Effective Use of Indirect Assessments for Student-centered Learning

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Abstract

Indirect assessments have not caught the attention of many educators. Most instructors focus on using direct assessments to measure student learning outcomes. However, effective use of indirect assessments can provide instructors with valuable information to make teaching improvement based on student feedback. This paper will present a research project that implemented multi-dimensional assessment activities to evaluate student-centered learning. The analyzed indirect assessment data have been used strategically to enhance teaching quality and curriculum enrichment, to improve student learning as well as for research program expansion.

Keywords: Direct assessment, indirect assessment, student-centered learning, learning engagement, student feedback, Artificial Intelligent, civil engineering education

Introduction

Texas Southern University (TSU) is located at Houston, the fourth largest city in US. TSU is ranked as the second nation's largest HBCU (Historically Black College and University) by enrollment with 12 colleges and schools and offering more than 100 undergraduate and graduate programs and concentrations. College of Science, Engineering & Technology has the largest enrollment every year and educates students with knowledge and skills for the job market. The National Science Foundation created a grant program HBCU-UP (Historically Black Colleges and Universities Undergraduate Program) to enhance the quality of science, technology, engineering and mathematics (STEM) instructional and outreach programs at HBCUs as a means to broaden participation in the Nation's STEM workforce. TSU civil engineering program has been awarded this grant for four years (2015-2019) to design an artificial intelligence project. The project seeks to infuse innovative Electrical/Computer Engineering specialized Artificial Intelligence (AI) tools into traditional Civil Engineering problem-solving routines through problem-based learning approach (PBL). It helps bridge current curricula gap in the Department of Engineering at TSU. The objectives of the project are: 1) to develop an intelligent knowledge database to document, compare, and analyze cutting-edge AI applications in civil engineering field, which can be used as the platform and educational media for curricula development and implementation for PBL approaches in classroom; 2) to add one new interdisciplinary course to the Department's curricula "AI Tools for Engineering Problem Solving" for all senior engineering major students; 3) to enrich current curricula by integrating innovative AI application case studies into more than fourteen existing courses being offered in the Department, 4) to foster interdisciplinary academic setting by hosting server-based intelligent database in the College of Science, Engineering and Technology and to provide web- and classroom-based workshops and tutorials to all interested students and faculty; and 5) to support undergraduate students' early involvement in research.

In the project implementation, besides developing hands-on projects and research activities through the use of AI tools, a series of assessment activities were designed to make sure students are learning what project designed for them to learn and to find out the impact of the project on student learning. Student learning is affected by different factors. It is very essential to collect precise and wide-ranging assessment data from difference sources in

order to make effective improvements in course design and instructional quality to enhance student learning. A good assessment practice shifts the focus from blaming students for not achieving expected learning outcomes to finding out true reasons behind student learning issues. The grant project implemented multi-dimensional assessments. Student learning outcomes are evaluated through direct assessments in course assignments; projects, group activities, quizzes and exams, and student grades have been used to analyze student class performance at the same time to provide meaningful information for course improvements. In addition to the direct assessments in class, two indirect assessments have been conducted to collect data on student learning from their perspective. Both indirect assessments have been using survey method. One was developed in-house, the Research on the Integrated Science and Engineering Curriculum (RISEC). This survey is specifically targeting at student learning and using the AI tools in their hands-on projects and research activities to find out 1) student engagement and interaction in the process of learning, 2) student research and problem solving skills, 3) student feedback on how the artificial intelligence infusion project contributed to their learning, and 4) student open feedback on overall effectiveness of instructional delivery and project implementation. The second survey is CURE, the Classroom Undergraduate Research Experience (CURE) survey, which has been used nation-wide to measure student experiences in "research-like" or other science courses. In this project, CURE data is used as a bench mark to compare TSU students with Nation-wide students in STEM field in science attitude, learning experiences, learning gains, learning benefits and overall evaluation of the course. The survey results give the instructor an opportunity to find out the course teaching effectiveness, and more importantly to compare TSU students with national counterparts in academic performance. The additional value of these surveys is to find out the impact of AI infusion on student learning and their future career. The indirect assessment data contribute to the project's success in several aspects. Firstly, the data have been used to make instructional improvement, secondly, student feedback provided very important information for AI project expansion, thirdly the data help the instructor to compare the performance of TSU students with national peer in STEM field, and lastly, the data provide evidence of the impact of AI tools on student learning. The data are also very effective in checking the alignment of student performance with the instructor's expectation as well as the alignment of student learning and project goals. Effective indirect assessment activities make students feel respected in the process of learning in providing suggestions for instructional improvement. Students are truly involved in the process of teaching and learning with constructive feedback and their learning experiences.

