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Narrative Integrated Career Exploration Platform

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Career and technical education play a significant role in reducing high school and college dropouts as well providing necessary skills and opportunities to make suitable career decisions. The recent technological advances have benefited the education sector tremendously with the introduction of exciting innovations including virtual and augmented reality. The benefits of NL and game-based learning are well-established in the literature. However, their implementation has been limited to the education sector. In this research, the design and implementation of a Narrative Integrated Career Exploration (NICE) platform is discussed. The platform contains four playable tracks allowing students to explore careers in artificial intelligence, cybersecurity, internet of things, and electronics. The tracks are carefully designed with narrative problem-solving reflecting contemporary real-world challenges. To evaluate the perceived usefulness of the platform, a case study involving university students was performed. The results clearly reflect students' interest in narrative and game-based career exploration approaches.

Keywords: narrative-centered learning, vocational education, e-learning, game-based learning, education

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INTRODUCTION

Narrative-centered Learning (NL) can be utilized to provide interactive and personalized form of content to students. In contrast to the traditional form of content delivery which are static and methodical in nature, NL exploits the key aspects from both gaming and storytelling that naturally engages the human brain. The dramatic growth of the video game industry, which generates three times more revenue than the film industry (Taylor, 2017), has shifted the focus of researchers into utilizing video gaming concepts to student learning curriculums (Eseryel et al., 2014; Shute et al., 2015). The vast advancement in technology has enabled video games to reach an unprecedented level of mainstream popularity. Particularly, due to better computer hardware and graphics, video gaming has been more realistic and complete. Virtual Reality (VR) technology is set to become the next great tool in video gaming and earlier research have shown promising results in implementing VR in education (Guazzaroni and Pillai, 2019; Zhang et al., 2020). Similarly, storytelling is effective for content delivery because it engages the emotional side of the brain. Using narratives, the students can learn to connect different concepts easily. Stories also have a lasting impact and as a result helps the students to remember the concepts for long time. Unlike video gaming research which has been emerging more recently, research into storytelling for education can be dated back to the 1980s (Farnsworth, 1981) with numerous works in the 1990s showing the positive impact of storytelling in classrooms (Mason, 1996). Research in the field of storytelling for learning is still active with the term "digital storytelling" finding its popularity. Digital storytelling utilizes

computer program to combine various digital media including text, images, audio narration, and video to convey a particular concept with the art of storytelling (Robin, 2016). However, simply assimilating gaming and storytelling would not be complex enough to deliver educational content or experiences. Consequently, researchers have looked into implementing the narratives in a virtual learning environment by utilizing Narrative intelligence which enables a human or a computer to organize experience into narrative (Riedl and Young, 2006). This approach often uses Narrative generation to dynamically generate stories that can be tailored to the user's taste and ability, providing almost an infinite outcomes and possibilities. A multitude of research work have applied this approach of NL in various domain, including microbiology (Rowe et al., 2009), mathematics (Rodrigues et al., 2017), negotiation training (Kim Hill et al., 2009), and language learning (Lewis, 2010).

Narrative-centered learning has the ability to integrate digital elements like interactivity, rewards, and feedback in compelling stories. This unified digital approach comprising of gaming and storytelling can engage young minds more effectively than traditional forms of knowledge delivery which are static and methodical in nature. Much of the existing research in this area focuses on improving academic learning outcomes and increasing student motivation levels in school environments. The increasing digitization of learning systems and the rise of flexible or work-from-home careers signifies the need for educational systems that integrate aspects of vocation and profession into the knowledge acquisition phase. This process will aid in preparing students with a greater sense of career readiness and cultivate practical hands-on skills before entering the industry or progressing in academia.

In this work, we propose an interactive career exploration platform that blends learning outcomes and connects them to real world careers using a narrative learning approach. A system with interactive module that allows for live decision making, as well as provides narrative real-world problem solving is designed and tested. The platform can assist students in developing a better understanding of the career they want to pursue, thereby increasing their overall career awareness, confidence in decision making and readiness for the future.

