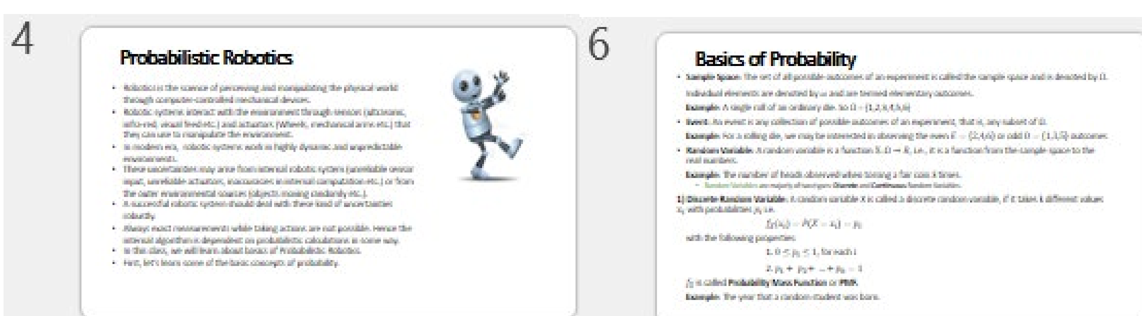


Alternatively, searching Google Images for the presenter's prompt: "deep dive into probabilistic robotics" resulted in more maps and graphs, illustrating how robots "sense" their surrounding environment, as captured in the following snapshots:

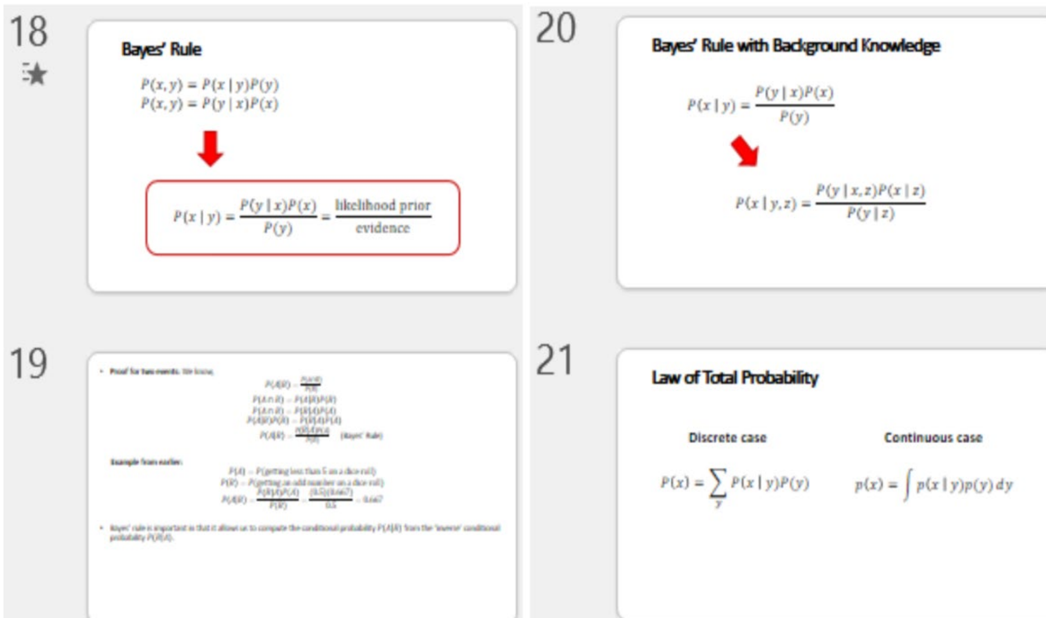




- The majority of Slides are overpopulated with words.



- A significant number of slides are heavily populated by stand-alone mathematic equations that don't even have an example to explain, especially belonging to the section: Basics of Probability.



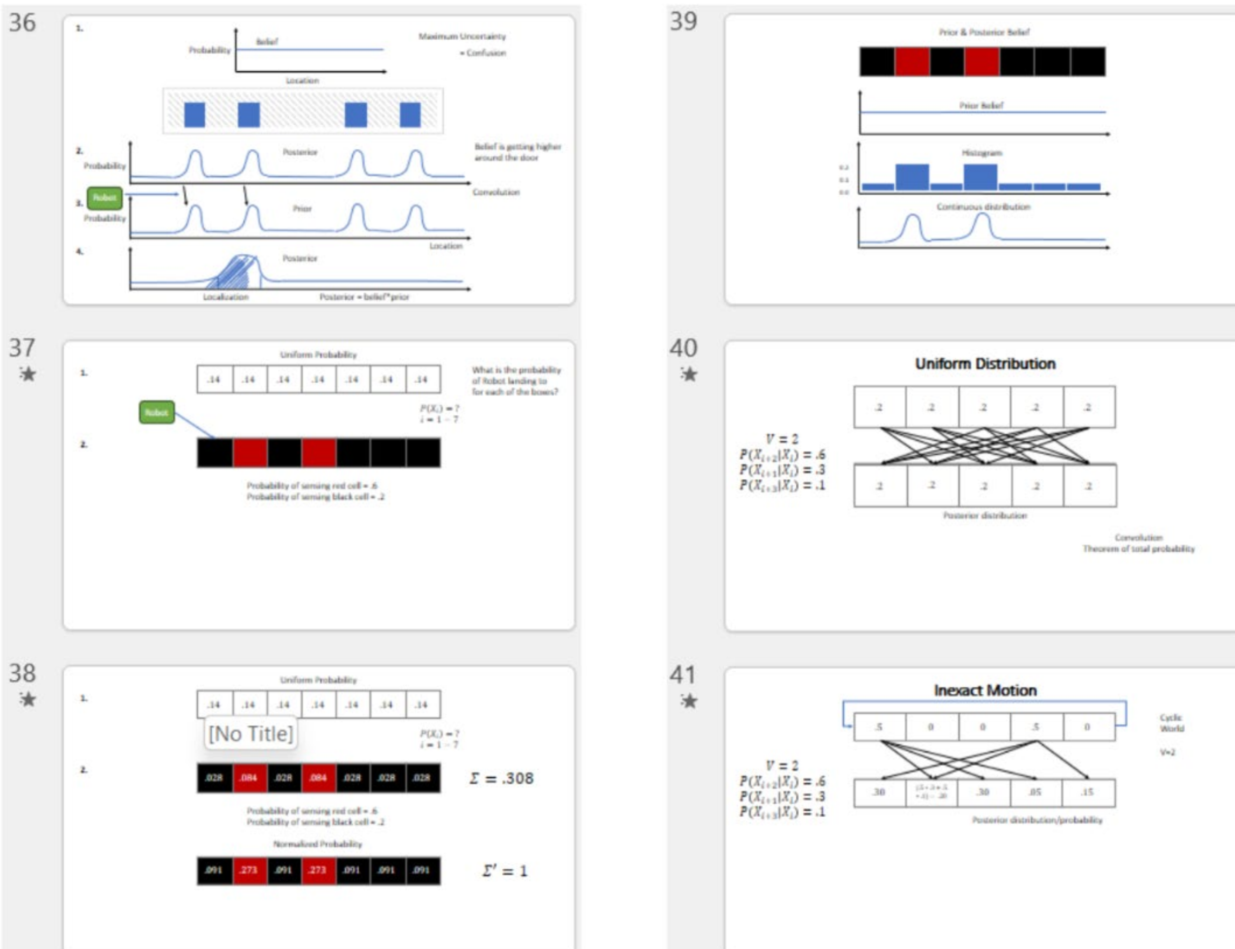
- Missing more assessments

  Must engage learners with more than 1 assessment slide (slide 42 out of 44–too late–that the presenter couldn't even present in time) to find out their level & attune the lecture accordingly, while also helping them make their knowledge more transferable.

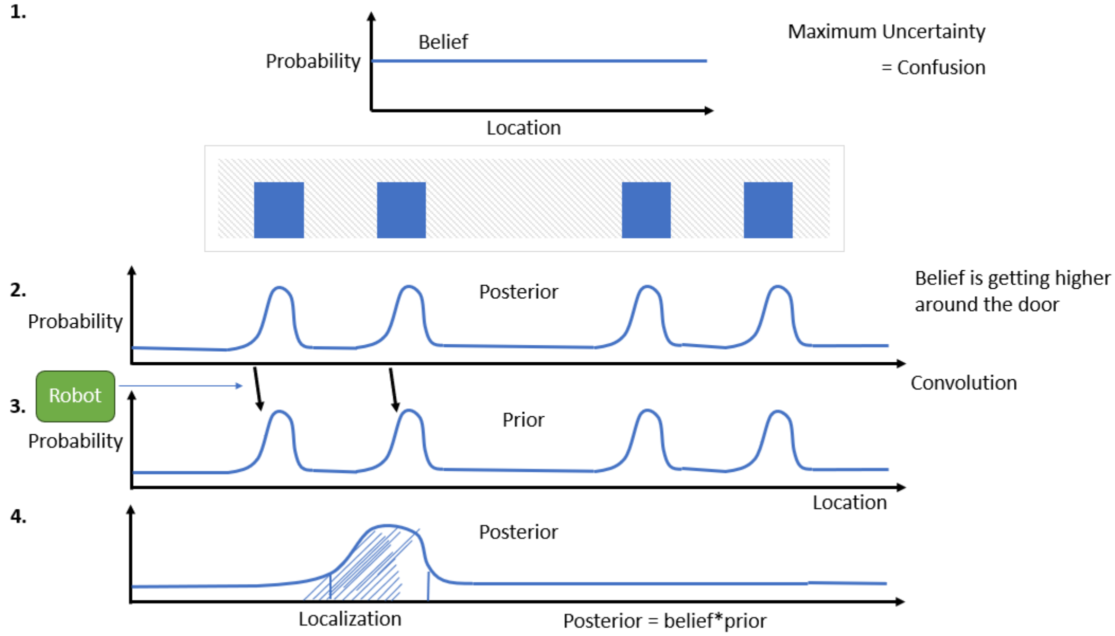
  Note: That "Homework" slide (slide 42) does not have clear instructions on what is expected from students, or guidance as to how it could be solved. Despite that, students could make an inference on what the *lecturer may need from them based on the previous slide, which covers the exact same concept "Inexact Motion", albeit with a different layout (hence, potentially even more confusing to students). Still, students should not be guessing the presenter's intention, this should be stated clearly.*

- Missed opportunity to further students' understanding of the math behind existing visual elements, caused by the lecture not having a set objective and it being over-populated with untransferable mathematical concepts.

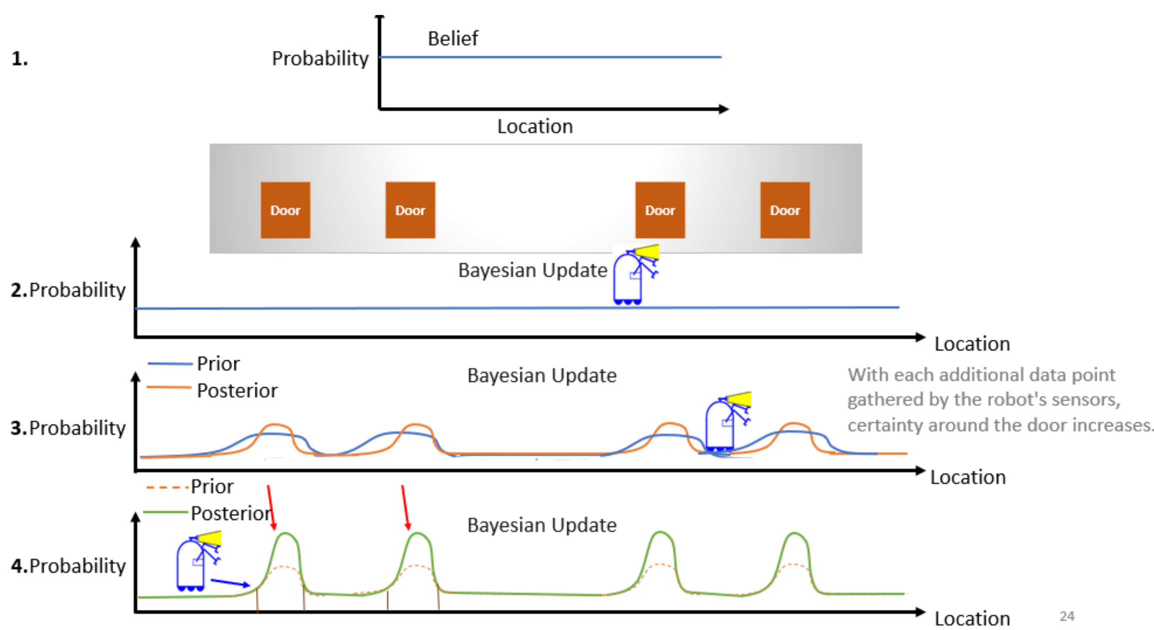
Slides 36 to 41 (out of 44) are only made up of graphs and table (see below), and the presenter couldn't get to explaining them due to time constraints. Sadly, the mathematical concepts they address–"Uniform Distribution" and "Posterior Distribution"–could have been addressed much earlier on, around slides 11-12 and 17, 26, respectively. This is a missed opportunity because those visual elements would have been much easier to explain and for students to understand and follow due to their less abstract nature, explaining complex mathematical equations. Hence, they must be reshuffled or distributed differently for the next summer camp–if not completely deleted if not surviving the lecture's specific LO.



- Slides not easy to read without explanation, as illustrated below:



Slide redesigned to make it easy to grasp without even requiring presenters' explanation.



Closure:

- Only referencing the study from where the lecture was compiled, which turned out to be a complete Book of 492 pages that the presenters took bits and pieces from and did not account for students' level of knowledge in the subject.

Development Process

Project Development

Following the UbD model, I completely redesigned the lecture on Probabilistic Robotics. I used the UbD model because it reverses-engineers the desired goal. Furthermore, it would not only assist the program in better delivering the curated material to students, keeping their learning at Bloom's understanding level, but will also give the program after its third anniversary, the chance to really try and invest in the collective effort of turning the summer program lectures to a more complete curriculum. One that not only covers the basics of AI Robotics, but also offers intermediate and proficient level instructional experience, for the sake of its expansion.

Developers

As a graduate student of Instructional Technologies looking to graduate this semester, I completed 90% of the following documents, including developing the majority of them from scratch and completing other to 85% completion for the sake of submitting them for review for the purpose of graduation. However, other documents had only their frameworks and an initial 1st draft setup by a coworker instructional designer who is also volunteering with STFT and who's a San Francisco State University alum too: Mrs. Ioanna Kravariti. The project did not cost STFT anything, except for the hours of labor of its volunteers.

Developed Material

The table below contains all developed material for this creative work project in one place.

Table 1. Prepared material in the efforts towards a lecture redesign

Links	Document Titles & Assets
Link	Program Implementation Guidelines, including the entire Program Review for Quality
Link	Lecture Evaluation – Specific to the selected exemplary presentation
Link	Understand by Design Lesson Plan
Link	Evaluation and Quality Assurance following 4 Rubrics & Standards
Link	Dr. M's post-lecture survey results
Link	Redesigned PPT in question + Link to the original PPT by Mr. B

Resources Needed

In terms of physical resources, I used the internet and my laptop to have access to Google Classroom and replay the lecture, available on the company's Google Drive. I used PPT to redesign it and add elements to it, and I searched for multiple resources for guidance on teaching probability and robotics to HS Students. I also looked for standards and researched the UbD model to guide my redesign of the presentation, as the major instructional deliverable of this paper. In terms of human capital, I reached out to Dr. Hu for questions about STFT and as the subject matter expert on the Scientific material I needed to double-check my understanding of, as well as called Mrs. Kravariti to discuss the aim of my work a number of times. There is no additional cost of my work.

Production Process

I first worked on finalizing the program's implementation guidelines to gather all the standards and regulations that any STFT presentation should aim to abide by, for us to start unifying our lectures and getting them up to professional recognized standards. I then, replayed the lecture in question. Adding observations to the existing lecture evaluation document that I had populated alongside Mrs. Kravariti during his presentation. This time I was much more critical even of his monotonous voice tone. I then looked to NGSS for the standards that he covered in his lecture. After that, by gathering all forms of materials (textbooks, journal articles, blogs, PPTs, previously created lectures, etc.), I familiarized myself more with the UbD model to apply it to the lecture in question, which I did. This process was carried out simultaneously while I looked for standards and rubrics to abide the lecture to, insuring a standardized evaluation of the material and boosting the lecture's quality. Finally, I started redesigning the lecture following all the above, while still looking for other available lectures online teaching the topic to high schoolers or upper level classes, especially when I couldn't understand the material myself. In terms of timeline, this took around 7 weeks from start to finish: working on it part-time between 6pm and midnight every day of the week and on the weekend, with only a few exceptions, such as on Thanksgiving for instance.

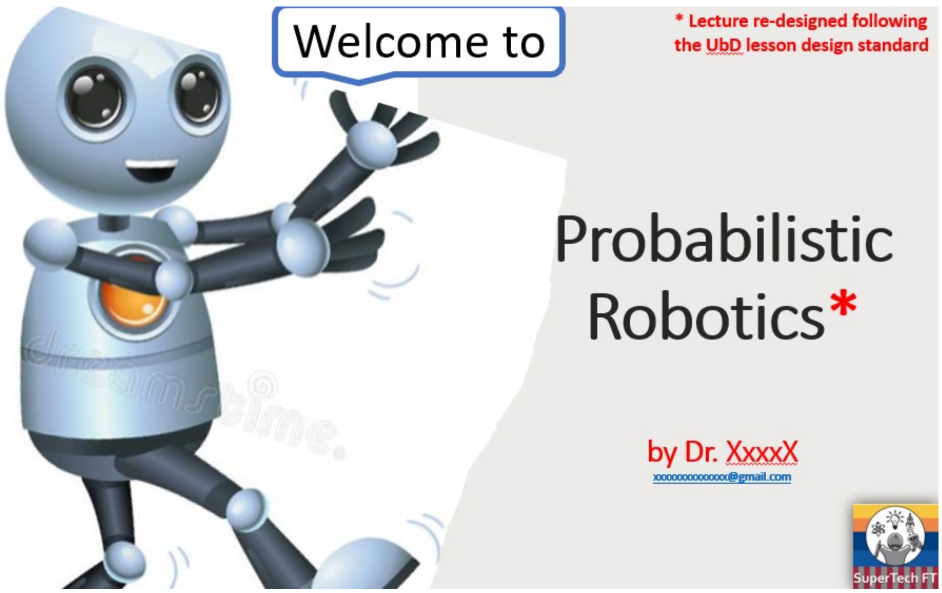
Content Outline

Lecture Redesign

The lecture was redesigned using only PPT.

