ASSESSING AND TEACHING THE 21ST CENTURY SKILLS FOR CAREER READINESS

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Synopsis:

The National Association of Colleges and Employers defined 8 competencies that students need for jobs. Texas Southern University received a 3-year grant from the NSF to design an Artificial Intelligence project - a collection of most up-to-date real world case studies in the civil engineering field. The objective of the project is to infuse innovative AI tools into traditional problem-solving routines through problem-based learning approach to prepare student for the marketable readiness.

Teaching and Assessing the 21ˢᵗ Century Skills for Career Readiness

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Abstract

The National Association of Colleges and Employers (NACE) defined eight competencies that students need for jobs. Critical thinking, problem-solving, communication and collaboration are listed as top competencies. It is the responsibility of higher education to prepare students for the society with the marketable competencies. Texas Southern University (TXU) received a grant from the National Sciences Federation to design an Artificial Intelligence project - a collection of most up-to-date real world case studies in the civil engineering field. The objective of the project is to infuse innovative AI tools into traditional problem-solving routines through problem-based learning approach to prepare student for the marketable readiness with the competencies defined by NACE. A research study has been integrated in the project implementation to assess the project and ensure the quality of the implementation. This paper will share with audience the entire project design and implementation as well as the research data.

Keywords: Artificial Intelligence, curriculum alignment, 21ˢᵗ century skills, direct assessment, indirect assessment, engineering education, STEM education, marketable skill, career readiness

Introduction

Texas Southern University (hence TSU) is one of the Nation's largest historically black universities, and it has more than one hundred undergraduate, graduate programs and concentrations. The Division of Human Resource Development in the National Sciences Federation (NSF) established a grant program specifically for the Historically Black Colleges and Universities Undergraduate Program (HBCU-UP). The program is to provide support to achieve a short-term, well-defined goal for improving the quality of undergraduate STEM education at HBCUs. TSU won the HBCU-UP grant, which lasts for three years from 2015 to 2018 and has extended one more year to 2019. TSU has been using the grant to infuse modern

Artificial Intelligence to design an innovative project to improve the quality of student learning at undergraduate level. The course has been designed and improved around some of the most important competency skills that are vital to prepare students for their career readiness.

Career readiness for the new college graduate is defined by NACE as "Career readiness is the attainment and demonstration of requisite competencies that broadly prepare college graduate for a successful transition in the workplace" In December 2014, the National Association of Colleges and Employers (NACE) Career Readiness Committee surveyed 606 organizations representing nearly 20 industries from for-profit private organizations, public held firms, government agencies, and nonprofit organization of all sizes. Based on the survey data, seven essential career readiness competencies were identified, and later one more competency was added, see Table 1 below.

Table 1: Career readiness competencies identified as absolutely essential by percent of respondents

	Competency	Percent of Respondents
1	Professionalism/Work Ethic	97.5 %
2	Critical Thinking/Problem Solving	96.3 %
3	Oral/Written Communications	91.6 %
4	Teamwork/Collaboration	90 %
5	Information Technology Application	72 %
6	Leadership	55.9 %
7	Career Management	45 %
8	Global/Intercultural Fluency	

The Partnership for 21st Century Skills believes that making the connection between learning and the real world is imperative for student success. With clear definition of the competencies required for student's success, it is an urgent task for higher education to prepare our student as much as possible for these competencies when they step into the society.

Education Paradigm Shift

As early as 2008, based on extensive research data, three technology giants, Cisco, Intel and Microsoft, concluded that "most education systems have not kept pace with the dramatic changes in the economy and the skill sets that are required for students to succeed. These skills include the ability to think critically and creatively; to work cooperatively and to adapt to the evolving use of technology in business and society" (Cisco's Technology News Site, 2009). Ten years later in 2018, the State of Workforce EdTech reported that "education providers face their own unique challenges in the workforce ecosystem" (p.4) and "formal institutions are failing to adequately prepare students for workplace. Only one-third of students feel workplace ready" (p.8, 2018). The changing in education systems is crawling, and most schools are still teaching traditional skills and knowledge that are not updated for today's job market. The urgency calls for an education paradigm shift to the development of new curriculum programs that are relevant to modern job market. Preparing students with technology competencies in a digital age is becoming a pressing task for all educational institutions. TSU is taking the lead in this education

paradigm shift and heading to the right direction. AI project provides a new path and magnitude of effective teaching and student learning via the infusion of the innovative and advanced technology into traditional curriculum to keep STEM education updated and to provide students with an access to the first-hand data for problem-solving.