Related Works

Rowe et al. (2011) developed an game-based learning environment to study the impacts of NL on eighth grade students. Prior to playing the game, the students took a pretest. The learning environment was built on a 3D game engine using an United States state curriculum for eight-grade microbiology with the objective of supplementing regular classroom instruction. The game posed various problem-solving challenges to enhance their learning and another test was taken after playing the game. The comparison between the test scores showed that students who scored higher during the pretest displayed greater engagement with the NL environment. Another interesting finding is that both gamers and non-gamers achieved improved learning outcomes. In Min et al. (2017), the authors developed a game-based learning platform named *Engage* to introduce computational thinking to middle school students. The curriculum for the NL environment was developed around the Computer Science principles course learning objectives for United States middle school students. A popular Machine Learning (ML) algorithm known as Long Short-Term Memory Networks (LSTMs) (Hochreiter and Schmidhuber, 1997) was developed to assess the performance of the students. The LSTM-based assessment framework infers students' post-competencies by using as an input the environment interaction data and pre-learning assessments. This method works better because it is more scalable unlike traditional methods which are built around hand-authored rules and statistical models. The results show that LSTM-based model outperformed the previous state-of-the-art approach in providing more accurate predictions of students' post-competencies. The authors in Emihovich et al. (2020) attempted to find the impacts of video gameplay on students' problem-solving skills. Undergraduate students were required to play either a roleplaying game or a brain-training game. The students were assessed on their problem-solving skills 20 h before and after playing the game using the Tower of Hanoi and the Programme for International Student Assessment (PISA) problem solving tests. The authors concluded that there was no significant difference between the results of both the groups on either problem. In other words, playing video game did not enhance the students' problem-solving ability but at the same time did not diminish their ability according to this work. A literature survey between 2008 and 2018 containing 20 empirical studies highlighted that 45% of the studies concluded to positive relationship between engagement and learning using game-based applications whereas 20% highlighted mixed findings (Shu and Liu, 2019). Another study of 273 trainees was conducted to investigate the impacts of gamified content on learning outcomes by assessing a text-based training against text-based training enhanced using game fiction (Armstrong and Landers, 2017). The results indicate that gamified content was more satisfactory to the subjects compared to plain content, although they did not find any significant change in declarative knowledge (i.e., facts). Another interesting conclusion was that the non-gaming group performed better at procedural knowledge (i.e., specific skill or task). This demonstrates that gamified content improved engagement but at some cost of effectiveness. A game-based learning environment was proposed in Sung and Hwang (2013) for students to share what they have learned during the game-playing process and determine the impacts of such applications on elementary school students. The role-playing game presents a narrative of an ancient kingdom where people are infected by poisoned river water and the character studies ancient medical books to find out the cure. Besides improving the learning attitudes and motivation of students, it also enhanced their learning achievement and self-belief that can be credited to the knowledge organizing and sharing facility of the gaming environment.

Implications to Career and Technical Education

Career and technical education (CTE) can be defined as "an educational strategy for providing young people with the

academic, technical, and employability skills and knowledge to pursue post-secondary training or higher education and enter a career field prepared for ongoing learning" (Brand et al., 2013). Instead of educating students about a limited set of skills needed for entry-level jobs, CTE focuses on preparing students for a career. Study shows CTE programs to be effective in reducing dropout rates, providing certifications that are recognized by the industry, encouraging post-secondary education admission, and allowing students to earn dual enrollment credits (Plank et al., 2005). According to Russell and White (2020), more than 70% of parents believed that CTE programs were beneficial in engaging students and were good for their child and more than 85% of business leaders believed CTE programs teach students transferrable skills that can benefit them in this economy. Despite the great benefits that CTE brings, there is an opportunity for technology to enhance the programs. According to McComb-Beverage (2012), students as young as 11 years old are able to actively engage in career development process by using career exploration activities. However, using traditional CTE approaches, career exploration is limited project-based learning and engagement with industry professionals (Castellano et al., 2014). These approaches provide limited exposure to students due to practical and resource limitations. For instance, a student interested in a lot of different careers will probably fail to explore them all through traditional approaches. This is where latest technology, NL-based gamified learning, can provide a groundbreaking career exploration platform. Using such an approach would not only allow students to explore all possible careers they are interested in, but also learn about the necessary skills associated with a career. Technology has already been shown to be effective in career guidance. According to Falco and Steen (2018), "computer-assisted career counseling, or career development activities that incorporate technology, appear to support retention, and academic achievement." A playable case study where students can act out a virtual internship and learn cybersecurity skills showed that using such experiential career exploration can allow students to make a better decision whether or not to pursue a career, understand the skills and trait needed for a career and increase their confidence to succeed in a specific career (Giboney et al., 2019). The proposed framework aims to provide students with a "week-in-the-life" simulated experience of a cybersecurity professional where the character is hired for a company called Cybermatics and has to solve intriguing problems as part of a storyline (Giboney et al., 2021). A comprehensive platform that can integrate the various career clusters (States Career Clusters, 2007) into a NL-based application has the potential to revolutionize career exploration and guidance. The impacts of VR on career education programs was explored by Kim and Lee (2021) on third grade students. The VR-based career education program demonstrated a high level of satisfaction and interest among students and had a positive effect on the student's perception of career. Similarly, Acosta et al. (2019) highlighted that augmented reality applications increased students' attention, relevance, confidence, and satisfaction in vocational education programs. These studies further signify a need for engaging technology in advancing CTE programs.

