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Interdisciplinary Inquiry-based Teaching and Learning of Sustainability in Saudi Arabia

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Abstract

Saudi Arabian citizens, including university students, are in an interesting and precarious situation – they care for sustainability, but their economy thrives because of oil production. This study used an author-developed instrument to briefly explore 135 Saudi university students' (nine disciplines) knowledge, awareness, evaluation and convictions of how to facilitate the nation to achieve sustainable development goals (SDGs) per *Vision 2030* despite living in an oil-based economy. Within this context, the paper then reports 31 female Saudi pre-service teachers' (also university students) experience with and reaction to using inquiry-based learning (IBL) to teach sustainability. Their feedback as emergent educators is invaluable for Saudi initiatives concerned with Education for Sustainability (EfS). Study participants were from Saudi's Eastern Province (convenience and snowball sampling) with data collected in fall 2019. Recommendations include integrating IBL into teacher education, supporting IBL with Saudi cultural and religious practices, and communicating anthropogenic impact to Saudi citizens.

Key words: inquiry-based learning (IBL), sustainability and climate change, pre-service teachers, Saudi Arabia, education for sustainability (EfS)

Introduction

At the time of writing, the COVID-19 (a novel coronavirus) pandemic had brought more than 300,000 global deaths in six months (Picheta, 2020). Many economies have ground to a halt, but we now have cleaner air because of the decline in carbon (CO_2) emissions caused by fossil fuel combustion. When humanity resumes their normal lives after the pandemic, greener lifestyle and long-term sustainable, functional systems will be needed to curb a resurgence in massive carbon emissions that devastatingly affect humanity, wildlife and nature (Rasmussen, 2020). (By mid-January 2021, the number of the global COVID-19 deaths has reached 2.00 million (World Health Organization, 2021)).

There are five top oil-producing countries in the world. Pre-pandemic data from the Energy Information Administration (EIA) (2018) showed that the Kingdom of Saudi

Arabia (KSA) ranked second in the top five, contributing 12 % of the world's total oil production. From a closer-to-home perspective, the Saudi Arabian (SA) petroleum sector accounts for roughly 42 % (nearly half) of its gross domestic product (GDP). However, while sustaining Saudi's economy, oil production is also contributing to global air pollution (The World Factbook, 2020).

There is a link between the production and burning of fossil fuels, such as petroleum and natural gas, and extreme weather conditions, such as flash floods and environmental degradation, including deforestation and desertification. This link ties into the imbalance in the carbon cycle, which contributes to global warming and climate change. Saudi citizens, including university students, are in an awkward and precarious situation – they care for sustainability (Alghamdi & El-Hassan, 2019a), but their economy thrives because of oil production (Alyousef & Varnham, 2010; Kingdom of Saudi Arabia, 2016, 2018).

Instead of the conventional Education for Sustainable Development (ESD) approach (UNESCO, 2006), the education most needed to restore earth's health is Education for Sustainability (EfS) (Selby, 2006). The former focuses on *development* (which can include oil production), and the latter concerns *sustainability*, which would critically challenge development and oil production. EfS depends on inquiry-based learning (IBL) and teaching (Ireland, 2007; McGregor, 2020; Selby, 2006) (to be discussed), which educators must learn so they can offer EfS.

To that end, this investigation was two-fold. First, it examined Saudi university students' evaluation, knowledge, awareness, convictions and suggestions of how to facilitate their nation's achievement of its sustainable development goals (SDGs) advocated in its new national development plan – *Vision 2030* (Kingdom of Saudi Arabia, 2016, 2018). Second, the investigation sought contributions from prospective teachers who had to be able to employ innovative sustainability pedagogies. Appreciating that pre-service teachers' (PSTs) insights should not be overlooked, several agreed to employ the inquiry-based approach and then share their experiences with the researchers. The key focus of this paper is the findings from prospective teachers with a brief, contextual nod to other university students' ideas.

Literature Review

An imbalance in ecosystems is proof of anthropogenic (human generated) causes of loss of wildlife and reduction in the habitability of the earth (directly or indirectly). Examples include rising sea levels, collapsing coastal ecosystems (due to historical overfishing) (Duarte, Dennison, Orth, & Carruthers, 2008), large-scale deforestation, detrimental wildfires and floods, and continuous desertification (Gibbens, 2019; World Wildlife Fund, 2019). The fate of humanity and the health of the world are interconnected and deeply influenced by the anthropocene ethos (Trenberth, 2018). Alberro (2019) also points out the widespread and deep-rooted attitude of the separation of humans from nature in Western culture must change in order to mitigate environmental crises. The literature review profiled the scope and depth of damage caused by unsustainable development in concert with any messages of hope. It served to reinforce what Saudi university students must learn, come to terms with and respect (and what teachers need to teach) if they intend to support sustainable development (SD) while living in an oil-

producing nation (per the vision of Saudi's new national development plan). Then, EfS is explained as is the IBL approach.