Student Learning Assessments

"Assessing what really matters to student learning" or to instructor's teaching, or both? There are still a lot of instructors who teach and assess their students in the same way as they were taught and assessed when they were students in schools, mostly focusing on memorized knowledge. Since mid-80s assessment movement, demanding to know how students learn in school, mainly driven by accreditation requirements, more and more attention has been paid to use assessment data for the improvement of student learning. However, largely, the good practice has not been implemented in schools due to lack of resources, such as proper training of faculty to design and teach effectively, understanding modern challenges on educational system, few of teachers "have had formal instruction on how to do it and do it well. Even fewer of us (teachers) have had training on how to provide evidence of what students are learning in ways that are acceptable to external stakeholders" (Barkley & Major, 2015, p1). In addition, with increased number of enrollment, teaching process has been trimmed to the minimum via online automated tools. The feedback and interaction from both sides, instructors with students, and students with students, are disappearing in this automation. The classroom assessments have become a simple tool to sign grades to students and label them with levels. Assessment results are seldom used for professional development and instructional improvement. In order to solve this problem and truly improve student learning, teachers need to be more systematic and sensitive observers of learning and more efficiently and effectively identify what is important for students to learn, and implement appropriate activities to ensure that students learn it (Barkley & Major, 2015). 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). These three principles stress on course design based on student knowledge, background information and needs and utilize student feedback and instructor's reflection for course improvement. "Without knowing how students spend their time, it's almost impossible to link student learning outcomes to the educational activities and processes associated with them" (Kul, 2001, p15). The more teachers know and understand students, the more efficient and effective the teaching will be.

Assessment, in different format, is the only way to evaluate what and how student learn and how well they learn. Both direct and indirect assessments are effective methods to collect data for this purpose. Direct assessments provide for the direct examination or observation of student knowledge or skills against measurable learning outcomes (Roger, 2006). These assessments will provide data on student knowledge learned and grasped in classroom activities – what students learn. While, indirect assessment is a strong supplement to direct assessment in giving teachers information on how students learn from their perspectives and experiences, assessing what really matters to student learning (Kuh, 2001). "Indirect assessments of student learning ascertain the perceived extent or value of learning experiences. They assess opinions or thoughts about student knowledge or skills. Indirect measures can provide information about student perception of their learning and how this learning is valued by different constituencies" (Roger, 2006). The importance of assessments has been undermined by most teachers because most of them are using assessment to evaluate what have been taught to students by simple assigning grades without thorough understanding the true meaning of assessments. Student grades have rarely been analyzed to find out the real problems of student learning issues. Mostly, the teachers tend to blame students for lack of efforts in learning instead of connecting assessments with instructional alignment and teaching practice. The best assessments are those whose results are used to inform meaningful, important decisions (Suskie, 2018).

RISEC Survey

In this project, direct assessments were designed to fully engage students in hands-on activities to practice and explore the real world case studies and learn the knowledge and skills to solve problems. Since the AI tools are newly developed and integrated in the teaching and learning process, it is extremely important to get feedback from student learning experiences to further improve the quality of the tools and also get to know the impact of the project on student learning. Two indirect assessments have been strategically incorporated in the project as mentioned earlier. At the end of the semester, students were asked to take the RISC survey to provide feedback specific regarding the implementation of AI tools. RISEC survey has three sections; the first section is collecting the 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; and the last section is open responses from students regarding the overall project quality and recommendations. The following data were collected from a sophomore level civil engineering class in spring 2018 semester. The participation rate is 78%, twenty-one out of twenty-seven students took the survey. The following table 1 shows the data results from the participants for the first section in the survey.