Based on the existing works in the literature, the significance of NL as well as game-based learning is well-established. Although they have been very effective in improving education, there currently exists no implementation of a system that can integrate NL-based gamified learning to provide a career exploration platform. Therefore, this manuscript presents a novel design, implementation, and testing of Narrative Integrated Career Exploration (NICE) platform utilizing NL and game-based learning. Following are the key contributions of this work:

1. It highlights the recent progress in narrative and discusses the immense potential of gamified and narrative learning for advancing CTE.
2. It proposes a design and experimental implementation of a novel NICE platform to facilitate career aptitude and exploration.
3. It performs a case study to assess the proposed platform and quantifies the satisfaction levels of students with such platforms and discusses future research directions.

MATERIALS AND METHODS

Narrative Integrated Career Exploration Overview

At the initial stage of development, a total of four playable career exploration tracks were deployed. Each track represents an emerging technology with projected significance in global industry and academia (Leoste et al., 2021). The tracks focus on applications of artificial intelligence, cybersecurity, internet-of-things, and electronic design. Each track session lasts an average of 15 min, and presents introductory concepts taught at the first-year level within ABET-accredited university courses. The hands-on experiments are designed based on engineering projects carried out in domain-specific industry internships, and graduate research projects at the American University of Sharjah (Cse Portal, 2021). Specifically, the theoretical content for each of the tracks were derived from the initial lecture material and companion laboratory assignments belonging to the following taught courses with their respective catalog codes offered at the American University of Sharjah: Artificial Intelligence (CMP433), Cybersecurity (COE444), Embedded Systems (COE410), and Electronic Circuits (ELE241). A detailed coverage of the material will be provided when each track is discussed.

The NICE framework incorporates certain aspects of gamification including the completion of discreet evolving tasks with attainable rewards (scores, unlocks, profile evaluation), immediate and delayed feedback for player selections, and permissible failure with the opportunity to reframe mistakes (McGonigal, 2011; Jordan Anstead, 2016).

Each track has the following elements as part of the student's user journey while navigating the platform:

i) A narrative framing a real-life application of the concept.
ii) Decision points integrating psychometric attributes in vocational questionnaires.

iii) Assessment points that serve to periodically reinforce the theoretical foundations by promoting active recall.
iv) Progress tracking and game-like incentives for engaged and successful completion of tasks.

For the psychometric attribute tracking, the traits are borrowed from the big five personality traits theory (Goldberg, 1993). As the traits are widely accepted in the research community as an initial screening for personality inclinations, this serves as a viable candidate for the scope of this project. The big five personality traits consist of openness, conscientiousness, extroversion, agreeableness, and neuroticism. Each of the five traits have sub-traits, which is reported in Nießen et al. (2020), for a total of thirty traits. These traits will be utilized for personalization of tracks, suggestions for improvement, and offering individualized avenues for decision making within the platform tracks.

To represent these traits, consider a set of $N = \{i_0 \dots i_{29}\}$ elements, where the $i - th$ element corresponds to the i^{th} trait as enumerated in **Supplementary Table 1**. The real number values between −1 and +1 determines the quantitative extent of a trait. Hence, if a person is extremely "dutiful" ($i = 8$ as shown in **Supplementary Table 1**), then the eighth element of their vector will be +1, whereas if they are moderately non-dutiful, then it would be −0.5. Note that if a trait is not relevant to a decision, it gets a score close to zero, whereas positively correlated traits are scored close to +1, and negatively correlated are scored close to −1. Consider a student exhibiting no discernable personality traits, their set representation would be a set of all zeroes. Consider a student who is NOT open ($i_0 \dots i_5$), but VERY conscientiousness ($i_6 \dots i_{11}$), their trait representation would quantitatively be for example, *{−0.9, −0.8, −1, 0.95, −0.9, −1, +0.9, +0.8, +0.7, +0.6, +1, +0.8, 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0}.*

Each choice for a decision point will have an associated 30-element set with predefined range of scores. If a user makes a certain choice, the associated array is added to their score. Thus, if they make five consecutive choices where the "trust" characteristic (trait $i = 18$) is +1, then the 18th element of their overall score would be +5, indicating that they are trustworthy. Note that we sum the arrays over all their decision choices. Therefore, if students select something that represents "warmth" in their first decision point but select something completely opposite in the next decision point, the scores will cancel out, and their overall "warmth" score would be approximately zero. As the students make more decisions and complete more tracks, their effective "personality" will ideally converge to a representation with minimal variance. The personality scores are intended to provide users with a meaningful guide to ultimately select their career and education paths that suits their overall personality. For instance, a user with an extremely introverted personality may not find careers such as event planner and human resources manager suitable.

