COMPUTER AIDED ENGINEERING FOR HANDS-ON SUSTAINABILITY EDUCATION

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ABSTRACT

Sustainability is a balanced distribution of the environmental responsibility of economic development between and within nations; hence it's very important for future professionals to learn and adhere to the sustainability guidelines for the economic, environmental, and social accountability. Sustainability teaching requires immersing the students to understand the issues pertaining to the intricate pillars of sustainability. The traditional pedagogical methods seem to clarify the issue but failed to provoke the student's interests. In order to achieve such blend of aptitude and passion, the students need to learn sustainability by implementation, research and modeling solutions that pertain to them. The proposed study suggests putting computer aided engineering to work rather than physical prototyping. Programming language such as C++, .Net environment and MATLAB provide suitable test beds that allow multiple scenarios to be studied and tackled by the students who, thereafter, start to appreciate sustainability needs and understand the challenges that impede the upholding of the resources without compromising the ones in the future. The main objective of this work is to engage the students' engineering skills as well as social, environmental and economical believes to generate solutions that are both technical and humane. The proposed study aims to enhance the students' ability to research about the effect of the human footprints on their home and the outcomes of upholding recycling and renewable energy sources. The students then probe different theories which increase sustainable practices and decrease resources exploitations then propose solutions that can be modeled and tested.

INTRODUCTION

As the name implies, sustainability is the guide for all to live and let live making it one noble practice that reflects on the generation's serenity and security. While it is easy to convince people to value the sustainability guidelines, it is hard to have them practice such belief. Some blame such negligence on the slow tangible consequences; i.e. if one cannot see and feel the consequences, all efforts are needless (Basiago, A. D., 1998). Another reason to blame is the lack of clear and robust metrics to properly measure sustainability which, in turn, reduces the adherence and motivation (Brinkmann, R., 2016).Some blame the authorities for inadequate incentives to the individuals who undertake sustainability initiatives (Dernbach, J. C., & Mintz, J. A., 2011). Furthermore, people hesitate to follow and love the sustainability guidelines due to the fact that many companies are reported losing when poorly adapting sustainability themes (Lang, A., 2014).

Such challenges are not limited on the industry; education of sustainability is clearly affected as well. For instance, in many situations, sustainability education is ignored or barely addressed and the developing awareness within the educational community and the public is often neglected leading to hindrance of sustainability acceptance(Gauthier, C., & Daudigeos, T., 2015).Sustainable development is also difficult to teach due to many challenges that makes it hard to define and implement such as the lack of totally reorienting an entire education system to effectively adapt sustainability. Another challenge is the failure to connect the students' learning with the existing controversial sustainability issues. Students are still taught to concentrate on recycling materials as the main exercise of sustainability; yet, many issues that our students face in their everyday walk of life are not connected to their correct sustainable measures (Grange, L. L., 2017). This work recommends Computer Aided Engineering capabilities to give the students efficient outcomes while opening the possibilities for multiple scenarios. Many advantages are recognized for computer modeling over physical prototyping such as convenience of workplace which is not limited by laboratories or equipment. Another advantage is the freedom of time which is available whenever there is a computer available. Also, the time to achieve the task is always reduced when working with computers (Seyajah, N., 2015). However, one of the prominent advantages of computer modeling is allowing for fast modification of the scenarios and test the outcomes swiftly and inexpensively. This fast and easy manipulation of the parameters is very helpful to show the students how little compromises in one's lifestyle may lead to significant sustainable merits. Finally, research is assigned to the students aiming to ensure feasible modeling and exposing the importance of sustainability on homes and families. Computer aided engineering is a branch of CAD responsible for engineering

analyses and emulation. CAD software are diverse and plentiful pursuing to provide accurate and expedited results, however, such software are black-boxed i.e. the users are not concerned with the data crunching processes that deliver perceptible outcomes. In order to get the students intrigued, this work aims to involve the students in building new solutions that perform the computer aided engineering functions. One of the recommended tools is the Dot Net environment that allows for proper coding and easy access graphics user interface.

METHODOLOGIES

The students are initially assigned with setting the bases for a successful problem solving methodology by carrying out what's known as the problem definition stage. Here, the problems are identified and proper mitigation measures are defined. At this stage the students are driven to perform initial research targeting their community and recognize the sustainability challenges faced by their own people in their day and age. Such interaction can be performed by media search or interacting with the public to identify the latest concerns and, hereafter, generate objectives and success criteria. This stage is crucial in the engineering design process but as crucial to the teachings of sustainability when having the students involved and understand the impacts of sustainability negligence.
The next step is for the students to identify functions that suggest feasible actions to reduce the effect of the misuse. Each objective requires at least one function to guarantee the solution success; besides, the identified functions help determining the possible methods and means to achieve the needed mitigations as illustrated in Figure 1. The determined methods are then used to derive correct mathematical models to enable simulation for further scaling and replication.Effective research methodologies are implemented in this stage with the instructor's supervision making it an ideal setting to teach and train students the research methodologies with clear goals.

