

Responsible STEM Graduates: Developing the Awareness-Reflection-Engagement (ARE) Model for Sustainability

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SUMMARY

Reflection has been effectively used in higher education to encourage students to seek beyond the descriptive and simple response to critical, deep thinking and, effectively, make better choices. More recently, reflection and reflective practices have been introduced as a means of engaging students to make more sustainable choices. Based on Dewey and Schön's foundation of reflection as linked to specific actions which apprentices or workers undertake in their daily tasks, i.e. reflection-in-action and reflection-on-action, this paper attempts to show that reflection on sustainability can instigate changes in behavior and attitude. The paper concludes with how reflection can and should be implemented as a solid, formative pedagogical tool at all levels of education to ground sustainability in reality and create authentic change agents for the future workplace.

Keywords: STEM students, sustainability, Sulitest, critical reflection, authentic engagement

INTRODUCTION

Over the past few decades, the topic of sustainability has come to the forefront in the workplace with increasing pressure on all industries to make more sustainable choices to preserve the environment, enhance social equity, and create economic benefit for stakeholders. In order to prepare a future generation of engaged employees, higher education institutions have been entrusted with the responsibility of including sustainability into their curriculum and programs. Nonetheless, simply embedding sustainability concepts into the curriculum or introducing sustainability initiatives on campus have shown mixed results, particularly in regards to engagement and replication of sustainable actions outside of the classroom and in the 'real world'. Students often do not see the relevance of studying about these topics or participating in these initiatives and faculty are overwhelmed with crammed course loads and full schedules. To increase the possibility of authentic engagement toward sustainability that will replicated later,

we posit the need for introducing a new approach to teaching/learning about sustainability, i.e. a critical reflection on sustainability in the form of written reflections into the academic programs. To this purpose, we propose the following two Research Questions:

RQ 1: In what ways did students’ critical and reflective thinking change toward the three pillars of sustainability?

RQ 2: What critical reflection of sustainability could students apply to their profession?

REFLECTION

Previous literature has examined reflection in diverse disciplines and at all levels. Dewey (1938) defined reflection as an “active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions which it tends” (p. 9) which begins with a state of doubt, hesitation, perplexity, or mental difficulty (Hebert, 2015). As seen on Table 1, previous research has examined various forms of reflection built upon Schön’s initial proposition of reflection-in and reflection-on action in relation to completing a task.

Table 1. Types of reflection.

Reflection	Definition	Source
Reflection-in-action	Thinking while doing the task	Ryan and Byrne, 2013; Schön, 1987; Thompson and Pascal, 2012; Yanow and Tsoukas, 2009
Reflection-on-action	Thinking after the event	Ryan and Byrne, 2013; Schön, 1987; Thompson and Pascal, 2012; Yanow and Tsoukas, 2009)
Reflection-after-action	Prompted by assessment of action	Clegg, Tan, and Saeidi, 2002
Reflection-as-action	Tacit knowledge which is both an awareness of self and the environment by the way of the body	Hebert, 2015
Reflection-about-action	Thinking about social, economic, and political purposes and conditions of teaching and learning	Leitch and Day, 2000
Reflection-for-action	Planning and thinking ahead to make the best use of the resources that are available	Thompson and Pascal, 2012

Previous literature has examined different models of reflection or levels of reflection that could be implemented in HE institutional settings. Table 2 summarizes some of the models deriving from the literature.

Table 2. Models of reflection

Reflection Model	Steps	Source

Gibb's Model of Reflection	Description, feelings, evaluation, analysis, conclusion, action plan	Roberts, n.d.
Watson-Glaser's 5-step appraisal of critical thinking	Inference, recognition of assumptions, deductions, interpretation, and evaluation of arguments	Cavdar and Doe, 2012
4 levels of reflection	Reporting/responding, relating, reasoning, and reconstructing	Ryan, 2012
Larrivee's 4 levels of reflection	Pre-reflection, surface reflection, pedagogical reflection, and critical reflection	Morrow, 2011
4 levels of reflection	Personal, interpersonal, contextual, and critical	Morrow, 2009
Kolb's reflection	Active experimentation, concrete experience, reflective observation, and abstract conceptualization	Morrow, 2009; Roberts, n.d.
Brookfield's 4-lens framework	Autobiography, students' eye, colleagues' eye, and theoretical literature	Kamardeen, 2015
Baker's Model of Reflection	Identification, description, significance, and implications	Kennison, n.d.