Narrative Integrated Career Exploration Implementation

The NICE platform includes a user-friendly Graphical User Interface (GUI) offering several main features to students including playable career exploration tracks and tools for supporting career decision making. **Figure 1** presents an overview of the NICE system architecture and highlights its main components. A three-tier architecture is followed as per the modular client-server standards (Ramirez, 2000), comprising of a presentation layer (website page), an application layer (user tracking and decision making), and a data layer (databases and management). The architecture and programmatic flow are also displayed in **Figure 1**.

To elucidate the functioning of the platform, two sample scenarios are provided. In the first scenario, students access their profiles through the front-end web page using their credentials. Once they open a track, the narrative and visualization module are initiated by retrieving files from the database module. The narrative and visualization module continues to interact with the decision-making module to update the overall progress of the students on the student profile module. After students complete a track, their status is saved in the database module. Consequently, the email module is triggered to send a summary of their results, scores, and progress to their registered email address. In the second scenario, a teachers access their profiles through the front-end web page with their credentials. As an administrative user, the teachers can add, delete, and modify student information through the admin module. Moreover, they can contribute by introducing additional tracks with narratives, decisions, and concepts to the database module.

Learning is the process for acquisition of relevant knowledge or skills, and assessment is a way to observe the performance and generate insights about the learning of the individual. von Davier et al. (2019) proposes navigation as a critical component in the learning-assessment loop. Navigation is defined as the ability to find a path from one's current state to a goal state, and includes the utilization of social emotional learning skills, decision making skills, in conjunction with academic skills. Bobek 2017 states that understanding one's abilities, knowledge gained from education/work, exploration of goals, and management of college/job search actions are key dimensions for effective career planning. As such to generate reliable holistic insights along both the learning and social dimensions, it was imperative to introduce the traits and sub-traits outlined in **Supplementary Table 1**.

Within the decision making module, the decision points are application-based, assessment-based or behavior-based. In the former case, the student is prompted to make an estimated guess about what course of action is needed in a narrative scenario. For instance, in the AI track, the student is asked if they wish to consider a data pre-processing technique (missing value imputation, listwise deletion, feature scaling, etc.) before using machine learning algorithm. The expectation is that the student can piece together an appropriate solution given only basic information, such as the nature of the dataset, definitions of the feature-values, method of its acquisition, and purpose of the task. In the assessment-based decision point case, the student is required to select one/or more relevant answers to a multiple-choice question or perform the cloze procedure to proceed. The question itself is rooted in fundamental concepts and examines the pre-existing knowledge of the student. For instance, in

the electrical track, the student is prompted to solve a basic circuit analysis question by leveraging Ohm's law/Kirchhoff's law. Finally, the behavior-based decision case contributes toward the formulation of the individualized psychometric attribute tracking matrix. For instance, in the cybersecurity track, the culprit character that is caught by playing through the track and solving the application and assessment decisions is revealed to be a friend of the student's character. The student is then presented with a decision wherein they would have to evaluate their mutual history, character motivations, and severity of the hacking offense to choose whether to report the culprit, join the culprit, or condone the culprit. This branching narrative stemming from the player's decisions is purported to be confer a notion of completeness to the experience of the student. Each behavioral decision has certain values associated with it in terms of the sub-traits it addresses. It is worth mentioning that the values are not objectively set, but rather relative in the sense that certain decisions are evident of openness, while others are definitively indicative of neuroticism. In the case of complex decisions, the values for each trait are selected such that their combination sums to 1 (the maximum for any single trait), and the individual traits are assigned values relative to its saliency as compared to the other traits.

Furthermore, the three types of decision points bring three different advantages to the student experience on the platform. Application-based decisions can possibly trigger the hypercorrection effect, which is the phenomenon leading to errors committed with high confidence having greater recall when the true answers are revealed in a delayed manner (Butterfield and Metcalfe, 2001). Assessment-based decisions reinforce learning by utilizing the testing effect prevalent in traditional effective learning methodologies. It is theorized that the inclusion of a spaced repetition algorithm that can bring back certain questions in the assessment-based decisions can improve learning outcomes in the long run as well, but this has not implemented in this iteration (Greving and Richter, 2018). Behavior-based decisions are utilized to garner insights (albeit naively at the current state of the platform) about the psychological make-up pertaining to the student based on their interactions in the story narratives (Tamborini et al., 2018). All the technical questions are based on the quiz and exam material used by the lecturers belonging to their respective taught courses. The behavior decisions are drafted with the aid of a psychologist and career counselor from the American University of Sharjah.

In the narrative and visualization module, the narrative situations are simplistic at the current stage, and have a similar flow as the structure outlined below:

- Student joins a new company or is called to respond to an emergency.
- Supervisor assigns student a task or student is supposed to resolve the emergency.
- Student navigates through the track through a series of decisions (application, assessment, and behavioral) which engages critical thinking, active recall, and personal intuitions.
- Student is presented with the organic conclusion of the current self-contained track with new tracks unlocked based on their performance and decisions in the current track.

