2021-2022 NEOM AI REPORT

INTRODUCTION

For the Academic Year of 2021 - 2022, Neom Community School (NCS) partnered with ReadyAI to produce AI-centric curricula tailored to the needs of NCS, the units of inquiry that guides the school's academic programming, and the Kingdom of Saudi Arabia's Vision 2030, including Neom's "*bold and audacious dream of a New Future [as] an accelerator of human progress that will embody the future of innovation in business, livability and sustainability*" (Vision 2030).

This report will detail the various curricula produced by ReadyAI, including program overviews and objectives as well as alignment with NCS priorities and Saudi Arabia's goals for its Neom Project. Additionally, the report will detail the visits by ReadyAI staff throughout the academic year.

Roozbeh Aliabadi
CEO ReadyAI

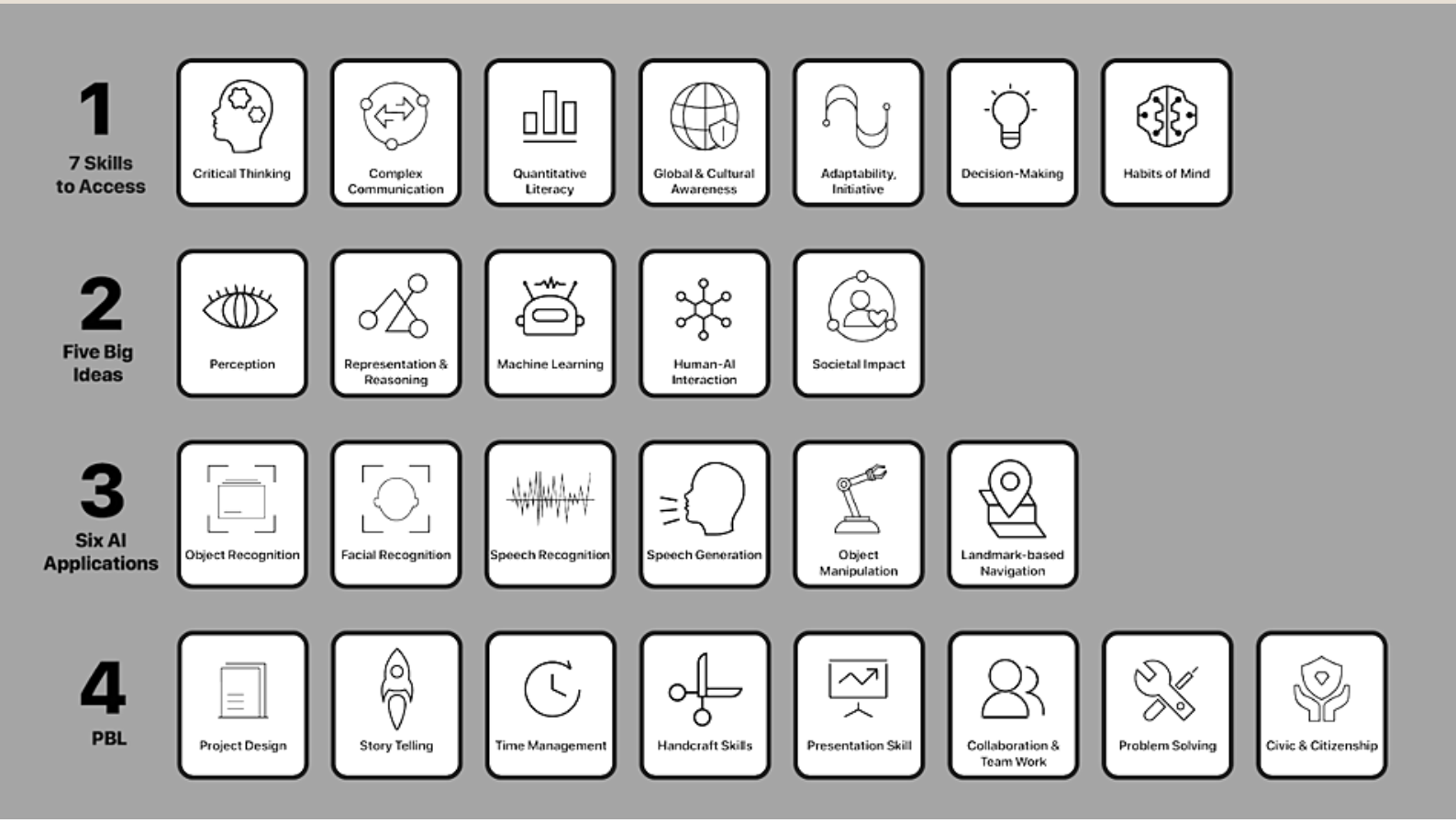

Figure 1 - 7 Skills, 5 Big Ideas, 6 AI Applications, and PBL (Project Based Learning)

IMPLEMENTATION OF AI CURRICULUM IN NEOM, SAUDI ARABIA

Why AI education? This question may be posed by honest-hearted educators who wonder whether students can learn even about AI and whether this can be done in a meaningful way. However, as this report will detail, AI was taught in a impactful and *transdisciplinary* way at Neom Community School during the 2021-2022 Academic Year, establishing NCS as a leader in AI education for K-8.

