Innovative Assessment Practice to Improve Teaching and Learning in Civil Engineering

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***Abstract*—The professional skills are essential for engineering student along with conceptual knowledge. The main objective of this paper is to explore an innovative assessment practice that was implemented to enhance teaching and learning for an undergraduate student in Civil Engineering. The practice was developed to increase students' engagement, and encourage collaboration and critical thinking to achieve sustainable learning. Emerging technology and e-tools were the key of improve this practice. The practice was evaluated through students' performance during the semester, and through the analysis of student's feedback, peer review and external feedback. Generally, the feedback demonstrated the effectiveness of this practice in improving students' understanding of the subject area and their academic performance. The total satisfaction was more than 90% and showed students' satisfaction with the pedagogy adopted. The results showed a significant improvement in students' performance in both internal and external marks. The final exam average increased by 20% and the total average increased by 15.4 % from the previous semester. This paper highlights the importance of linking learning and assessment as a core part of the teaching and learning process.**

***Index Terms*—sustainable learning, deep learning, formative assessment, engineering learning attributes**

I. Introduction

Assessment is a fundamental component of the teaching and learning process. Since the early 1990s, many higher educational institutions have moved to modularization of degree programs. However, the drawback of this model is that the students are assessed at the end of a module [1] and students focus on assessment more than learning. Quality assurance accreditation defines assessment in higher education as any process that evaluates an individual's knowledge, understanding, abilities or skills [2]. Therefore, assessment is one of the most significant influences on students' experience of higher education and evidence for the qualification being obtained [3].

The assessment usually is subdivided into two categories, summative assessment and formative assessment [4]. Summative assessments is usually used to evaluate the efficiency of educational programs and is important for certification [5]. However, formative assessment is important for checking the student's development and potential [5]. Biggs (1999) defines summative and formative assessment in a learning perspective as "assessment of learning" and "assessment for learning", respectively.

Although, different learning and teaching methods have innovated to improve student' performance, the students still probably choose what to study based on what and how they will be assessed and without doubt the assessment drives student learning [6]-[8]. Therefore, many researchers agree that "assessment defines the curriculum" and, that the best practice is to improve student's involvement through what they value [9], [10].

A traditional type of assessment used to focus on scientific principles and knowledge [11]. It usually supports surface learning and memorization more than deep learning [12]. One of the major obstacles of deep learning in higher education is that students focus more on grades than on learning [10], [13]. Many researchers have developed innovative assessment approaches that have caused a shift in educational practice to focus on "assessment for learning" instead of "assessment of learning" [14]-[16]. Biggs (1999) provides a constructive alignment model in curriculum design that considers effective alignment as the principal element for effective assessment. He emphasizes the strong relationship between assessment and learning outcomes [5]. The KWSK Assessment Triangle describes the three broad elements on which every assessment should rest [17] as shown in Fig. 1.

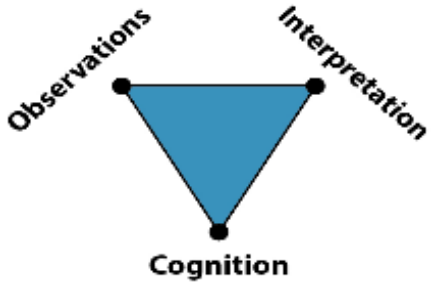

Figure 1. The KWSK assessment triangle [18].

Ref [18] claim to have improved the assessment practices in University of California, USA using Berkeley Evaluation & Assessment Research Assessment (BEAR) System. The BEAR Assessment System was based on four principles: developmental perspective, match between teaching and assessment, the creating of quality

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evidence, and management by teachers to allow suitable feedback [18]. Kearney (2014) generated a model of self- and peer-assessment known as Authentic Self and Peer Assessment for Learning (ASPAL). The model focusses on dependable assessment tasks and involving students in every step of the process from creation of the assessment criteria, providing examples of their work, pilot marking and providing peer feedback. The study showed that the most of students found it valuable and innovative [6]. El-Maaddawy (2017) presented a new assessment model for senior-level civil engineering design course that integrated formative, summative, and Student –Self Assessment (SSA). It was found that this innovative practice improved students' understanding of topics, independent judgement, and self-arranged learning skills [8]. It is a fact that assessment usually drives student learning. Therefore, improving assessment will lead to enhancement of student learning. An effective assessment focuses on students' potential and prepares them for final assessment and lifelong learning [12] and [19]-[20].