The narratives are manually written by the authors, and the branching decision points are inspired by both fictional accounts and real-life industry experiences.

The AI, IoT, and electronic tracks have two characters, with the exception of the cybersecurity track where there are three characters. Each character sprite is animated with five basic emotions: joy, fear, sadness, disgust, and anger. Sentiment analysis of the description/dialogue in a single instance (small part of the full track) using the *Valence Aware Dictionary and sentiment Reasoner (VADER)* (Hutto and Gilbert, 2014) *approach* to attune a character(s) with a respective emotion and then render the particular spite on screen.

One of the future goals is to automate the narrative creation process in favor of random generation, with considerations of consistency with the track theme, similarity to existing stories, and comprehensibility in terms of logical flow. Open-source variants of GPT-3 can be made to artificially generate semi-realistic story scenarios wherein the decision points can be integrated through conditional training on the lecture material. However, the nature of the data available for this process would be a considerable bottleneck for the quality of the generated narratives, which brings to light the laborious

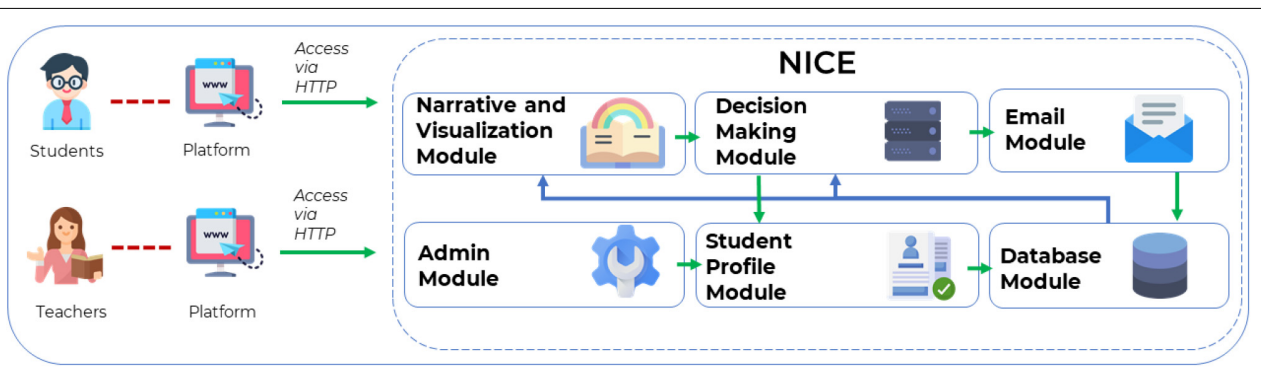

FIGURE 1 | Narrative Integrated Career Exploration (NICE) platform architecture.

alternative of university-level volunteer crowdsourcing for internship experiences and short fiction.

Implementation

The proposed framework was implemented on a workstation with Windows OS, an AMD Processor with 3.1 GHz speed (Ryzen9-5900HX) and 16 GB of RAM. The Python (3.8) programming language was used for developing a Node + Express server to support the proposed framework. The cloud-based Google Firestore was used as the NoSQL database. The admin, email, and database modules are purely auxiliary implementation tools in the NICE framework. Google OAuth 2.0 login was employed to enable authentication. The user-interface of the platform was designed using the Ionic (3.0) and Angular 2 frameworks. The ngrok service was used to expose the running server to be accessed over the internet, and the waitress package allowed for production-level concurrency. The animated characters and effects were purchased from artists through creative art website dribble.io. Admin level users, such as instructors can create quizzes (decision points), write narrative scenarios, and order the track elements, select the branches for each decision, and choose an available character template. The VADER tool helps in selecting the right character-emotion pair, per story. The specified information is pushed to the database and is realized on the front-end of the platform. The student's login to the platform, select a track from the homepage, and follow its course.

Narrative Integrated Career Exploration Platform Evaluation

After the design of NICE platform, it was important to perform a real-life case study to determine the overall effectiveness of the application. In the first phase of testing, university students from various parts of the globe were invited to use the platform. Initial comments from the students were considered to improve the user interface, and narrative presentation of the platform. The next phase of testing planned would involve integrating the proposed application to high school and first year university CTE courses.

To empirically validate the interest and applicability of the platform with students, a case study incorporating the five-item Likert scale was designed. A Likert scale is a psychometric response scale to measure respondent agreement with the different statements probed (Likert, 1932). In this study, the available options on the Likert scale were (1) Strongly Disagree; (2) Disagree; (3) Neither Agree nor Disagree; (4) Agree; (5) Strong Agree.