Table 1. *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.	85%	15%	0%	0%
2	The activities/assignments in this class helped me improve my understanding of the content knowledge.	76%	24%	0%	0%
3	My interest in the subject matter has increased due to the activities/assignments in this class.	62%	38%	0%	0%
4	My interest in future research has increased due to the activities/assignments in this class.	67.8%	23.8%	9.5%	0%
5	I was motivated to do more than the minimum requirements in this class.	57%	38%	5%	0%
6	I worked on a project that required integrating ideas or information from various sources.	62%	33%	5%	0%
7	I put together ideas or concepts from my other courses when completing assignments or during class discussions.	48%	38%	10%	5%

From student report, 100% of them think the learning activities and assignments have helped them either very much or quite a bit in engaging their learning process, in helping improve their understanding of the content knowledge and increased their interest in the subject matter. 95% of students think either very much or quite a bit that they were motivated to do more than minimum requirements in the class and they integrated ideas and information from other resources when they worked on the project. 90% of them reported either very much or quite

a bit that their interest in future research had increased 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 creates an optimal learning environment to increase student learning interest and drive their motivation that links to their goals in academic achievement and professional career in their future.

The last five questions in section one focus on the coursework emphasis on the mental activities, intending 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 2 below.

Table 2. *Coursework Emphasis on Mental Activities*

No	Question	Very much	Quite a bit	Some	Very little
1	**Memorizing** facts, ideas, or methods from your courses and readings so you can repeat them in pretty much the same form.	29%	67%	5%	0%
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.	52%	48%	0%	0%
3	**Synthesizing and organizing** ideas, information, or experiences into new, more complex interpretations and relationships.	52.4%	42.9%	0%	0%
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.	42.9%	47.6%	5%	0%
5	**Applying theories or concepts** to practical problems or in new situations.	61.9%	33.3%	10%	0%

100% of students reported either very much or quite a bit that the coursework emphasize on analyzing, synthesizing and organizing ideas and information. 95% of students think very much for quite a bit that the course emphases on making judgements and 90% of them think the coursework emphasizes on applying theories or concepts to practical problems. These data indicate that the coursework and learning activities are in alignment of project and teaching objective, which is to train students to use knowledge and skills to solve practical problems.

One of the objectives of the grant project is to support undergraduate students' early involvement in research. In the first section, seventy-five percent of students reported that their research interest increased due to the class activities and assignments. The second section of student survey is focusing on collecting data (Table 3) on student research skills related to the use of AI tools from their own learning experiences.

Table 3. *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%	38%	5%	0%
2	Your ability to "make connections between this course to other engineering courses"	42.9%	47.6%	9.5%	0%
3	Your ability to "develop a plan to address or resolve a specific question or problem."	52%	48%	0%	0%
4	Your ability to "collect and interpret data and information in an attempt to resolve the question or problem."	57%	38%	5%	0%
5	Your ability to "analyzing different scenarios and finding the best solution."	52%	33.3%	15%	0%
6	Your ability to "trouble shoot your solutions"	42.9%	47.6%	5%	5%
7	Your ability to "utilize different knowledge source other than textbook related information to solve a question or problem"	53%	33%	14%	0%
8	Your "awareness of the responsible conduct of being an engineer/researcher."	33%	62%	5%	0%

9	Your ability to "use new tools/algorithms/software to solve a problem"	62%	33%	5%	0%
10	Your ability to "articulate your research findings through written assignments, final products, and/or oral presentations."	71%	29%	0%	0%

Ninety-five percent of students think that this course has contributed very much or quite a bit to improve their ability to identify basic principles and knowledge related to core material, to collect and interpret data and information in an attempt to resolve the question or problem, and to increase their awareness of the responsible conduct of being an engineer and researcher. Ninety percent of student reported that the course has contributed very much or quite a bit to make connections between this course to other engineering courses, and use new tools/algorithms/software to solve a problem. The division of courses tends to isolate knowledge from one course to another. Isolated knowledge creates a barrier to understand the real nature of the problem. It narrows down the possibilities, opportunities and abilities to solve the problems. In reality, everything is interconnected through one way or another. It is extremely important for students to make connections of knowledge between different courses and with the real world. AI tools build a learning environment that facilitates students to make the connection of knowledge with real world.

