

An Application of Formative Assessment Theory to Improve Business Student Learning on Environmental Sustainability

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Abstract

In business education, an important outcome is students' knowledge and skills promoting environmental sustainability. The goal of this study is to apply formative assessment theory to assess business student learning on environmental sustainability. The formative assessment includes observations, questioning, discussions, self-assessment, case presentations, short essays, quizzes, etc. Environmental sustainability is assessed in seven areas, including environmental sustainability policy and administration, climate change, resource efficiency, clean products and services, resource use, alternative energy, and waste management. A framework is developed incorporating student learning goals, formative assessment, and student performance. The study uses a rubric to evaluate 103 students on awareness of environmental sustainability in a traditional business course in the middle of semester. The results indicate that students' knowledge on environmental sustainability improved significantly through formative assessment practices. Therefore, more integration of environmental sustainability in business courses is recommended for students to think critically and solve meaningful environmental problems.

Keywords: Environmental Sustainability, Formative Assessment, Business Students, Formal and Informal Assessment

1. Introduction

Environmental sustainability is defined as meeting human needs without compromising the health of the ecosystem (Callicott & Mumford, 1997) from the business standpoint. Environmental sustainability requires that current businesses consider the long-term impact of their activities for the benefit of future generations. Economic development in most developing countries is largely driven by the expenses of natural resources, which leads to dramatic increase in greenhouse gases and severe damage of the natural environment, such as the release of chemical toxins into the environment. As a result, some developing countries lack access to safe drinking water and sanitation (Hart, 1997). World Commission on Environmental and Development warns that the current generation borrows environmental capital from future generations with no intention or prospect of repaying.

Environmental sustainability is one of the most important areas in business education (Borin & Metcalf, 2010; Brundiers et al., 2010; Brundiers & Wiek, 2011). Business students are the future leaders and will have a great influence on society as they enter businesses, institutions, governments, and other organizations after graduation. Sustainability has been integrated into universities' mission and values, strategic planning, curricula, research, student life, operation and purchasing, and community partnership (Hiller Connell & Kozar, 2012). Sustainability education typically focuses on critically examining information about the myriad of problems that exist, and exploring possible sustainable solutions to these problems (Burns, 2011, 2013; Shephard, 2008). Instructor-centered education is not sufficient for teaching sustainability because of the complexity and deeply challenging nature. In business education, an important outcome is students' knowledge and skills promoting environmental sustainability (Burns, 2011, 2013; Juárez-Nájera et al., 2006; Rusinko, 2010). Remington-Doucette et al. (2013) indicate that sustainability education might be most effective if infused into traditional business courses. This paper addresses this concern and explores how to enhance student learning on environmental sustainability through formative assessment in traditional business courses. Effective teaching involves engaging and challenging student to expand their knowledge and skills with different learning activities. Formative assessment is one of the most useful ways of improving the process of student teaching (Bennett, 2011).

Formative assessment consists of a set of interactive activities that an instructor uses to evaluate student understanding, learning progress, and academic needs in class. It includes formal and informal assessment activities used by the instructor during the learning process (Ruiz-Primo, 2011; Ruiz-Primo & Furtak, 2004, 2007). The goal of formative assessment is to monitor student process and identify the weak areas in learning. The instructor, therefore, can modify teaching and learning activities immediately in the classroom to improve student performance (Sadler, 1998; Yorke, 2003). This research develops a framework for improving student learning on environmental sustainability based on formative assessment theory. A formative assessment practice is conducted to assess student awareness of environmental sustainability in a traditional business course. The goal of the study is to address the immediate need of socially responsible business leaders, integrate formative assessment theory with education of environmental sustainability, and explore how to improve student performance through high quality instructor-student interactions.

The remainder of the paper is organized into four parts. Section 2 is a review of formative assessment theory. The formal and informal formative assessments are discussed to form the theoretical foundation for this research. In section 3, a framework is proposed to assess student learning on environmental sustainability. The formative assessment is based on student learning goals about environmental sustainability and the outcome of the assessment is enhanced student performance. Section 4 is a case study of formative assessment of student awareness of environmental sustainability. Scores of subject coverage, instructor assessment outcome, and end-semester assessment results are compared and discussed. The emphasis is on how to improve student performance through formative assessment practices. Section 5 is the conclusion and recommendations.