In order to implement the key goals of teaching through problem based learning and project based learning, the AI curriculum designed for NCS presented both "challenge" assignments and "mini-projects" throughout the design process. Such "challenge" assignments occurred during the middle of a lesson, presenting students with a challenge mid lesson. For instance, one lesson might present content with students. After some direct instruction, students are presented with a specific instance where they need to apply the direct instruction or where they need to solve a problem in preexisting code.By introducing such challenges, students are encouraged to work in teams, collaborate and communicate to present ideas to address the challenge, think critically about the instruction they were presented, analyze the issue at hand, and generate novel solutions that perhaps even the instructor did not envision during the design process.

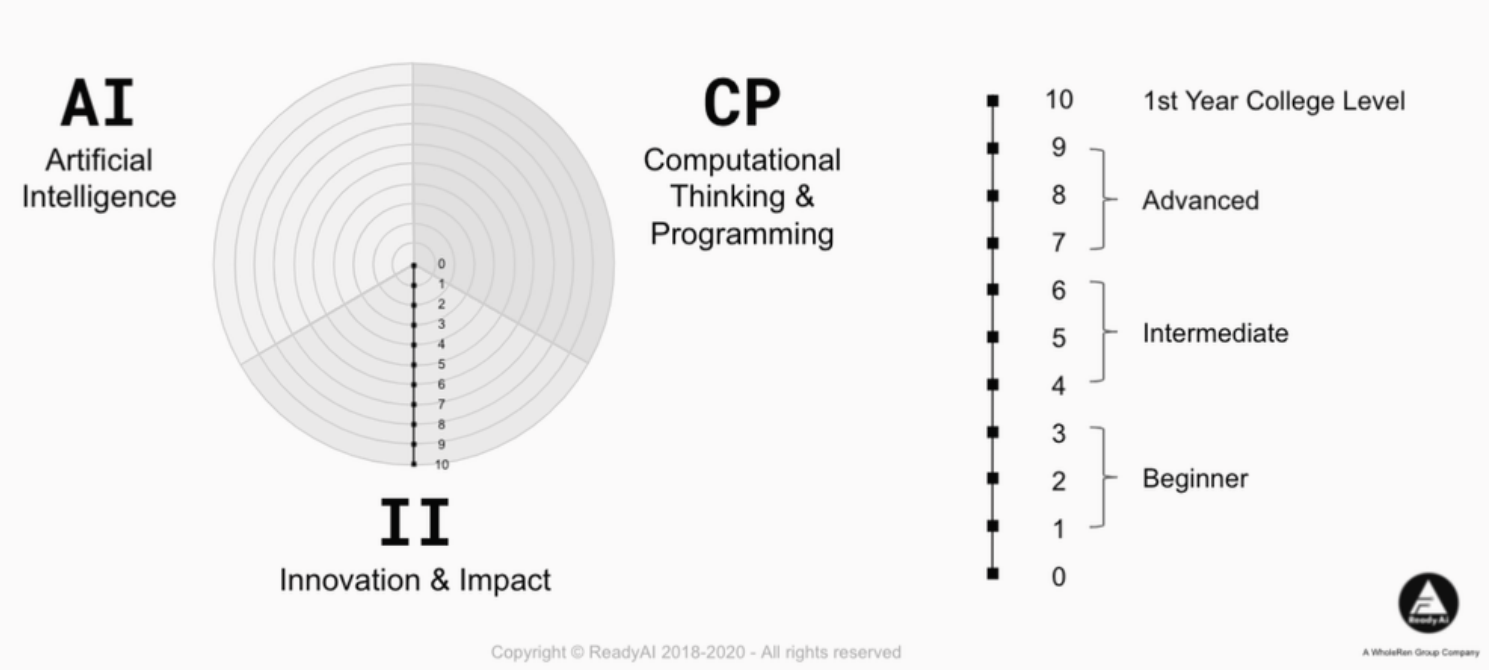

Figure 2 - Measuring AI Competency: Artificial Intelligence Concepts and Applications + Computational Thinking and Programming + Innovation & Impact of each designated age

Figure 3 - NCS Administration discusses the implementation of AI into the curriculum

The fifth hour of the Beginner AI & Calypso Curriculum presents just such a challenge. After learning about AI motion, object recognition, and object interaction, students are presented with a challenge that requires them to code the AI robot to navigate between objects and “put fires out.” Thus, students are imagining a situation where the issue of fires is addressed by AI, helping to negate the issue of putting humans at risk for fire prevention and fighting. Students have been provided the tools needed through the instruction of the coding and other practice sessions with troubleshooting, but when presented with a challenge, students are asked to apply the information they have learned and the engagement up to that point.