In this paper, Baker's 4-Step Model of reflection was used as the foundation of the MBA student reflection papers, where the importance of evaluating and taking each decision can have dramatic effects on a larger community. This is a potential challenge STEM student may face in their respective workplaces as well.

Written Reflection

Students have different levels of academic learning, and different students have different learning experiences (Ash & Clayton, 2004). Their language choices, construction of phrases, and willingness to share affective responses may be rooted in linguistic or cultural traditions (Wong, 2019). Some students are gifted writers, generally speaking, but still choose to describe step-by-step what they do when reflecting (Wong, 2016). Following a list of precise questions could be too restrictive to encourage authentic reflection and to a lesser extent, authentic critical reflection. This could lead to a generation of 'reflective zombies' (de la Croix & Veen, 2018) who do little more than regurgitating template responses to any reflective questions.

RESEARCH SETTING AND METHODS

In this exploratory study, from January 1, 2019 to May 19, 2019, all students completed a critical reflective writing assignment on sustainability in a Master's Program at a STEM University in the Southeast. The population included a sampling of 21 students from one

Business Foundation course that was taught by 11 faculty members during the five-month period.

During the first week of class, the students took the Sulitest that provided the instructors a baseline of the students' knowledge on sustainability. In this course, students completed four research papers on topics that are relevant to sustainability with the following prompts:

1. Explain the concept of sustainability relating to business with examples of sustainability in an organization.
2. Discuss the importance of sustainability to an organization.
3. Explain the concept of sustainability, examples of leaders in organizations and their role in sustainability.
4. Explore the current sustainability models being used in organizations with an example of a company that includes sustainability in their strategic initiatives.

At the conclusion of the course, the students completed a critical reflective writing assignment based on the following prompts:

- Prior to starting this class, describe your understanding of sustainability issues.
- How did you acquire that knowledge?
- How has your learning "shifted" your way of thinking, behaving, or communicating about sustainability?
- What will you do differently to improve sustainability in the future?
- Reflect on how sustainability would or would not apply in your chosen profession.

RESULTS

The initial Sulitest test provided an overview of the baseline for the students' knowledge on sustainability. The Sulitest discussed covers knowledge from four key areas. See Table 3 Sulitest Global Results for the breakdown of scores from the student population and the benchmark Worldwide. The Sulitest assesses the level of knowledge in economic, social, and environmental responsibility in HE students at all levels throughout the world to drive changes in pedagogy and curriculum toward a more sustainable future (Decamps et al., 2017). Its scope includes addressing existing knowledge of the challenges facing society and the planet through general knowledge assessment of social, environmental, and economic issues. For this developmental paper, we have chosen the Sulitest to ascertain what our students know about sustainability prior to this course and to raise awareness about sustainability challenges they may be facing in the future workplace.

Table 3. Sulitest Global Results.

Knowledge Theme	Study	Worldwide Benchmark
Sustainable humanity and ecosystems	56%	58%
Global and local human-constructed systems	58%	56%
Transition towards sustainability	53%	54%
Role to play, individual & systemic change	53%	53%

Source: Sulitest, 2019

As seen on Table 3, the students in this study performed almost identically to the worldwide benchmark. This suggests that their previous and existing knowledge of sustainability

is no greater nor worse than other participants. As seen on Table 4, the respondents attained their previous knowledge through their job, the news media, or school. Respondents had the highest understanding of environmental sustainability; in fact, numerous respondents mentioned that they had not even considered the social or economic aspects of sustainability in previous discussions.

Table 4. Sustainability Themes from Critical Reflections.