It now consists of 30 slides divided as such:

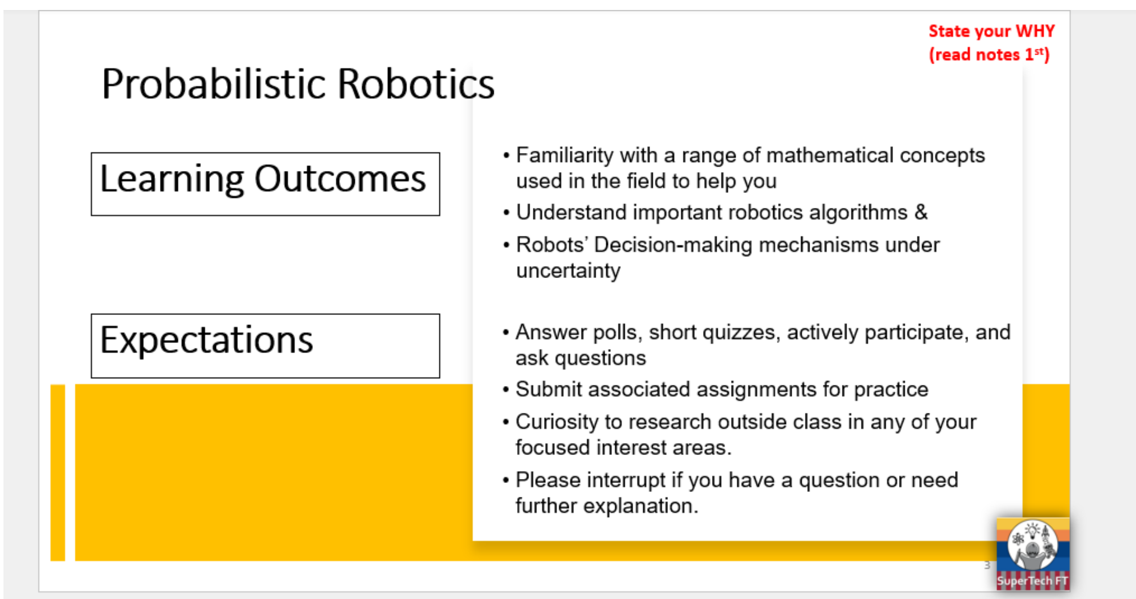
- 1 Title slide
  - Animated and inviting students' attention.
  - Includes presenter's Name and Contact information.



Add LinkedIn if approved by presenter.

- 1 dedicated Introduction slide to establish presenter's credibility.

- 1 Outline slide: Included LO and Expectations from students.

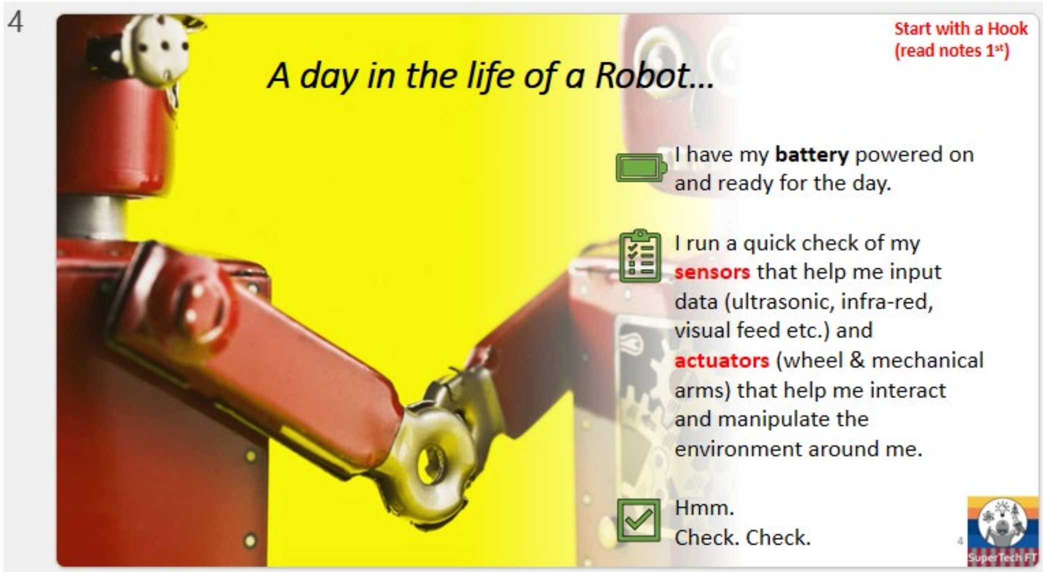


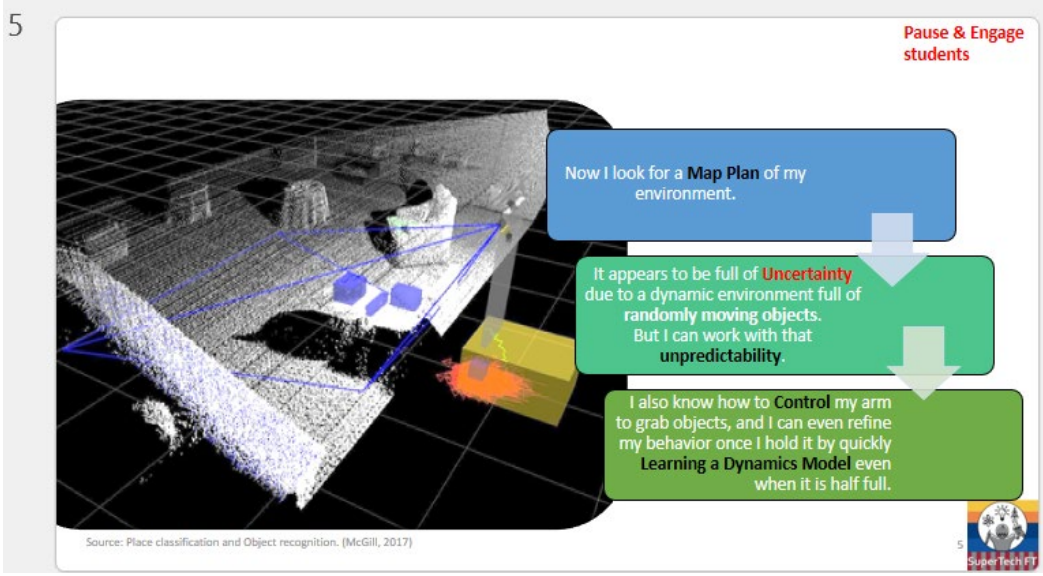
START READING THIS 1st: The point of this lecture is for you to understand how robots operate and make unsupervised decisions, which necessitates that we cover detailed fundamental mathematical concepts to essentially set you up with a good foundation to help you better understand the bigger picture: The data science & probabilistic calculations behind a robot's decision, how it works to reduce uncertainty as rigorously as possible and the massive probabilistic computations that occur behind it. That is why as a "Learning Outcomes," we're going to help you gain Familiarity with… *NOW, READ Slide, then Go to Next.*

Note: Presenter's observations are crucial [placed under the slide, inside the Notes section, as displayed here, right above] to not only share the LO and set expectations as sort of a "code of conduct" encouraging students to be more proactive. But also, to place the lecture as part of the entire program.

***Context*:**

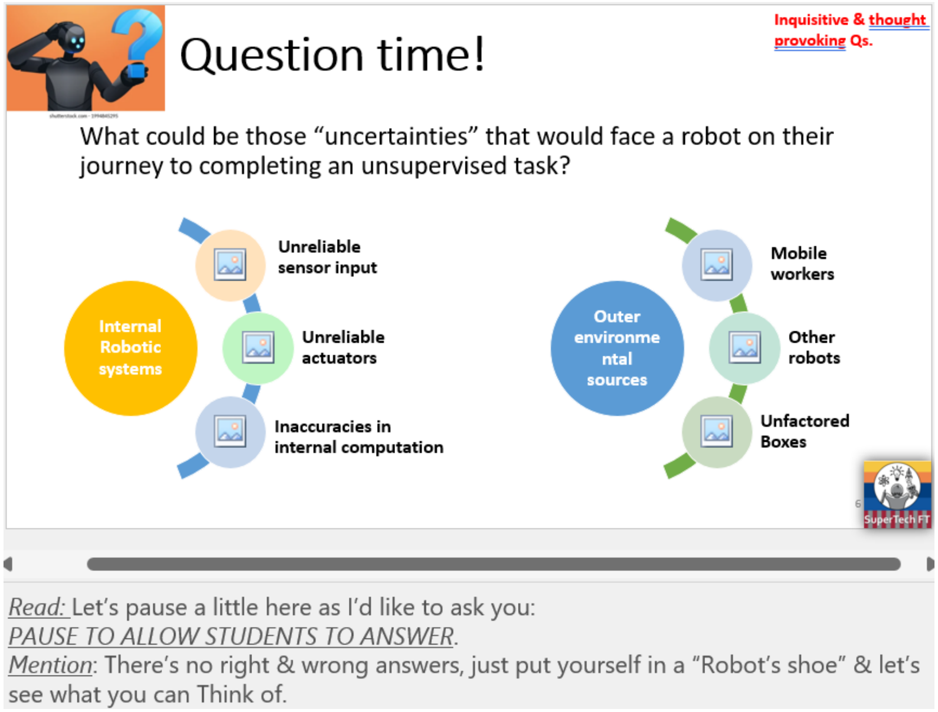
- 3 slides sharing a story to Start the presentation.
    - Using storytelling, "A day in the life of a Robot" hooks students and immediately attracts their attention to the lecture.





- It also allows for the 1st assessment to test students' rationale, using a simple question:

> "What could be those "uncertainties" that would face a robot on their journey to completing an unsupervised task?" [example of an assessment question].

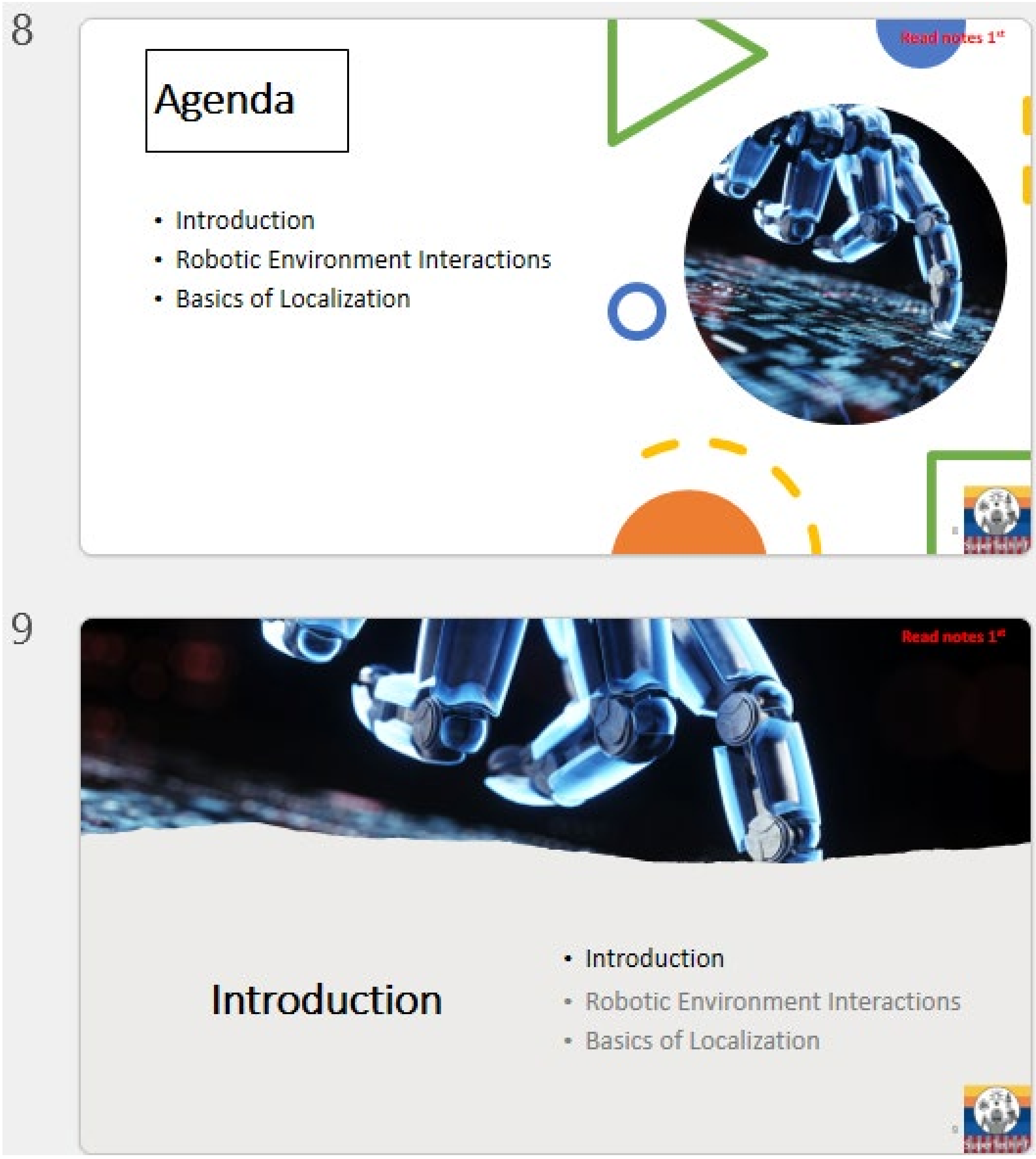


Note: That this could be answered by students' raising hands digitally (available feature on Zoom and widely used, so students are already familiar with it) or via mentimeter as a data collection tool that would simultaneously keep participants engaged.

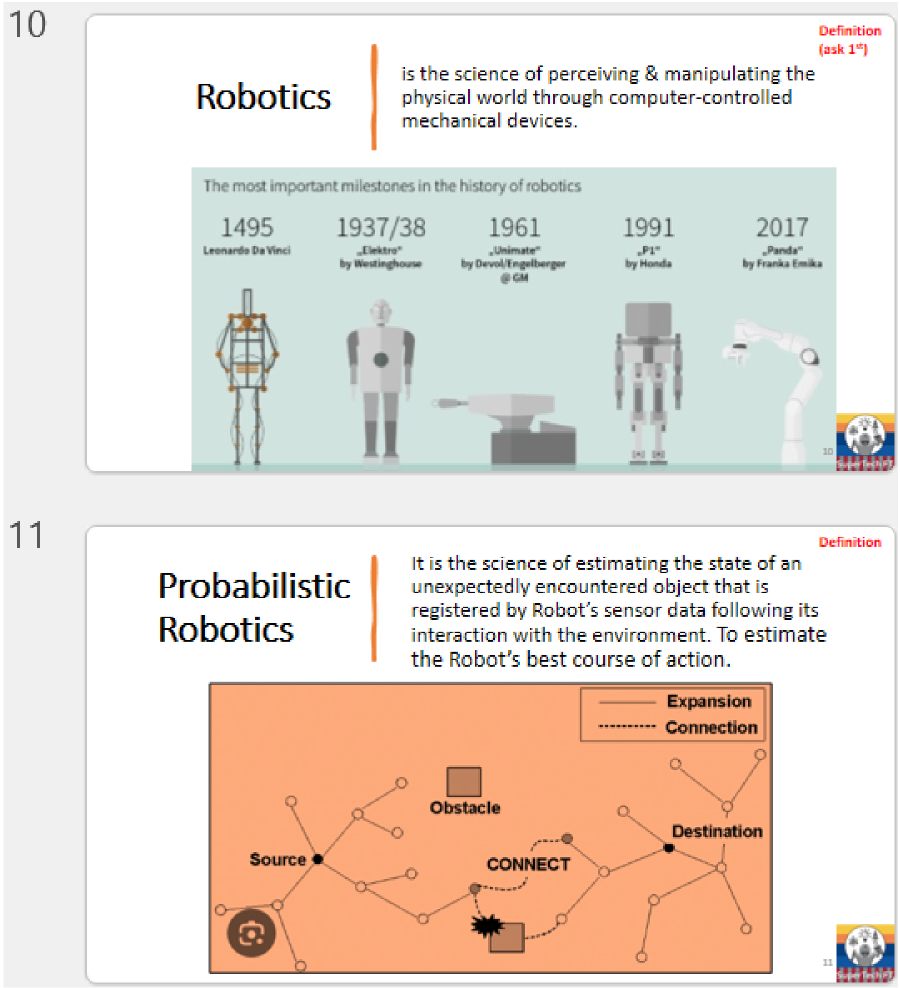
- As the story goes, the lecturer is already building their knowledge of the topic of the presentation without the students even sensing that load.

- 1 Agenda slide followed by a slide introducing what will be covered topic-by-topic.

Note: This is arranged by using grey font over the topics that won't be covered immediate and leaving the one in question in black font. (Ex. slide 9, below.)