Threats to Sustainability and Restoration of Earth's Health

In the long history of human food systems, both environmental and human health issues are mounting. The use of pesticides and synthetic fertilizers is contaminating air, water and soil. The use of hormones in animal husbandry is a major concern. Furthermore, poor practices in meat production is an issue. For example, the use of preventive antibiotics in animal husbandry contributes to antibiotic resistance in humans. The unregulated consumption of bushmeat and wild animals also poses human risks (Lindgren et al., 2018; Milner et al., 2017).

Coupled with the growing world population, human premature death is on the rise along with related issues, including malnutrition, which is now being addressed (Lindgren et al., 2018). Many people are undernourished and stunted and conversely many are overweight and obese (FAO et al., 2017). The world needs sustainable food systems such as those employed in India. They are adopting healthy dietary foods that could reduce dietary water footprints to meet future constraints "whilst minimising changes to cost and simultaneously cutting GHG emissions" (Lindgren et al., 2018, p. 1508; see also Milner et al., 2017). GHGs are greenhouse gases (e.g., CO_2 and methane) that contribute to global warming or *global heating* as Selby (2007) has reframed it. Excessive carbon emissions are causing adverse health effects, even loss of life (Public Health England, 2018).

About one-third (31 %) of the land area on the earth is covered with forests; trees are the lifeline of our planet (World Wildlife Fund [WWF], 2019). Sustainable forest management (SFM) is essential to restore the health of the earth. MacDicken et al. (2015) investigated the progress of SFM, explaining that *if* it were full strength, it would be possible for ecosystems to renew themselves to ensure their long-term productivity and health. They concluded that "the evidence shows a trend favorable to SFM globally" (p. 55). An enabling environment for SFM is mostly in place, and progress at the operational level is evident in support from governments, industry and communities. That said, some forestlands are yet to be sustainably managed (MacDicken et al., 2015).

Another negative development is the loss of the Amazon rainforest, called the lungs of the earth. Gibbens (2019) poignantly described the sight of the intensely burning Amazon rainforest due to wildfires. This phenomenon is destroying a significant portion of the rainforest and habitats, made worse because these fires were deliberately set in the cause of deforestation to make way for business activities. According to WWF (2019), around 17 % of the rainforest was lost in the last 50 years due to deforestation. This crime against nature and humanity was committed by heads of transnational corporations who wanted land for their own economic activities, such as cattle ranching and soy growing. As a result, "we're losing 18.7 million acres of forests annually, equivalent to 27 soccer fields every minute" (WWF, 2019, para. 2). Without trees and vegetation (both on land and in water), wildlife loses food sources and habitats, and the carbon in the atmosphere cannot be absorbed at its usual rate. Failure to absorb CO_2 emissions, which have already reached an alarming rate, is causing severe impacts on the health of both humans and all living creatures.

Consequences of Global Warming and Possible Deterrents

It is now commonly known that the consequences of global warming can be calamitous as evident in the extreme and frequent changes in climate patterns resulting in the paradoxical, simultaneous rising of sea levels and shortages of potable (drinkable) water. These consequences lead to the displacement of climate refugees, people who are forced to leave their region due to climate change-induced alterations to their natural environment (Boano, Zetter, & Morris, 2008). Unprecedented results of global warming include melting glaciers in the Tibetan plateau and flash floods in Saudi Arabia (United Nations High Commissioner for Refugees [UNHCR] (UK), 2019).

Although the environment has become cleaner amidst the global COVID-19 pandemic lockdowns (Rasmussen, 2020), the improvement is only temporary. A long-term solution requires intervention to deter the resurgence of devastating CO_2 emissions. Continued reliance on fossil fuels is not sustainable. It is time to reconfigure the relations between humans and nature; wildlife and the environment (Roberts, 2020). This will require a different kind of education, more than education for sustainable *development* (ESD).

Education for Sustainability (EfS)

The dramatically improved clarity of air and water during the global coronavirus lockdown in spring 2020 is visible from space as is its resurgence once economies started to reopen (Rasmussen, 2020). The positive outcome is the result of the contraction and reduction of pre-pandemic economic development and consumption. For example, virtually all fossil-fueled planes were grounded around the world. Selby (2006) advocated that sustainability education should focus on the conservation of *nature* instead of the conservation of *development* and progress. He recommended Education for Sustainability (EfS). Explaining Selby's approach, McGregor (2020) clarified that "people need to pull back from aggressive production and consumption and live modestly by moderating their actions [with] sustainable moderation… that is the ultimate focus of education" (p. 5).

Instead of focusing on the sustainability of *development* as ESD does, EfS concerns teaching students to "respond to the complex sustainability issues they encounter in their personal and working lives" (Commonwealth of Australia, 2009, p. 10). Done properly, this pedagogy helps reorient the way people live by building capacity "to tackle the underlying causes of unsustainable trends and [strive for] systemic change" (Commonwealth of Australia, 2009, p. 10).

Using a collection of principles, educators strive to instill "the values and the motivation to take action for sustainability" (Australia Department of Education and Training, 2015, para. 2). This involves building knowledge and awareness of sustainability divorced from development, developing worldviews beyond mechanistic to ecological, polishing critical and creative thinking skills, instilling a reflective mindset, and valuing justice, participation, a future orientation and systems thinking (Australian Curriculum, Assessment and Reporting Authority, 2015; Commonwealth of Australia, 2009; Ireland, 2007).