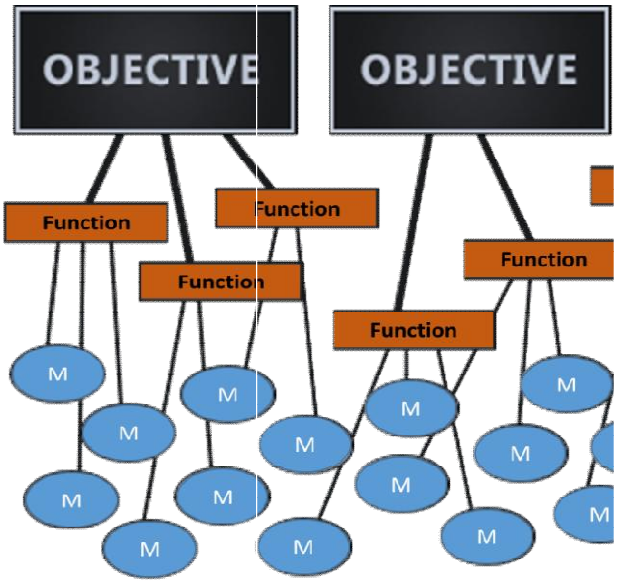

Figure 1: Problem definition stage helps the students identify the objectives of the project and draw valid plans to achieve them.

Statistics is one of the predominant fields for sustainability research; hence, the student need to understand that the demeanor of individual can be significant when studied as population. The figure below shows that for a targeted region, the students are directed to find many useful census information such as the number of households, average size of households, number of vehicles for each household, size of dwelling areas, as well as, other related information such as lifestyles and common practices. The data collected is usually stored in database accessible by the system.