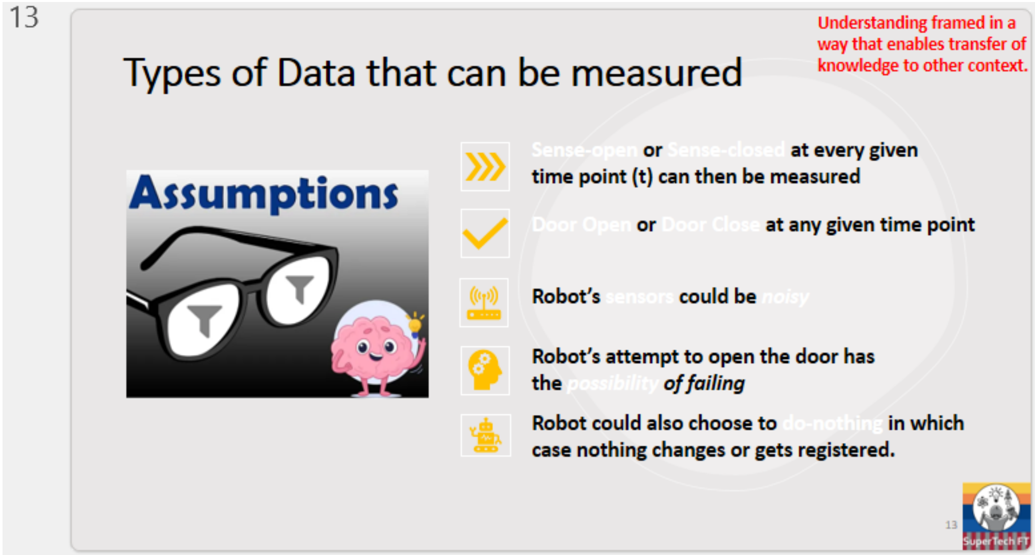
- 2 slides defining core concepts: Robotics (in general) and Probabilistic Robotics.

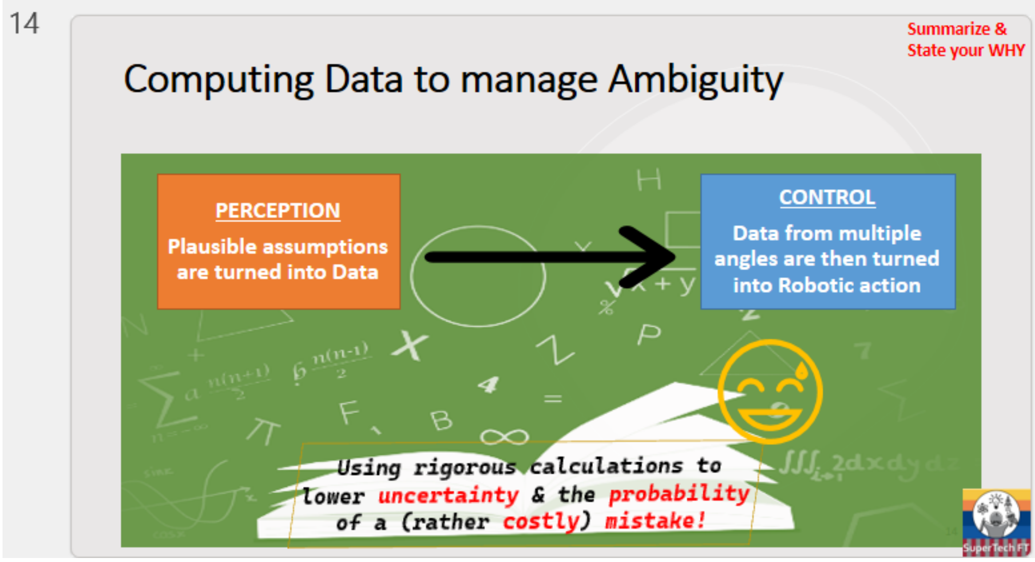


Note: Since the lecture is located around the 4th week, which means students should already know how to define Robotics, if asked, then, this is a good opportunity to invite students' recall. Not only to test their knowledge in the long-term memory, but also to get them engaging with the presenter as much as possible.

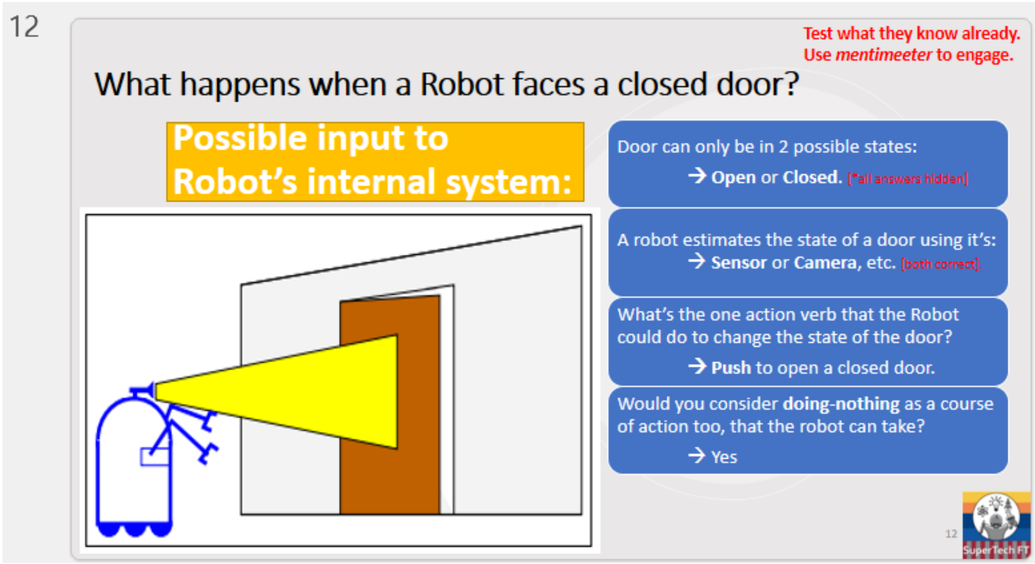
***<u>Content</u>*:**

- Slides are well designed with coherent color choices.





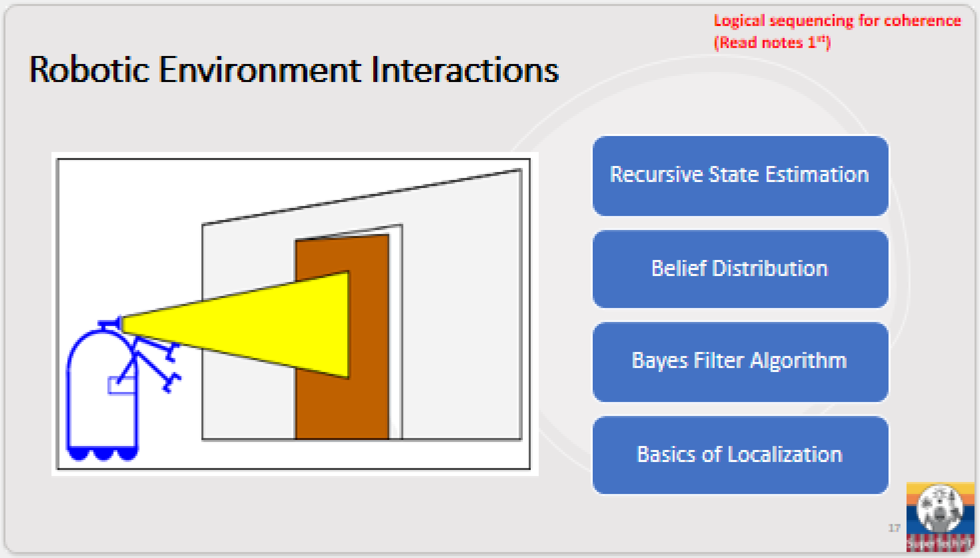
- The presenter would ask participants to answer one straightforward question at a time, progressively building the needed elements to reach the correct answer to a more complex question related to the new knowledge being taught. Using simple inquisitive prompts while pausing shortly enables students to engage their personal knowledge and common sense in guessing the answers to a topic they are not familiar with.



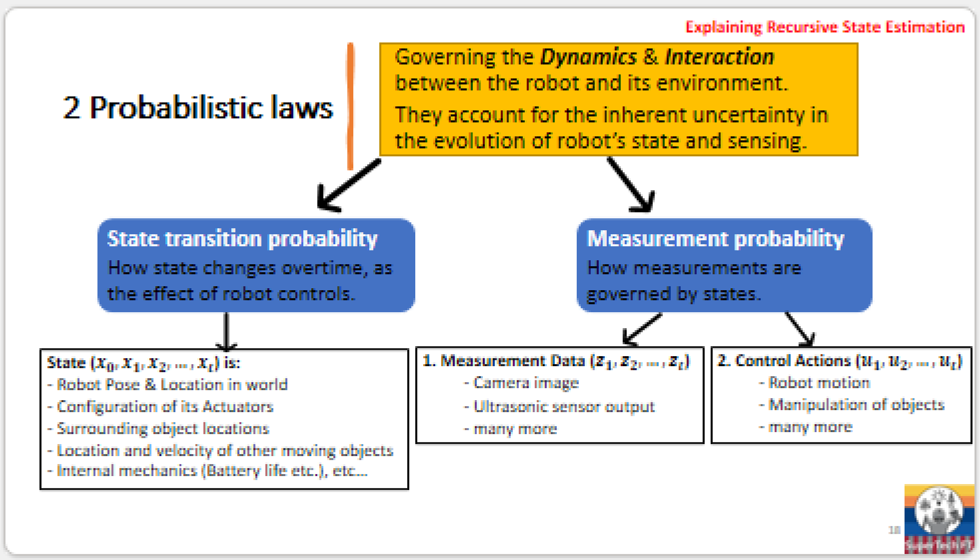
The correct answer for each blue box above will be revealed by mouse click, one question at a time.

- The lecture follows a logical sequence for coherence

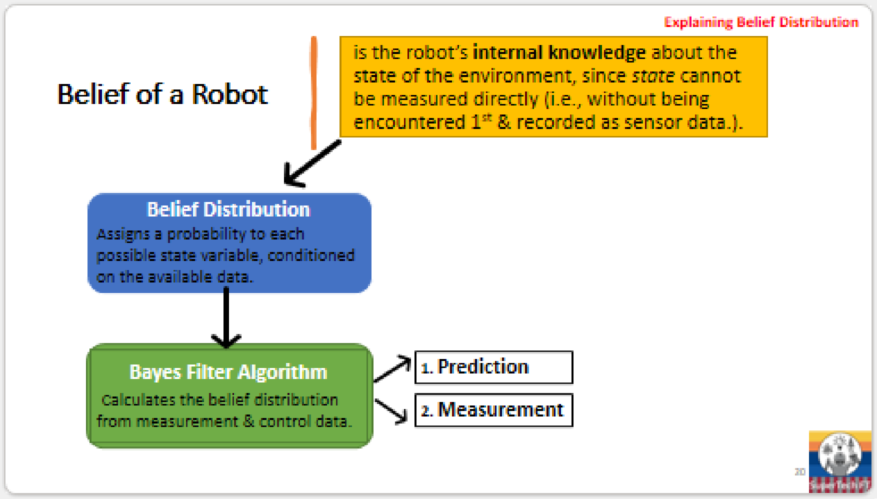
17


Logical sequencing for coherence (Read notes 1st)
Robotic Environment Interactions
Recursive State Estimation
Belief Distribution
Bayes Filter Algorithm
Basics of Localization
17

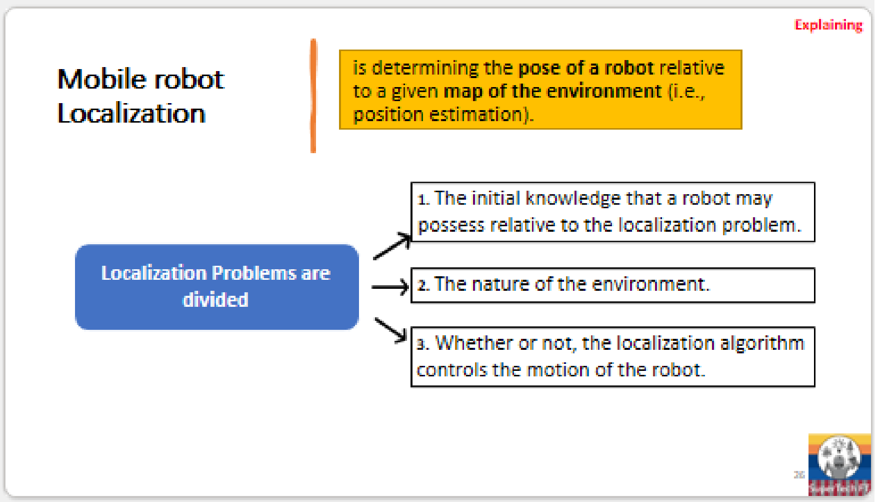
18


Explaining Recursive State Estimation
2 Probabilistic laws
Governing the ***Dynamics*** & ***Interaction*** between the robot and its environment.
They account for the inherent uncertainty in the evolution of robot's state and sensing.
State transition probability
How state changes overtime, as the effect of robot controls.
Measurement probability
How measurements are governed by states.
State ($x_0, x_1, x_2, \dots, x_t$) is:
- Robot Pose & Location in world
- Configuration of its Actuators
- Surrounding object locations
- Location and velocity of other moving objects
- Internal mechanics (Battery life etc.), etc...
1. Measurement Data ($z_1, z_2, \dots, z_t$)
- Camera image
- Ultrasonic sensor output
- many more
2. Control Actions ($u_1, u_2, \dots, u_t$)
- Robot motion
- Manipulation of objects
- many more
18

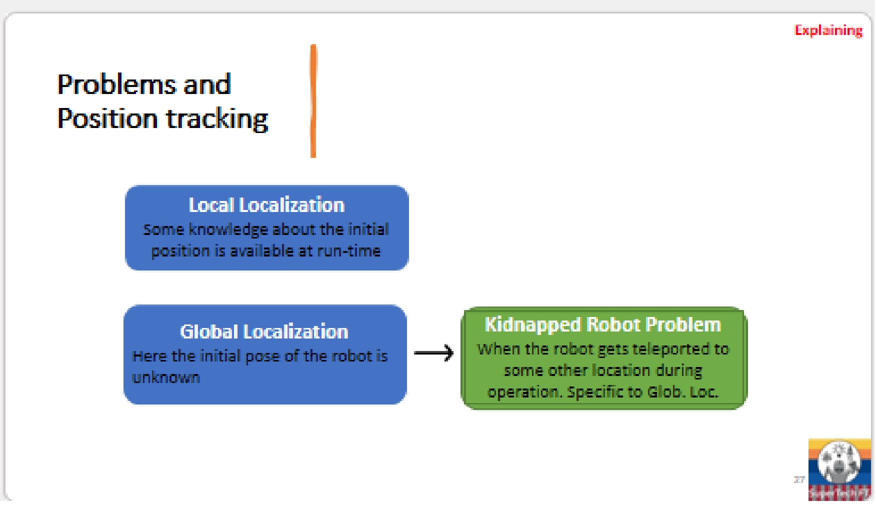
20


Explaining Belief Distribution
Belief of a Robot
is the robot's **internal knowledge** about the state of the environment, since *state* cannot be measured directly (i.e., without being encountered 1st & recorded as sensor data.).
Belief Distribution
Assigns a probability to each possible state variable, conditioned on the available data.
Bayes Filter Algorithm
Calculates the belief distribution from measurement & control data.
1. Prediction
2. Measurement

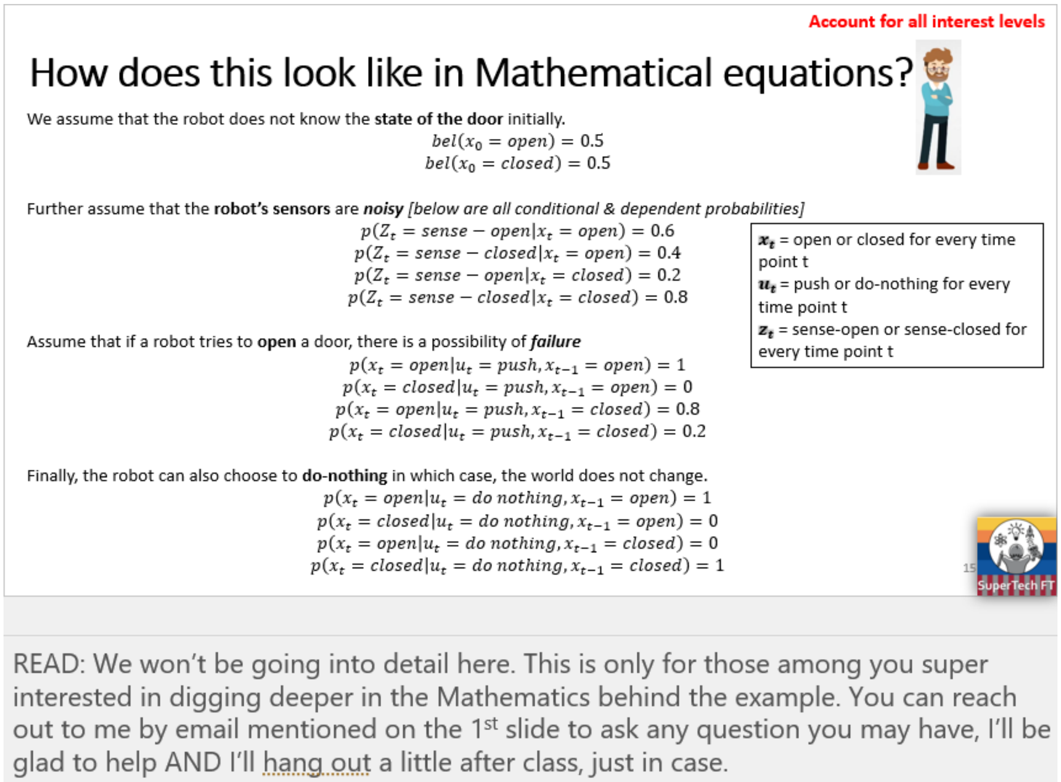
26


Explaining
Mobile robot Localization
is determining the **pose of a robot** relative to a given **map of the environment** (i.e., position estimation).
Localization Problems are divided
1. The initial knowledge that a robot may possess relative to the localization problem.
2. The nature of the environment.
3. Whether or not, the localization algorithm controls the motion of the robot.