Theme	Specific criteria (# respondents)	Examples from reflections
Understanding of sustainability issues	Related to environmental issues (7) No understanding (15)	Reference 2 - <i>I suppose I viewed sustainability as a hip buzzword which had manifested over the last decade or so, one that encompassed a broad range of efforts which sought to improve or reduce the impact on our environment, yet carried little practicality.</i> Reference 9 - <i>The social and economic aspects were not even a thought I had when having discussions on sustainability.</i>
Acquire that knowledge prior to class	Job (3) News Media (10) School (4)	Reference 3 - <i>I previously worked for an aircraft manufacturer. During my time with the manufacturer, I gained some experience relative to environmental sustainability considerations. I was involved in projects that aimed to optimize the overall efficiency of the aircraft.</i> Reference 4 - <i>Within the framework of everyday life, I've noticed a concerted effort by organizations to openly broadcast their application of sustainable practices, and noticed the increase of what I perceived to be as applications of those practices.</i> Reference 4 - <i>A misunderstanding of sustainability was formed during my undergraduate studies.</i>
Learning "shifted" way of thinking, behaving, or communicating about sustainability	Understanding and ability to apply three pillars (14) Requires change in organizational culture (8) Impact on environment (4) Mind set on that supports three pillars (11) Social responsibility of companies	Reference 6 - <i>I never drew the connection that social and economic sustainability considerations are in fact considerations surrounding sustainability. When I used to think about the decisions a business made, I use to only think about it in terms of profitability for the business or in the best financial interest for the business. I never thought to consider these decisions as sustainability decisions.</i> Reference 7 - <i>Further research led me into the importance of sustainability to the organization and how leadership can initiate and maintain successful sustainability programs in their organization and how they are adopting sustainability practices and models. An overall picture emerged which shifted my views on sustainability, rather than an obstacle sustainability practices can be approached as an opportunity.</i> Reference 1 - <i>Economics is the primary driver behind this rush to find a better more sustainable fuel source, but a close second is environmental and I believe the two are very closely linked. Fossil fuels are expensive because they are the only option for air travel at this time. So, any way a company can become more sustainable in the amount of fuel the burn and how much they need not only will the save money, but they will also whether intentionally or not have a positive impact on the environment.</i> Reference 3 - <i>I'm now under the impression that Sustainability is a profitable discipline that corporations actual desire to implement in their normal operations, and that that economic profits can be improved by implementing Sustainable business practices.</i> Reference 1 - <i>Sustainability is not just an idea or a hope. It's a concept that takes on possibly the largest challenge that businesses and humankind face together. It's the integration of social responsibility and environmental protection with the current corporate landscape. How to generate</i>

	and individuals (3)	<i>satisfactory profits while ensuring that business ethics are upheld and that the environment we operate in is preserved so that business and life can continue indefinitely.</i>
Do differently to improve sustainability in the future	Purchasing from sustainable organization (3) Recycling (2)	Reference 1 - <i>I intended to be more mindful of the businesses I patronize. Prior to making a purchase, I believe it worthwhile to ask myself about the organization's reputation, its corporate philanthropy efforts, its employee engagement, etc. I plan to consider where and how goods I buy are made and at least consider instances where paying a little bit more when I am able to is worthwhile.</i> Reference 2 - <i>I have implemented recycling in my home, composting, purchasing paper straws, and using reusable grocery bags.</i>
Reflect on how sustainability would or would not apply in your chosen profession	Creating more efficient organization (8) Environmental (6) Stakeholders as employees (2) Strategic initiatives by organization (8)	Reference 5 - <i>As I continue my career as an Air Force officer, I begin to understand that higher-level positions come with greater scopes of responsibility. Maintaining a sustainable organization is one of many contemporary stakeholder expectations for our Air Force and, thus, for its leaders. As I move up, sustainability then becomes as much of an interest item for me as for any private business manager.</i> Reference 6 - <i>As a Chief Operating Officer for a nonprofit, I have a wonderful platform from which I can improve my organization's sustainability. We are a social organization that exists to prevent human trafficking; however, those we serve live in a horrendous environment: poor or no running water, pollution and smog, garbage lining the streets in which they live. Although we are socially centered, we need to implement programs that will positively affect the environment as well.</i> Reference 1 - <i>Caring about society begins with the corporates' employees and their families, which makes me think about one of my parents' lessons; being a good human being will be your best contribution to the society. As a leader, I can start sustainability from myself, with comprehensive studies and based on the best version I can be of myself. As a result, I can take care of my employees, their personal and professional progress.</i> Reference 8 - <i>There is an opportunity to further our impact by encouraging sustainable change in the organizations we partner with. If we were to communicate our sustainability goals to each partner, the response would almost assuredly be positive. There are already business leaders that want to make a positive impact on society, so it's not a reach to expect that they would be interested in incorporating sustainability models within their own organizations. Sustainability is important, regardless of the size or type of organization. I can not only help grow a business and make a positive impact, it can also be the determining factor for the ultimate success or failure during a crisis.</i>