The curriculum adaptation and development at TSU is closing the gap between school education and workplace. Every semester, more and more students are benefiting from AI projects. In the early stage of the AI project in school year of 2015-2016, only two small-scale pilot studies were conducted. However, the positive results received from both studies laid a solid foundation for project improvement and expansion. The AI infusion project has been systematically integrated into the curriculum since fall semester of 2016. Students of all levels from freshman to senior in both Civil Engineering program (CIVE) and Civil Technology program (CIVT) participated in the project. The initial AI project design paid particular attention to the alignment of student learning to instructional objectives, student expectations and 21st century skillsets. The AI project focuses on the top marketable competencies for modern jobs. In AI project, students use the artificial intelligent tools to learn new concepts and knowledge, and apply the knowledge in hands-on projects to solve problems through critical thinking with creative mindset, and collaborating in an effective communication environment.

AI project is a collection of real-world case studies. The grant Principal Investigator (PI) developed an interactive and comprehensive intelligent database to document, compare, and analyze cutting-edge AI applications in Civil Engineering field. Both documented and undocumented (literature and experts' opinions) information such as reference books, calculations being made, algorithms being used, other computer programs executed, expert recommendations and rules-of-thumb (heuristics) were included. Students improved their information literacy, media literacy and technology literacy while searching for relevant knowledge information. AI project helps students learn how to analyze and synthesize data to conceptualize and formalize knowledge pieces into specific relationships and hierarchy. Key concepts, technical and non-technical attributes, heuristic knowledge and information such as obscure behavioral and mathematical models are first extensively documented and then organized for better understanding of the following AI paradigms: evolutionary computing, artificial neural networks, fuzzy system, knowledge-based system and others. The students received mentoring from faculty not only as their classroom instructor but also as researchers. For future engineers, the ability to understand the problem and to see the big picture is instrumental to their success as practitioners. AI project also helps students to make a sound decision based on hands-on practice and research analysis. They utilize simple if-then rules to program small yet functioning blocks that support decision-making process. Students then gradually expanded and linked those blocks into a bigger block with added information (from their own literature review findings or guided knowledge acquisition). Students built several independent mini blocks for carefully selected AI applications such as soil classification systems and basic engineering material selection. These blocks were later "assembled" together with the help from the mentor into the database. This "Lego-building" approach as one example provided perfect hands-on learning experiences for undergraduate students. This activity promoted students' creativity, collaboration and communication skills.

Assessing the 21st Century Skills

The assessment of the project focuses on the evaluation of student competencies and the data have been used to inform teaching efforts and ensure that students have enough resources to acquire the 21st century skills. The data are also used by the instructor to identify student's level of learning and readiness for future job market. More importantly, the instructor is using the data to improve teaching practices in ways that accelerate the growth and development of students by directly targeting students learning to the needs for reality, by focusing the project on the 21st skills required by the job market.

Since the launch of the AI project, a systematic research study has been integrated in the entire process of project implementation. Both direct and indirect assessment methods have been used to establish baseline data and measure the progress of desired student learning outcomes based on the program goals. Direct assessment uses student assignments, tests and projects. Instead of sole use of traditional method to assess student learning, the assessment activities in the course are directly related to the project design objectives and student learning with required 21st century skills as a focus. The direct assessment collected data from student learning performance to help instructor check out the alignment of project objectives with student learning outcomes and also to help instructor adjust teaching methods and strategies to improve overall quality of teaching and student learning. At the same time, indirect assessments have been implemented very effectively in this project to ensure a thorough understanding of students from learner's perspectives. Carnegie Mellon Eberly Center for Teaching Excellence and Education Innovation provides seven teaching principles. Three of them highlight the importance of understanding of students, and use reflection and feedback for professional progress. "Effective teaching involves acquiring relevant knowledge about students and using that knowledge to inform our course design and classroom teaching. Effective teaching involves recognizing and overcoming our expert blind spots. Effective teaching involves progressively refining our courses based on reflection and feedback" (Teaching Principles, no date).

Before fall 2018, two indirect assessments were conducted each semester; one is the Research on the Integrated Science and Engineering Curriculum (RISEC) survey, which was developed in-house. RISEC survey collects feedback from students on learning engagements, knowledge acquisition, impaxt of artificial intelligence tools, their overall feedback on instruction quality, and their suggestions for project improvement. The other one is the Classroom Undergraduate Research Experience (CURE) national survey. The CURE survey was designed to measure student experiences in science courses in STEM field. In fall 2018, CURE survey was terminated due to the adjustment from the sponsors. So, only RISEC data in spring 2019 semester are reported in this paper.

Findings

RISEC survey has four sections; the first section is collecting data about student learning engagement and interaction related to learning activities and assignments; the second section is about student learning outcomes related to the research components and use of AI tools; the third section is specifically about the impact of AI infusion, and the last section is open responses from students regarding the overall project quality and recommendations. In spring 2019, three

classes participated in the AI infusion project from Civil Engineering program. They are one freshman class CIVE141, one sophomore class CIVE224 and one junior class CIVE335. A total number of 91 students enrolled in these classes. The survey is voluntary, hence 52 students took the survey, with a participation rate of 57% overall. The participation rate for each class is CIVE141-57%, CIVE224-65% and CIVE335-49% respectively. The following Table 2 and Table 3 show the data results from all participants for the first section in the survey.