This example also illustrates the importance of project based learning. Students in this case are given a project to complete, that is, to turn the AI robot into a firefighting entity. This project requires students to imagine a situation where AI could be useful to human society, and then to apply their knowledge of AI to create a project that demonstrates the capacity of AI to help solve human problems. Moreover, later in the curriculum, students are given the opportunity to create their own projects, thereby identifying areas of their concern that facilitate human AI interaction and positive societal impact thanks to the development of AI.

Figure 4 - Students inquire into facial recognition using Teachable Machine

In addition to challenges, students are presented with mini-projects. These mini-projects also serve to meet the needs of learners engaged in problem based learning and project based learning. For instance, students are presented with a mini-project towards the end of the Beginner AI & Calypso Curriculum where students are, across multiple days, actively engaged in the ideation, creation, and presentation of a museum. Students identify the theme of the museum by combining their interests and the history of their culture, given that the students represent all parts of the world—from Saudi Arabia to South America to the South Pacific. Students then research pieces of art or other cultural or historical artifacts that the museum will showcase. After physically creating the museum, coding the actions of the AI robot, troubleshooting the challenges, and testing their projects, students prepare an outline and present their project. In this particular case, NCS hosted an AI night and invited parents of students engaged in the curriculum. Students then presented their projects to a large group of their peers, parents, teachers, and the broader Neom community.

In addition to embodying project based learning, this case example demonstrates problem based learning. To initiate the project, the teacher discusses challenges museums face, including the expense of hiring tour guides, the inability of humans to remember the quantity of details necessary to speak cogently on thousands of pieces of artwork and artifacts of a museum, and tracking the inventory when artwork or artifacts are rotated, an issue commonly faced by museums across the world (CITE THIS). Students propose manners that AI and AI robots could assist in addressing these problems, and they are encouraged to redress these problems within the curriculum. Moreover, students face discrete problems while coding their projects, and with the aid of a well-trained instructor, they are assisted—not told—how to overcome those problems in designing and coding their projects.

Finally, problem based learning is illustrated in the limitations of AI. The AI robot will only respond to users according to its coding. For instance, when introducing itself, if only one line of coding is provided for the AI robot, then the robot will continuously repeat that same line whenever it introduces itself. To museum guests who visit the museum several times, this may become monotonous and demonstrate how AI does not meet the goal of Big Idea #4, i.e. Natural Interaction (CITE). Thus, students are introduced to strategies to address this problem and they propose, test, and implement coding that ensures the AI robot does not seem hampered by the limitations of basic AI.

In all these facets, the curriculum written for and piloted by NCS demonstrates how the implementation of AI instruction must address a range of needs, including challenging students with problems, facilitating their generation and creation—and presentation—or projects, and foster critical thinking in line with admirable goals as articulated by the vision of Neom (CITE).

THE AI INQUIRY CURRICULUM

NCS also sought to present students with a more inquiry based curriculum of AI. Titled the "AI Inquiry Curriculum," students were introduced to a more independent presentation of AI concepts. From computer vision to AI style transfer, students inquire into the everyday uses of AI that have so surreptitiously and seamlessly integrated their way into people's everyday lives. In this series of discrete lessons, students are introduced to an example of AI in their lives. Then, they are taught to ask questions into its functionality and implications. Finally, each lesson concludes with students experimenting and inquiring into future uses and ramifications of the technology.

To use one example, the AI Inquiry Curriculum explores the use of facial recognition technology already used in Neom. Upon entering the Neom camp, users' faces are scanned by a system. At which point, they are either greeted or asked to wait for a security guard who would then check the person for identification and permission to enter the facilities. To a computer scientist, this represents obvious use of AI. However, to the general residents and visitors of Neom, this seems like just a matter of fact experience. Students, who have become so acclimated to the process that they don't question the nature of the experience, are asked in one lesson of the AI Inquiry Curriculum to describe what technology is being used. By pausing for a moment and being prompted to think about what is taking place, students recognize that technology is being implemented seamlessly into their lives.

"AI was one of the most popular programs in the ECA (Extracurricular Activity) program. Students have enjoyed learning about Cozmo and have shown interest in programming their own projects and showcasing their work to family and friends."