2. Formative Assessment Theory

Formative assessment has attracted great attention in education research (Nicol & Macfarlane-Dick, 2006; Sadler, 1998). Formative assessment is a process of eliciting understandings from students and using them to enhance student achievement (Bennette, 2011; Wood, 1987). It involves gathering and interpreting information from students and then taking actions to improve identified weak areas (Ruiz-Primo & Furtak, 2004, 2007). Student's problem solving ability improves under the guidance and support of instructors (Vygotsky, 1978; Wood, 1987). The instructor and students interact and collaborate during the assessment process to reduce the gap between desired and observed student performance (Boud & Molly, 2013; McMillan et al, 2013; Ruiz-Primo & Furtak, 2004, 2007). Formative assessment is directly associated with the enhancement of student learning because it is an ongoing process and provides immediate feedback to student activities. The instructor modifies teaching and learning activities based on information gathered during the assessment to motivate student engagement. Gikandi et al. (2011) suggest that teaching and learning processes need to change from instructor-centered to assessment-centered to provide students with opportunities to demonstrate their developing abilities and receive support to enhance their performance. The feedback from formative assessment is most effective since it monitors student progress toward the learning goals and promotes students to develop effective learning strategies.

2.1. Formal and Informal Formative Assessment

Formative assessment can be formal or informal (Yorke, 2003). Ruiz-Primo and Furtak (2004, 2007) argue that formal and informal assessments are two different forms of formative assessment. Formal formative assessment is structured and it provides instructors with more control. It is a planned activity designed to gather information about student understanding. Students work on an activity (e.g., a test or writing assignment) designed or selected in advance by the instructor so that information may be more precisely collected. It is the instructor's pre-designed assessment to monitor student learning during teaching. During formal formative assessment, the instructor takes time to conduct detailed analysis of student information and plan actions based on this analysis. The main player of formal assessment is the student.

Ruiz-Primo (2011) defines informal formative assessments as ongoing strategies that help instructors acquire information from students that can immediately be used in instruction. Although informal formative assessment is not planned, it is still necessary for the instructor to prepare in advance since the instructor needs to provide immediate responses to students' unexpected questions and incorrect reactions. Cauley and McMillan (2010) point out that formative assessment can identify specific student weak areas in the instruction, provide immediate feedback to students to help them correct their errors, and identify and implement instructional correctives. Student learning improves through informal observations and oral questions posed to students while content is taught or reviewed. Instructors are the main player of informal formative assessment and they use the content knowledge and pedagogical skills to guide their ongoing teaching (Black & Wiliam, 2009).

The student may not be appropriately prepared for the informal assessment. Ruiz-Primo and Furtak (2007) propose the ESRU informal formative assessment cycle. ESRU cycle consists of four steps: (1) instructor elicits response, (2) student responds, (3) instructor recognizes student response, and (4) instructor uses student response. It is noted that the instructor uses the student’s response to start another cycle to continuously improve student performance.

Potentially, most teaching activities in the classroom can be opportunities for informal formative assessment, such as discussions, observations, questioning, etc. The purpose of assessment can be conceptual understanding, practical skills, or social skills (Moss, 2008). Informal formative assessment can take place during classroom activities, office hours, student organization activities, or field trips. A student’s incorrect response to a question can trigger an instructor’s assessment. The instructor can quickly adjust the classroom activities to emphasize the weak areas identified in the assessment. In the informal assessment, the instructor freely moves in different directions based on student responses (Ruiz-Primo, 2011). Through the interaction between the instructor and students, students can effectively interpret and internalize the concepts they experience (López-Pastor & Sicilia-Camacho, 2015).

2.2. Comparison of Formal and Informal Formative Assessment

Ruiz-Primo and Furtak (2004, 2007) identify the differences between formal and informal formative assessment. In formal formative assessment, the instructor gathers information at a planned time, takes time to analyze the information, and takes actions to improve the problematic areas. In informal formative assessment, the instructor acquires information during learning and immediately uses the information to address the concerns of students. Figure 1 summarizes Ruiz-Primo and Furtak (2004, 2007) model.