Table 2. Learning Engagement / Interaction Related to Learning Activities and Assignments

No	Question	Very much	Quite a bit	Some	Very little
1	The activities/assignments in this class engaged me in the learning process.	80.8%	7.7%	7.7%	0%
2	The activities/assignments in this class helped me improve my understanding of the content knowledge.	71.2%	19.2%	9.6%	0%
3	My interest in the subject matter has increased due to the activities/assignments in this class.	75%	13.5%	7.7%	3.8%
4	My interest in future research has increased due to the activities/assignments in this class.	65.4%	19.2%	9.6%	3.8%
5	I was motivated to do more than the minimum requirements in this class.	67.3%	23.1%	7.7%	1.9%
6	I worked on a project that required integrating ideas or information from various sources.	65.4%	23.1%	5.8%	1.9%
7	I put together ideas or concepts from my other courses when completing assignments or during class discussions.	61.5%	25%	9.6%	1.9%

From student data, 88.5% of them reported that the learning activities and assignments have helped them either very much or quite a bit in engaging them in learning process and the class project required them to integrate ideas or information from various sources; 94% reported that the learning activities and assignments help improve their understanding of the content knowledge; 89% of students stated that their interest in subject matter and their interest in future research had increased very much or quite a bit due to the activities and assignments in the class; AI Tools are a collection of real world study scenarios, which are the situations that are happening in real life around them. When students study and practice those cases for knowledge acquisition, they see the connection between classroom activities and reality. This connection motivates them to learn more than minimum requirements in the class. The increased interest in the subject matter and research prepare them for their future career.

The last five questions in section one are from the National Survey of Student Engagement questionnaire (NSSE). The intention of using them is to find out if students had increased the ability of knowledge application through analyzing, synthesizing, making judgement and applying theories to solving practical problems, see Table 3 below.

Table 3. Coursework Emphasis on Mental Activities

No	Question	Very much	Quite a bit	Some
1	**Memorizing** facts, ideas, or methods from your courses and readings so you can repeat them in pretty much the same form.	46.2%	38.5%	15.5%
2	**Analyzing** the basic elements of an idea, experiences, or theory, such as examining a particular case or situation in depth and considering its components.	61.5%	30.8%	7.7%
3	**Synthesizing and organizing** ideas, information, or experiences into new, more complex interpretations and relationships.	53.8%	36.5%	9.6%
4	**Making judgments** about the value of information, arguments, or methods, such as examining how others gathered and interpreted data and assessing the soundness of their conclusions.	50%	44.2%	5.8%
5	**Applying theories or concepts** to practical problems or in new situations.	57.7%	30.8%	11.5%

From the data, 90.4% of students reported either very much or quite a bit that the coursework emphasize on analyzing, synthesizing and organizing ideas and information; 94.2% of students stated very much or quite a bit that the course emphases on making judgements about the value of information through examination and interpretation of data; 92.3% of them agreed that the coursework emphasizes on analyzing the basic elements of an idea, experiences, or theory, such as examining a particular case or situation in depth and considering its components and 88.5% of them reported that the coursework emphasized on apply theories or concepts to practical problems or in new situations. These class activities are crucial in preparing students for the 21st job market. The data by NACE in Job Outlook 2019 reported that 100% of employers that deem critical thinking/problem solving as very to extremely essential in new hires. The National Council for Excellence in Critical Thinking (Scriven & Paul, 1987) define it as critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. The data indicate that the coursework and learning activities are preparing students in the right direction and helping them to get ready for the readiness of job place.

Early involvement of undergraduate students in research will enrich their learning experiences and benefit them for their future life since research activities promote and encourage student's deeper learning and 21st century skills through investigation, experimentation to discover and present the facts in their written and oral communication. "Research experience allows students better understand published works, learn to balance collaborative and individual work, determine an area of interest" and "through exposure to research as undergraduates, many students discover their passion for research" (Madan & Teitge, 2013) for their future studies and career options. The hands-on AI infusion project helps students in each research step from identifying research topics, developing effective plan to gather necessary resources and information to eventually applying their learned knowledge and skills to solve the problem. 89% of students reported in the first section of the survey that their interest in future research had increased either very much or

quite a bit due to the activities and assignments in the class. The following second section reports data (Table 4) on student research skills related to the use of AI tools from their own learning experiences.