Deep learning and assessment is essential for the engineering profession more than other disciplines [21]. Generally, students prefer surface assessment types, which does not fulfil the long-term requirements of the engineering profession but instead helps them achieve their immediate, short-term goals [22].

Graduate Attributes are the set of skills, understandings and personal attributes of graduates for getting a job and being successful in their chosen professions [23]. These skills include creativity and innovation, creation and evaluation, decision-making supported by critical analysis and judgement, implementation of ideas through leadership and management, and communication and strategy skills. Employability skills can be teachable [24] and transferable [23].

Transportation engineering is considered as one of the most challenging subjects to teach in civil engineering because of its complexity and interdisciplinary nature [25]. Therefore, the main objective of this study is to develop an innovative and sustainable assessment that improves professional skills, and fosters deep and life-long learning in civil engineering through developing appropriate formative and summative assessment types. This will increase students' engagement, and encourage collaboration and critical thinking to achieve sustainable learning. It was implemented in the Highway and Transport engineering module offered by the Civil Engineering Department, Middle East College, Oman. This module is part of the programme that is offered in partnership with Coventry University, UK. Background information about innovative assessment concepts is first presented. Examples introduced and adopted in this study are then described. Comparative analysis of students' performance along with the respondent feedback are presented and discussed in terms of their significance. This work was a part of assessment to fulfil the requirements for award of PG Cert (Post Graduate Certificate) in education from Coventry University. Finally, the main findings of the work are then summarized along with recommendations.

II. Methodology

The aim of my practice is to implement an innovative assessment practice through developing appropriate formative and summative assessments. Emerging technology and e-tools were the key of improve this practice. Many e- tools have been applied such as Socrative for short answer and online assessment, internet-based simulation for interactive and visualization learning, Padlet, and Mindmap. A total of 71 students who registered in the Highway and Transport Engineering module in the Spring 2017 semester were involved in this study. The practice was implemented for two full time and part time sessions. The students in each session belong to different cultures, nationalities, and experience. The practice technique is explained in next section. The practice approaches implemented were evaluated using both qualitative, and quantitative methods [26], [27]. The quantitative method implies analysis of student performance in CW and final exam and analysis of the survey findings. The qualitative method includes online analysis of the feedback of students, internal (from the department) and external moderator (Coventry University) through Padlet, and module evaluation survey by the Quality Assurance Office in the college. The total number of students who completed the questionnaires was 44. A hard copy of the questionnaire was distributed to students to ensure high participation rates [26].

To ensure accuracy of the findings, the coursework, final exam, and classroom activities were moderated through an internal moderator from the department and an external moderator from the partner university (Coventry University).

III. The Pedagogical Technique

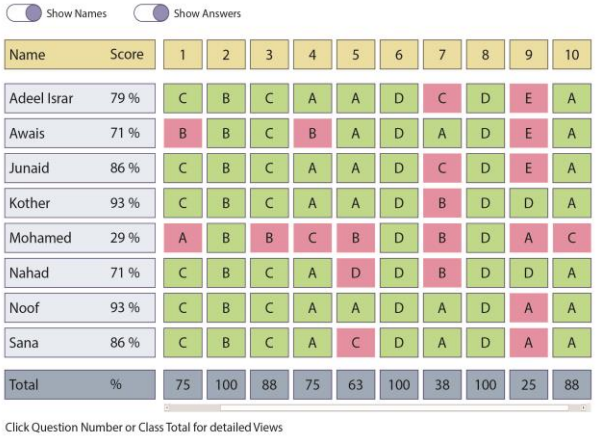
A semester in the academic calendar has 16 weeks. Different constructive approaches had to be engaged deliver the content of the subject based on the objectives of assessment. Selecting the appropriate assessment methods and activities was very critical in such a module. The methodology adopted in the current study was planning the module through selecting the group in the class, suitable activities, assessment and evaluate students' performance. Evidences of these practices are available on my online Evernote portfolio at: https://www.evernote.com/pub/siham109/module2task3.

A. Formative Assessment

The keystone of successful learning is aligning assessment with learning Outcomes [28], therefore the first step in designing a formative assessment was to select the type of assessment. The outcomes of Highway and Transport Engineering Module focused on critical analysis, evaluation process and decision-making. Therefore, the classroom activities were designed to include different activities. Among these approaches, the problem-based learning approach has been used widely. This approach, has proven to be an effective practice with transportation engineering [29]-[31]. After a specific amount of content is presented during the class, students

were tested on their understanding by solving challenging problems.