Ebtesam Barnawi, Science Teacher, NCS

Students then move from recognizing the everyday and even subtle uses of technology to facilitate human experience. When asked what would happen if the AI technology were not used at the entry points to Neom, students recognize long queues might develop, which in Saudi Arabia might mean residents and visitors bake in the Arabian desert sun. Students are also prompted to inquire into how the technology work, even testing similar technology using black box apps. First, students are prompted to discover the power of the technology by obfuscating part of their face. At what point does the AI system no longer recognize a person? Does it require obscuring the lower part of the face or the upper part of the face? What if only half of the face is visible? By posing such question, students are exploring the large limitations of the system. After training a system on a student's individual face, students then explore the limitations not just the computer vision and recognition tool but even machine learning and facial recognition. Students are prompted to wear glasses, hats, fake bears and mustaches, and so forth to see if the AI systems continuously recognize them first as a human being and second as the individual on which the system was trained. Finally, and true to the larger goals of project based learning, students explore how such curriculum could be used to facilitate their own lives and the discrete needs of their communities.

This example represents just one lesson of the AI Inquiry Curriculum. Future expansion of the AI Inquiry Curriculum might explore through the inquiry into chat bots; user-experience recommendations such as those demonstrated by recommended videos on YouTube, Netflix, and Spotify; and AI generation of human-like writing, such as in the form of poems.

BENEFITS OF THE AI INQUIRY CURRICULUM

AI Inquiry in the manner presented above presents many benefits. For one, the lessons are non-sequential. This tyle of curriculum presents students with opportunities to engage a variety of material, some of which will admittedly not interest them quite as much as other material. Any reasonable instructor or curriculum designer will recognize that even the best lessons only reach a majority of students, not all.

Moreover, the benefits of this curriculum include introducing students to a wide range of real life applications of AI. Because each lesson introduces students to an extant technology, students are prompted to reflect on how AI has already integrated itself into their lives. Additionally, through inquiry, students are asked to reflect how such technology is not inherently agnostic. AI is not unimpactful in human life. Every bit of AI technology comes with societal impact, and no technology is inherently beneficial nor inherently deleterious. To use the example above, facial recognition facilitates the entering of the Neom facility, speeding up entry. However, such technology also allows the camp to employ less guards. It also documents and tracks individuals' location and entry to the camp, raising questions of security and privacy.

Another interesting benefit is the flexibility this type of curriculum presents. As new technology finds its way into the marketplace and individuals' everyday lives, this approach permits lessons to be added, removed, and rethought entirely in order to present students with the most nimble and current curriculum possible. To use the example above, new examples of facial recognition apps are being introduced all the time thanks to companies across the world seeking to release the next greatest app. These can be introduced at will, without having to redesign an entire program. It also allows students to challenge technology that is marketed as that next greatest app, questioning whether it in fact is or whether it should be so universally adopted, based on its human interaction capabilities, its ability to collect users' personal data, and a cost-benefit analysis of its societal impact.

Finally, the method of inquiry into AI concepts prompts students to explore the uses of technology in a discrete manner. In other words, students are free to explore that technology for that lesson alone. Students are not necessarily required to make larger connections to other curricular concepts. Students can learn about the technology for learning about the technology's sake. This approach presents a certain freedom to explore a concept without having to explore larger connections of it, presenting a less stressful method of learning.

CHALLENGES OF THE AI INQUIRY CURRICULUM

Such an approach also presents challenges. For one, this approach presents challenges found in across extant AI lessons and curriculum (Zhou et al., 2020). When other institutions and well-meaning AI lesson designers present AI curriculum, even those with substantial repute within the field, the lessons are disconnected and do not build towards a cohesive whole. While this design process permits the aforementioned benefits, it also challenges the ability of designers to have larger objectives in a curriculum and measure whether students are meeting those objectives. When discrete lessons can only be grouped under a larger goal such as “Students will explore the use of current technology and analyze its impact,” it becomes difficult to measure whether students explored two or twenty current technologies.

Overall, when students learn about AI in isolation through a curriculum similar to the AI Inquiry one designed and implemented for Neom, their perspective and understanding of AI may be limited. They become analyzers, which is beneficial to an extent, but they do not become active creators and contributed to an AI ecosystem, where they can begin to recognize their role in designing their own AI powered future.

"After the student learned the basics of how to program Cozmo, their curiosity to move forward to the next level triggered them to develop or improve their communication skills and creativity in problem solving and debugging. Also, some of the activities we did in class helped them in recognizing some of the environmental crises and what our responsibility toward them are."

Abbas Hawsawi, Education Technology Professional, NCS

On the other hand, when paired with other curricula that introduce AI in a more sequential manner, as well as when AI is integrated in a transdisciplinary way such as what is beginning to take shape at NCS, then the benefits of exploring a broad base of technologies in the form of the AI Inquiry Curriculum become more salient. Designers of AI curricula would greatly benefit from an approach that pairs the sort of “one off” lessons currently being produced with a more serial approach that builds towards larger and measurable goals, generating nascent AI designers and thinkers equipped to shape their communities and their world with the potential AI offers.