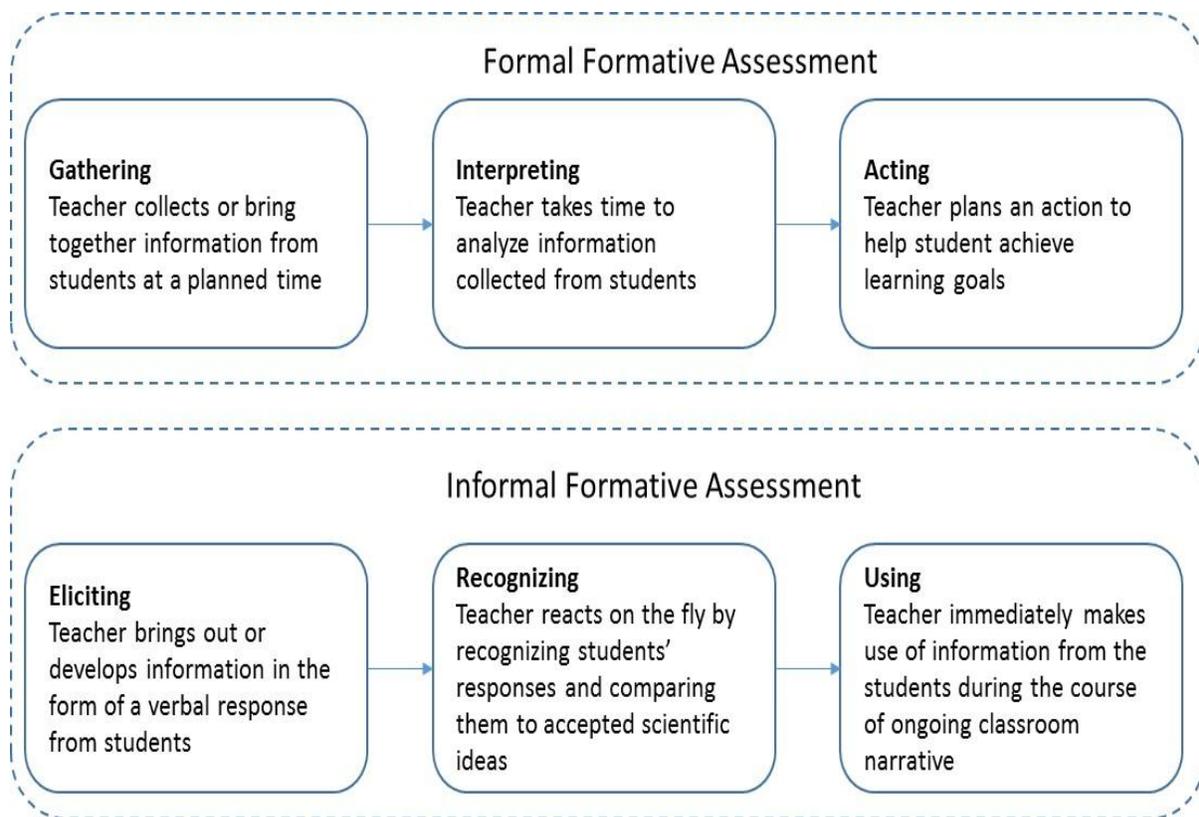


Figure 1: Comparison of Formal and Informal Formative Assessment

Both formal and informal formative assessment techniques start with collecting information from students. The first step of formal formative assessment is to gather information at a planned time from the whole class, while that of informal assessment is to collect information by eliciting responses from part of students during class. The second step of formal formative assessment is for instructors to take time to analyze the information collected from whole class, while that of informal assessment is for instructors to react to students' responses spontaneously during class. The third step of formal formative assessment is for instructors to plan an action to respond to assessment results, while that of informal assessment is for instructors to immediately provide feedback to students' responses. Formal formative assessment uses standardized assignments such as quizzes or midterm tests to determine student learning and progress. Informal assessment on the other hand does not rely on tests to measure a student's understanding and involves more interactions between the instructor and the student (Ruiz-Primo, 2011). Although informal formative assessment is an important technique to improve student learning, it is not a replacement of formal formative assessment. Informal assessment can stimulate student creativity in expressing their ideas about a topic and formal assessment is a systematic and structured technique to formally evaluate student performance. Education literature suggests the combination of formal and informal assessment strategies to measure student learning and enhance teaching effectiveness (Ruiz-Primo and Furtak, 2004, 2007)