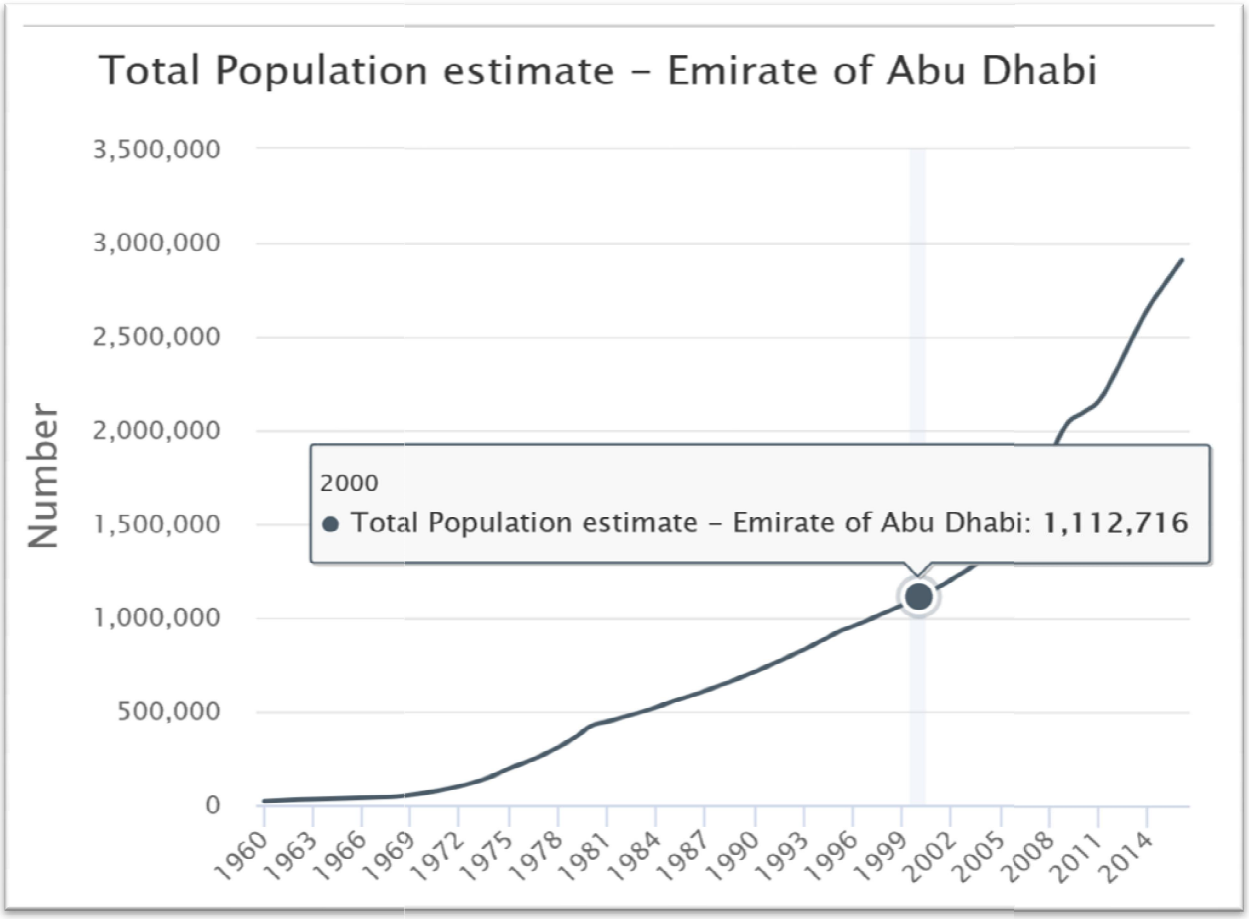

Figure 2: Abu Dhabi Census Data(World Bank Open Data., n.d.)

The electricity consumption is another research track delegated to the students to appreciate the measures recommended by sustainability guidelines. As showing in Figure 3, a database is established to be integrated in the overall metrics for sustainability. In same page, water consumption and water abuse research is undertook helping the students build another database for water sustainability measures. The students, also, need to be aware of the possible sustainability redemptions through waste management such as recycling which is the one practice that seams to be neglected and unappreciated by many for reasons that are pinned on the fact that the merit of recycling are inconspicuous(Ittiravivongs, A., 2012). One of the goals of this work is to open the student's eyes on the significance of the waste handling practicesthat does not only help increase the revenue of the community but it also reduce harmful effects to the environment. Transportation is one field that contribute significantly to the sustainability metrics, hence, the students are assigned with research tasks to probe the factors that contribute to the harmful consequences on the defined sustainable state. Identifying and understanding the causes of harm in the transportation field leads the students to conceptualize and search for proper mitigations which in turn will be augmented to the overall system.

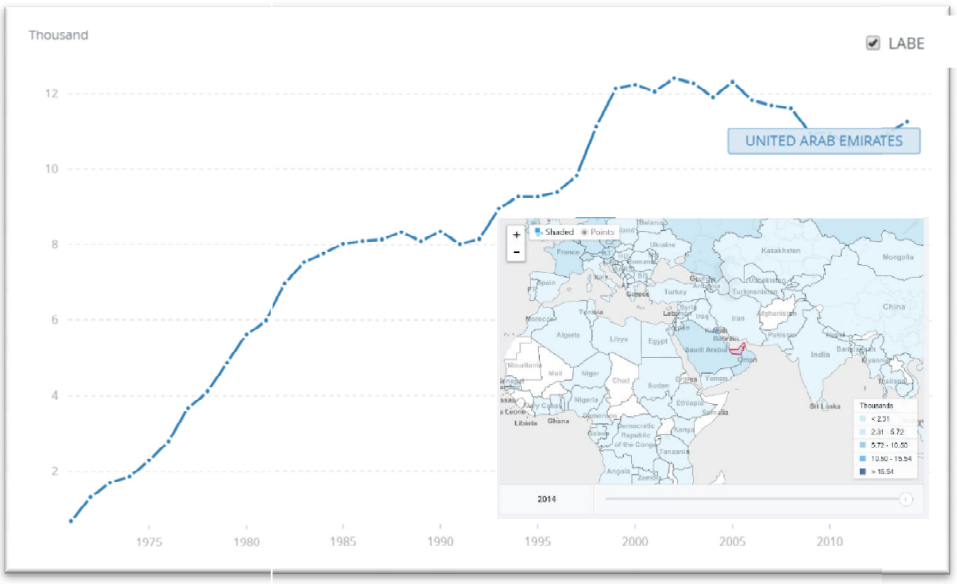

Figure 3: Regional Electricity Consumption in kWh per capita(World Bank Open Data., n.d.)