Another approach was inquiry-based learning, where within this approach, students were responsible for analyzing their knowledge and looking for proof for their understanding of the topic [32]-[33] Appendix A shows examples of formative assessment. Likewise, to quickly evaluate students' understanding of content, the short-answer test feature in Socrative was implemented in different sessions. Fig. 2 illustrates multiple choice tests using Socrative [34]. The students were divided into groups, and each group discussed and shared their findings with other groups.



Name	Score	1	2	3	4	5	6	7	8	9	10
Adeel Israr	79 %	C	B	C	A	A	D	C	D	E	A
Awais	71 %	B	B	C	B	A	D	A	D	E	A
Junaid	86 %	C	B	C	A	A	D	C	D	E	A
Kother	93 %	C	B	C	A	A	D	B	D	D	A
Mohamed	29 %	A	B	B	C	B	D	B	D	A	C
Nahad	71 %	C	B	C	A	D	D	B	D	D	A
Noof	93 %	C	B	C	A	A	D	A	D	A	A
Sana	86 %	C	B	C	A	C	D	A	D	A	A
Total	%	75	100	88	75	63	100	38	100	25	88

Figure 2. Multiple choice tests using Socrative.

B. Summative Assessment

The summative assessment includes one coursework (50%) 0f the marks and final exam (50%). The coursework was developed to reflect the concepts and skills with clear criteria for judging students' performance [30]. The course work was considered as a part of the activity that depends on project-based learning. It was developed to improve students' critical thinking and team work skills. The coursework was designed to include three parts: a real-life case-study project, problem simulation, and numerical problems [30].

The first and second part of the project included real life case studies for geometric design, LOS and Intersection design. A customized excel sheet was designed to manage each student's data. The main objective of the designed excel sheet was to allow each student to have his own data in order to create different case study and to reduce the academic plagiarism between students. The excel sheet contains the first part the information about the module such as module title, module code, semester, types of assessment. In students name each student can his/her name from the drop list and directly, student ID, session and all other data will change. When each student chooses his/her name, the data in the sheet will change and give him different case according to traffic volume, % of trucks, Split directional… etc. For example to estimate ATS (Average travel speed), LOS (Level of Service),v/c,PTSF (Percent time-spent-following another vehicle), the characteristic of the segment will change for each student. Different cases create different result analysis, discussions, and conclusions of each students. Fig. 3 shows the excel sheet design. The given data was designed according to Highway Capacity Manual (HCM 2000). The third part of the project is parking design where the students collect data from the field. Students work collaboratively in groups to collect the data. Appendix B shows coursework given to the students. It is important to develop the coursework to reflect the concepts and skills with clear criteria for judging students' performance [32]. The coursework was prepared in which all assessment requirement, learning outcomes, marking criteria for each part, guidelines, regulations and policies were clear using Bloom's Taxonomy [35].

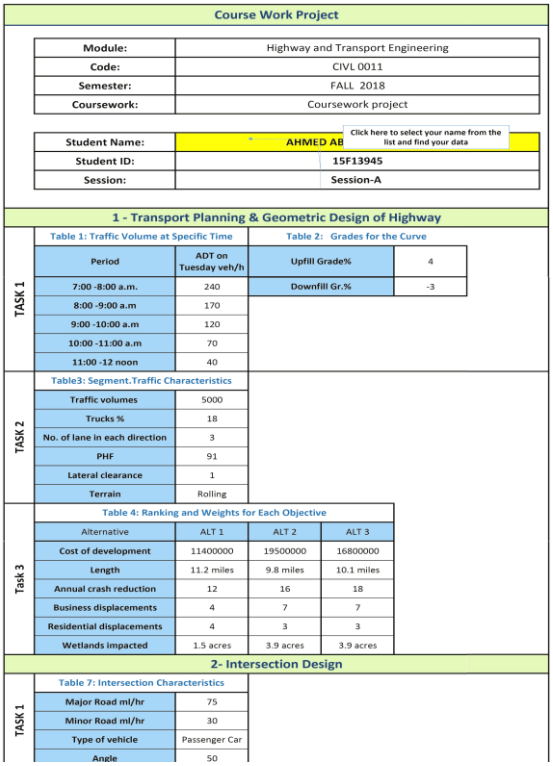


Figure 3. Using MS Excel spreadsheet in the design of Coursework.