CALYPSO-BASED LEARNING WITH AN AI ROBOT

The Calypso-based Curricula implanted said software paired with the robot Cozmo. Cozmo is an AI powered robot with the abilities to engage AI to navigate, recognize faces, recognizes objects, and interact with those objects. Thus, using Calypso, a non-sequential block based coding software, students can learn about AI and major concepts in computer science.

The Calypso-based curricula were broken into three separate nine week units consisting of one hour of material per lesson. The following provides a programmatic overview of each along with overall student learning objectives and a topical breakdown:

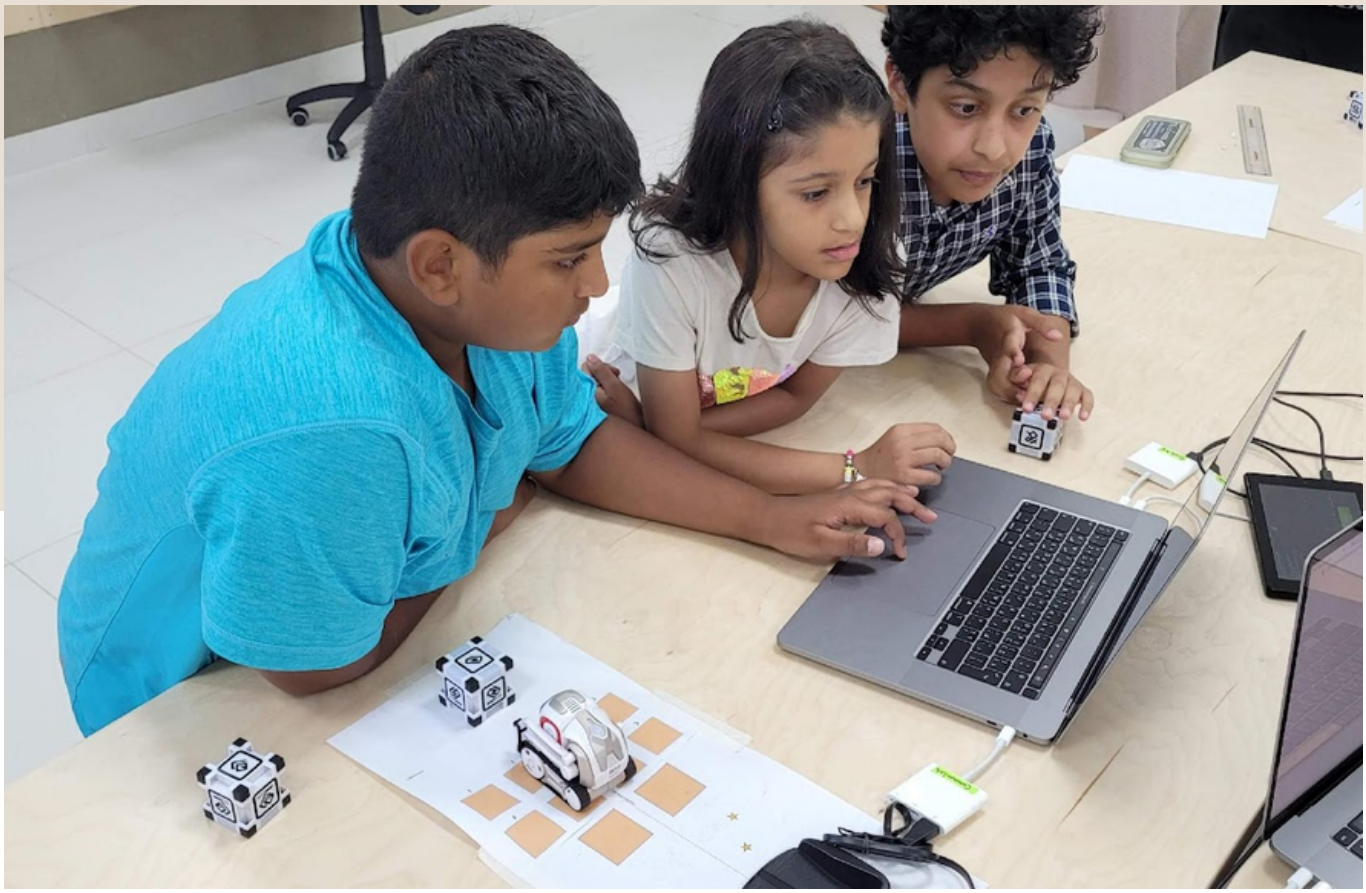

FIGURE 5 THREE STUDENTS COMPLETE THE FIRST LESSON OF THE BEGINNER AI & CALYPSO CURRICULUM

BEGINNER AI & CALYPSO CURRICULUM

In this first of three sequential programs, students are introduced to Calypso, produced by Visionary Machines, LLC., a Pittsburgh-based company founded by Professor David Touretzky, a research professor at Carnegie Mellon University. In order to understand AI and how computer science governs the actions of AI, students are introduced to the five laws of Calypso and how Cozmo interacts with the world through them and because of them. Throughout the curriculum, students will demonstrate their learning in project based exercises integrated into each lesson and culminating in a larger final project.