To better appreciate the sustainability efforts, the students need to study the different pillars that define the sustainable world and analyze the connection that relate the three pillars with each other. It usually build a shock to the students to learn that the endeavors to sustain the world does not stop at recycling and saving many. As showing in Figure 4, the students come to learn that sustainability is one of the leading arenas in maintaining human's prestige, serenity and health and it is important to understand the interrelated pillars to achieve sustainability (Anderson, K., 1996). The challenge, however, is finding objective metrics that models the proportional relations among the three pillars. One of the endeavors that studies this relationship in an objective manner is done by Pye et al. the study examines the direct effects of environmental negligence on the social dimensions focused on the European regions to analyze the linkages between the environmental and social strategies. As sought, such studies propose solutions optimize the potential synergies among the environmental, social and economic sustainability measures (Pye S., Skinner I., Meyer-Ohlendorf N., Leipprand A., Lucas K. Salmons R., 2008).

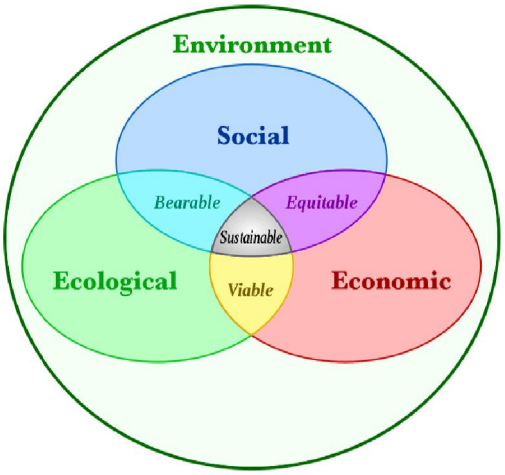

Figure 4: The three pillars of sustainability are interconnected making it important to understand the effects of the three pillars concurrently to achieve sustainability (Pye S., Skinner I., Meyer-Ohlendorf N., Leipprand A., Lucas K. Salmons R., 2008)

Some of the studies recommend Artificial Intelligent (AI) tools to propose correct ways to model the intercut aspects of sustainability. Such works expose the students to the cutting edge technologies that help them create objective reasoning for subjective decisions. A study by Khoshnava et al. applies a hybrid decision making methodology to resolve multiple incompatible and conflicting criteria to align the three pillars of sustainability with a particular objective. As illustrated in Figure 5, the proposed solution is a hybrid model that employs fuzzy analytic network process for aligning and ranking sustainability criteria based on the social, environmental and economic aspect of sustainability (Khoshnava, S. M., Rostami, R., Valipour, A., Ismail, M., & Rahmat, A. R., 2016).