3. Formative Assessment of Student Learning on Environmental Sustainability

3.1. Environmental Sustainability Issues

Previous studies have identified important environmental sustainability issues in college education. Wright (2002) reviews definitions and frameworks in higher education and identifies emerging themes and priorities of environmental sustainability in different universities. Abraham (2006) designs a pollution prevention hierarchy including source reduction, reuse or recycle, energy recovery, waste treatment, and secure disposal. Abraham (2006), Watson et al. (2013), and Watson et al. (2017) design a rubric to assess student knowledge and ability to engage in environmental sustainability. Their main concerns are improving natural ecosystems, using life cycle thinking to all activities, implementing environmental sustainability management system, minimizing natural resource depletion, preventing waste, protecting natural ecosystems, using renewable energy sources, using inherently safe and benign materials, developing clean products and technology, replenishing depleted resources, lowering materials and energy consumption, designing green packaging, and developing green supply chain and clean production. Based a review of previous research, this study summarizes environmental sustainability issues into seven categories:

1. Climate change: Addressing global warming, emissions, acid rain, and ozone depletion.
2. Resource efficiency: Addressing clean production, eco-efficiency, and protection of natural ecosystems.
3. Clean products and services: Developing clean products and technology, green supply chain, green packaging.
4. Resource use: Addressing depletion and conservation of materials, energy, and water, reduction of materials and energy consumption.
5. Alternative energy: Addressing alternative and renewable energy and technology.
6. Policy and administration: Addressing government and company policies and management systems that enforce environmental sustainability.
7. Waste management: Waste reuse and recycling.

3.2. Framework of Formative Assessment of Student Learning on Environmental Sustainability

Student understanding of environmental sustainability is closely associated with student critical thinking skills related to sustainability (Broundiers et al., 2010; Brundiers & Wiek, 2011). Critical thinking of environmental sustainability involves several skills including understanding the environmental issues, logically analyzing and evaluating information sources, and synthesizing and applying different perspectives to propose well-reasoned solutions. Solving environmental issues requires students to apply high-level skills such as the ability of interpreting, analyzing, integrating, evaluating, reasoning, deducting, and generating. Students are able to understand the significance of environmental problems, combine the information to better understand the relationship between various environmental challenges, form logical opinions about the critical issues, and produce creative solutions to environmental challenges (Burns, 2011, 2013). Following Facione and Facione's (1994) Holistic Critical Thinking Scoring Rubric (HCTSR), this study proposes the three-level learning goals related to environmental sustainability, (1) awareness, (2) analysis and application, (3) synthesis and evaluation.

Students are able to identify core issues of environmental sustainability, conduct research and explore these core issues, and apply diverse perspectives to develop effective strategies to the real world problem (McNaughton, 2004).

- (1) Awareness (students are able to identify core issues of environmental sustainability accurately and appropriately).
- (2) Analysis and application (students are able to conduct research and explore core issues of environmental sustainability).
- (3) Synthesis and evaluation (students are able to apply diverse perspectives to propose effective policies and strategies to the real-world environmental issues).

The formative assessment process is based on student learning goals and the outcome of assessment is improved student achievement (Carless, 2007). Nicol and Macfarlane-Dick (2006) also propose that student-learning goals affect assessment tactics, which in turn influence student learning. Wiek et al. (2014) find that engaging student in problem solving through inquiry of problems and interactive learning is effective for sustainability education. Sidiropoulos (2014) suggests that formative assessment increases student engagement and results in improved student learning. This study proposes a framework integrating student-learning goals, formative assessment, and assessment outcomes (see Figure 2).

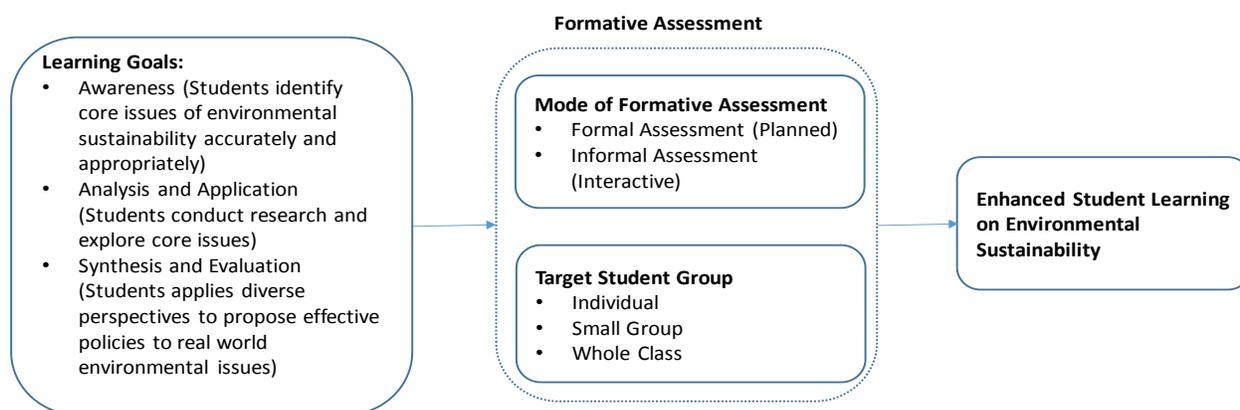


Figure 2: A Model of Formative Assessment of Student Learning on Environmental Sustainability