All of the six principles of marking and grading were considered using rubrics [32]. According to MEC policy, all assessments should be reviewed by internal and external moderators before uploading to students. The marks also were moderated by internal and external moderators to ensure that the marks awarded were fair, consistent and according to marking criteria. Appropriate, timely, constructive, and effective feedback as well as student peer feedback through group's discussion were critical components that constitute a successful practice. Finally, all assessment and marks were reviewed according to MEC policy and quality assurance by internal/peer and external moderators.

IV. Result Analysis

A. Students Performance

To evaluate the students' performance, a comparative analysis of the average marks between the current

semester and previous semester was conducted. Table I shows comparison between students' marks in spring 2017 semester and previous semester fall 2016.

TABLE I. MARKS FOR SPRING 2017 SEMESTER AND FALL 2016.

	Spring 2017	Fall 2016
Coursework	37.52 [50.00]	38.17 [50.00]
Final Exam	33.14 [50.00]	23.09 [50.00]
Total average	70.66	61.25
The difference between CW and Final Exam	4.38	15.08
SD	9.80	9.15

The spring 2018 group obtained higher average marks (average=37.52, SD=9.8), while, students in fall 2017 scored lower average (M=61.25, SD=9.15). The exam average increased by 10/50 from the previous semester. The total average increased by 15.4 % from the previous semester. Using formative assessment improved the learning process, permitted the monitoring of learning and feedback, and identified learning difficulties and student's weakness. Additionally, it was a practice to summative assessment that improve students' performance in the final exam. The coursework was more challenging and that helped student to improve other skills that include team-work, communication, leadership, critical thinking, problem solving and decision-making abilities.

B. *Survey Analysis*

The survey was compiled by the module coordinator and was customized to obtain student perceptions of the effectiveness of the innovation assessment approach. The students were asked to indicate their degree of agreement with the survey items using a 5-point agreement type scale. Fig. 4 shows students' feedback on the assessment Approach. The survey included seven statements related to the improvement that the students achieved from the assessment, making criteria and the feedback: (1) The assessment helped me to improve my learning and understanding of the module's topic, (2 The assessment improved my deep leaning, and (3) The assessment prepared me for life-long learning,(4) The assessment improve my ability to apply what I know to real-life problems,(5) The assessment helped me to work in a team,(6) The marking criteria was clear(7) The teacher used to give regular feedback and support.

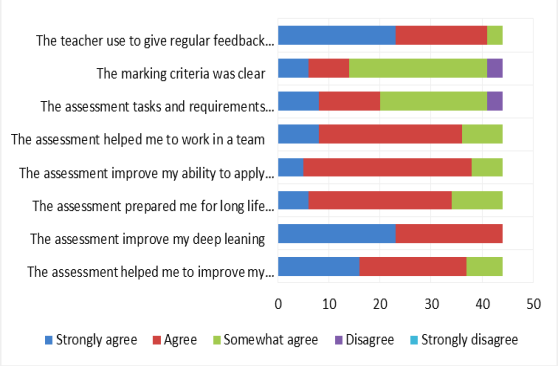


Figure 4. Students' feedback on assessment approach.

The responses to the questions showed that a significant percentage of students (91%) agreed that the coursework enhanced the learning process and contributed to the high performance in both formative and summative assessments.

The second survey was the Module Evaluation survey that was compiled by the Student Experience office at MEC in Middle East College. The students were asked to indicate their satisfaction on the whole module that includes ten statements; example items are: (1) the module work and assessments were well coordinated and scheduled. (2) The assessments were clear and understandable (3) the faculty uses innovative methods of teaching in this module (4) The faculty has provided effective/ useful feedback to the assessments. Fig. 5 show the MES. The overall satisfaction was very good, ranging from 95% to 100%.