Student Learning Outcomes:
At the end of this curriculum, students will

- Identify the five laws of Calypso
- Compare and contrast actions based on computational thinking
- Create projects that demonstrate their understanding of the 5 Big Ideas in AI

This beginner's curriculum presents a nine lesson sequence, meant to encompass one academic term at NCS. Each lesson approximates an hour of material, allowing students to engage AI for one hour a week.

The following is a list of topics in the Beginner AI & Calypso Curriculum

01 Introduction to Cozmo and Computer Vision

02 The First Law of Calypso

03 Motion with Cozmo

04 The Second Law of Calypso

05 The Fireman Challenge - Project Based Learning Exercise

06 Multiple Actions and Conflict Resolution

07 The Third Law of Calypso

08 Dependent Actions & Rule Indentations

09 Dependent Actions & Rule Indentations

INTERMEDIATE AI & CALYPSO CURRICULUM

In the second of three sequential programs, students continue their exploration of Artificial Intelligence through Cozmo and Calypso. In this curriculum, students learn about key concepts in Artificial Intelligence and computer science more broadly, including state machines, computer logic, and human-introduced randomness. Students also complete their first major project, a Museum Challenge, where students are asked to program Cozmo to navigate around a museum of students' creation, showcasing the artwork and interacting with visiting patrons. This final project allows students to connect their own discrete cultures and interests with the functionality and artificial intelligence that Calypso and Cozmo permit students to engage.

Student Learning Outcomes:
At the end of this curriculum, students will

- Explain the function and use of state machines
- Distinguish between AI actions that use the "Not" function and other forms of logic
- Create and present a project that combines the beginning and intermediate functions of Calypso and Cozmo.