27

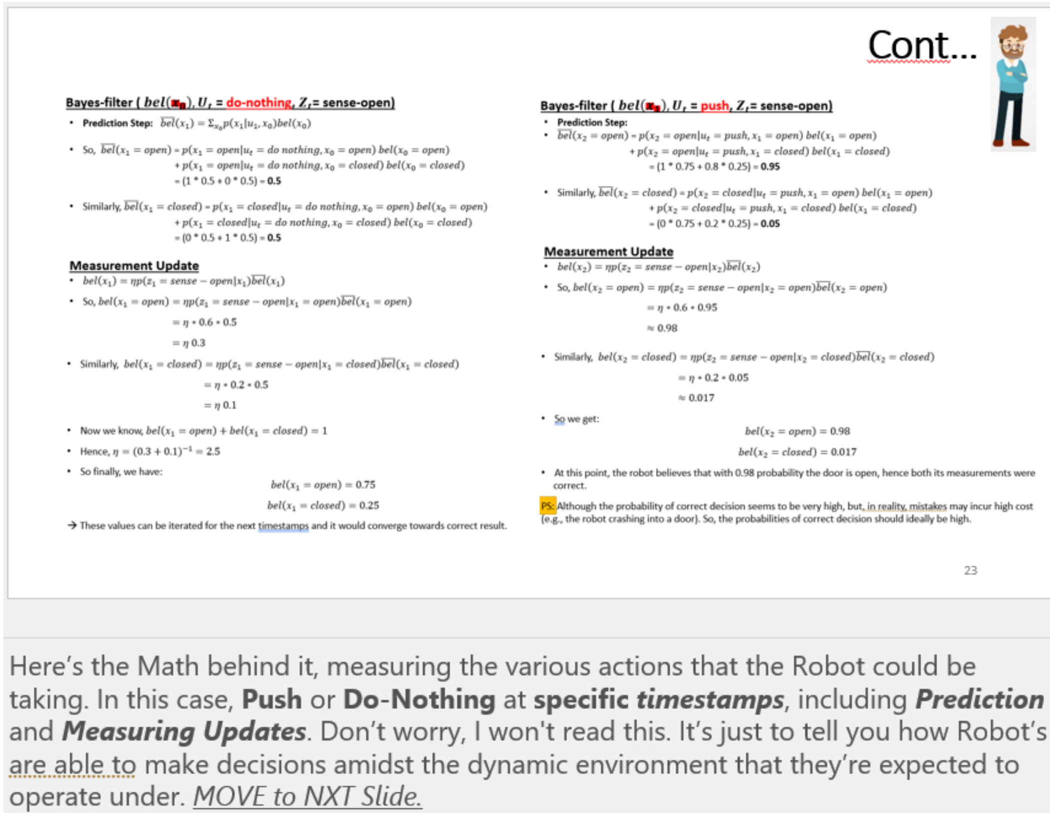

Explaining
Problems and Position tracking
Local Localization
Some knowledge about the initial position is available at run-time
Global Localization
Here the initial pose of the robot is unknown
Kidnapped Robot Problem
When the robot gets teleported to some other location during operation. Specific to Glob. Loc.

- Account for all students’ level of interest [read Notes, under slide.]

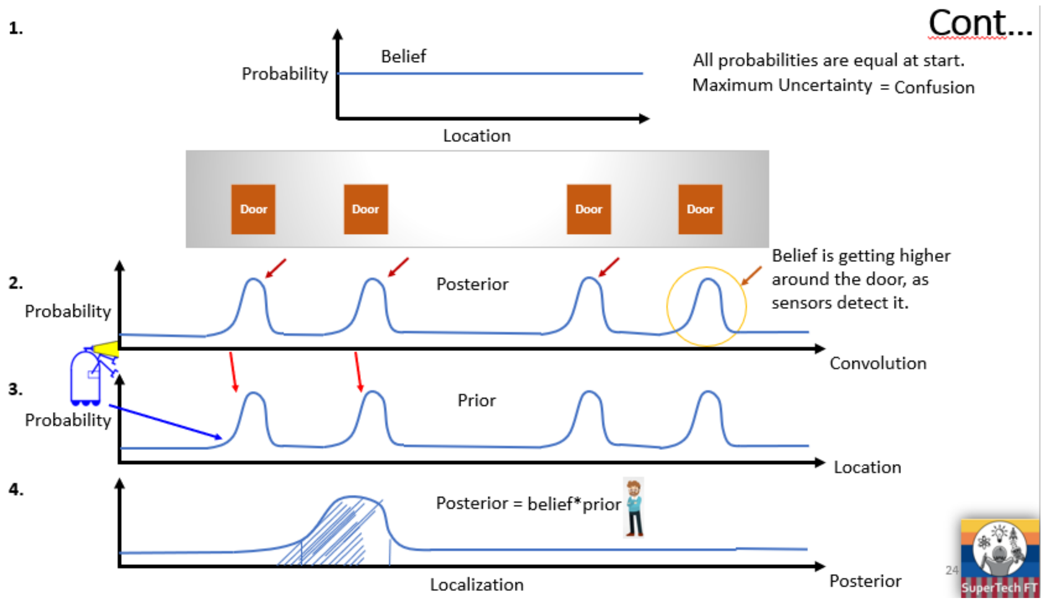


Since 2 participants mentioned in the post-lecture survey that they enjoyed the mathematical equations behind the lecture, I had to account for those students and keep the heavily abstract slides that explain the example covered above. However, I also kept in Notes a statement for the presenter to read in an attempt to keep other students from feeling intimidated by the algorithms written that they can make no sense of.

- Combined 4 mathematical slides into 1 where it made sense & justified why the slide is there. [read Notes, under slide.]

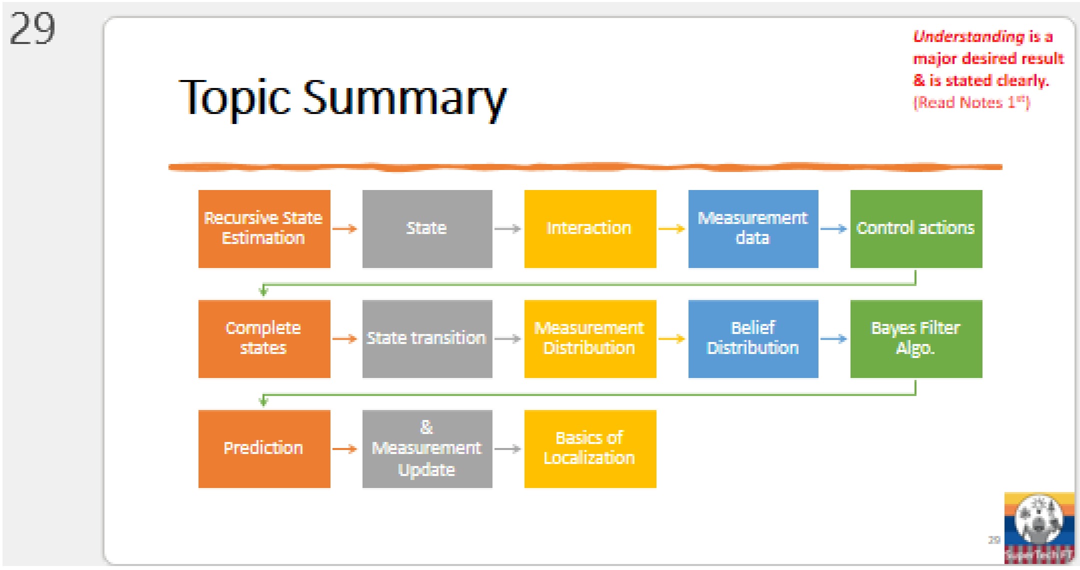


- Transformed the graph slide that is relevant to the example discussed, to make it clearer to read.

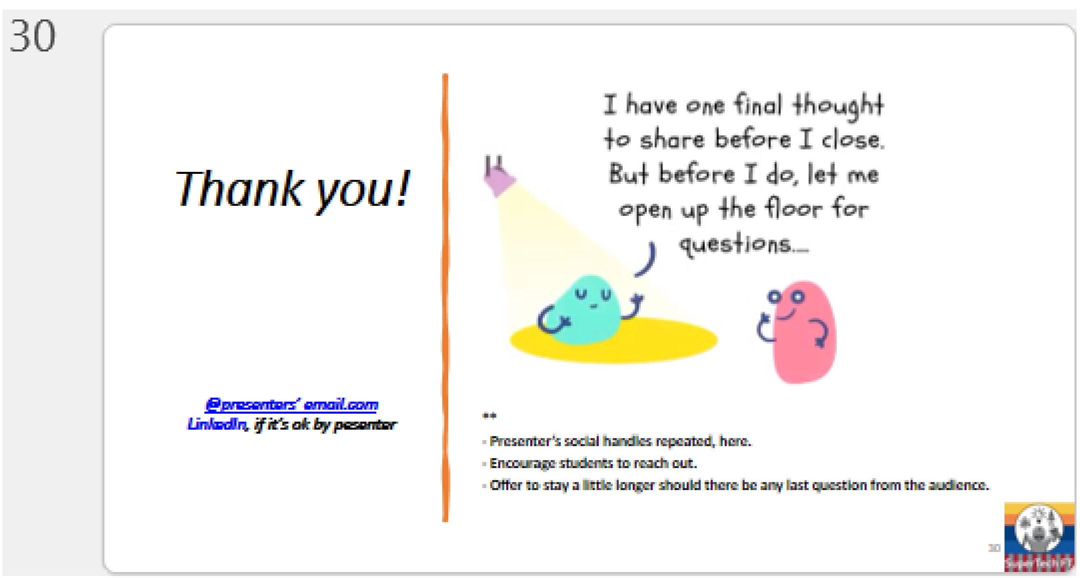


Closure:

- Added a Podcast on Robotics for anyone interested from among students.
- Added a Topic Summary to cover what they'd learn to emphasize on their understanding of the topics discussed.



- Added a Q&A slide and repeated the presenters' contact details there. Also restated that the presenter welcomes students to reach out for any question or reason they may have. Finally, they'd offer to stay a little longer should any more questions come up.



An alternative last slide design could impart students with an inspirational quote, instead:

A good decision is based on knowledge and not on numbers - Plato

XXXXXX XXXXXX
Generative AI | Data Science Leader | C Suite Advisor| Public Speaker

xxxxxx@gmail.com

LinkedIn

End of presentation

Section 4: Formative Evaluation

Formative Evaluation Process

So far, the AI Robotics program offered by STFT has had a head start against competition for having had 3 yearly runs of its summer program prior to the most recent hype over everything AI. To build on this opportunity, and maximize its benefit for program participants, it is necessary to have a built-in system of program and lecture assessment and evaluation. These systems are currently in place and, at least a lecture-by-lecture, students' evaluation is collected through the post-lecture survey sent to them following each presentation.

Expert Review

Similarly, my redesign of a presentation should be assessed by experts on the subject and an expert in instructional design to highlight improvements to its instructional effectiveness, which is why I sent the redesign to its initial developer–called Mr. B. to keep his identity anonymous–to STFT's president, Dr. Hu, and the team's instructional design coworker, Mrs. Ioanna Kravariti.

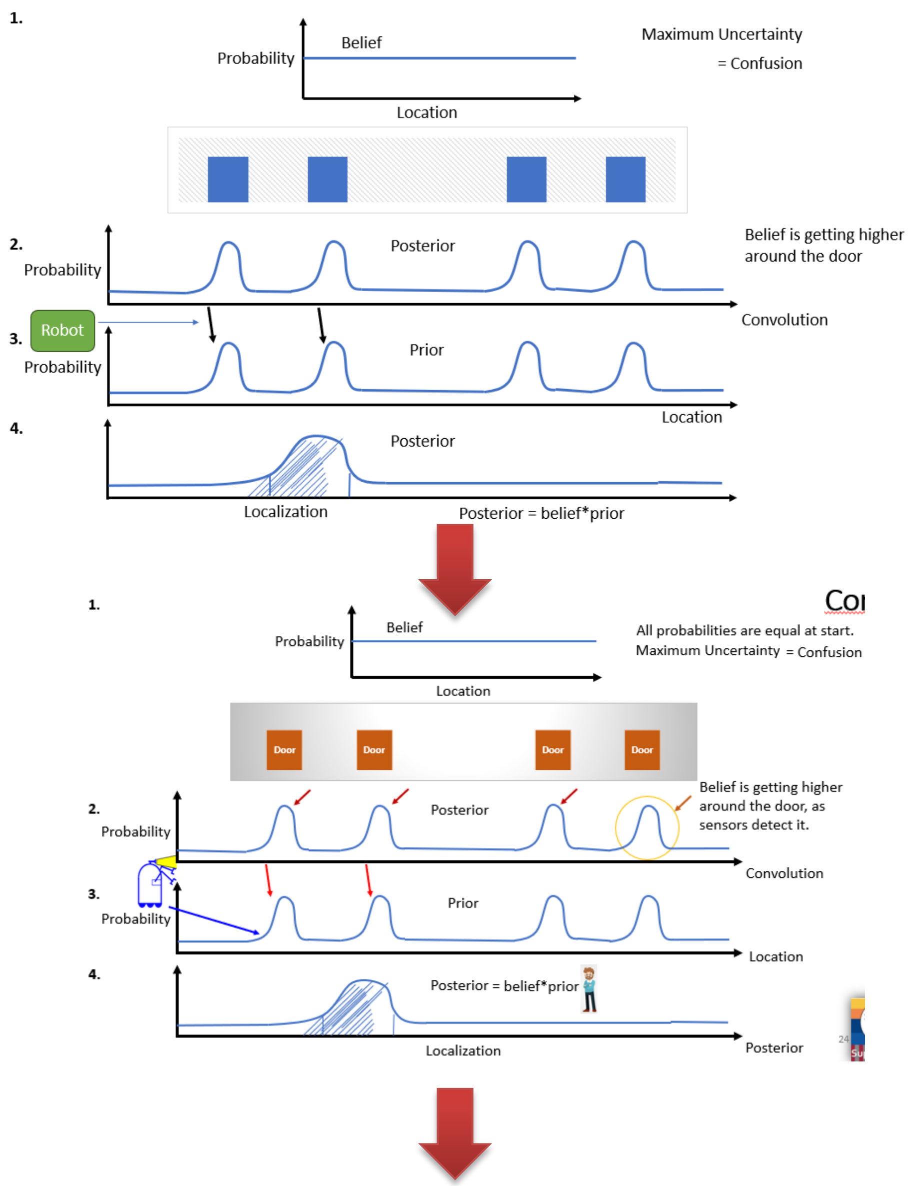
Mrs. Kravariti believed the redesign to be a step in the right direction, especially in making the connection between 3 notoriously difficult scientific fields: Probability, Statistics, and Robotics. She also liked starting with a scenario to attract learners' attention from the get-go. However, she strongly recommended that I reconsider eliminating all the mathematical equations from the presentation. Her argument is similar to mine, that STFT's core mission is to reduce the barrier of entry into the Robotics field, and those Algorithms alone are enough to intimidate the students who are not mathematically inclined and who happened to be the vast majority of our participants based on their earlier discussed negative feedback of the lecture being too technical.

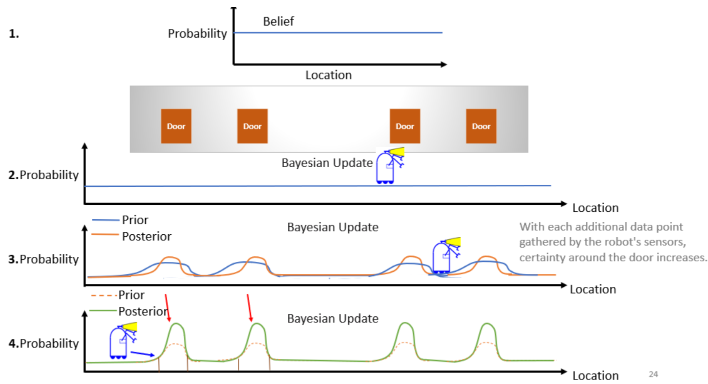
The professional ID also mentioned that I should be gathering in a standalone script document, all the comments I proposed, suggesting how the lecturer could be presenting the content in each slide. Those suggested comments and their sequence, to be read before or after the slide, are currently available in the Notes section of each slide, and they are intended to guide the lecturer on what they should be focusing on in each slide: To either highlight key points in it, build on previous knowledge, or simply dissipate any potential feeling of "overwhelm" that could have been felt by non-mathematically inclined participants upon the display of heavily mathematical slides–otherwise STFT's core mission would be compromised. However, if I were to combine them, they would lose their context and sound too simplistic to draw value from for other applications, which is why I didn't consider her valuable recommendation.

Finally, Ioanna mentioned that I should be "grouping" slide elements so that the PPT format doesn't disform between those who would access it through laptop versus their mobile phones. This reminded me that I should test my presentation for accessibility, but I didn't do it.

As for Dr. Hu, his feedback was positive, mentioning that this form of master's degree by a public university, is more practical and therefore better than what he had anticipated it to be as an external supervisor to the creative project. His believes are based on his background at MIT where seemingly a master's thesis essentially purports the publication of its results.

Dr. Hu also reached out to help me fix a mistake in one of the slides as designed by Mr. B. How the slide was representing elements originally and how it ended up looking like. As a typical supportive visual illustration, the figure is symbolic of how much work can be put in simplifying instructional material and tailoring complex concepts to learner's level understanding for a more effective outcome.