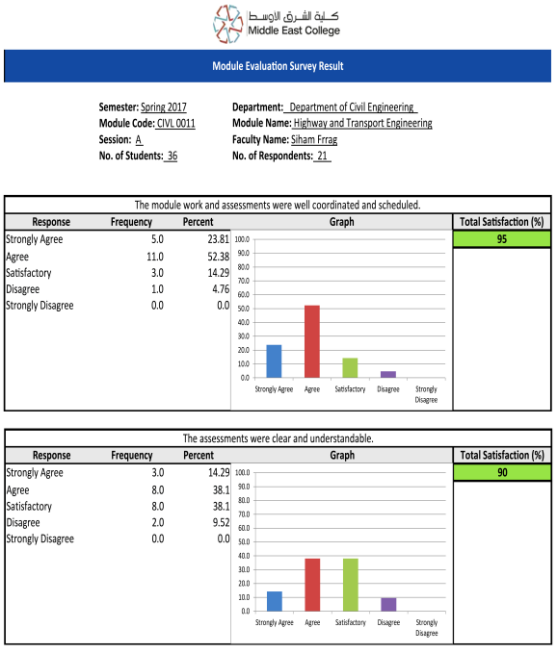


Figure 5. Module Evaluation survey results.

C. *Feedback*

The qualitative approach includes the feedback from student, internal, and external moderators' feedback. In general, the responses were mainly positive

1). *Students' feedback*

The students' feedback was collected online using Padlet form. Example of students' feedback are; The project connect the real life with study, Good team work, Very creative, Always new things, always creative and happy to be in the class "So creative".

2). *Moderator feedback*

The feedback from both internal and external moderators were positive as they agreed that the Coursework was standard, met the learning outcomes, and marking is fair, consistent and accords with the assessment criteria. The external moderator (M Davison) at the end of the semester provided feedback on the module, assessment and activities and his feedback was "Module split 50/50 coursework assessment / exam. The

coursework assessment based upon geometric highway design and evaluation (50), supported by formative assessments (example sheets) will help the students learning in support of the Coursework assessment and final examination. The coursework assessment builds upon formative assignments relating to particular aspects of Highway design and supports learning in relation to the style of questions posed in the end examination. Grades awarded were generally fair and consistent with no failures, need to ensure grades and comments clearly align with generic grade descriptors. Learning Outcomes of modules are appropriately assessed. Exam grades show a wide range with a significant improvement in terms of higher grades than with previous cohort in relation to coursework assessment supporting examination. This has also resulted in a far better correlation between the coursework assessment and exam grades than seen previously" also "Overall module grade averages coursework assessment 37.5/50 Exam 33.1/50 SD 9.8 98.5% pass rate (66/67) Exam average increased by 10/50 from previous cohort.

The analysis of the feedback, and questionnaire results showed that the methodology was effective in enhancing the students' understanding of the module, improved their team work skills, and supported active learning relevant to the real life. Linking the activities to the assessment was effective in motivating students to share the activities and preparing them for summative assessments. Formative assessment helped the teacher to measure students' progress, nature and extent of their difficulties.

V. Conclusion

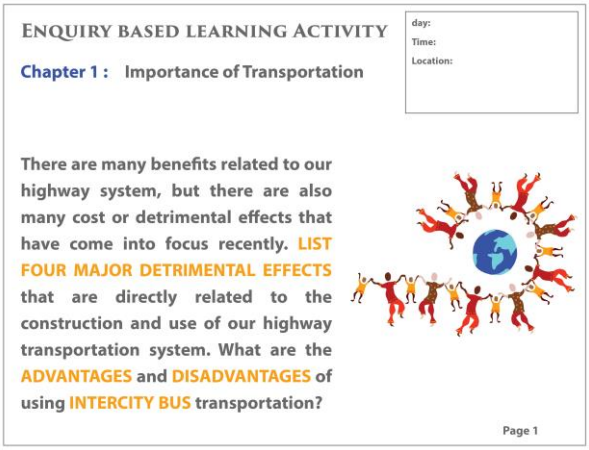
This research attempted to explore the importance of linking learning and assessment using both formative and summative assessments. The assessment was used as a core part of the teaching and learning process. Using formative assessment improves the learning process, permits the monitoring of learning and feedback, and identifies learning difficulties and student's weakness. Additionally, it is a practice to summative assessment that improves students' performance in the final exam. Online quizzes give prompt and comprehensive feedback. It enhanced students' flexibility around the time and place of taking the assessment task. Using rubrics increases the reliability of marking criteria and gives clarity to students about task expectations and how they are assessed. Group projects and real-life projects improve students' performance in teamwork, time management, communication and technology. The implementation of effective assessment enhances student learning and engineering graduate attributes through the provision of professional skills such as critical thinking, problem-solving, teamwork, collaboration and creativity to achieve sustainable learning.