Among many advocates of adopting effective pedagogies in educating students of (tech-savvy) Generation Z in the 21st century, Cēdere and Keviša (2018) embraced the

transdisciplinary approach to teaching and learning of natural science. The teaching and learning of EfS can adopt similar approach as well. Salite et al. (2016) saw transdisciplinary approach as a solution that "can open a new perspective for understanding and interpretation of the complex phenomenon of sustainability" making it possible to integrate research and a myriad of learning activities. Transdisciplinary approach (as opposed to traditional approaches) forges "a link between science, real life, [students'] personal interests and participation in the process of learning" (Cēdere & Keviša, 2018, p. 8).

Inquiry-Based Teaching and Learning

The inquiry-based approach to teaching and learning is a powerful instrument for EfS. IBL can be an effective way for students to learn about and address interdisciplinary issues such as unsustainability, climate crisis, global warming and heating, and gray carbon emissions (Ontario Ministry of Education, 2013). "When used effectively, it increases student agency in learning and can strengthen authentic connections to the world around them" (Science Learning Hub, 2017, para. 4). Furthermore, employing IBL enhances diverse learning outcomes including "the development of students' [a] active thinking skills and conceptual understanding…, [b] abilities to formulate hypothesis [sic] and questions … and [c] [academic] performance levels (Effendi-Hasibuan, Ngatijo, & Sulistiyo, 2019, pp. 538– 539).

The IBL approach is ideal when exploring interdisciplinary knowledge or cross-curricular subject matter. Inquiry requires more than "simply answering questions and getting a right answer. … It is enhanced by involvement with an Inquiry Community in social interaction in which each can learn from the other" (Kuklthau, Maniotes, & Caspari, 2007, p. 133). IBL espouses investigation, exploration, search, quest, research, pursuit, and study (Baraquia, 2018). The application of inquiry learning thus helps cultivate a culture of inquiry, which encourages students to learn collaboratively (Kuklthau et al., 2007).

Banchi and Bell (2008) identified four levels of IBL: confirmation inquiry, structured inquiry, guided inquiry and open inquiry. IBL "requires a degree of scaffolding tailored to the level and experience of the students" (Science Learning Hub, 2017, para. 4), so they are motivated by intrinsic interests and equipped with the skills to conduct their own research and investigation.

Interdisciplinary Nature of Sustainability Inquiries

The study of (un)sustainability is interdisciplinary in nature and involves knowledge of many disciplines (Cairns, Hielschere, & Light, 2020; Walshe, 2016), including but not limited to: social, natural and physical sciences; geography and urban studies; formal sciences (computer, mathematics, statistics), applied sciences (technology, business, medicine); and the arts and humanities (law, history, philosophy, ethics). Interdisciplinarity seeks intersections, connections, synergies and tradeoffs among disparate and divergent ideas. The intent is to create a new integrated whole that can be used to address (un)sustainability (Cairns et al., 2020).

Baraquia (2018) added the notion of "interdisciplinary contextualization" wherein educators contextualize the lesson by embedding it in the "cultural, historical, ideological fabric" (p. 54) of learners' lives. This way, they remember what they learned, because it was meaningful. Authentic learning is further assured if interdisciplinary contextualization is combined with IBL. The latter ensures that learners are provided opportunities to "make connections, draw conclusions or generalizations, explore and work cooperatively, discuss and debate, express knowledge in a variety of ways, and use multiple intelligences" (Baraquia, 2018, p. 54).

Method

This study unfolded in fall 2019 in the Eastern Province of Saudi Arabia. The research design comprised two parts. Part one involved administering an author-developed questionnaire (both English and Arabic) to 135 university students enrolled at a university to which the lead author had ready access. Respondents (who participated voluntarily) were recruited through university colleagues and the lead author also reached out via email and text to previous students. The entire process was facilitated by convenience and snowball sampling augmented with WhatsApp. Most (≈ 60 %) of the instruments were delivered and returned by email to the researchers with the remaining (≈ 40 %) hand delivered and picked up then returned to the researchers. Respondents were assured anonymity and advised that their answers would be used for research.

Section A of this instrument collected demographic information (area of study, type of degree, age and sex). Section B comprised 10 questions intended to measure their knowledge, awareness, evaluation and convictions of how to facilitate SA achieving its SDGs per *Vision 2030* despite living in a fossil fuel producing country. Five questions (#1–4, 9) were either matching, yes/no or had a Likert scale. Five questions (#5–8, 10) were open ended and dealt with their inclination to support SD in Saudi Arabia, possible actions to protect their community's environmental well-being, any responsibilities to future generations, and how their culture and religion affected their views on SD. Data were analyzed using descriptive statistics (frequency counts and percentages), and open-ended questions were analyzed separately to glean collective responses and positions.