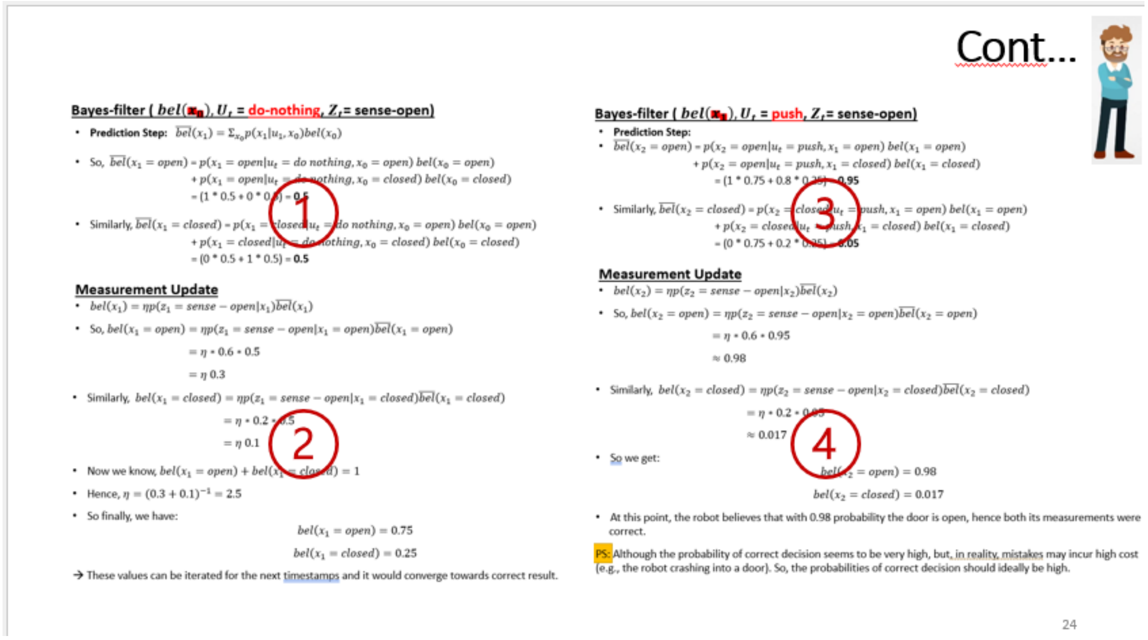


Learner Review

The program runs once a year during the summer. Therefore, I could not test it on our participants, but relied on the expert reviewers' comments detailed above. However, despite not being tested on HS students, on the effectiveness of the lecture redesign, the effort in itself marks a pivotal initial step in the right direction. At the very least, it provides the summer program with a medium-fidelity prototype of a commendable redesign that holds potential for replication in other presentations. One that has been strategically rendered to adhere to the UbD framework and established standards for quality assurance, hence, positioning the program to attract attention and interest from potential future partners. These partners may, then, be inclined to consider its adoption and implementation, possibly as a pilot project in a school district, which would, in turn, provide us with valuable opportunities to refine our approach through feedback and collaboration with various stakeholders, ultimately contributing to the program's overall success in benefiting students.

Analysis of Findings

After hearing of Ioanna's resistance to the heavy mathematical slides, I reformed the redesign to combine 4 mathematical slides into 1 as seen below (slide 23).



I also colored the difference between the 2 equations in red to alert students that each equation is specific to a certain calculation.

Finally, although I had done that already, Ioanna's comment made me revisit the Notes section in every slide, thinking about what the presenter could say to dissipate any possible feeling of overwhelm that students who are not mathematically inclined, aren't discouraged from paying attention to the remaining of the lecture. Hence, I added scripts like this one, relevant to the above slide example:

> *"Here's the Math behind it, measuring the various actions that the Robot could be taking. In this case, Push or Do-Nothing at specific timestamps, including Prediction and Measuring Updates. Don't worry, I won't read this. It's just to tell you how Robot's are able to make decisions amidst the dynamic environment that they're expected to operate under. MOVE to NXT Slide."*

In terms of evaluating lectures and providing feedback on presentation styles, it is evident that certain presenters did better in one aspect, while others stood out in other areas. Although Ioanna and I have noted specific suggestions for each lecturer, perhaps it might be better to have a brief one-on-one meeting between the IDs and each presenter. This approach is more likely to yield a positive outcome and come across as less judgmental than creating and implementing a general performance development training. As these personalized sessions can offer targeted guidance on enhancing students' engagement and improving teaching methods based on individual strength and areas of expertise.

Summative Evaluation

For my project, I accessed numerous sites promising to teach Robotics, AI and Machine Learning. It is clear that there is substantial need to introduce students to the field while prestigious universities around the world, such as McGill University, slowly deploy a standalone curriculum teaching the multidisciplinary subject of mainstream media. However, it's also clear that school-led mobilization and implementation of the discipline is still critically scarce, with only notorious schools in Silicon Valley being able to afford such a school-level initiative.

Experts' Feedback and Revision

At the instructional level, teaching AI Robotics to HS students' prerequisites by default that the curriculum offers a hands-on-approach for students to translate Bloom's comprehension stage into action. Having a hands-on activity, similar to STFT's mBot and DoBot coding, is the correct approach towards the application of the UbD model. Then, the latter framework would allow the program to scale and expand to a more intermediate and proficient level, relative to its ambitions. However, it's dangerous to stay stuck at Bloom's taxonomy understanding level, because the competition offering a practical application of students' learning would render STFT obsolete.

Ioanna's hesitation towards the mathematical content in the presentation made me reassess my approach in redesigning the lecture. Initially, and before initiating the task of redesign, I had implored Dr. Hu to consider–and reconsider once again lately–deleting the presentation all together and reallocating its allotted time towards the creation of a different lecture. One that is closer in relevance to students' lack of knowledge, based on our assessment of that from analyzing their post-lecture surveys. Even if we were to keep it due to its indispensable concepts in AI Robotics, we need to be more sensible about the big picture of the program. Working strategically, for instance, we could break down the key concepts it addresses and distribute them across multiple lectures to ensure that they are covered properly.

After a brief followup meeting with Dr. Hu in this regard, I agree with the points he raised against deleting the lecture. Dr. Hu made a valid argument that we want to give students a realistic picture of what they can expect from entering the field of AI Robotics, and since probability and statistics, integral to mathematics, are the essence of AI, they should be aware about the possible complexity of getting to their end goal without that being a deterrent to their interest in the field. In that case, as the ID, my responsibility is then, to make the material more comprehensible.

To investigate an alternative solution to the aforementioned matter, I explored Khan Academy's Introduction to Statistics module. I found that it consists of 67 videos with an average of 10 minutes each, explaining one concept at a time. All contributing towards the completion of the entire module to come out with an effective learning objective that is targeting 1st year university level students, rather than our programs' students admitted with no prerequisite for their selection.

Finally, Dr. Hu presented another reason why he insists "on adding probability is that it is part of math CCSS mandatory official school district evaluation." Noting that while it's mandatory, "Many HS [students] skip it, [due to] lack of teachers, [or other] difficulty," (personal communication on Slack, December 2nd, 2023). His insight helps explain why some post-lecture surveyed students actually enjoyed the mathematics part of the lecture, as opposed to the majority who did not. It, thus, underscores the reason why we could be considering assessing learners' academic level before admitting them into the program, as the well-established principle in instructional design and academia, in general, holds true: "One size does not fit all." However, this is completely unacceptable, as it contradicts the program's welcoming approach to all learners with a HS diploma, which brings us back to the initial challenge of incorporating technical content that suits the various math-tolerance levels of our students.

Looking at the big picture, the same way Dr. Hu is appropriately emphasizing the importance of accurately representing the mathematical prerequisites for entering the field despite the potential compromise to its core mission, in order for students to make a sound judgement about their fit in it. There is another key element that is currently missing that would similarly empower participants to better assess their options in making a more informed decision about their choices.

The program completely lacks mention of an up-to-date account of current salary trends and average reports of the specific subfields that students could be looking to pursue in the AI Robotics job market. Including information of their expected average annual earnings, salary increases, the average salaries by job title and expertise, the regional averages in the US, and perhaps even going as to sharing the state of pay inequities, like the existing Gender Pay Gap and Racial Wage Gap in the industry.

In fact, this serves as a good example on how one lecture could give participants another entry point into the field without the necessity of having a strong mathematical inclination. If one feels passionate about advocating for wage equality, for instance, their career pursuit after graduation could lead them to serving this endeavor in the AI Robotics industry without having to study Engineering.

While some presenters briefly mentioned the need for skilled workers in the field with relevant up-to-date data, however, their approach addressed general trends at best. Therefore, dedicating a lecture on the various fields within AI Robotics, tailored to personal skills, interests, points of strength, weakness, and aspiration, could serve as a valuable substitution to the technical lecture in question.

Such a lecture could even be considered as comprehensive recap that specifically allows students to distill all the accumulated information they had gathered over the 6 weeks and lets them step into the business realm of numbers, opportunities, realistic expectations and potential professional growth. An example of this is a final project I had undertaken at San Francisco State University in the Fall of 2022, as part of the course ITEC 0852-01 Instructional Technologies in Organizations. Back then, I gathered information from all the guest speakers we encountered throughout the semester and created a Mind Map detailing the required of skills of each job title, along with its corresponding job responsibilities, average pay scale for entry-level positions, and job-growth outlook data (See Appendix).

Another thing to consider given that the program has been running for three years, therefore, accumulating a substantial archive of recorded material, is to pre-create a standardized template of what a lesson plan should look like. Including the instructional events and suggested strategies in alignment with the learning objectives. For instance, if the LO requires that the student is able to distinguish between *supervised* and *unsupervised* learning, a Venn diagram could be used to illustrate the two concepts. After that, when *supervised* learning is revisited in a subsequent lecture, students could be given the chance to collaborate together on remembering the missing element of that previously presented illustrative diagram. This approach leverages their prior *understanding* established in an earlier lecture while promoting collaborative peer learning.

Summary

In an ideal world, IDs, educators, and experts would collaborate in analyzing the standards and developing a hands-on, practical curriculum focused on specific targeted skills. However, due to the program's short duration relative to its complex interdisciplinary content, the current lectures are addressing skills at the lower levels of Bloom's Taxonomy. However, going forward, for the program to gain a reputation for effectively delivering on its core mission, we must dedicate more focus on targeting higher-order thinking skills such as *analyzing*, *evaluating*, and *creating*. This is crucial for the program to garner the recognition it deserves, for delivering on its aspirational objectives.

Indeed, to achieve this objective, it is imperative for the program to adopt the UbD model as a crucial step in that direction. By starting with the end goal in mind, each amended lecture would gradually bring us closer to creating a program that fundamentally fosters deeper thinking among students. This approach also encourages them to actively engage with and bring in their perspective to a fast-changing field, rather than passively listening to the sage-on-a-stage that can never keep up with the evolving pace of the field.

With the guidance and direction of IDs, STFT can proactively prepare for a better run to its program next year by developing materials (presentations, videos, diagrams, visual, etc.) beforehand, to ensure the delivery of an engaging and effective instructional experience in an online class. Especially since we can leverage the existing content from 3 consecutive summer programs, allowing us to build upon existing assets, rather than starting from scratch. Instead, we could now be revising, improving, and adding to material to further enhance the program deliver.

Conclusion

Crafting an ideal student experience is a rigorous undertaking marked by challenges and time constraints. The process demands the collaboration of SMEs, who are often occupied with other commitments. These experts may not always be readily cooperative, either because their primary objectives may not align closely with the responsibilities of an instructional designer dedicated to creating an optimal learning or training experience, or because, in this case, the program's presenters are volunteering their time for the summer program, without a direct vested interest in its outcome. These conditions make the process of developing an optimal student experience inherently even more complex.

Anecdotally, even for this project, the presenter of the lecture upon which this creative work was built, could not find time to feedback on his own presentation redesign. Therefore, giving an accurate example about how uncooperative SMEs could be when approached with a project beyond their immediate circle of priority. Although in their defense, the presenter was attending a conference and must have been caught up with work upon their return to office. But that's what IDs are usually facing the majority of the time with similar undertakings of multiple shareholders.

Having said that, I still believe that as an ID, if I were given more time and resources to redesign the lecture to a high-fidelity wireframe, my approach would have been to collaborate directly with the experts on translating their wealth of knowledge to a student-centered, project-based instructional experience. Then, I would assist these experts in effectively conveying their vision to our student participants, while taking into consideration their academic levels and prior proficiency in the subject matter. Additionally, I would ensure that the lectures align with the standards set by the EdTech company and adhere to the LO established by STFT's education team for students to achieve during the summer program. This comprehensive approach aims to enhance the program's quality and alignment with both educational standards and the expertise of the instructional team.

After that, I would ask our volunteer SMEs and presenters to verify that the LO we've developed align with their intended teachings and cover any potential gaps (i.e., ensuring that students have all the necessary information to grasp the concepts discussed in their lectures). Once they approve of that Scope, I would proceed to develop relevant formative and summative assessments tools to "test" whether students meet the established LO. Ideally, the assessments should be easy enough for students to answer had they been paying attention, and not stupid enough to insult their cognitive capacities. Step-by-step, I would guide presenters to seamlessly integrate these tools into their lectures, while taking into account the time allotted for each lecture and adjusting its content and structure accordingly. And in the event that the busy presenter couldn't afford the extra time to creating these assessments, I could assist them by drafting those, then allowing time for amendments and corrections as needed.

After that is complete, I would move to the *development* phase, where I would develop strategies to incorporate all the above discussed elements into engaging and effective instructional material. However, this production process is not only time-consuming, with numerous independent variables to consider, but also requires a dedicated team of IDs and financial resources to set up a more effective program without compromising quality. In fact, presently, the program is now operated and managed by a team of volunteers, retirees, and busy professionals with demanding full-time jobs.

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Appendices

*All Appended material in 1 Link

Appendix A1. Program Flyer

Appendix B1. Built in Assessments

Appendix C1. CSU Channel Islands

Appendix D1. The Next Generation Science Standards (NGSS – For Engineering Design)

Appendix E1. Program's Outline and brief description

Appendix F1. Curriculum and Program Schedule

Appendix A2. Guideline for STFT Leader-Teachers

Appendix B2. Mind Map

Appendix C2. Students' Post-Lecture Survey of Lectures and Lab Sessions

Appendix D2. Post-Lecture Survey Results

Appendix F2. Snapshot of the Program Implementation Evaluation

Appendix E2. Mr. B's Lecture Evaluation following 4 Quality Assurance Rubrics

Appendix A3. Post-Lecture Survey Results

Appendix A1. Program Flyer


INSPIRING EDUCATORS
Nine (9) PhDs and twelve (12) C-level executives bring their insights and serve as role models.
SCOTT MAUVAIS
DR. HEIKO HOFFMANN
MARINA BILL
DR. AIMAN OMER
DR. REID BLACKMAN
DR. MOJTABA AZADI
DR. DAVID KOEPSELL
DANIEL CHRISTADOS
KRYSTOF LITOMISKY
GEORGE WILLIAMS
AARON PRATHER
SANJIB BASAK
DR. XIAO XIAO
DR. MICHAEL SIMS
ROBERT KNIGHT
PRABHJOT SINGH
AMAZING ASSISTANTS
Our remarkable Teaching Assistants have many accolades.
ELVIN LI
2023 SAN FRANCISCO OFA FELLOW
VEDA LEE
2023 SAN FRANCISCO OFA FELLOW
RYAN LEE
SUPERTECH FT NSF STUDENT INTERN
ALIVIA ZHAO
SUPERTECH FT NSF STUDENT INTERN

Appendix B1. Built-in Assessments

Earlier 15

Post Internship Survey 2023 AI Robotics Youth Program	Thursday, Aug 3
Create a GitHub account 2023 AI Robotics Youth Program	Tuesday, Aug 1
7/27 Quiz: LLMs and Generative AI 2023 AI Robotics Youth Program	Monday, Jul 31
AI Robotics Post-Talk Questions 2023 AI Robotics Youth Program	Monday, Jul 31
mBot Assignment: Line Following 2023 AI Robotics Youth Program	Monday, Jul 31
Krystof Litomisky Post-Talk Questions 2023 AI Robotics Youth Program	Monday, Jul 31
Aaron Prather Post-Talk Questions 2023 AI Robotics Youth Program	Monday, Jul 31
mBot Assignment: Object Avoidance 2023 AI Robotics Youth Program	Monday, Jul 24
mBot Assignment: Calibration 2023 AI Robotics Youth Program	Monday, Jul 17
7/12 Quiz: Control Systems 2023 AI Robotics Youth Program	Thursday, Jul 13
What is the difference between automatic and autonomous systems? 2023 AI Robotics Youth Program	Thursday, Jul 13
7/11 Quiz: Sensors and Actuators 2023 AI Robotics Youth Program	Thursday, Jul 13
7/10 Quiz: Energy and AI Robots 2023 AI Robotics Youth Program	Thursday, Jul 13
Code Tenderloin Swag Design 2023 AI Robotics Youth Program	Wednesday, Jul 12
Build an mBot 2023 AI Robotics Youth Program	Tuesday, Jul 11

Appendix C1. The Next Generation Science Standards (NGSS – For Engineering Design)

HS-ETS1-3 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-3. **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.

- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

Crosscutting Concepts

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Connections to HS-ETS1.B: Developing Possible Solutions Problems include:

Earth and Space Science: HS-ESS3-2, HS-ESS3-4 **Life Science:** HS-LS2-7, HS-LS4-6

Articulation of DCIs across grade-levels:

MS.ETS1.A ; **MS.ETS1.B**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-ETS1-3)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-3)

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. *(HS-ETS1-3)*

Mathematics -

MP.2 Reason abstractly and quantitatively. *(HS-ETS1-3)*

MP.4 Model with mathematics. (HS-ETS1-3)

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

The section entitled "Disciplinary Core Ideas" is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas*. Integrated and reprinted with permission from the National Academy of Sciences.