Table 4. Student Feedback on Research Knowledge and Skills Related to the Use of AI Tools

No	Please rate how this course has contributed to your improvement in the following areas:	Very much	Quite a bit	Some	Very little
1	Your ability to "identify basic principles and knowledge related to core material".	57.7%	32.7%	9.6%	0%
2	Your ability to "make connections between this course to other engineering courses"	57.7%	32.7%	9.6%	0%
3	Your ability to "develop a plan to address or resolve a specific question or problem."	55.8%	32.7%	5.8%	3.8%
4	Your ability to "collect and interpret data and information in an attempt to resolve the question or problem."	59.6%	30.8%	5.8%	1.9%
5	Your ability to "analyzing different scenarios and finding the best solution."	55.8%	28.8%	11.5%	1.9%
6	Your ability to "trouble shoot your solutions"	51.9%	28.8%	17.3%	0%
7	Your ability to "utilize different knowledge source other than textbook related information to solve a question or problem"	59.6%	25%	9.6%	3.8%
8	Your "awareness of the responsible conduct of being an engineer/researcher."	67.3%	26.9%	1.9%	1.9%
9	Your ability to "use new tools/algorithms/software to solve a problem"	55.8%	28.8%	9.6%	5.8%
10	Your ability to "articulate your research findings through written assignments, final products, and/or oral presentations."	48.1%	42.3%	5.8%	3.8%

Above 90% of students reported that AI Infusion course had contributed very much or quite a bit to improve their ability to identify basic principles and knowledge related to core material, to develop a plan to address or resolve a specific question or problem, to collect and interpret data and information in an attempt to resolve the question or problem, as well as to articulate the research finding through written assignments, final products, and oral presentation. More importantly, as high as 96.2% of students reported that the course has increased their awareness of the responsible conduct of being an engineer and or research.

Artificial Intelligence infusion in this course is extremely important to introduce and expose the modern technology to students. The third Section of the survey is collecting student feedback on the impact of the Artificial Intelligence Infusion in the course.

Table 5. Student Feedback on the AI Infusion

No	Please rate how the Artificial Intelligence (AI) project has contributed	Strongly agree	Agree	Dis-agree	Strongly disagree

	to your learning in the following areas:				
1	I enjoyed the AI project in the course.	51.9%	32.7%	13.5%	1.9%
2	I think the AI project was very challenging to me.	61.5%	25%	11.5%	0%
3	I think it is important to introduce AI knowledge in this course.	71.2%	28.8%	0%	0%
4	I think it is necessary to integrate AI project in this course.	65.4%	25%	7.7%	0%
5	AI project has increased my interest in using more advanced technology in problem-solving.	61.5%	26.9%	7.7%	1.9%
6	AI tools are very efficient in comparison to the traditional method in the process of solving problems.	61.5%	36.5%	0%	0%
7	AI project has improved my ability in problem-solving.	51.9%	36.5%	9.6%	0%
8	AI project has opened my mind in using advanced knowledge to solve problems in the future.	51.9%	40.4%	1.9%	3.8%
9	I like to see more projects in my future courses to use AI tools as learning resources.	53.8%	38.5%	5.8%	0%
10	I will recommend AI infused course to other students.	61.5%	28.8%	7.7%	0%

Despite the challenging from the AI project (by 85%), 84.6% of students still reported that they enjoyed the AI project in the course. 100% of students strongly agreed or agreed that it is important to introduce AI knowledge and 9.04% of them reported that it is necessary to integrate AI project in the course. As compared to the traditional method, 98% of students agreed that AI tools are very efficient in the process of solving problems. 92.3% of students reported that AI project opened their mind in using advanced knowledge to solve problems in the future. AI project has exposed the technology that students will be using in the future, which will definitely prepare them to adapt to the job market a lot easier.

Conclusion

Technology today will be dramatically different in 20 years when our students are at their middle age for both their career and family life. "Futurists estimate that up to 85% of the jobs that will exist in 2030 haven't been invented yet" (p.3, Report by IFTF). A good instructional alignment should be connected to societal needs, and student skills are marketable to serve their professional purposes and contribute to the society (Wanyan & Liu, 2018). AI project connects the classroom learning with the real world scenarios. It helps align current curricula in the Department of Engineering at the TSU with societal needs and helps students learning new knowledge and develop problem solving, critical thinking and communication skills through problem-based and collaborative learning. "Creating an aligned, 21st century public education

system that prepares students, workers and citizens to triumph in the global skills race is the central economic competitiveness issue for the next decade" (Partnership for 21st Century Skills). TSU is in the forefront to prepare qualified students for modern digital age through the Artificial Intelligent infusion with increased awareness of being competitive and responsible citizens. "The translation of skills into the marketplace must be made clearer in order to connect three critical audiences: people looking for good work, employers looking for good people, and educators looking to build good programs and engage students (p.4, Report by IFTF).

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