For part two of the investigation, 31 female teacher trainees (PSTs) enrolled in a public university in the Eastern Region of SA (lead author access) voluntarily agreed to participate. They tendered their responses via email during a semester break. Anonymity was assured, and they were aware that their contribution would be used for research. An instrument was developed to facilitate a two-step process: use the IBL approach and then assess their experience. Regarding the former, four questions/tasks lead them through the process of using IBL to research flash floods in Saudi Arabia and its neighboring regions.

After completing the IBL assignment, seven questions queried them about their actual experience (e.g., was it motivating, were they left with too many questions, were they satisfied with sources found). Three open-ended questions wrapped things up and focused on how they would improve the IBL activity. Data were analyzed using descriptive statistics (frequency counts and percentages), and all questions were analyzed separately to glean collective responses and positions.

Part One: University Student Results

Demographics

There was a good mix of respondents studying in a wide range of disciplines (24 % did not answer this question). In descending order, these included education, health sciences, humanities, science, computer science, engineering, math, business and finance, and languages. Most (67 %) respondents were aged >25. Slightly more than half (56 %) were female (41 % male). A small percentage (3 %, n = 4) did not specify their sex. Most (75 %) were enrolled in an undergraduate degree. Detailed results of this part of the investigation are available on request with a brief summary shared herein to provide context for part two of the study, which is PSTs' (also university students) trial usage of IBL. In the following sections, nominal dialogue is integrated only when doing so reinforced the poignancy or implication of a result.

Evaluation, Knowledge, Awareness, Convictions of Achieving *Vision 2030*

While Section A of the instrument gathered demographics, Section B sought insights into Saudi university students' evaluation, knowledge, awareness, convictions and suggestions of how to facilitate the country to achieve its SDGs per *Vision 2030*. First, a telling result emerged when asked if they had ever heard of social movements or global events such as *Global Climate Strike*, *Earth Day,* or *Extinction Rebellion.* Nearly all (83 %) said "no". This result implies a deep lack of awareness among Saudi university students of worldwide youth movements that bring millions of people together to stand up for humanity and the earth.

Supported Sustainable Development

Most respondents correctly answered questions that assessed their knowledge and understanding of fossil carbon (*gray carbon*) and *green carbon* (deriving carbon from renewable resources). The majority (87 %) supported sustainable development (SD), including fossil carbon reduction, despite being citizens of a fossil fuel producing country. Seven reasons were tendered for supporting SD (see Figure 1, frequencies) with the most common reasons being reduction of negative impact of unsustainable development (29 %, n = >40) and protect the environment (22 %, n = >30). Fewer respondents (7 %) said they supported SD because it involved seeking energy alternatives or preserving human health and lives (mentioned <10 each).

In another telling result (see Figure 1), virtually no one (n = <5 %, 3.7 %) said they supported SD because they thought it would help sustain the future or raise awareness of the anthropogenic impact on all life. Respondents seemed to lack an appreciation for or realization that anthropogenic damages were happening now (not in the future). While very few said SD would sustain the future, they still said they supported SD (87 %, n = 118) despite living in an oil-producing country. Ironically, changing Saudi's economic model so it shifts away from unsustainable oil production would also impact their future (Alyousef & Varnham, 2010).

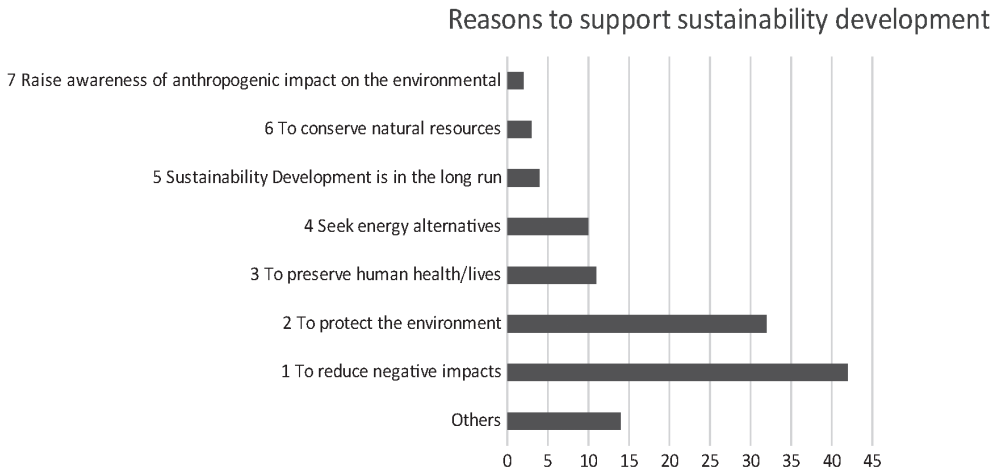

Figure 1. University students' reasons for supporting sustainable development in Saudi Arabia

Plausible Actions

The majority (90 %) of respondents offered multiple suggestions for what they could do to protect the environment as members of *the community* (see Figure 2, frequencies). This high response level reflects an apparent belief that they *can* become active members of the community to protect the environment. The four most common actions (mentioned 25–35 times each) were sustainable waste disposable, resource conservation, awareness raising, and green carbon and afforestation (tree planting). A noteworthy result was mentioning less (<15 times) the preventative measures like education and knowledge or punitive measures such as law enforcement.