Appendix D1. Program's Outline and Brief Description

Supertech FT Course for Tech SF Program

Date: about late 2020, early 2021
By: Albert Hu

A Supertech class for Tech SF lasts about six weeks, with course syllabus and contents in compliance with state and/or nationally recognized professional standards. It consists of three main parts:

Part 1 of 3: refresh of high school math and physical science, for about 4 weeks. It is a quick one-month review (agile), showing students also curated online sites for further learning and practice, life long.

Part 2 of 3: introduction to emerging/growth fields, for about 2 weeks. Each day is one introduction to at least a growth field: WiFi, solar energy, robotics, etc.

Part 3 of 3: tools. During the six weeks, the class will visit SF Made and Human Made sites, for the teachers there to show students the tools and the safe usages of them.

On the education standards, we have for Part 1 of 3, set to be California Department of Education's Common Core Standards for Mathematics and Physical Science.

For Part 2 of 3, we are completing the list of professional standards. By this I mean NABCEP standard for Solar, CWNP for wireless technician, ..., etc.

The initial LMS (Learning Management System) is Google Classroom. If needed later on, we can switch to other specialized LMS.

Appendix E1. Curriculum and Program Schedule

			Dates: Mon., June 26th - Thu., Aug 3rd, 2023							
WEEK ONE	**6/26**	**Monday**	**6/27**	**Tuesday**	**6/28**	**Wednesday**	**6/29**	**Thursday**	**6/30**	**Friday**
Robotics Lesson (Afternoon)	1pm - 2:30pm		1pm - 2:30pm	Dr. Albert Hu: Introducing Scott Mauvis on AI and Society (retired Micrsoft senior director)	1pm - 2:30pm	Dr. Albert Hu: Overview of 2023 AI Robotics Youth Program	1pm - 2:30pm	Dr. Michael Sims: Space-faring AI robots (former JPL robotics program director; recorded video)	10am - 11:30am	**Marina Bill, President of International Federation of Robotics**
Break	2:30pm - 2:45		2:30pm - 2:45		2:30pm - 2:45	Break Time	2:30pm - 2:45	Break Time		
Lab	2:45pm - 3:15pm		2:45pm - 3:15pm		2:45pm - 3:15pm		2:45pm - 3:15pm			
Soft Skills	3pm - 4pm	Welcome, Community contract, Soft Skills; Whats all the fuss about	3pm - 4pm	Successs and Failure	3pm - 4pm	Mindset Matters	3pm - 4pm	Communications		
WEEK TWO	**7/3**	**Monday**	**7/4**	**Tuesday (Holiday)**	**7/5**	**Wednesday**	**7/6**	**Thursday**	**7/7**	**Friday**
Robotics Lesson (Afternoon)	1pm - 2:20pm	Daniel Christadoss: Kinematics and Inverse Kinematics	1pm - 2:20pm		1pm - 2:20pm	Dr. Mojtaba Azadi: Biomimetic and advnaced applications of kinematics	1pm - 2:20pm	Dr. Albert Hu: design and manufacture of robots	11 am to 12:30pm	**Dr. David Koepsell: Ethics in Science and Technology**
Break	2:20pm - 2:30pm	Break Time	2:20pm - 2:30pm		2:20pm - 2:30pm	Break Time	2:20pm - 2:30pm	Break Time		
Lab	2:30pm - 3pm	Dobot Kinematics (Daniel Christadoss)	2:30pm - 3pm		2:30pm - 3pm	Dobot AI-RETA Introduction	2:30pm - 3pm	Dobot AI-RETA Kinematics and inverse kinematics		
Soft Skills	3pm - 4pm	Critcal Thinking	3pm - 4pm		3pm - 4pm	Mindset Matters	3pm - 4pm			
WEEK THREE	**7/10**	**Monday**	**7/11**	**Tuesday**	**7/12**	**Wednesday**	**7/13**	**Thursday**	**7/14**	**Friday**
Robotics Lesson (Afternoon)	1pm - 2:20pm	Dr. Albert Hu: Energy and AI Robots	12pm - 1:30pm	Dr. Albert Hu: Sensors and actuators	1pm - 2:20pm	Dr. Albert Hu: Control theory and practice; automation and autonomous system	1pm - 2:20pm	Dr. Aiman Omer: Humanoid robot		**InOrbit Site Visit**
Break	2:20pm - 2:30pm	Break Time	1:30pm - 1:40pm	Break Time	2:20pm - 2:30pm	Break Time	2:20pm - 2:30pm	Break Time	11am - 12pm	Presentation by **Florian Pestoni**
Lab	2:30pm - 3pm	mBot open box, mBot sensors and actuators	1:40pm - 2:45pm	Overview of assignment 1: mBot calibration	2:30pm - 3pm	Assignment 1 due, start assignment 2: obstacle avoidance	2:30pm - 3pm	mBot work time	12pm - 1pm	Lunch (Costco pizza)
Soft Skills	3pm - 4pm	Work Ethic	2:45pm - 3:45pm	Chase Bank Financial Literacy	3pm - 4pm	Mindset Matters	3pm - 4pm	work/life balance	1pm - 3pm	Hands-on control of robots
WEEK FOUR	**7/17**	**Monday**	**7/18**	**Tuesday**	**7/19**	**Wednesday**	**7/20**	**Thursday**	**7/21**	**Friday**
Robotics Lesson (Afternoon)	1pm - 2:20pm	Prabhjot Singh: Intro to ROS	1pm - 2:05pm	Aaron Prather, ASTM Internation Director of Robotics, Automation and Autonomous Systems	1pm - 2:20pm	Krystof Litomisky: former NASA JPL, CEO of AI Robotics firm, now Nvidia	1pm - 2:20pm	Stanley Yang. CEO Neurosky. Brainwave devices for assistive robots	10am - 1pm	**OFA Summer Celebration**
Break	2:20pm - 2:30pm	Break Time	2:05pm - 2:15pm	Break Time	2:20pm - 2:30pm	Break Time	2:20pm - 2:30pm	Break Time	11:30 am - 12:30 pm	**Dr. Reid Blackman**
Lab	2:30pm - 3pm	ROS + Gazebo Sim w/ TurtleBot 3	2:15pm - 2:45pm	TurtleBot hardware with Cloud-IoT demo of IoT on celluar HAT, and overview with InOrbit	2:30pm - 3pm	Programming languages intro, for the purpose of AI and Robots (mentioning mBot)	2:30pm - 3pm	Review assignment 2, introduce assignment 3: line following		
Soft Skills	3pm - 4pm	Attitude	2:45pm - 3:45pm	Chase Bank Financial Literacy	3pm - 4pm	Mindset Matters	3pm - 4pm	Meditation		
WEEK FIVE	**7/24**	**Monday**	**7/25**	**Tuesday**	**7/26**	**Wednesday**	**7/27**	**Thursday**	**7/28**	**Friday**
Robotics Lesson (Afternoon)	1pm - 2:20pm	Dr. Bashir Mohammed: Introduction to AI and Machine Learning (recorded video)	1pm - 2:15pm	Dr. Albert Hu: AI and Robotics	1pm - 2:20pm	Sanjib Basak: Probability and Statistics	1pm - 2:20pm	Sanjib Basak: From Attenion to ChatGPT with LLM	11 am to 12:30 pm	**Dr. Xiao Xiao, founder of Friendly Robots**
Break	2:20pm - 2:30pm	Break Time	2:15pm - 2:25pm	Break Time	2:20pm - 2:30pm	Break Time	2:20pm - 2:30pm	Break Time		
Lab	2:30pm - 3pm	Machine Learning in AI robots	2:25pm - 2:45pm	Color Sorting Intelligent Algorithm	2:30pm - 3pm	Shape Sorting Intelligent Algorithm	2:30pm - 3pm	Brainwave device control of intelligence algorithms		
Soft Skills	3pm - 4pm	Financial Literacy-Chase Bank	2:45pm - 3:45pm	Chase Bank Financial Literacy: Financial Institutions	3pm - 4pm	mindset matters	3pm - 4pm	Smart Goals		
WEEK SIX	**7/31**	**Monday**	**8/1**	**Tuesday**	**8/2**	**Wednesday**	**8/3**	**Thursday**	**8/4**	**Friday**
Robotics Lesson (Afternoon)	1pm - 2:20pm	Dr. Albert Hu: Review of AI Robotics Program	1pm - 2:20pm	George Williams: Computer Vision	1pm - 2:20pm	Dr. Heiko Hoffmann: Cognitive Robots	11pm - 3pm	OFA Culminating Event	11am -	**Code Tenderloin Graduation**
Break	2:20pm - 2:30pm	Break Time	2:20pm - 2:30pm	Break Time	2:20pm - 2:30pm	Break Time				
Lab	2:30pm - 3pm	iRobot SLAM demo	2:30pm - 3pm	Code generation by generative AI	2:30pm - 3pm	Multi-modal generation by generative AI				
Soft Skills	3pm - 4pm	Resume Workshop Cont	3pm - 4pm	Interview Workshop	3pm - 4pm	Job Search				

Appendix F1. Program Implementation Evaluation Guidelines

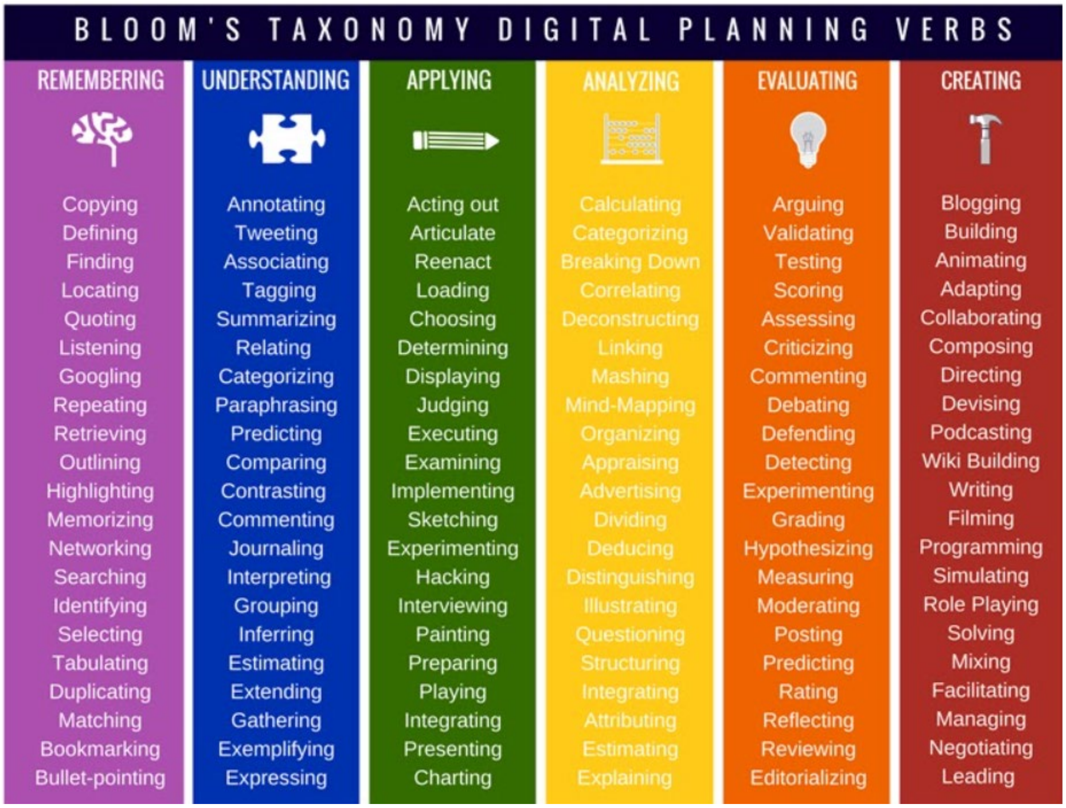
Overview

The program assessment process followed an observation-based approach to complete this Program Implementation Evaluation Guidelines report.

In evaluating the effectiveness of the learning experience provided by SuperTech FT we adopted specific industry-standards based on elements of the following online course quality standards:

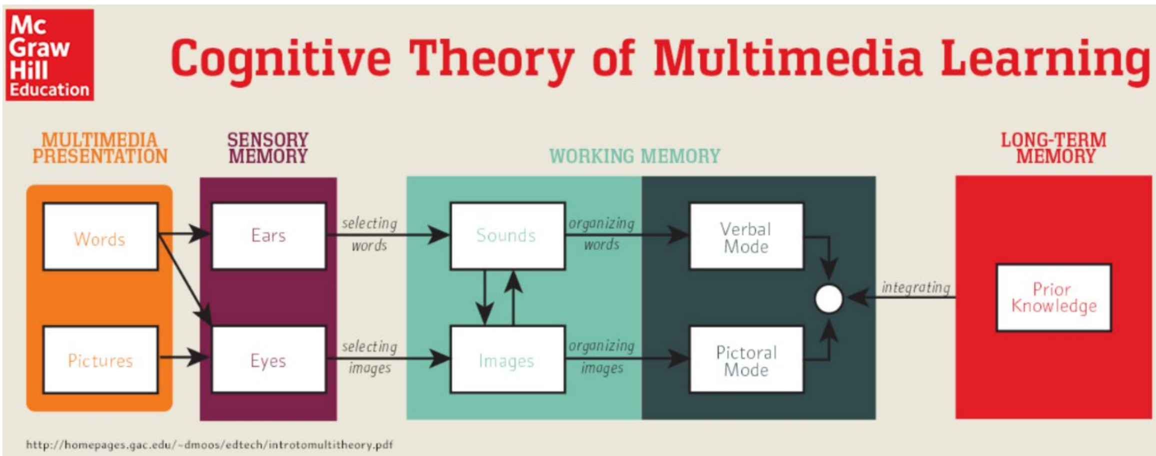
- The SUNY Online Course Quality Review rubric (OSCQR) for course Design.
- The Universal Design for Learning Principles for the implementation of methods and strategies to promote students' engagement with a) the content material, b) the facilitators and presenters, and c) their peers.
- Bloom's cognitive taxonomy framework, specifically *Understanding* as a targeted learning outcome (Figure 2).

Figure 2: Bloom's Digital Taxonomy Verbs for Digital Learning (TeachThought, 2017)



- Mayer's Multimedia Learning Principles (Figure 3), specific to the promotion of students' recall, targeting their long-term memory.

Figure 3: Cognitive Theory of Multimedia Learning (McGraw Hill, 2019)



- Gagne's Nine Events of Instruction.

Table 2: A learner's perspective and example of Gagne's 9 instructional events (compiled by the author)

Segments of Learning	Events of Instructions	Types of learning objectives	Learner perspective	Examples
Opening	1. Gain students' attention	Icebreaker & warming up activities	Focus my attention on the learning task	"Ok, everyone, let's jump in!"
	2. Inform learning objectives	Learning scope & setting expectations	Tell me why am I here & what will I learn.	"Today, we'll be exploring the ethical aspect that we must consider before the commercial deployment of AI Robots"
	3. Stimulate recall of	Review of the previous lesson	Provide context.	"Who can remember the

	prior knowledge for Info. retrieval			difference between structured & unstructured data?"
Presentation	4. Present the content material	From easy to complex	Tell me what you need me to know or do.	"Humanoids can be described and defined as..."
	5. Provide learning guidance	Examples & guided practices	Show me how to do it.	"Here are several examples of how computer vision can be used"
Practice	6. Elicit performance	Skills practice	Let me try it myself.	"I need all of you now to try and operate your own mBot based on our lab session."
	7. Provide feedback	Knowledge reinforcement	Let me know how am I doing.	"Yes, you're right, Robots still have a long way to go before they can be commercialized to every home."
Closing	8. Assess performance	Daily quiz	Hold me accountable for learning	"Great job, excellent point. Data must be cleaned before that AI/ML can make good use of it."
	9. Enhance retention & Transfer to the job	Assignments	Help me turn my learning into real, useable results.	"Don't forget to turn in your links to G-Classroom, of your working mBot"

- Keller's Motivational Design Model, promoting Attention, Relevance, Confidence, and Satisfaction (ARCS) (Kurt, 2021).

Figure 4: Syntax of ARCS Model supported video tutorial (Wahyudi, et. al, 2017).

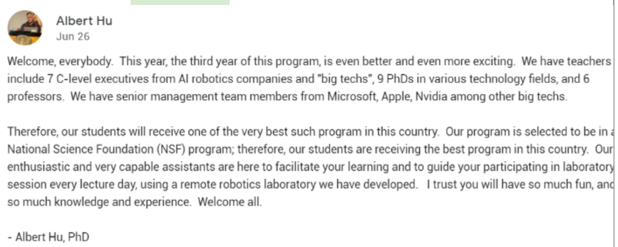
No	Syntax	Learning Process
1	Attention	Engage and focus the attention of the students
2	Relevance	Convey the purpose and benefit of learning
3	Attention and Relevance	Deliver learning material using video tutorial
4	Attention and Relevance	Use concrete examples related with real life
5	Attention and Relevance	Create groups heterogeneously
6	Relevance	Give learning tutorial
7	Confidence and Satisfaction	Provide opportunities for the students to participate in learning
8	Satisfaction	Give feedback
9	Satisfaction	Conclude any material that has been delivered at the end of the lesson

Table 3: Online Program Quality Review Rubric Standards (compiled by the Author)

<table>
<tr><th colspan="3">Quality Review Rubric Standards</th></tr>
<tr><th>Standards</th><th>Observations</th><th>Suggestions</th></tr>
<tr>
<td>Welcome and Getting Started Content</td>
<td>

- Welcoming students and a "getting started" message on Google Classroom.

→ STATUS: Available.



</td>
<td>

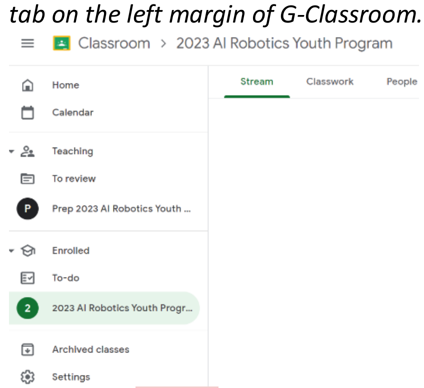
- Write 2-3 sentences about the major learning goals of the entire prog.
  - What skills and knowledge the students will have acquired by the end of the program
  - Use verbs that describe observable learning behaviors focused on participants' *Understanding*, as a Bloom's learning objective.