In the open section of student feedback, ninety-five percent of students think it is important to introduce AI knowledge in the course, ninety percent of students reported that AI tools are very efficient in comparison to the traditional method in the process of solving problems. The data analysis from RISC survey is instrumental to the instructional improvement and project expansion. Students provided very positive feedback on AI integration, learning activities and improved research skills, which confirmed the impact of AI infusion on student learning.

CURE survey

The second indirect assessment uses Classroom Undergraduate Research Experience (CURE) national survey. CURE survey "grew out of a creative collaboration of faculty from Grinnell College, Hope College, Harvey Mudd College, and Wellesley College. The CURE may be used as a pretest-posttest or posttest-only survey to measure student experiences in "research-like" or other science courses" (Grinnell College). It is licensed under a Creative Commons Attribution-Non Commercial-Share Alike 4.0 International License, copyright 2005-2018 Grinnell College. The survey has three components, 1) a pre-course survey including demographic questions, reasons for taking the course, level of experiences on various course elements, science attitude and learning style questions, 2) a post-course survey including estimation of learning gains in the course elements, estimation of learning benefits, overall evaluation of the experience and science attitude, and 3) a brief survey for the course. In this project, CURE survey is used as a tool to collect bench mark data to compare TSU students with Nation-wide students in STEM field, and to measure students learning outcomes related to undergraduate research experiences and investigates various elements related to student learning involving the use of AI tools.

The following reported data were collected in spring 2018 from civil engineering class CIVE339 and civil technology class CIVT337 with a total enrollment of 19 students, 14 male students and 5 female students and 95% of them are seniors. Students participated in both pre-course and post-course surveys voluntarily. All students participated in both pre and post surveys. For the sections of course elements, course benefit, and attitudes toward science, CURE analyst provided TSU with mean data. So, the data analysis method of Independent-Samples T Test is used to compare TSU mean results with that of national data to find out statistical significance with the confidence level set at 95%.

In the pre-course survey, there is a question of ten reasons to take the course for students to rank. The top six reasons for TSU students to take the course are listed in table 4, which indicate student's expectation for the course. Besides needing the course to fill a major requirement, students wanted to learn about science and research process through hands-on research experience for desired employment after college.

Table 4. *Top Six Very Important Reasons to Rake the Class*

No.	Reasons to take the course	%
1	I need it for graduate or professional school.	65%
2	To fill a distribution requirement	63%
3	I need it for my desired employment after college.	61%
4	To fill a requirement for my major	58%

5	To learn about science and the research process	58%
6	To get hands-on research experience	53%

In the pre-course survey, students were asked to assess their prior experience on 25 course elements, and in the post-course survey, students were asked the same course elements to rate their gains they have made as a result of taking the course. TSU students showed their improvements in 21 out of 25 course elements, a coverage of 84% overall, which is higher than the Nation-wide results of 19 out of 25 course elements, which is 76%. The mean comparison result from Independent-Samples T Tests between TSU pre-course experience and post-course gains generates a P=0.000, which is statistically extremely significant, see Table 5 below. When compare TSU students' post-course gains with nation-wide post-course gains, again, the Independent-Samples T Tests generates P=0.000, see Table 6 below.

Table 5. *Mean Comparison of TSU Pre-course Experience and TSU Post-course Gains*

Groups	Elements	Mean	Std. D.	t	df	Sig. (2-tailed)
TSU Pre-course Experience	25	3.6944	.16169	-5.999	48	0.000
TSU Post-course Gains	25	3.9704	.16362			

Table 6. *Mean Comparison of TSU TSU Post-course Gains and Nation-wide Post-course Gains*

Groups	Elements	Mean	Std. D.	t	df	Sig. (2-tailed)
TSU Post-course Gains	25	3.9704	.16362	5.525	48	0.000
Nation-wide Post-course Gains	25	3.6160	.27588			

The top six post-course gains reported by TSU students are listed below. These knowledge and skills are directly associated with student ability to conduct research through the use of computer technology and to produce research results.