4. An Example of Formative Assessment on Student Awareness of Environmental Sustainability

4.1. Rubric for Assessing Student Awareness of Environmental Sustainability

Formative assessment is conducted in a traditional business course. A total of 103 students participate in the study of formative assessment of awareness of environmental sustainability. Eight case studies are assigned during the semester to analyze environmental sustainability issues in different company settings. Case studies are announced at the beginning of the semester and students are required to prepare for class discussions. Cases cover a variety of environmental sustainability issues including waste management, clean production, green products, global warming, and ecosystem. A rubric is developed to assess student awareness of environmental sustainability issues (see Table 1).

Table 1: Rubric for Assessing Business Student Learning on Environmental Sustainability

Performance	Exceeds expectation (5)	Meets expectation (3)	Does not meet expectations (1)
Awareness of environmental sustainability issues: policy and administration, climate change, resource efficiency, clean products and services, resource use, alternative energy, and waste management.	Awareness: Identifies the environmental sustainability issues associated with the business and discusses these issues thoroughly in class activities.	Awareness: Identifies most of the contemporary issues associated with business, but misses some; discussion of the issues is not completely thorough.	Awareness: Fails to recognize key issues or the discussion is cursory.

Student awareness of environmental sustainability is assessed in three levels: (1) do not meet expectations (score 1), (2) meet expectations (score 3), and (3) exceed expectations (score 5). Students with a score of five (exceed expectations) should be able to identify the environmental sustainability issues associated with the business and thoroughly discuss these issues in class activities. Students with a score of one (do not meet expectations) cannot recognize key issues and the discussion is cursory. A rubric is an effective tool for conducting assessment since it makes expectations clear and readily available to students. This method ensures that instructors systematically and continuously evaluate student progress during teaching (Watson et al., 2017).

4.2. Assessment Results and Discussions

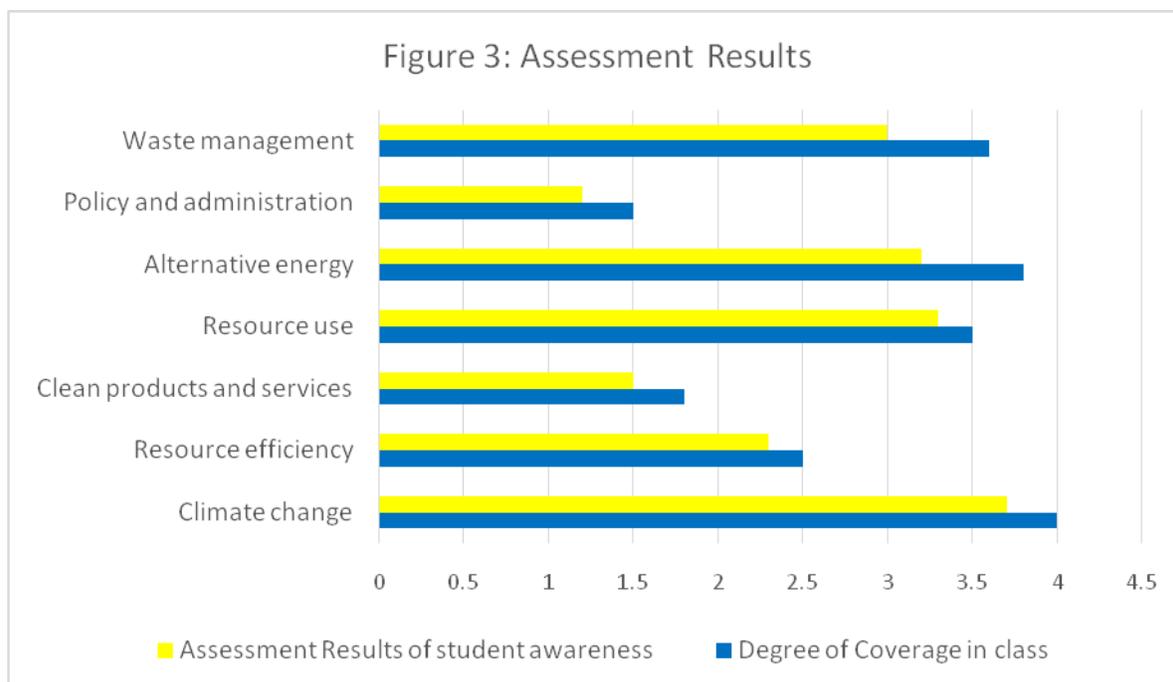
The formative assessment is conducted in the middle of semester. The assessment results are summarized in Table 2. In the assessment, student awareness is assessed on a scale of 1 to 5 (5 being the highest). Before the assessment, the instructor rates the degree of coverage of the environmental issues on a scale of 1 to 5 (5 being the highest). The instructor also conducts an assessment at the end of semester to summarize student learning on awareness of environmental issues.