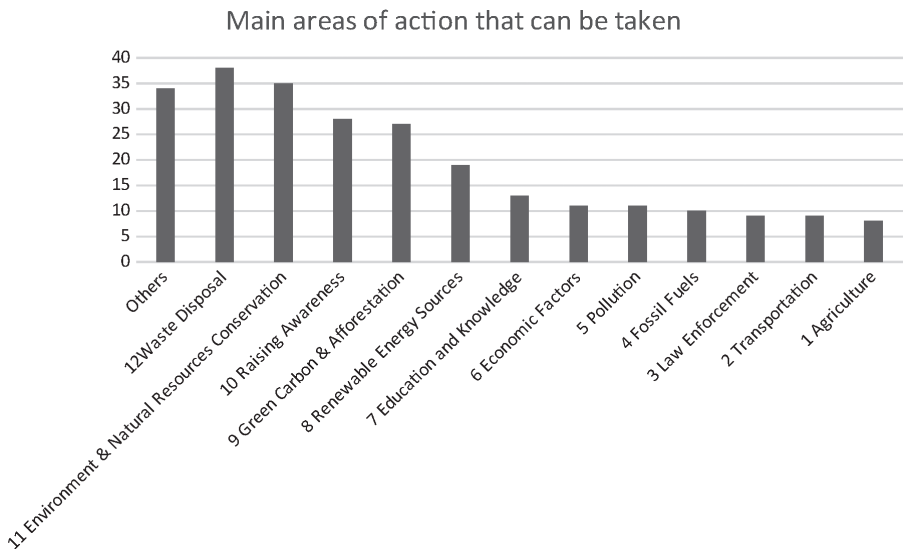

Figure 2. University students' proposed actions as community members to protect the environment

Securing Future for Next Generation

As a member of *society*, the respondents expressed their responsibilities toward ensuring that the younger generation has a secure future (see Figure 3, frequencies). Mostly, they felt it was their responsibility to cultivate a culture of awareness, ensure education and research on sustainability, and conserve the environment and resources for the next generation (mentioned ≈ 30 times each). Very few university students felt it was their responsibility to give advice and guidance, get involved with community service, or provide a good upbringing to prepare younger citizens to be sustainable (mentioned <5 times each). Perhaps this is because respondents were adults but not yet parents who might have increased environmental concerns (Milfont, Poortinga, & Sibley, 2020).

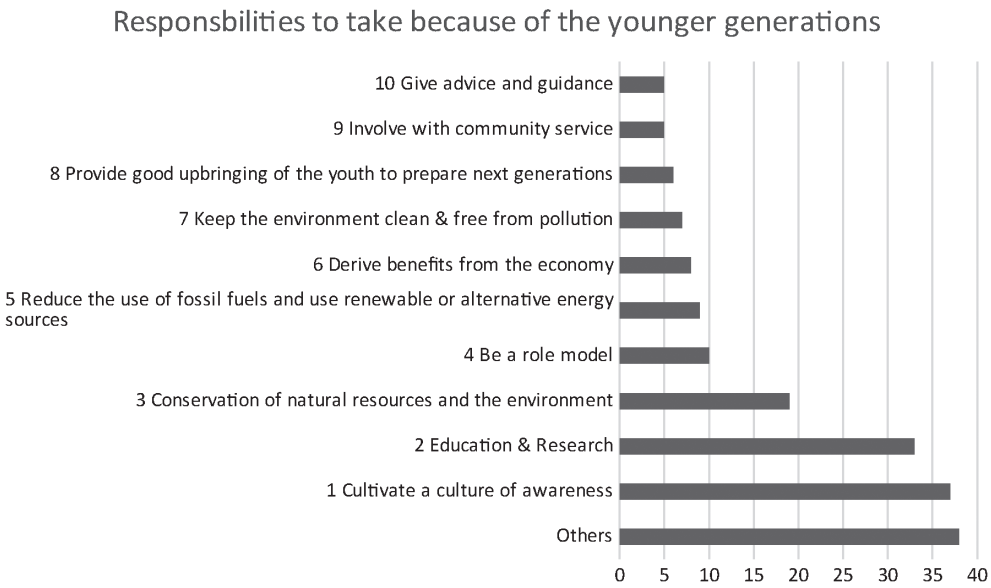

Figure 3. Major responsibilities for ensuring next generations' future

Culture, Religion and Sustainability

The majority (91 %, n = 123) of respondents answered the question about how their religion and culture affected their views on restoring the health of the earth, but some (7 %) did not, and 2 % said they did not know the answer. Those who answered tendered affirmation of how their culture or religion informed their views of healing the earth with highlights presented in Table 1. Two other selected statements exemplify their collective answers: *"The religion of Islam instilled in us many values and urged the conservation of the land and the environment; that is a religious duty"* and *"The land and what is from it is a blessing of God that a Muslim must thank God for so that the blessings will be increased."*

Table 1
Respondents' Thoughts on How Culture and Religion Affect Views on Restoring the Earth