→ Consider repeating this process at the beginning of every lecture.
→ STATUS: Currently missing.

——————————

- Set up an easy-to-access space where expected online behavior is indicated, including:
  - Policies & Disclaimer about using participants' pictures, and
  - Rules for a successful participation.

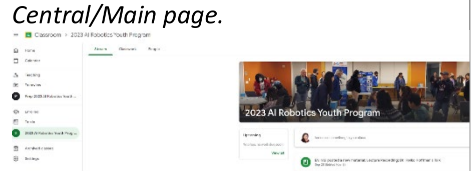
→ Consider sharing these verbally once during the onboarding 1st session, as part of the general "housekeeping" announcements
Note on placement: This could be the name of the space, located as a page or tab on the left margin of G-Classroom.



→ STATUS: Missing.

——————————
</td>
</tr>
</table>

		• Remind participants of the value behind their active participation, at least twice more after that.
		→ STATUS: Available & often repeated by Dr. Hu.
		——————————
		• Start with an ice-breaker exercise, followed by a friendly one-by-one intro. to all STFT's team
		  ○ This would establish a welcoming learning environment,
		  ○ Make the team approachable.
		→ STATUS: Missing a formal icebreaker activity, except on some occasions while waiting for all participants to login, during the first 5 minutes.
		→ Consider starting every lecture with an icebreaker.
		→ Team intro., mainly carried out by Dr. Hu. But could be made better.
		→ Consider letting the team intentionally share about their ambitions, for example, & what got them interested in the AI Robotics field, etc. The target is to make them as approachable as possible, to encourage students to later reach out for assistance later.
		——————————
		• Develop a collaborative exercise in breakout rooms to initiate students' intro. to one another.
		→ STATUS: Missing.
		——————————
		• Create a space where students could introduce themselves, their hobbies, what they're looking to gain out of the program. This would allow for participants to learn about each other & find common grounds, perhaps reaching out to one another, or making it easier for them to connect.
		→ STATUS: Missing.
		Placement: Same place as screenshot above.

Course Information Area and Syllabus	→ STATUS: Rubric completely missing.	• Set up a dedicated Course Information area where the Syllabus is positioned prominently with easy access. • Provide a printable syllabus option. *Placement: Same place as above displayed*. —————————— • Provide information about the list of lecturers and guest speakers. *Placement: To be placed at the Central/Main page.* 
Skills for Using Technology Tools	• Google Classroom, Google Forms, Zoom → STATUS: The LMS and supportive tech. tools used are appropriate and easily navigable among participants.	• Enable YouTube Closed Captions for all the links we play, for accessibility purposes. → STATUS: Missing. —————————— • Link an easy-to-follow YouTube tutorial on how to navigate Google Classroom in case there were participants unfamiliar to it. → STATUS: Missing. *Placement: To be placed on the left margin.*
A Logical, Consistent, and Uncluttered Layout	• Agenda shared using an Excel sheet table-format that is organized by weeks and color-coded by day & event. → STATUS: Clear and effective.	→ Consider making the Agenda easier to locate by creating a page/tab for it in G-Classroom. *Placement: To be placed on the left margin too.*

Appendix A2. Guideline for STFT Leader-Teachers

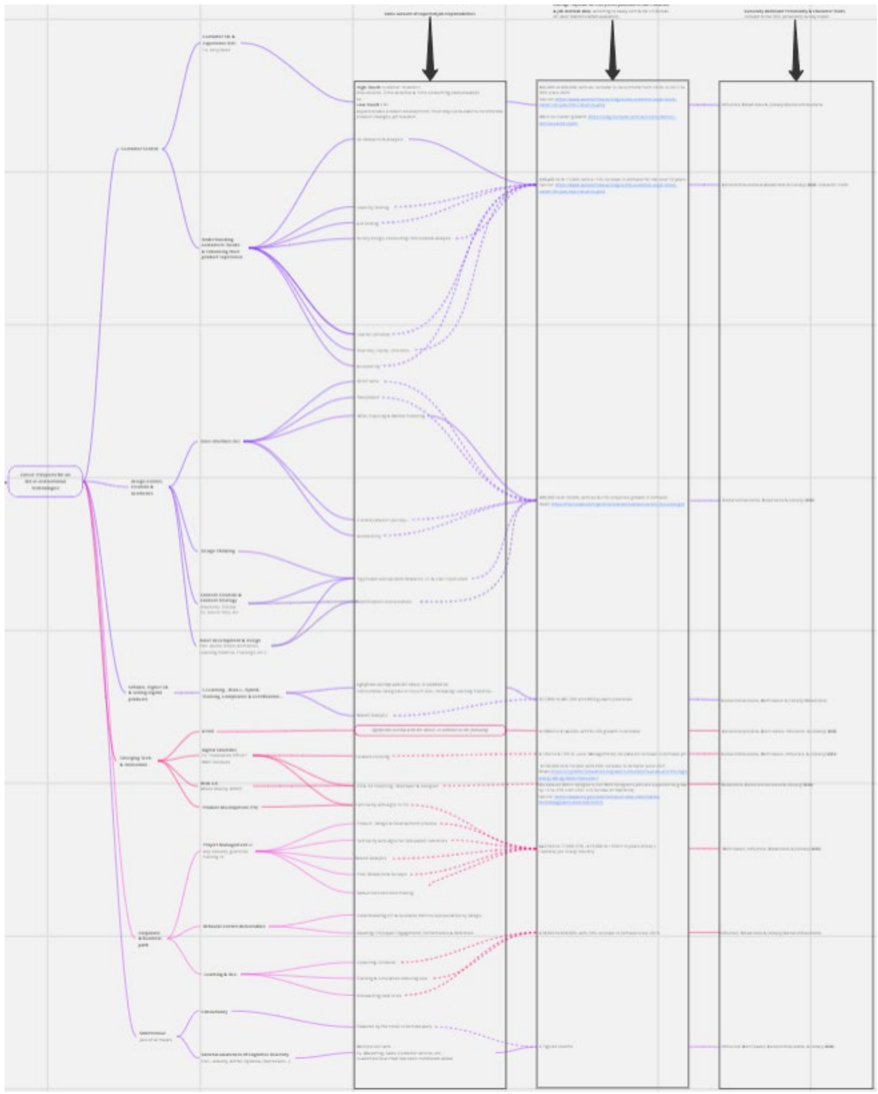
Guideline for Supertech FT Leader-Teachers

Version 5/25/2020

We will offer a sample syllabus and lecture session for leader-teachers.

1. Develop a syllabus for your lectures with teaching materials in compliance with California State and/or recognized national professional standards
2. Syllabus should include a *References* section, which include material used in the course, such as books, videos, and curated on-line education resources.
3. Each lecture lasts 60 minutes to 75 minutes; each day of Supertech FT course consists of two lectures and a rest period in between.
4. It is preferred that you break down the lecture to 5 to10 minutes "nuggets," with each 'nugget' explaining a key concept. Then a small break/breather before going on to the next nugget.
5. The small break/breather can be a short assignment for practice, or a two-question short question/quiz for confidence building purposes.
6. Each nugget can be a short video of your lecture, a curated short online/Youtube video, or the demonstration of the tools used in the technology/trade.
7. After the lecture session, a 20 minutes self-study period;
8. Assignments and short quizzes for the 20 min self-study period;
9. Take-home/Off-class review material;
10. Take-home/Off-class quizzes;
11. All the reviews and quizzes are for the purpose showing students the type of additional study in order to pass certification examinations/tests
12. Tools used for the technology described in the lecture
13. Inspirational stories and short videos from people who have overcine barrier in this field.

Appendix B2. Mind Map



Appendix C2. Students' Post-Lecture Surveys of Lectures and Lab Sessions

July XXth Lecture Survey

We hope everyone enjoyed the lecture. We'd love if you could give feedback on your experience with each speaker. Thank you!

Consider 1-5 as a scale where 1=Lowest and 5=Best.

mahmad@supertechft.com **Switch account**

* Indicates required question

Email*

Record **xxxxxxx@xxxxxx.com** as the email to be included with my response

1. How would you rate this lecture/Lab session?*

2. How informative was the lecture/Lab session?*

3. How easy was it for you to understand the lecture/Lab session?*

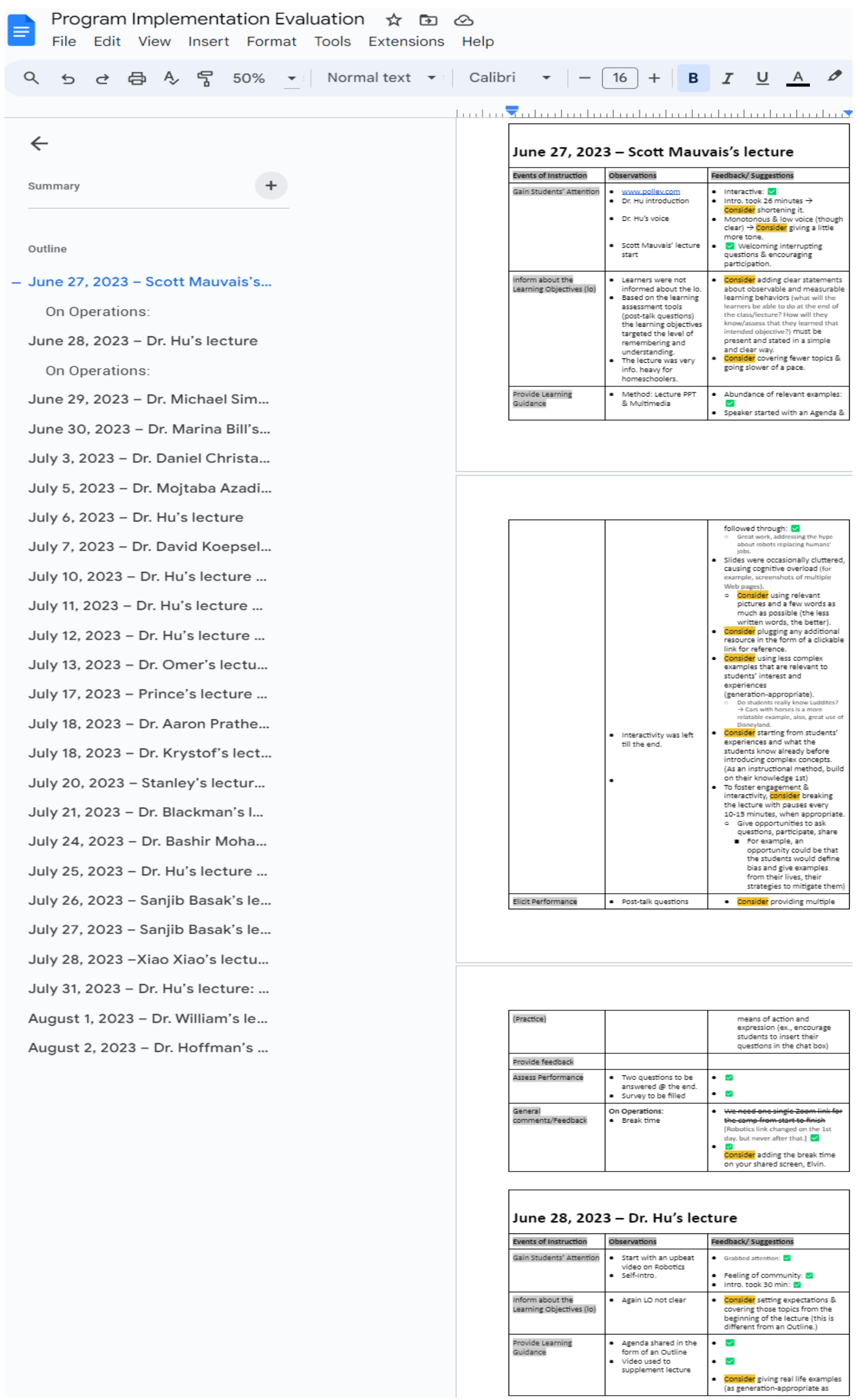
4. What did this lecture/Lab session do well? (Write at least 2 sentences)*

5. What suggestions do you have to improve the lecture?*

6. Dr. B. will also be presenting tomorrow. Are there any topics you'd like him to clarify/review in more depth tomorrow? Do you have any other questions?

Example: "I was confused about the notation he used. What do the symbols mean?"

Appendix D2. Snapshot of the Program Implementation Evaluation



Appendix E2. Mr. B's Lecture Evaluation following 4 Quality Assurance Rubrics

Evaluating Dr. M's Instructions following a combination of 4 quality assurance rubrics QOLT, QM, OSCQR & EquIP

Mr. B.'s lecture entitled: "Probabilistic Robotics"

1. **Assessment of Students' Learning**
    - The lesson failed to cover age-appropriate learning objectives in alignment with the target outcomes of the program. (see Section 5 for details)
    - Learning assessment was achieved by the presenter asking questions to engage participants as he explained abstract concepts, as one student mentioned:

        "I liked how he asked questions really anyone could answer.
        It was a good introduction to statistics and probability."
        (Anonymous student, post-lecture survey form, 2023)

2. **Facilitation of Instruction**
    - Catch learners' attention:
        - Available agenda

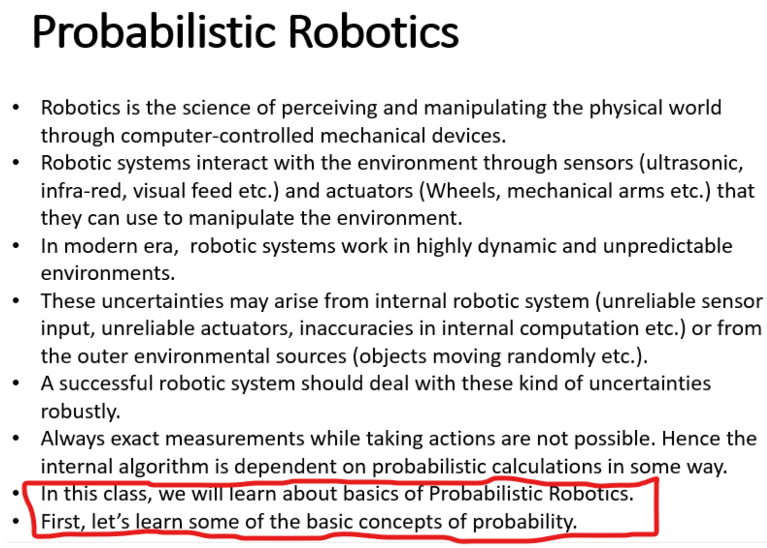
Content

- Introduction to Probabilistic Robotics
- Basics of Probability
  - Axioms of Probability Theory
  - Sample Space
  - Event
  - Random Variable
  - Expectation
  - Moments
  - Covariance
  - Normal Distribution
  - Uniform Distribution
  - Joint and Conditional Probability
  - Prior Probability

- Recall prior knowledge:
  - The presenter engaged students with Mathematics recall questions, as 1 participant reported:

    "Very encouraging to keep yourself engaged in order to understand the content. The questions were also helpful in keeping the audience on track." (Anonymous student participant, post-lecture survey form, 2023)

- Inform about the learning objectives (LO):
  - The LO is written at the end of a slide that is character heavy.



→ Consider dedicating 1 slide to place the LO on.

- The LO should be made clearer, measurable, targeting students' deeper thinking, such as the following:

  By the end of this lecture, you (the student) will be able to have up to 80% clearer understanding of some very basic mathematical concepts and formulas related to how robots operate, including:

    - How probabilistic algorithm is measured to prepare for different scenarios,
    - The basics of sensors and sensor data,
    - How robots' interaction with the environment works, and
    - Algorithms of Robot systems' control decision, etc…

- Provide learning guidance: Lecture supported by examples, as one participant explained:

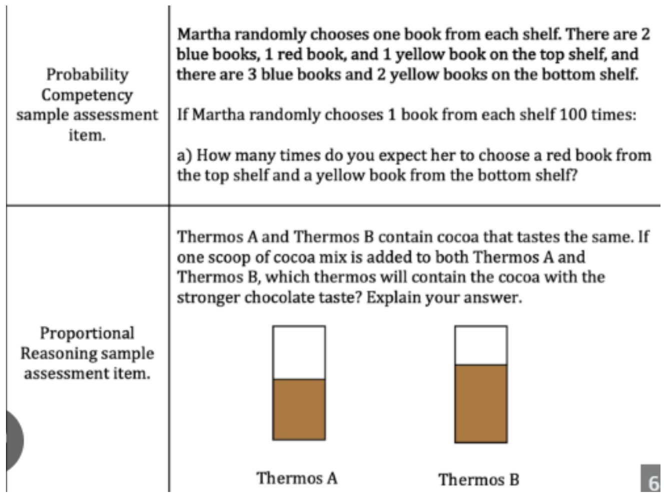
"I think he did a good job explaining and had examples that helped to enforce the learning. Examples are always helpful for me to see how the material is applied." (Anonymous student, post-lecture survey form, 2023)

- Opportunities for practice:
  - The lecture discussed highly abstract material, and while the presenter asked students to answer some questions in class to assess their understanding of the abstract concepts, the presenter could still use interactive tools like Kahoot to allow for more practice and in a gamified setting, hence, making the dry mathematical material easier to grasp.

    → Consider following up with a question or 2 in the forum to consolidate their understanding of the discussed concepts.