Table 2: Assessment Results of Formative Assessment

Sustainability Issues	Factor 1	Factor 2	Factor 3	Difference Factors 3&2*
Climate change	4.0	3.7	4.3	0.59
Resource efficiency	2.5	2.3	2.7	0.39
Clean products and services	1.8	1.5	2.5	1.02
Resource use	3.5	3.3	3.8	0.52
Alternative energy	3.8	3.2	4.2	0.96
policy and administration	1.5	1.2	3.0	1.75
Waste management	3.6	3.0	4.1	1.14
Note: Factor 1: Degree of coverage in class before the formative assessment; Factor 2: Formative assessment results in middle of semester; Factor 3: End of semester assessment results. *: All differences are significant at $p < 0.01$.				

The results show that students understand issues of the climate change and alternative energy very well. The weak areas are issues related to clean products and services and policy and administration. It is understandable that climate change is having significant and costly effects on our communities and health. Solving environmental problems require long-term collaborative actions for sustainable development. Developing renewable energy resources is one of the most efficient and effective solutions. Based on the assessment results, the instructor should make plans to address the weak areas such as issues related to clean products development, green packaging, green supply chain, and environmental policies and administration.

The assessment results show that student awareness is closely related to instructor coverage of the issues in learning (see Figure 3 for a detailed comparison). Climate change has received the highest coverage in class, and the student awareness score is the highest based on the assessment results (3.7 on the scale of 1 to 5). Issues on policy and administration have received the least attention in class, and student awareness score on this issue is the lowest (1.2 on the scale of 1 to 5). It is interesting to find that scores of assessment at the end of the semester are higher than formative assessment results during the semester. The differences between scores of two assessments are significant at $p < 0.01$ on all environmental issues.



5. Conclusion and Recommendations

In this study, a framework is proposed to study how to enhance student learning based on formative assessment. Literature on sustainability education and theory of formative assessment are reviewed and integrated to form the research framework. Important environmental sustainability issues are reviewed and used to form student-learning goals related to environmental sustainability. Formal and informal formative assessment are analyzed and applied to the evaluation of student performance. The sample study on student awareness of environmental sustainability implies that formative assessment is very useful to the improvement of student learning.

Through formative assessment during the semester, student overall knowledge of environmental sustainability increases substantially, although student performance in certain areas such as resource efficiency and clean products/services are relatively weak. This article argues that formative assessment can be a powerful tool to support student motivation due to its timely feedback and immediate instructional correctives.

This study indicates that the incorporation of sustainability across a curriculum should be balanced among all sustainability issues and dimensions (Watson et al, 2013). Although this course emphasizes sustainability in student learning, awareness scores in certain areas are relatively low in this research. Further, certain environmental issues may be missing in student learning in the course. Therefore, it is necessary for business faculty to develop a comprehensive plan to ensure that all aspects of environmental sustainability are addressed in the program (Krizek et al, 2012). Holden et al. (2008) point out that the pursuit of sustainability within the university involves student learning, faculty learning, institutional/operational learning, and learning at the university-community interface.

Although this article focuses on formative assessment, it is important for scholars to explore different types of assessment. Future research is recommended to investigate the integration of both summative and formative assessment techniques in traditional business courses to enhance student learning on environmental sustainability. Formative assessment is important to facilitate teaching and learning rather than to measure students' learning. Summative assessment is important for accurate information and evaluation of the effectiveness of overall program. Summative assessment is useful to identify program strengths and weaknesses as part of the program improvement process. Therefore, both formative and summative assessments are essential for student learning.

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