1	God created us on the earth to build and preserve it, not to destroy it. From this logic, we must preserve the environment, rebuild the earth, and reduce corruption.
2	God created man from the earth (clay) and made provision for humans (Qur'an, 23: 12–15 & 18–21), appointed man (Adam) as a vicegerent on the earth (Qur'an, 2: 30–33) and warned us "to make no mischief on the earth (including: cause no corruption in the land)" (Qur'an, 2: 11).
3	As Muslims, we are obligated to protect the environment and conserve natural resources, thereby avoiding overconsumption.
4	Self-censorship and self-monitoring of own behavior and manner to earn God's grace and to show fear of God.
5	The Prophet (*pbuh*) was reported to say: "If a Muslim plants a tree or sows seeds, and then a bird, person or animal eats from it, it is regarded as a charitable gift (*sadaqah*) for him."

To wrap up, Alghamdi and El-Hassan (2019b) painted a grim picture of Saudi university students' knowledge of sustainability, but students had a good attitude toward green living. Compared to their results, we found that Saudi university students seemed to have a better grasp of what constitutes environmental sustainability and a more positive attitude toward and greater awareness of CO_2 emission reduction and their impact on sustainable living. These results affirm Alghamdi and El-Hassan's (2019a) finding that Saudi university faculty members (specifically ESL instructors) thought sustainability and Saudi energy issues should be included in higher education curricula.

Part Two: Pre-service Teachers' Findings

In the second part of the investigation (more qualitative in nature), PSTs completed an IBL assignment and then answered questions about the experience offering recommendations for improving it. Nominal dialogue is integrated into this section when doing so reinforced the poignancy or significance of a finding.

PSTs' Reactions to the IBL Experience

The PSTs completed the assignment virtually, not at the university site or in person. Twenty-eight (n = 28) completed IBL assignments were returned electronically with duplicates because group work was excluded. Their task was to complete an inquiry about the causes, frequency, and consequences of flash floods in desert regions (a symptom of climate change). They were asked to comment on (a) the sources they used and their perceived worth in completing the assignment (e.g., newspapers, research journals, the internet and social media); (b) why they chose to work alone or in a group and the value of this mode; and (c) whether they found the IBL experience motivational and if it left them wanting – if they still had questions.

The majority (90 %, n = 25) of participants found the IBL activity *very* motivating with three PSTs (10 %) saying the opposite, one because the topic was too narrow. They felt it was motivational, because the tasks helped them understand and learn that climate change was happening in Saudi Arabia manifested in flash floods in a desert (an

oxymoron). They discovered previously unknown-to-them information about flash floods and their impact on local Saudi citizens. The IBL activity not only raised awareness of individual actions that might cause climate change but also how to prevent flash floods. Some PSTs said that it was an *"eye-opener"* to understand the types of conflict happening right around them and in the world. They also learned the importance of staying alert, preparing for what would be coming and, above all, finding solutions to flash floods and other aspects of climate change.

Participants saw value in being able to choose between Arabic (mother tongue) and English to complete the assignment. From iterative readings of their answers, we sensed that Saudi-speaking PSTs had their own way of framing questions intimating that writers of teaching/learning materials could benefit from better communication with their targeted audience (i.e., Arabic-speaking educators).

PSTs also appreciated having different types of questions to answer, thus enabling them to carry out the investigation in more depth. The PSTs also said that more questions could have been provided to make the IBL activity more interesting. Of the 31 questions, the PSTs tendered for consideration, 71 % pertained to climate change and *not* flash floods, the actual focus of the assignment. Targeting flash floods, PSTs thought the inquiry should have queried why and when most flash floods happened in general and why in a desert? Regarding climate change, they wanted a chance to inquire about (a) how to raise awareness of climate change, (b) how dangerous is climate change and how easy is it to combat, (c) and what is the Saudi government doing about climate change?

The majority (71 %) of PSTs preferred working alone with slightly more than one quarter (29 %) choosing group work to complete the IBL activity. They worked alone mainly because they felt that group work was too slow (and took too much time), distracting, acrimonious, and it was too challenging to communicate. Working individually would help them learn and gain deeper understanding, which would make them self-reliant and more confident. Group work was preferred, because they can learn from each other's backgrounds, perspectives and points of view. Several said that group work was more efficient leading to more detailed and better information about the issue. Others appreciated the help within a group, because they found the tasks to be difficult, especially figuring out what the questions meant.

Most university students are keen to use social media. But only one-fifth (19 %) of the PSTs (also university students) used these platforms to collect data to inform their inquiry about flash floods in SA. They benefited from the (a) images and pictures of flash floods and (b) archived information and threaded discussions. They also used social media to communicate with fellow students to help them understand the learning tasks, and some contacted family members or others to seek help with their inquiry. The 81 % who did *not* use these platforms said that they distrusted using social media for IBL activities, because multiple opinions were distracting, and these media did not give reliable information.