1. A project where students have input into process or topic
2. A project entirely of student design
3. Work on problem sets
4. Computer modeling
5. Present results in written papers or reports

There are twenty-one items that are measured in the post-survey for learning benefits from the course. TSU students had 17 (81%) items scored higher than Nation-wide data. The Independent-Samples T Test generated P=0.000, which is statistically extremely significant. See Table 7 below.

Table 7. *The Mean Comparison of Course Benefits between TSU Students and Nation-wide Students*

Groups	N	Mean	Std. D.	t	df	Sig. (2-tailed)
TSU	21	3.8914	0.14427	5.195	40	0.000
Nation-wide	21	3.6043	0.20822			

The top six benefits reported by TSU students from the course are as listed below. AI infusion not only prepares students to be technologically competitive in either careers, but also increases students' self-confidence that will help them achieve greater successes in all aspects of their life.

1. Clarification of a career path
2. Confidence in my potential to be a teacher of science
3. Ability to read and understand primary literature
4. Learning to work independently
5. Skill in how to give an effective oral presentation
6. Self-confidence

In the section of science attitudes, students were asked 22 questions in both pre-course and post-course surveys. TSU students reported 17 (77%) items with positive changes. In mean comparison of TSU student pre-

course to post-course science attitude, The Independent-Samples T Test generated P=0.014, which is statistically significant. See Table 8 below. This course has enhanced students' concept of science knowledge and also further strengthened their science attitudes.

Table 8**.** *The Mean Comparison of TSU Student Science Attitude Change in Pre and Post-course Surveys*

Groups	N	Mean	Std. D.	t	df	Sig. (2-tailed)
Pre-course Science Attitude	22	3.5945	0.35626	-2.551	42	0.014
Post-course Science Attitude	22	3.8509	0.76261			

In the post-course survey, there are four questions that serve as an overall assessment of the course. The following table 9 shows the results of TSU students' rating for the course.

Table 9. *Overall Course Rating by TSU Students*

No.	Rating Questions	Strongly Agree
1	This course was a good way of learning about the subject	83%
2	This course was a good way of learning about the process of scientific research	84%
3	This course had a positive effect on my interest in science	80%
4	I was able to ask questions in this class and get helpful responses	84%

The CURE survey results from TSU students are very affirmative and positive. Students expressed their expectation of taking this course, which is to learn about science and research process through hands-on research experience for desired employment after college. In the survey, they provided strong evidence that AI infusion did impact their knowledge acquisition and research ability improvement demonstrated in their report in learning experience enhancement, knowledge gains and course benefits. AI infusion is a very well-timed project that prepares TSU students with the skills and knowledge for their future professions. US Bureau of Labor Statistics reported that "more than 50% of today's jobs require some degree of technology skills, and experts say that percentage will increase to 77% in the next decade" and "Employment of computer and information technology occupations is projected to grow 13 percent from 2016 to 2026, faster than the average for all occupations" (Aril, 2018). Through hands-on AI projects, TSU students have been equipped with the research knowledge and problem-solving skills to be competitive in the job market.

Conclusion

Involving students in the process of course design and instructional delivery is very important for efficient and effective teaching practice. When instructors understand student's needs and the factors that affect students learning, instructors can consciously pay attention to those factors and properly address them through different teaching strategies. In the grant project, due to the effective use of both direct and indirect assessments, the course instructor used the analyzed data make curriculum and instructional improvement to expand AI infusion to benefit more students. Effectively integrating student feedback in the teaching process creates a genuine student-centered learning because the course design and delivery are truly around students and for the students. Most student-centered learning is focusing on learning activities that are conducted by students with the guidance of instructors, very rarely including student learning factors in the process of course design and delivery. Fink pays attention to students to determine what they believed were truly significant learning experiences that changed the way they lived their personal, social, civic, or professional lives (2013). Direct assessments are important to evaluate student learning outcomes, however indirect assessments can be used effectively to better understand student needs and know more about their learning challenges, which can help instructor design a true student-centered learning and improve overall education quality.

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