RESULTS

Narrative Integrated Career Exploration Tracks

During the initial phase of development, four comprehensive career exploration tracks were deployed and tested. The tracks are accessible online using the following webpage.[1] The implementation descriptions for each track are presented next.

Track A

In the narrative background of the artificial intelligence track, a healthcare facility needs to increase its patient screening rate for detecting COVID-19. As the physicians are burdened by the rising number of cases, the student in the role of a data scientist and an epidemiologist teams up to employ computer vision for the automated detection of infections in lungs using patient Computed Tomography (CT) scans, as displayed in the left of **Figure 2**. The objective of this track is to confer the understanding of an artificial intelligence development pipeline, and the rationale behind the selection of the various steps involved in data collection and artificial intelligence model deployment. The student can select one or more relevant steps in the process, and based on their selection, their developed model reports a certain performance measured by the diagnostic metrics of accuracy, sensitivity, and specificity, as shown in the right of **Figure 2**. The additional terminologies are slowly revealed to the student over the entire length of the track. The motivation behind this track is to expose interested users to the emerging field of artificial intelligence and its application to the ongoing COVID-19 crisis.

This track introduces the concepts of supervised computer vision, model evaluation, and data preparation. The main challenge is the track involves the student using knowledge conveyed about a medical condition, to set up an effective COVID-19 screening machine learning model. The student can select a lung CT scan dataset with different stratifications of patient demographics and observe the effect of model selection on final performance scores. The impact of removing redundant variables or missing values will be observed by the student at

[1] https://odysy-ai.web.app/

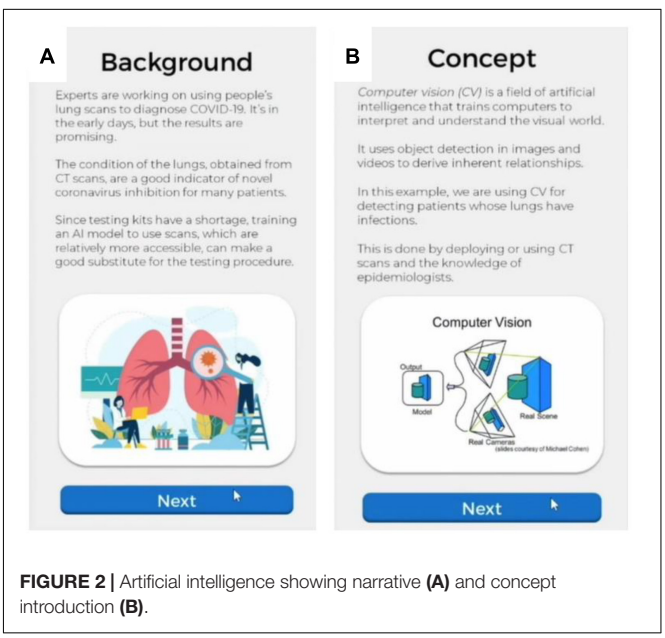

FIGURE 2 | Artificial intelligence showing narrative **(A)** and concept introduction **(B)**.

the end of the track only. The model evaluation criteria of sensitivity, specificity, positive predictive value, and negative predictive value are presented, and why they matter when making clinical decisions with certain models in terms of false positives, false negatives, and bias. Note that the students do not actually perform the live training of models in the track, but the tracks do indeed reflect actual training results conducted with regards to various research projects at the American University of Sharjah. Elements from the online data science training platform Kaggle (2022) were utilized as well, in order to better represent the nature of the challenge.

Track B

In the narrative background of the cybersecurity track, a computer in a business-critical location has been breached, and the student has to make the right decisions (technical and logistical) to circumvent the systems and make it secure again. The track is interspersed with story elements (sporadically offering hints) as shown in left of **Figure 3**. Moreover, decision or assessment points that test the understanding of the cybersecurity concepts or underlying basic networking and computing fundamentals are also part of the track, as shown in right of **Supplementary Figure 2**.

This track introduces the concepts of cybersecurity compliance, network protocols, terminal commands, and penetration testing tools on both Windows and UNIX systems. The main challenge is the track involves the student using knowledge conveyed about Common Vulnerabilities and Exposures, to examine system vulnerabilities and trace a hacker's identity by surveying IP addresses, MAC addresses, trojan viruses, and Operating System specific information. The student uses network mapping tools to find open ports, ping scan technique to find active computers connected their system and performs a basic patch for a vulnerability. Elements from the online cybersecurity training platform (TryHackMe, 2018) were utilized as well, in order to better represent the nature of the challenge.