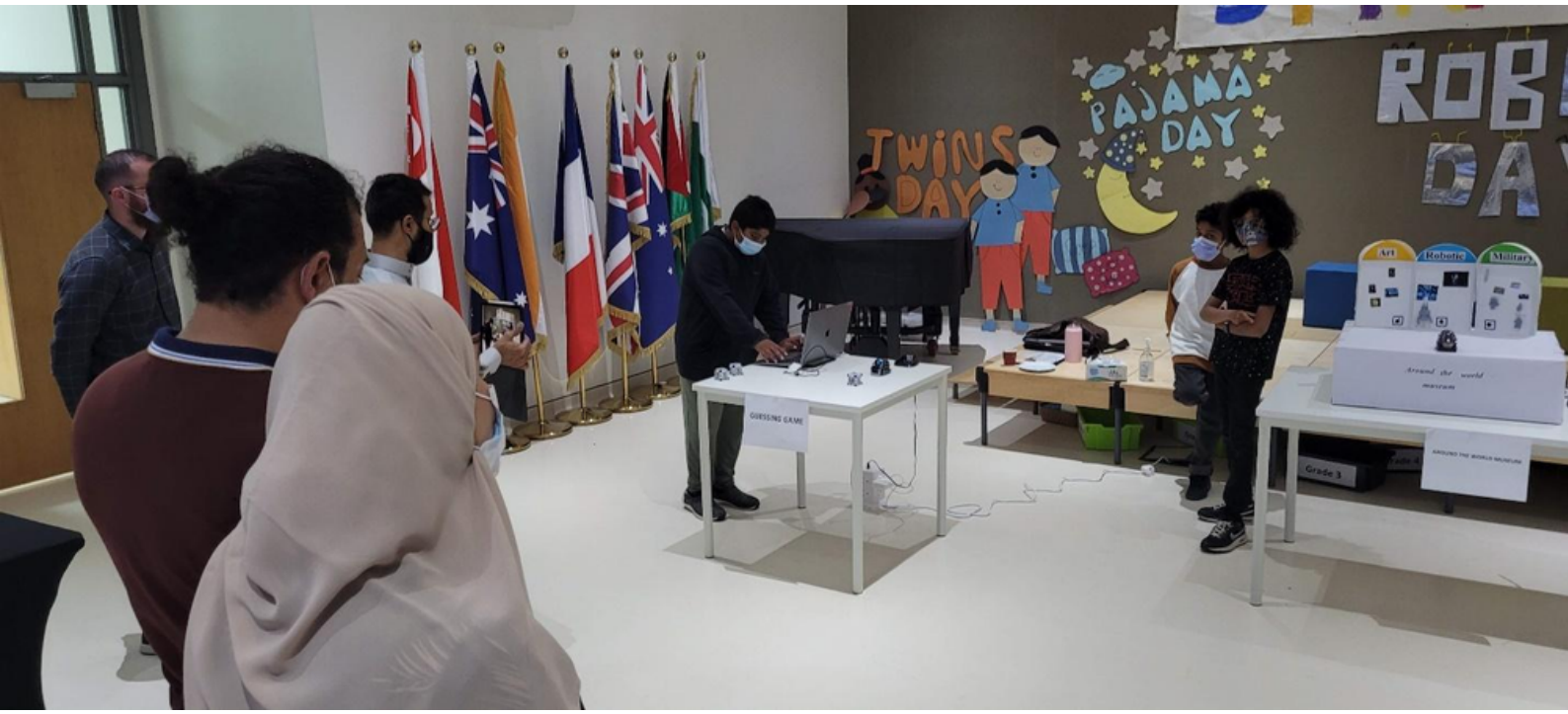

FIGURE 7 - A STUDENT SHOWCASES HIS PROJECT IDEATED FROM THE INTERMEDIATE AI & CALYPSO CURRICULUM IN FRONT OF HIS PEERS, PARENTS, AND TEACHERS.

This intermediate curriculum presents a nine lesson sequence, meant to encompass one academic term at NCS. Each lesson approximates an hour of material, allowing students to engage AI for one hour a week.

*FIGURE SEQ FIGURE * ARABIC 6 - STUDENTS MEASURE OUT THE DISTANCE OF COZMO'S VISION WHILE BUILDING THEIR MUSEUM PROJECTS*

The following is a list of topics in the Intermediate AI & Calypso Curriculum

01 State Machines - Unplugged

02 State Machines & Dialogs, Timers, and Conditions

03 Multiple Characters in Programming

04 Negation & Introduction to Logic in Computer Science

05 The Museum Challenge - Part I

06 The Museum Challenge - Part II

07 The Museum Challenge - Part III & Presentations

08 Randomness in Calypso

09 Calypso and Audio Importations

- Audio editing with QuickTime Player: https://youtu.be/yRvBOWXpObE
- Audio editing with VoiceMemo: https://support.apple.com/guide/voice-memos/edit-vmac7e39c22e/2.0/mac/10.1

ADVANCED AI & CALYPSO CURRICULUM

In the final of three sequential programs, students focus their learning through PBL (Project Based Learning). They will complete several projects and learn about the highest order functionality in Calypso, including Teachable Machine and the use of walls. They will complete their learning about Cozmo through a curricular capstone project.

Student Learning Outcomes:
At the end of this curriculum, students will

- Demonstrate their ability to build rooms and walls in Calypso
- Ideate a major Capstone Project
- Create, Troubleshoot, and Present their final Capstone Project

The following is a list of topics in the Advanced AI & Calypso Curriculum

01 Building Cozmo's Shack

02 Working with Walls and Rooms

03 Custom Map Layouts

04 Cozmo - The Home Aide Challenge

05 Teachable Machine and Calypso

06 Dogs vs. Rhinos – Differentiating Using a Visual Classifier and Cozmo

07 Calypso Curriculum Capstone I

08 Calypso Curriculum Capstone II

09 Calypso Curriculum Capstone III & Presentations

Calypso programming presents students with unique challenges. Coding must be accurate and respect the laws of Calypso that govern Cozmo's thinking. Students are taught, like with any programming language, the need to troubleshoot and identify problems. Moreover, because of the nature of using Cozmo, students then get to see the problems in real life. Whereas perhaps a Scratch or Python program won't run, Cozmo himself may begin to act erratically or the visible actions are counter to what was expected in the coding, presenting unique challenges but also unique avenues, compared to most coding curricula, to experience a true problem-based curriculum.

Additionally, because of Calypso and the real life manipulation of an AI powered robot, students can devise, create, code, and present real life projects. From teaching Cozmo to navigate from cube to cube, putting out 'fires' as signified by glowing cubes, to having Cozmo navigate around a set representing a museum, a home, a hospital or anywhere else students can ideate AI having an impact on humans, students are placed in the driver's seat of their learning. Students may at times be given a project to complete, or they may be tasked with an idea to bring to life. The Advanced Curriculum mentioned above closes the three semester unit on a capstone project that students must bring to life from beginning to end.

IB CURRICULUM & UNITS OF INQUIRY

The final curriculum designed for NCS represents arguably the most novel and innovative way of approaching AI instruction. While the previous curricula focus on AI as a discrete concept, the approach piloted at NCS represents both an interdisciplinary and transdisciplinary method of teaching AI. In this way, AI is not simply taught as its own concept. True, this is vital—students should recognize the ways AI is changing their world and the ethical questions this raises. However, by surreptitiously integrating AI into a broader curriculum driven by inquiry, students are introduced both to the subtle ways AI is changing their world but also how it is empowering designers, thinkers, educators, scientists, healthcare professionals, and just about every other field.