PSTs' Suggestions for Improving the IBL Experience

Participants' ideas on how to improve the IBL experience were likely shaped by the fact that virtually (99 %) none of them had ever researched climate change, let alone flash floods in their home country. A related finding is that 83 % of university student

respondents had never heard of the global climate change youth movement. That said, the PSTs offered feedback on how the IBL experience about climate change impact (e.g., flash floods) could be improved: (a) to provide key words in order to facilitate the search process, (b) to break the tasks down into even smaller steps to *lead* learners to the answer and (c) to give some directions on how to write a conclusion.

Two issues arise from this finding. First, the researchers *assumed* the PSTs (who already have an undergraduate degree) had previous knowledge of and experience with conducting a simple research project, including writing conclusions to complete their inquiry. However, it was noticeable that their dexterity with using sources, knowledge about data collection, and conclusion writing skills were lacking. Second, and very likely related, the nature of the participants' suggestions for improving the IBL experience suggest that they could have benefited from better scaffolding so the activity matched their level and experience (Science Learning Hub, 2017) rather than assuming pre-existing levels of expertise.

Nevertheless, their inputs will be essential in modifying the IBL assignment for future use. We anticipate that the final product can become a model for any climate change or sustainability related IBL investigation. Participants shared many ideas about other tasks that could be completed by students engaged with IBL activities aside from writing a report with conclusions (something not all felt comfortable with, per above). They recommended the creation of PowerPoints, digital posters, videos, brochures, visual representations and graphics, an online quiz using Kahoot, even a plenary session – anything it seems except formal report writing. The key reasons given for these recommendations were to make learning fun, vibrant and interesting and help learners grasp the gravity and seriousness of the issue.

Open-ended Comments

The researchers categorized the participants' open-ended comments about how to keep leaners motivated when engaging with interdisciplinary issues using IBL into two themes: education and community efforts.

Education. PSTs said that people could not rectify climate change unless they acquired knowledge about it. Secondary and university students need to learn that the environment is their home and that of their future family. They said this could be reinforced with a connection to religion and culture. They believed that because Islam urged humankind to preserve the environment and every living organism, it could be linked to environmental protection. This can effectively draw students' attention to the issues of (un)sustainability and the harmful consequences of climate change that impact Saudi society.

PSTs felt that learners needed help in making the connection between human activities and behaviors (anthropogenic) and their impact on the environment. It is important to show students what is *really* happening in the world leading to and because of climate change. They must learn how important it is to be educated, so they know what they are talking about and advocating for. They said that public school activities to raise such awareness and build knowledge might include integrating climate change research into art projects, engaging students in a pollution experiment, or creating an online social media forum to spread climate change awareness. They believed that these efforts

could make students verify sources and ensure their reliability to avoid sharing false and misleading information. One student said, *"Trump and his administration are claiming that climate change is a fake story. Discuss this."*

Community efforts. Although fewer comments fell within this category, the PSTs did offer insightful ideas. They felt IBL experiences should teach students to respect and uphold Saudi laws about environmental protection. People need advice and guidance about sustainable consumption of natural resources. The current Saudi lifestyle needs to be challenged and changed so sustainable consumption is ensured. PSTs were convinced that Saudi citizens could become informed and spread awareness of steps and actions that would protect the environment and preserve Saudi's natural resources. They said that efforts to foster solidarity and help people come together to tackle climate change should be enacted.

Discussion and Pedagogical Implications

Study results and findings have pedagogical implications pertaining to (a) inquiry-based teaching and learning about sustainability in Saudi Arabia, an oil producing nation, and (b) what pre-service teachers need to learn given their many years of an oil-dependent life (Alyousef & Varnham, 2010). Discussion points and recommendations herein promote Alghamdi and El-Hassan's (2019b) suggestion that Saudi secondary curricula should "privilege standalone courses pertaining to Saudi related energy issues. These curricula and courses should be ever-greened, kept fresh, current and relevant" (p. 534). Part of the ever-greening process could include imbuing curricula with interdisciplinary contextualized inquiry-based learning.

Supporting IBL with Saudi Cultural and Religious Practices

As Islam is deeply rooted in Saudi society, the PSTs' conviction and belief in the earth's health restoration was well-supported by their religion (see Table 1). They clarified that Islam urged people to preserve the environment and every living thing. Findings support the recommendation that educators use the Islamic teachings regarding the environment as a starting point when delivering sustainability lessons using the IBL approach. This would be an example of interdisciplinary contextualization (Baraquia, 2018). Several Saudi universities have already linked Islamic traditions to energy and sustainability related issues and concepts (Taleghani, Ansari, & Jennings, 2010). According to the findings of our study, in addition to focusing on culture and religion, IBL teaching materials for sustainability and climate change should cover aspects of the community and Saudi society.

Integrating IBL into Teacher Education

If educators use IBL activities as they draw on extreme weather conditions as evidence of unsustainability, students will not be able to turn a blind eye to these pressing issues. Interdisciplinary problem solving via IBL heightens awareness and promotes knowledge about how uncritically examined climate change will destroy their future (Baraquia, 2018; Cairns et al., 2020). PST participants successfully completed the IBL activity

about flash floods in Saudi Arabia, but they also wanted the activity to focus on a broader issue of climate change. This finding implies comfort with addressing broad interdisciplinary issues and teaching students using the IBL approach.