DISCUSSION

SUSTAINABILITY – AWARENESS-REFLECTION-ENGAGEMENT- (ARE) MODEL

To depict the ARE model (See Figure 1), we have created a chain much like a necklace or a fence. Through using a test like the Sulitest, we gauged students' initial awareness of sustainability. Through written reflection tasks with clear prompts, students were obliged to consider sustainability in a meaningful and critical manner. This reflection or introspection leads to a higher tendency to engage with sustainability as it is no longer an abstract concept, but a thoughtful process on the greater implications of their current choices. As the process continues

throughout the academic program, a new link in the chain is added leading to greater awareness, deeper reflection, and, subsequently, stronger engagement with sustainability principles. This chain continues, ideally and infinitely, throughout the entire lifelong learning journey.

**Awareness-Reflection-Engagement:
ARE Model for Sustainability Education**

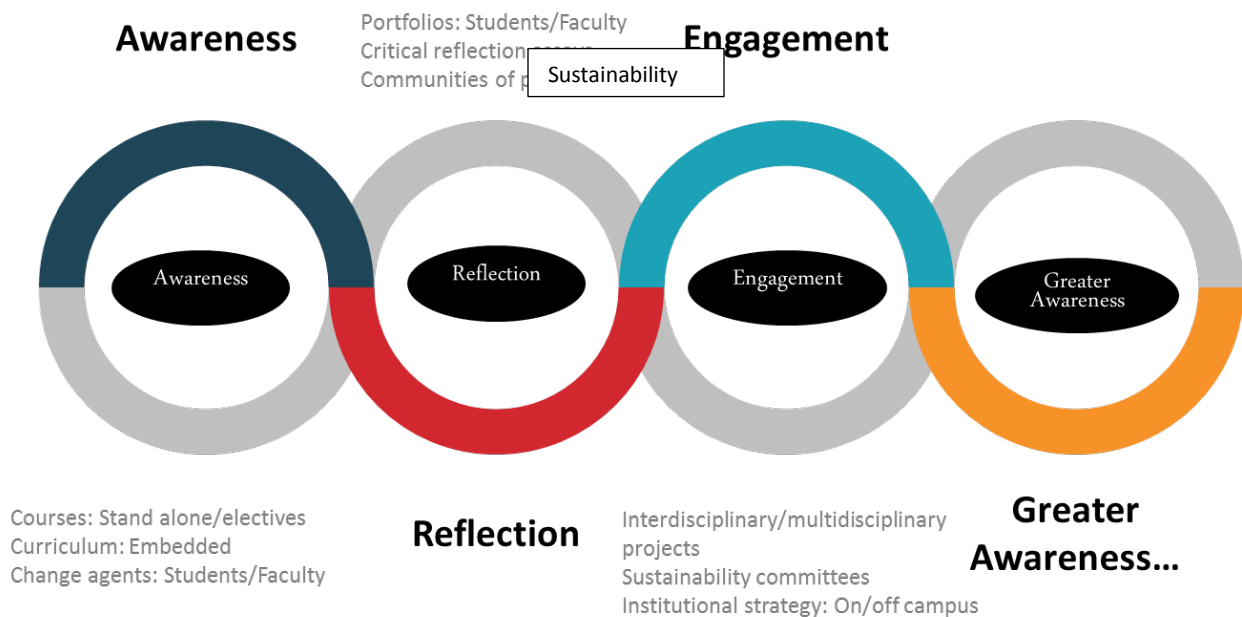


Figure 1: ARE Model

As seen in the ARE model (Figure 1), students can be made aware of sustainability concepts and initiatives via traditional means such as courses and curriculum. Certain students and faculty will be identified early on as ‘change agents’, i.e. those with greater awareness who can incite change in others. Nonetheless, it is the second step of the model, i.e. the reflection that will lead to the third and most important step, engagement with sustainable actions.