    → Try to use illustrations and graphs to illustrate mathematical concepts and equations, making them easier to grasp. For example:

Figure 5: Measuring probabilistic reasoning against proportional reasoning skill (Begolli et. al., 2021)



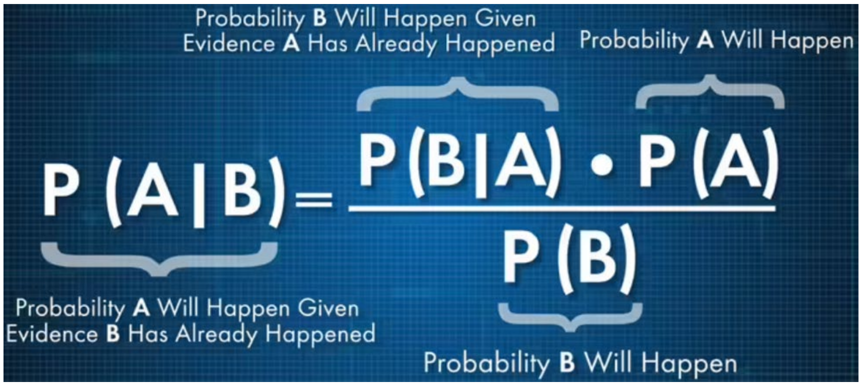
3. **Instructional Materials and Resources**

- Presentation: Occasional use of media (pictures, graphs and diagrams), and that was appreciated by participants, as they indicated in their post-lecture survey. However, at the beginning, those were cluttered with information.

  → Consider using fewer words in each slide or spreading information to other slides.

  → Consider including more illustrative representations of the abstract material, as the example below.

Figure 6: Bayes' theorem (Mancini, 2023)



4. **Student Interaction and Community**
   - Student-to-content interaction was facilitated through a media-rich lecture. The use of tools like Kahoot or Mentimeter, would further improve that aspect.
   - Student-to-instructor interaction was facilitated through a Q&A session at the end of the lecture, even though the floor was open for students to interrupt the speaker during the lecture.
   - Student-to-student interaction was completely absent.

     → Consider fostering student-to-student interaction by creating a simple activity to allow for students to work in groups and share their group discussion later.

5. **Technology for Teaching and Learning**
   - The technology used: Zoom and PowerPoint Presentation.

     → Consider using available tools to engage the learners further, like making use of the breakout rooms in Zoom.

6. **Accessibility and Universal Design**

→ Consider curating additional videos and readings in both digital and printable formats for the students who would like to learn more about the concepts.

Feedback on content delivery

Presenter's self-Introduction:

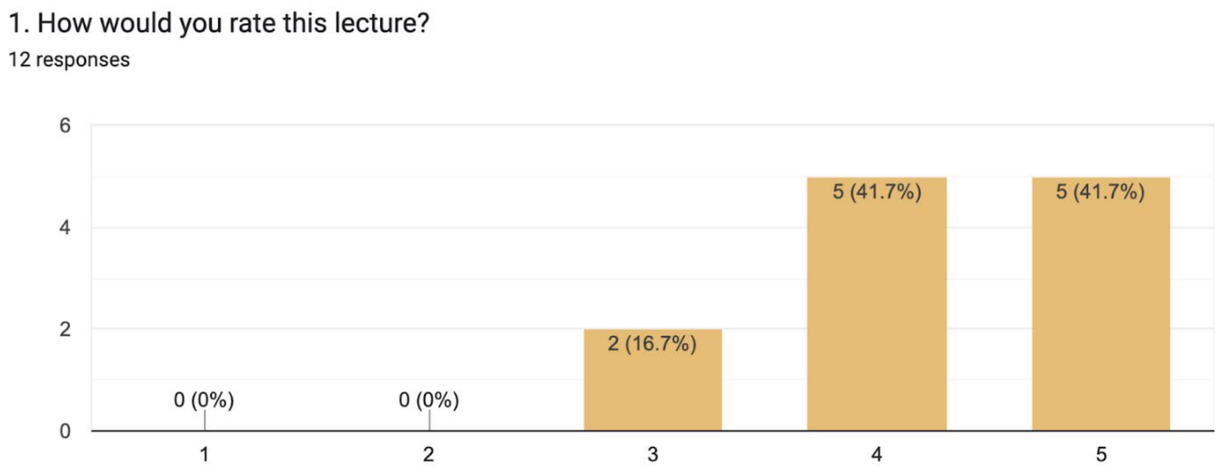
At the beginning of his lecture-style presentation, the presenter introduces himself and presents his achievements and reasons for being successful as a former Data Science Director at a Fortune 500 company, to his humble beginning as a high academic achiever. Although his message conveys clearly that hard work does pay off, and despite that he is completely entitled to feeling proud of his success, especially having to prove himself as an immigrant to the US, I couldn't help but feel that since our students are all first-generation citizens, his message may have been received different from how he intended it to.

In fact, some other presenters achieved similar professional successes despite challenges, but relegated their success to other factors that our students could have more of. Not only making those presenters more relatable for sharing a difficult start, but also naturally allowing our participants to imagine themselves in our presenters' shoes: venturing a fast evolving space with more questions than answers, yet still proving themselves and being recognized eventually. Therefore, I believe we should take every opportunity possible, including presenters' self-introduction, to encourage speakers to focus on highlighting specific personality traits they may have, like curiosity, ambition, hard work, and having a growth mindset, etc., to help our students dream about entering the space and similarly making their mark. Especially that this strategic approach goes hand-in-hand with STFT's core mission of attempting to encourage students to venture the AI Robotics field, rather than mistakenly confirming students' initial misconception that the space is only accessible to high achievers.

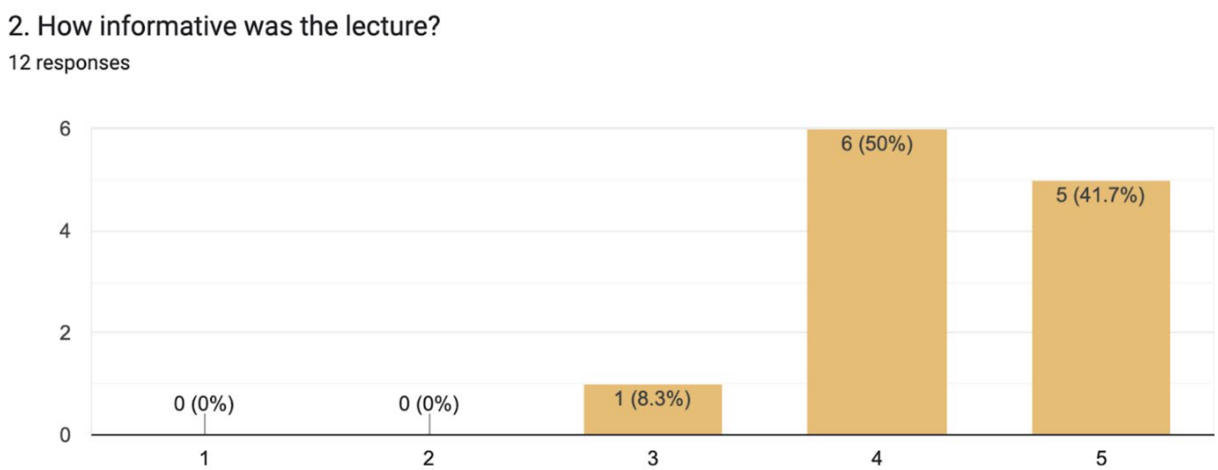
Appendix A3. Post-Lecture Survey Results

July XX - Mr. B.

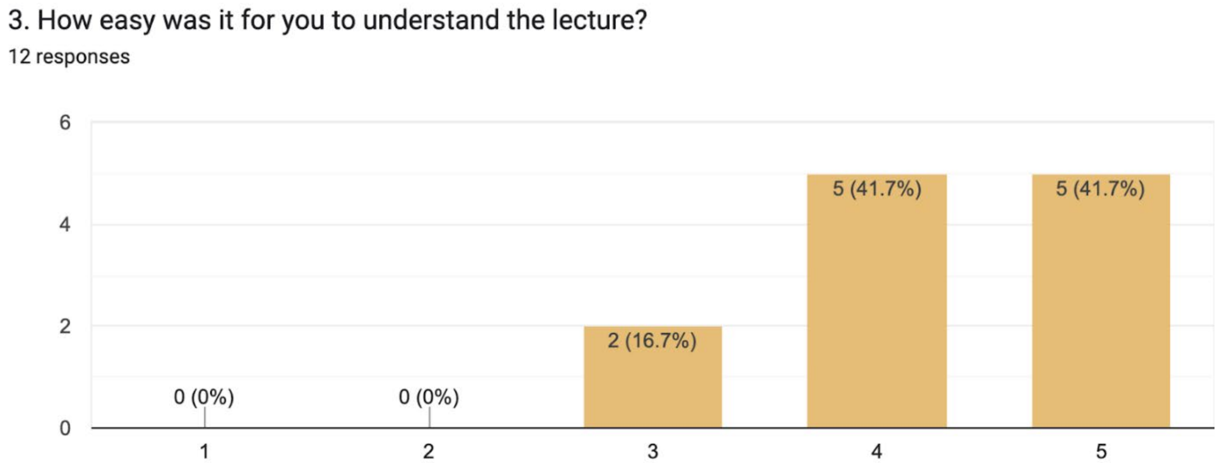
1-Average score:



2-Average score:



3-Average score:



4-What did this lecture do well?

- I think he did a good job explaining and had examples that helped to enforce the learning. Examples are always helpful for me to see how the material is applied.
- Information given out clearly.
- He was interactive and asked us questions. He was also easy to understand
- Showed me how the basics of sensors would work in a robot
- He explained the topic well. He also was very passionate about the topic
- The speaker's audio was clear and understandable unlike some other times. Even though I didn't understand any of the equations, it was nice knowing that there is something harder to learn.
- I liked how it was very in-depth with the math. I also like how he started from the very basics.

- Very encouraging to keep yourself engaged in order to understand the content. The questions were also helpful in keeping the audience on track.
- Slides included a lot of information. The examples used made the concepts much easier to understand.
- It explained well on what probability is and how it can be applied to different situations.
- I liked how he asked questions really anyone could answer. It was a good introduction to statistics and probability
- What I learned well were more formulas for Probability and why people use it. But also what the equation means.

5-What suggestions do you have to improve the lecture?

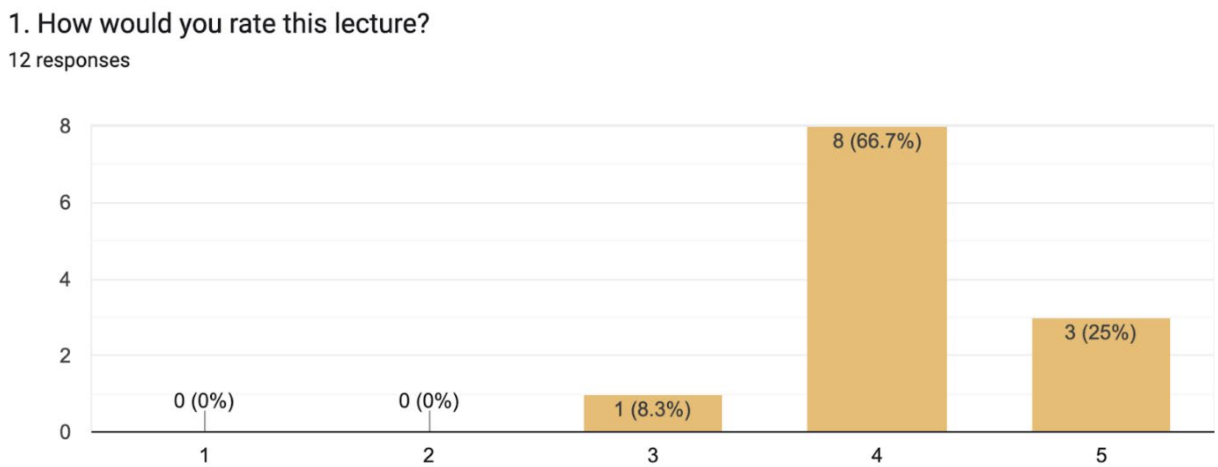
- N/A
- None
- I think maybe go a bit slower?
- None :)
- he did well i have no suggestions
- Aside from today's lecture, I'd think the overall audibility should be most important.
- I think it would have been nice to move more quickly through the examples, but all in all I think it was a good lecture.
- There were a lot of topics covered, so explaining them slower might help with confusion.
- It could explain more about what the symbols mean in calculating probability.

- It was a pretty big jump from basic statistics to robotic statistics. I was confused by the open door robot example.

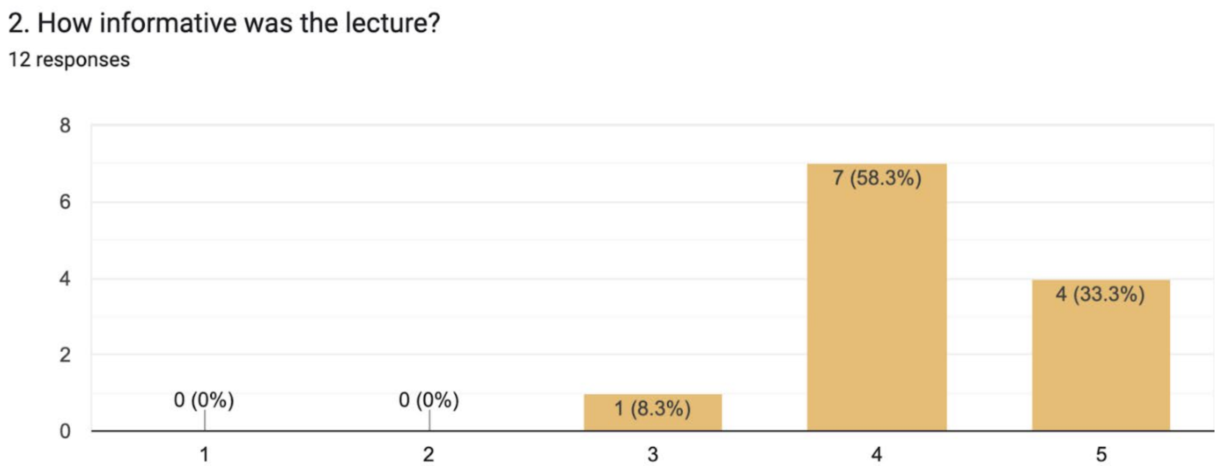
*** Students' survey results of Mr. B's 2nd lecture, includes substantial embedded feedback on his 1st lecture, actually***

July XX - Mr. B.'s 2nd lecture

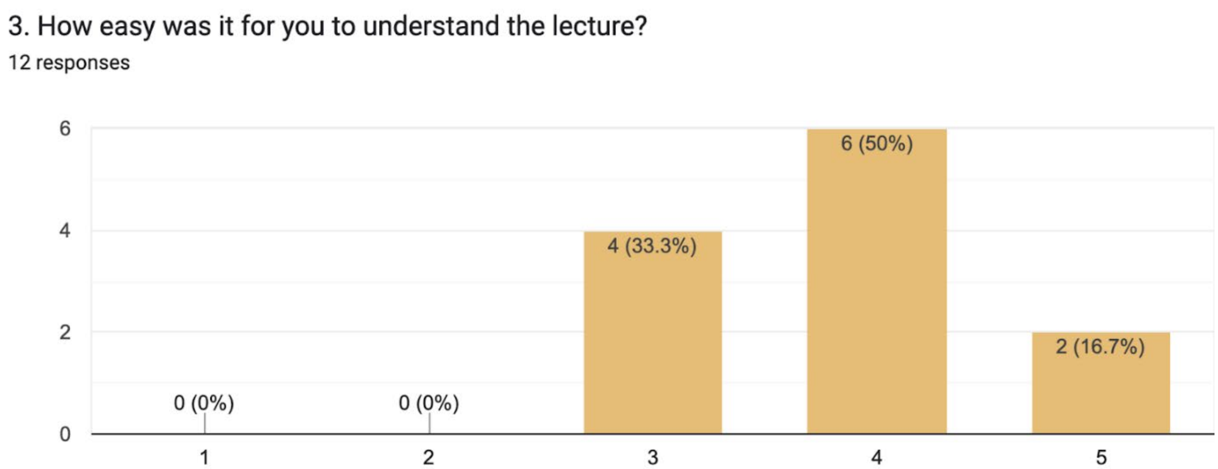
1-Average score:



2-Average score:



3-Average score:



4-What did this lecture do well?

- He explained things well and asked questions
- Grey presentation overall with. showed great Responses to questions asked by peers.

- Very easy to understand. The mention of popular topics (ChatGPT) made the lecture more interesting
- Audibility
- I liked trying to guess which face was real and which was AI generated. They also talked about some of the applications of AI and its issues.
- I feel like there was nothing that this lecture did bad or good on
- Helped explain how popular platforms operate and gave real world examples.
- I liked the face game we played. I also appreciated how he tried connecting to our own use of chatgpt.
- I liked how he talked about something relevant to today's world. Chat GPT is especially a controversial topic and it was interesting to hear him further explain about this AI.
- He provided a very helpful introduction to probability, explaining the concepts in detail and providing example problems to help apply them. Then on the second day he explained generative AI and how it's connected to deep learning, machine learning, and AI overall in a simple but informative way.
- It explained well on how probability and statistics can be used to program robots.
- I liked the pictures and the explanations behind them as it clarified any confusion I had. The general definition of a topic like LLM was also brief but great.

5-What suggestions do you have to improve the lecture?

- None
- N/A

- none
- Nothing
- None. Some of it was hard to understand though.
- same answer
- Maybe some more videos from the creators of the platforms on how they developed these models.
- Simpler terms being used.
- This isn't for the speaker, but I noticed a trend where Albert interrupts the speaker when they are presenting and it messes up the flow of the presentation. We are also limited on time so this takes away from the time they have to speak what they prepared.
- I wasn't sure how a lot of probability was connected to generative AI and how to apply those concepts - it would help to make that connection more clearly next time. Also to perhaps include more engagement with the interns, like asking mini test questions to the interns, or small games such as how we guessed which face was real or AI generated.
- It should explain more on how to solve bias within the probability.
- None