Track C

This track introduces students to Internet-Of-Things. The student is given the role of an operations engineer whose task is to contribute toward the electric vehicle charging initiatives of a fictional town named Goldcoast. The objective of this track is to introduce the concepts of smart monitoring with sensors, device communication protocols, and configuration of a microcontroller-based system. A sample from this track is displayed in **Supplementary Figure 3**.

This track introduces the concepts of internet-of-things communication protocols, Bluetooth low energy, and sensors. The main challenge is the track involves the student using knowledge conveyed about embedded systems and requirements, to install a sensing module that detects motion for counting frequency of electric vehicle arrivals to a charging station. The student is presented with quality, durability, and cost considerations of purchasing smart devices, and they use knowledge about microcontrollers, and energy efficient computing to realize a stand-alone interconnected system. Finally, the student is required to think and address potential limitations of the project, and brainstorm improvements for scaling the system across many charging stations.

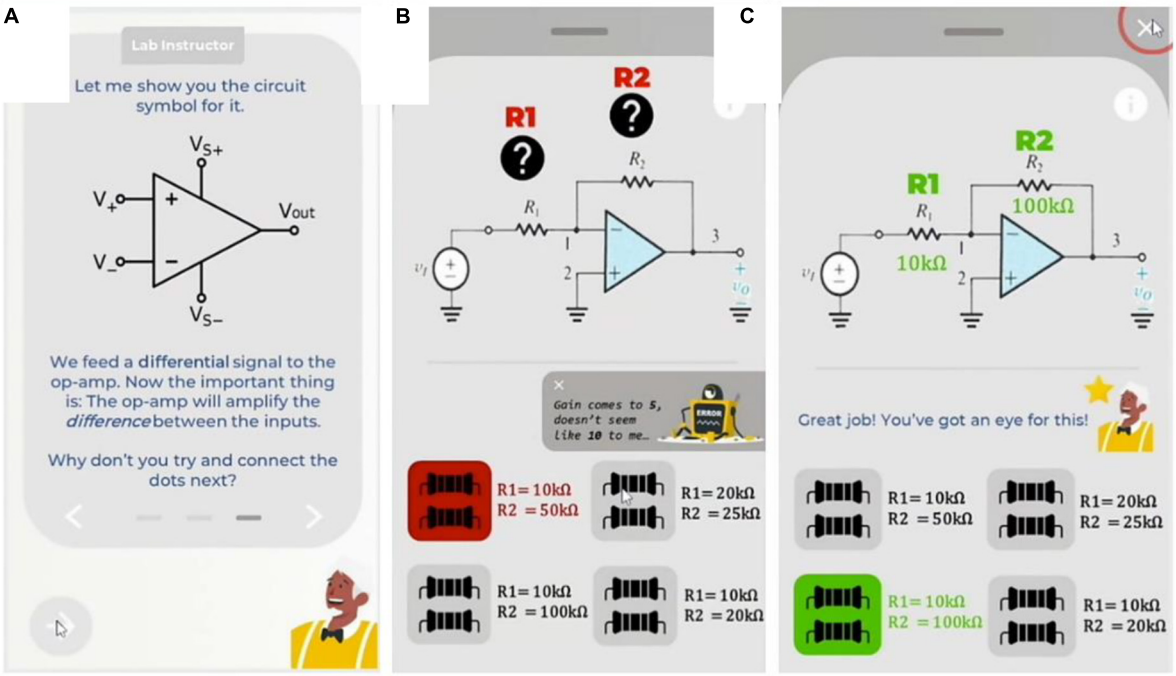

FIGURE 3 | Electronic design track sample showing concept introduction **(A)** and assessment **(B)** with immediate feedback **(C)**.

Track D

The final track in this phase is the electronic design track. The main character played by the student is a graduate student in a circuit design laboratory who has to deliver efficient circuits with the appropriate current, voltage, resistance, and power specifications to his supervisor. The basic concepts of electronic components are introduced and is followed by a series of assessments which progressively become challenging, as presented in **Figure 3**. Initially, the students must only select one component (i.e., resistors) at a time, while other variables are fixed. As they progress, they eventually must piece together a more complex circuit.

This track introduces the concepts of operational amplifiers, resistor combinations, open-loop gain, and input impedance. The main challenge is the track involves the student using knowledge conveyed about differential signals, to design a functional circuit that produces the desired level of gain. The student uses Ohm's Law, Kirchhoff's first and second laws, and basic understanding of voltages, currents, and resistances to develop this circuit. Finally, the student is required to verify the performance of the circuit in terms of gain, under varying external circuit requirements.

Kaggle and TryHackMe are generally used by individuals with a rudimentary understanding of the underlying principles yet integrating elements of the coding projected are intended to expose the layman student to the expanded scope of the field and show the bigger picture in a longer trajectory of learning.