Students' grades showed improvement compared to the previous semester. Students demonstrated high level of performance in both internal and external marks. Moreover, feedback from students, internal and external moderators showed appreciation of the innovative assessments implemented.

Finally, this paper has demonstrated the fact that Ms Excel spreadsheet can be used as a tool to improve the assessment design and generate a variety of cases studies and different scenarios for the same project and reduce the plagiarism and copying from peer students. Many of students' assignments were of high-quality and proved their ability to use critical analysis, team-work, and time management and increased their confidence.

Appendix

Fig. 6 show example of formative assessment: inquiry-based learning activity.


ENQUIRY BASED LEARNING ACTIVITY

day:
Time:
Location:

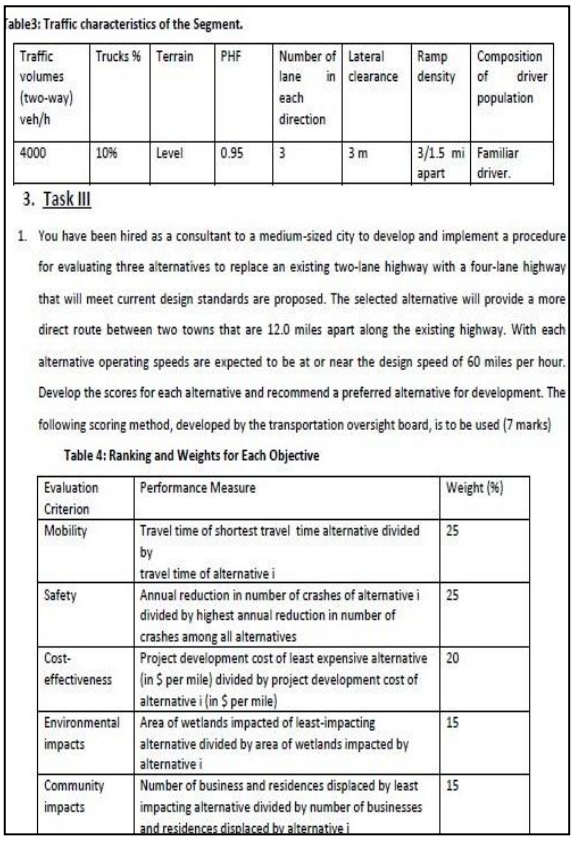
Chapter 1 : Importance of Transportation

There are many benefits related to our highway system, but there are also many cost or detrimental effects that have come into focus recently. LIST FOUR MAJOR DETRIMENTAL EFFECTS that are directly related to the construction and use of our highway transportation system. What are the ADVANTAGES and DISADVANTAGES of using INTERCITY BUS transportation?

Page 1

Figure 6. Example of formative assessment: inquiry- based learning activity.

Fig. 7 show example of summative assessment coursework.


able3: Traffic characteristics of the Segment.

Traffic volumes (two-way) veh/h	Trucks %	Terrain	PHF	Number of lane in each direction	Lateral clearance	Ramp density	Composition of driver population
4000	10%	Level	0.95	3	3 m	3/1.5 mi apart	Familiar driver.

3. Task III

1. You have been hired as a consultant to a medium-sized city to develop and implement a procedure for evaluating three alternatives to replace an existing two-lane highway with a four-lane highway that will meet current design standards are proposed. The selected alternative will provide a more direct route between two towns that are 12.0 miles apart along the existing highway. With each alternative operating speeds are expected to be at or near the design speed of 60 miles per hour. Develop the scores for each alternative and recommend a preferred alternative for development. The following scoring method, developed by the transportation oversight board, is to be used (7 marks)

Table 4: Ranking and Weights for Each Objective

Evaluation Criterion	Performance Measure	Weight (%)
Mobility	Travel time of shortest travel time alternative divided by travel time of alternative i	25
Safety	Annual reduction in number of crashes of alternative i divided by highest annual reduction in number of crashes among all alternatives	25
Cost-effectiveness	Project development cost of least expensive alternative (in $ per mile) divided by project development cost of alternative i (in $ per mile)	20
Environmental impacts	Area of wetlands impacted of least-impacting alternative divided by area of wetlands impacted by alternative i	15
Community impacts	Number of business and residences displaced by least impacting alternative divided by number of businesses and residences displaced by alternative i	15

Figure 7. Example of summative assessment coursework.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All the work was done by Siham G. Farrag and I had approved the final version.

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