IBL can be task-oriented or based on a problem (Hwang, Chiu, & Chen 2015). The PSTs asked for more technical directions to complete the assignment likely due to insufficient scaffolding on the part of the researchers (Science Learning Hub, 2017). Teacher education programs need to integrate IBL into their curricula instead of erroneously assuming that university graduates coming into these programs have already experienced it. Any opportunities for PSTs to practice IBL while in a teacher education program should extend over several weeks, so they can gain more competence with the approach (Plevyak, 2007).

On a related note, the research design gave Saudi PSTs a task, which they did complete, but many suggested the work would have gone easier if the tasks were broken down into even more minute steps. They were not challenged to problem solving. Future researchers interested in how well Saudi PSTs accommodate themselves to IBL should also pose the learning experience as a problem and not just as a collection of steps (Hwang et al., 2015). This would yield comparative data for refining how to orient PSTs to the merit of inquiry-based learning to teach sustainability in an oil-producing nation. They could become champions of using IBL in EfS instead of promoting ESD with its focus on development. The best way to address sustainability is through problem posing, problem addressing and, if fortunate, problem solving. Technical, task-oriented approaches are useful but not enough (Ireland, 2007; Selby, 2006).

Promoting IBL Collaboration with Online Academic Support

Ideally, the IBL approach encourages a culture of inquiry that is augmented with the creation of a community of learners, which is best achieved via group work (Banchi & Bell, 2008; Kuklthau et al., 2007). In our study, most (71 %) PSTs eschewed group work, thereby losing the chance to work together in a learning community and foster a culture of collaborative inquiry and learning. They could have drawn on this experience when they became teachers. Other researchers replicating this research protocol should consider advocating group work over individual IBL (Baraquia, 2018). To better ensure collaborative work when using the IBL approach, the provision of online academic discussion forums is also recommended. Online tutors could be assigned to guide students and answer their queries, and moderators could monitor the social aspects of online discussions keeping them orderly and respectful.

Augmenting IBL with Diverse Learning Tasks

The PSTs fervently shared ideas about how to augment IBL, which they enjoyed. Their recommended activities (e.g., videos, plenary sessions, artwork) would ensure that students with different learning styles could thoroughly and effectively use the IBL approach to learn about sustainability and climate change: visually, aurally, verbally and physically (i.e., kinesthetically using the body, hands and sense of touch) (Baraquia, 2018). Hwang et al. (2015) affirmed that IBL could be used with all learning styles if augmented with diverse learning tasks.

Communicating Anthropogenic Impact

On a final note, results affirm that earlier attempts by scientists to raise people's concerns about climate change may not have been deeply taken in Saudi Arabia. To illustrate, virtually none (99 %) of the PSTs had ever researched climate change before. They intimated that the anthropogenic (i.e., human generated) impact on the global climate would not become our immediate concern *unless* a closer connection was made for students between the imminent danger anthropogenic behavior posed to them and their habitats. Educators should strive to make this connection easier to understand.

Many online and offline resources can provide vivid images to convey this impact, and an array of school activities can raise people's awareness of the link between the anthropogenic ethos and climate change (glaringly evident in flash floods happening in urban cities). Hand in hand, findings suggest that students need to acquire (a) research and inquiry skills and report writing skills; to learn (b) how to select reliable sources and accurate data through verification of multiple sources; and (c) how to solve problems if the IBL is presented as a problem (Hwang et al., 2015).

Conclusions

Despite the fact that the Saudi economy relies heavily on its oil industry, university respondents from multiple disciplines were convinced that sustainability had to be achieved, because it was a long-term solution to existing environmental degradation, which, if left unattended, would diminish the chances of a good environment locally. This result suggests that achieving the SDGs while implementing *Vision 2030* depends on orienting university students to the impact of oil production on sustainability in the KSA. They are the future of industry, government and education. Furthermore, Saudi university respondents' lack of awareness of global climate change youth movements raises concerns (and opportunities), because these already existing platforms pave the way for positive dispositions toward combating sustainability and climate change.

Most PSTs applauded the learning of climate change using inquiry-based learning. They felt that the research task they completed raised their awareness of the local effects of climate change. They benefited from investigating, exploring, searching, going on a quest, pursuing, researching and studying. Findings suggest that teacher education programs should orient all PSTs to IBL from the interdisciplinary contextualization perspective. This would honor the role of Islam and Saudi culture and language in learning about sustainability in an oil-producing nation that is committed to achieving SDGs.

In short, the PSTs' positive feedback on the IBL experience was very encouraging. Their recommendations as emergent educators will aid in richer discussions of IBL pedagogical considerations for use in the Saudi educational context. Such initiatives bring the nation closer to Education for Sustainability implemented using interdisciplinary contextualization and inquiry-based learning. For this to happen, Saudi pre-service teachers must be socialized to these pedagogical innovations with on-the-ground findings from this study contributing to that vision. By reflecting on teaching and learning about sustainability, PSTs would be able to strengthen their "problem-solving and decision-making... and... critical-thinking abilities" (Aldahmash et al., 2017, p. 43).

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