Case Study Results

The duration of the study lasted 2 weeks, and the participants were recruited through an open call *via* email. Any student who had signed up for the American University of Sharjah's Fall 2021 enrollment inquiries mailing list within a 90-day period of May 2021–July 2021 (time of high-volume inquiries) was considered for inclusion. The students participating were not directly affiliated with the universities with this manuscript and were part of independent schools.

The study was asynchronously conducted as the students were not monitored live and had the freedom to perform the study tasks without supervision. The system tracked their decision points, time spent on each track from start to completion, and counted pauses as well. The students were instructed to do all four tracks, with the intention of selecting one or more of the four as their preferred career choice in this study. The intention was to only consider students at a pre-university, and late high school level. Out of 269 total students contacted, 145 responded to participate.

The study comprised of 145 participating students aged between 17 and 23. A student not being a currently registered university student was part of the exclusion criterion. Geographically, the volunteers were enrolled from universities in the United Arab Emirates, India, and the United States. Among the participants, all of them (100%) had prior exposure to educational technology enabled **supplementary tools** while either during school or university.

In the survey, the students were asked to answer three direct questions after completing the four tracks of AI Fundamentals, Cybersecurity Essentials, Introduction to Internet-Of-Things, and Electronic Design, listed as follows:

- Question 1: Experiential career exploration like NICE can better help you make decisions about career choices and university programs.
- Question 2: NICE can reinforce your decisions even if you have already decided your career path.
- Question 3: NICE successfully introduced concepts of core science, technology, engineering, and mathematics (STEM) specializations in practical settings and made me interested in a new domain.

The responses of the students are summarized in **Table 1**. The results indicate successful conveyance of positive impressions by the platform.

DISCUSSION

The goal of the conducted study was to ascertain the perceived usefulness of similar platforms on the end-user student level for CTE. The rationale is that if students themselves are not motivated to willingly navigate through possible career tracks, then it is likely platforms such as this will be deemed as a chore.

TABLE 1 | Distribution of survey responses and average scores for the three direct questions.

Options	*Respondents (%)*
Question 1: Experiential career exploration like NICE can better help you make decisions about career choices and university programs.	
Strongly agree	66 (45.5%)
Agree	54 (37.2%)
Neither agree nor disagree	22 (15.2%)
Disagree	2 (1.4%)
Strongly disagree	1 (0.7%)
Score	**4.225**
Question 2: NICE can reinforce your decisions even if you have already decided your career path.	
Strongly agree	45 (31.0%)
Agree	76 (52.4%)
Neither agree nor disagree	17 (11.7%)
Disagree	6 (4.1%)
Strongly disagree	1 (0.7%)
Score	**4.089655172**
Question 3: NICE successfully introduced concepts of core STEM specializations in practical settings and made me interested in a new domain.	
Strongly agree	52 (35.9%)
Agree	63 (43.4%)
Neither agree nor disagree	24 (16.6%)
Disagree	3 (2.1%)
Strongly disagree	1 (0.7%)
Score	**4.075862069**

This can lead to students selecting random decisions, unaligned with their true personality traits, and general theoretical understanding, rendering the purpose of the project ineffective.

The survey responses can be ranked in order of their selection frequency: Agree, Strongly Agree, and Neither Agree nor Disagree. Majority of the students chose "Agree," which likely reflects their general interest and intrigue toward this novel style of career exploration and content delivery. However, a relatively lower number chose "Strongly Agree" possibly because while the platform appears promising, they are not aware of any long-term impacts on their knowledge, and they have not yet validated the advantages in terms of their own learning outcomes. Students who selected "Neither Agree or Disagree" probably did not find the mode of delivery any more enticing or informational than any systems they have previously interacted with. Fewer than 2% of the total respondents selected "Disagree" and "Strongly Disagree." It is possible that they may be accustomed to a more traditional approach of learning (i.e., rote memorization and classroom learning), and hence do not find value in the offerings of the proposed platform.

It is worth mentioning that the demographic of students who participated in our study had some level of prior experience with technology in education. This may skew the results with a positive bias when compared with students who have solely interacted with traditional pen and paper methods, Further development of the toolkit involves the addition of sub-specializations in the STEM field, with a focus on the conjunction of introductory concepts with practical applications in the same domain. The immediate next goal involves incorporation of this platform into student orientation and advising programs with the intention of enabling comparison with traditional systems. Finally, the long-term plan is to partner with entities who perform campus recruitments to allow them to showcase the nature of responsibilities and enable students to make informed decisions.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

JR: conceptualization, methodology, writing—original draft, and writing—review and editing. SS: conceptualization, data collection, writing—review and editing, and project administration. MT and TA: conceptualization, data collection, and writing—review and editing. AS and AA: writing—original draft, writing—review and editing, and supervision. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2022.798950/full#supplementary-material

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