The following provides the curricular overview as well as the student learning outcomes and a topical list of lessons tied to individual grade-appropriate units of inquiry at NCS.

UNITS OF INQUIRY AND AI (GRADES K-8)

In this series of non-sequential lessons, students of varying ages can be exposed to various AI tools that allow them to explore not just AI but also their homerooms' units of inquiry. Through these lessons, students of varying levels can begin to explore major concepts in AI and its relevance to their bodies and their world.

Student Learning Outcomes:
At the end of this curriculum, students will

- Explain how AI functions relative to the subject being discussed in the class
- Demonstrate proficiency in AI skills
- Engage AI apps that illustrate concepts in their homeroom Units of Inquiry

The following is a list of topics in the Units of Inquiry and AI Curriculum

01 Kindergarten - Introduction to Neural Networks & Quick, Draw!

02 Grade 1 - AI and Emotional Recognition

03 Grade 2 - Pattern Recognition & Quick, Draw!

04 Grade 3 - AI, Emotional Recognition, and Effective Marketing

05 Grade 4 - AI & Your Body: An Inquiry through Radiology

06 Grade 5 - AI & Invasive Species

07 Grade 5 - AI & Invasive Species

08 Grades 7-8 - Hybrid Cars and AI Systems Integration

To be sure, students are learning about AI in an interdisciplinary way. For instance, as the lessons above evidence, young students engage AI in the context of learning about human emotions and interaction with one another. Thus, in a Unit of Inquiry seeking to offer lines of questioning related to the larger question of "How We Express Ourselves," students explore such answers but also explore AI in their attempts to grapple with answers.

Figure 11 - A student shows off his completion of a Google Quick, Draw! exercise.

Similarly, in later grades, students explore invasive species as part of a subunit on biomes within the larger Unit of Inquiry titled "Sharing the Planet." Again, through their study of interdisciplinary AI, students learn how AI is helping ecologists and other scientists to more quickly identify invasive species. Building on what AI is doing already in their world, students build a classifier and train it on images of various invasive life forms as well as native life forms. Students them prompt one another and their use of AI by testing the machine learning systems they created in order to see whether or not these systems are accurate in their classifications of invasive species.

AI instruction in this way, however, transcends mere interdisciplinary teaching. The concept of interdisciplinary education requires combining the learning about multiple concepts into a lesson or a series of lessons. Thus, in the aforementioned example, students are learning two disciplines through their study of AI and ecology. However, the model of AI education piloted by NCS and rooted in the International Baccalaureate® (IB) Program is transdisciplinary. Transdisciplinary suggests not just the combination of two disciplines but efforts that move beyond discipline specific solutions. In other words, an ecological problem does not need to remain solely an ecological problem. Problems in ecology did not arise solely thanks to a lack of ecology. Rather, industry, petroleum products, international trade, and a host of other disciplines contributed to the extant issues at hand. Because the problems did not develop in a vacuum, neither can the solutions. Researchers representing the wide spectrum of human abilities and intellectual pursuits can combine their skills and understanding to solve problems unsolvable solely by the discipline in question.

Transdisciplinary AI education intimates also employing a collaboration between instructors, where AI is taught not only by the AI or computer science teacher. Homeroom teachers responsible for teaching the broad base of academic skills must have a stake in their students learning about AI. When collaboration across teachers of different disciplines takes place, students remark on the ubiquity of the subject as well as how discussion of it pervades all the subjects about which they are learning. In other words, interdisciplinary sees math as math, language arts as language arts, AI as AI. At times, these can be paired. Transdisciplinary ceases the siloing of education and foregrounds the learner and the world around that person, a world that doesn't draw clear distinctions between academic subjects. Such must be the method of AI instruction as it has been for a year now at the Neom Community School.

Figure 12 - Grade six students explore Teachable Machine to help identify invasive species

CONCLUSION

Having produced an AI-centric curricula customized to the specific needs of Neom Community School in the context of the 2021-2022 academic year cycle, students at NCS were far more prepared for the challenges they will face in the future.

ReadyAI recommends that NCS builds on the successes of the 2021-2022 year through the creation of a vertically and horizontally-articulated K-8 computer science curriculum aligned with International Baccalaureate and its units of inquiry. Aligned to the IB program with its units of inquiry and fully integrating interdisciplinary assessments to reinforce IB practices and dispositions, and the curriculum will expand the hours of direct instruction while deepening engagement with artificial intelligence as well as more broad computer science concepts not formally instructed or assessed during the 2021-2022 year. As suggested by the Crown Prince, Mohammed bin Salman, we exist in a world that has provided ample reason to "think and work hard to take advantage of artificial intelligence and unleash its full potential to advance our societies and economies." This curricula as well as what will be produced for the 2022-2023 will make critical steps towards more fully realizing the goals articulated in Vision 2030 with specific emphasis on Neom's place as "an accelerator of human progress."

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