To answer the two research questions:

RQ 1: In what ways did students’ critical and reflective thinking change toward the three pillars of sustainability?

By writing critical reflection pieces, students in this study "shifted" their way of thinking, or mind set about sustainability by understanding and applying the three pillars (14), considering changes in organizational culture (8), thinking about environmental impacts, and recycling (2).

The most interesting additions were the ideas of purchasing from sustainable organizations (3), and attaching social responsibility to companies and individuals (3). The latter were not initially considered earlier in the course when the topic of sustainability was first broached. These results demonstrate the potential that reflection could have in changing behavior in the present and for the future.

RQ 2: What critical reflection of sustainability could students apply to their profession?

As seen in the reflection pieces, students associated sustainability with ‘Creating more efficient organization’ (8), ‘Environmental’ (6), ‘Stakeholders as employees’ (2), and ‘Strategic initiatives by organization’ (8). While the environmental pillar is prevalent, these respondents also considered the social aspect, via employees, and the economic aspect, when considering strategy. This is a positive outcome that suggests that reflection enabled them to think beyond the stereotypical environmental actions and consider other pillars of sustainability as well.

CONCLUSIONS

From the literature, it was clear that one of the key roles of HE institutions is to prepare today’s students to be future leaders (Seto-Pamies & Papaoikonomou, 2016; Zeegers & Clark, 2013) who will bring positive social change through sustainability practices and initiatives. By gauging students’ existing knowledge and building on that knowledge, HE institutions can prepare targeted curriculum for teaching about sustainability to encourage authentic engagement. However, simply embedding sustainability into the curriculum or as part of the school strategy has little effect if the students do not contemplate on a personal level the importance of these actions in the real world. Reflection is one way to ensure a deeper understanding of the topic. Nonetheless, students who may struggle to see reflection as anything but an abstract or unconstructive concept may shift into resenting it as a method forced upon them (Wong, 2016). They may refuse to reflect ‘on command’ or ‘go and reflect’ (Ash & Clayton, 2014) simply because the teacher set up this assignment. For this reason, reflection must be encouraged in a ‘safe space’ based on deeper awareness, understanding, and growth, focused on participant comfort, engagement, and empowerment (Beaudoin, 2012) to attain critical reflection that is transformative and wholesome.

IMPLICATIONS, LIMITATIONS AND NEXT STEPS

In our study, we chose the Sulitest as the starting point to gauge STEM students’ sustainability literacy. The Sulitest or any sustainability literacy test can be used to measure how much students know upon entering an academic program. Once ascertaining students’ level of sustainability knowledge, reflective pieces can be introduced as a way of thinking about sustainability and its links to the current and future choices the students will make. With this information at hand, HE institutions can strategically prepare curriculum, projects, and initiatives that align more effectively with the needs and interests of the students and the relevance of sustainability in their lives. Though our study focused on STEM HE students in particular, future studies could be conducted with other discipline areas or levels of education. Thus far, we have only collected data from a small number of critical reflections; nonetheless, we plan to continue

gathering written reflections from each new cohort to confirm our findings that authentic engagement is possible if the reflection phase is included in the learning process.

OUR CONTRIBUTION

This developmental paper contributes to the growing number of research projects on how to effectively teach sustainability in educational institutions at all levels. By adding in the element of reflection or why we choose to engage in sustainability initiatives, we believe to have found the missing link as to why sustainability is such an ephemeral and abstract topic that most students struggle to learn and/or replicate in the real world. We will continue developing our framework by adding more reflection elements at key points in the students' learning journey.

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