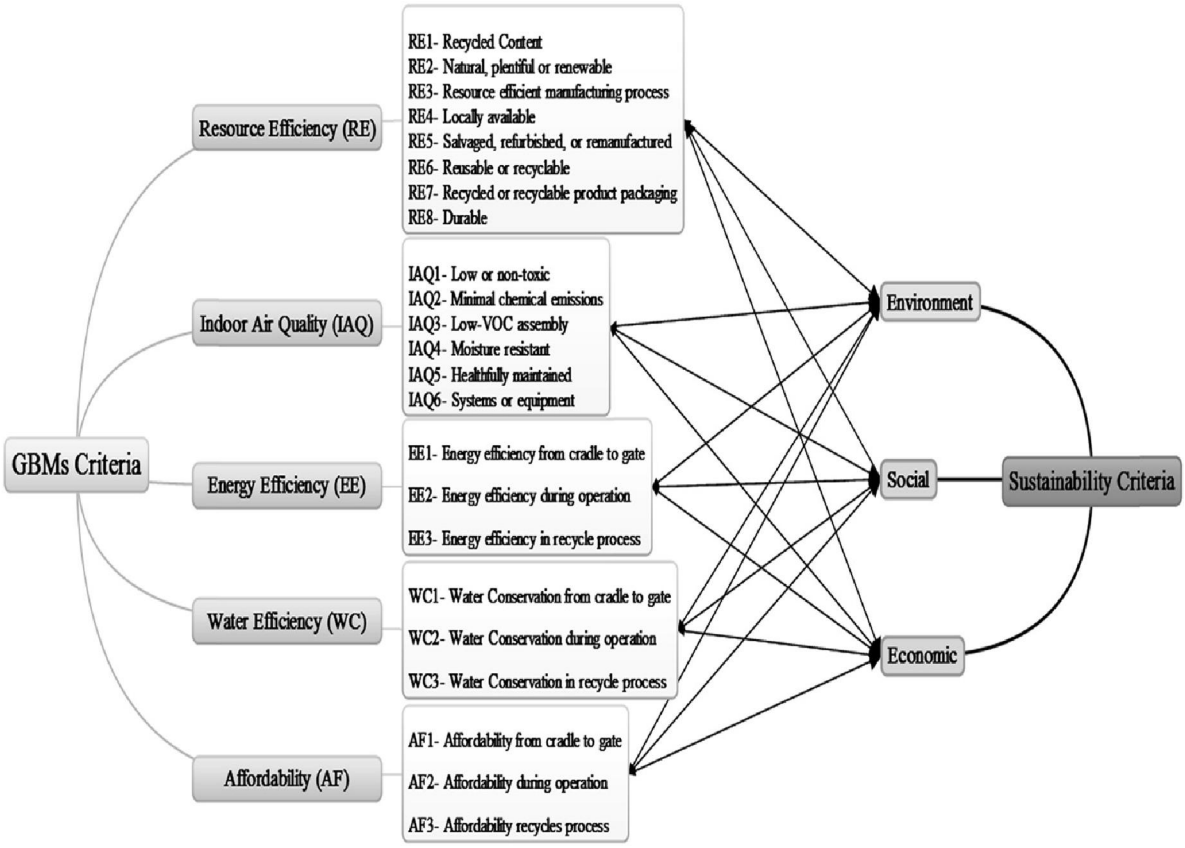

Figure 5: AI provide suitable tools to align the three pillars of suitability with a pursued solution to sustainability challenges, in this case the Green Building Material (GBM). (Khoshnava, S. M., Rostami, R., Valipour, A., Ismail, M., & Rahmat, A. R., 2016).

Computer Aided Engineering Modeling

One of the proposed tools used to expose the students to the power of Computer Aided Engineering is Solid Works. Equipped with tools and features that allows the user to find many sustainability measures that lead to the proper selection of the materials that make the designed product long lasting and benign to the environment at the end of its lifecycle. However, Solid Works and many CAD programs fail to contribute to the impacts of the social and the economic factors of the sustainability solutions. Hence, this study suggest the use of multi-paradigm numerical computing environment such as MATLAB. Being sophisticated and comprehensive, MATLAB allows for vast levels of interactions making it easy for the instructor to create templates and simplified models for the students use to enable the students to concentrate on the problem rather than the software operation. Using MATLAB Graphical User Interface (GUI) tools, the students seem to enjoy coding and implementing mathematical modeling for the targeted sustainability analyses.

The .Net (Dot Net) Framework by Microsoft provides another tool that opens the venue for modeling capabilities to the students. Being object oriented, .Net provides a framework class library that provides graphical user interface based on familiar Windows layout which can be controlled by easy controllers such as buttons, pulldown list,

pictures, tabs and more. The program is equipped with data base capabilities to store and retrieve statistical information and can be presented in an easy to share format. Moreover, database connectivity is permitted for information flow and concurrent collaboration. For swift execution, cryptography is endorsed to simplify complex algorithms into names that call for locked dynamic classes allowing extensibility of the .NET Framework cryptography classes. The students are also equipped with web application development, numeric algorithms, and network communications (Schildt, H., 2009).

The proposed work also suggests using preset templates that are simplified and resilient for the students to allow for alteration. The preceding figure shows a seed .Net GUI in which the students are given with guidelines to hypothesize scenarios and build proper solutions.

Figure 6: The proposed study provides a simplified .Net GUI for the students. The program provides needed tools needed to build and rationalize more sophisticated systems.

Behind the scenes, the proposed sustainability program is student friendly and can be coped with few tutorials. The students are taught to perform mathematical modeling for the searched mitigations such as the amount of resource savings with specific sustainable measures. The students are also guided to manage the needed information by populating the needed data and summoning them when needed; similarly, they learn how to create proper reports that reflect their findings for sharing and communication. Down the road, the students are delegated with

constructing correct models that govern the interrelating effects among the environmental, social and economic factors which ensure the sought sustainable solutions and circumvent possible risks that may jeopardize the success of the system. Such work can be simple and straightforward such as proportional relationship studies or can be sophisticated such as artificial Intelligence; hence, it is dependent on the students' classifications and aptitudes but is open for the students to excel.

RESULTS AND OBSERVATIONS

In order to assess such educational advance, a class consisted of 21 students for an Introduction to Engineering Design was selected for a pilot study. The study started by having the students answer a questioner that reflect their level of understanding sustainability and their well to involve themselves and their acquaintances in the sustainability efforts. As expected, many of the students were challenged when asked to connect sustainability with the social and economic outcomes, hence, many were reluctant to go the extra mile and get involved in sustainability practices, let alone endorse them to friends and family.

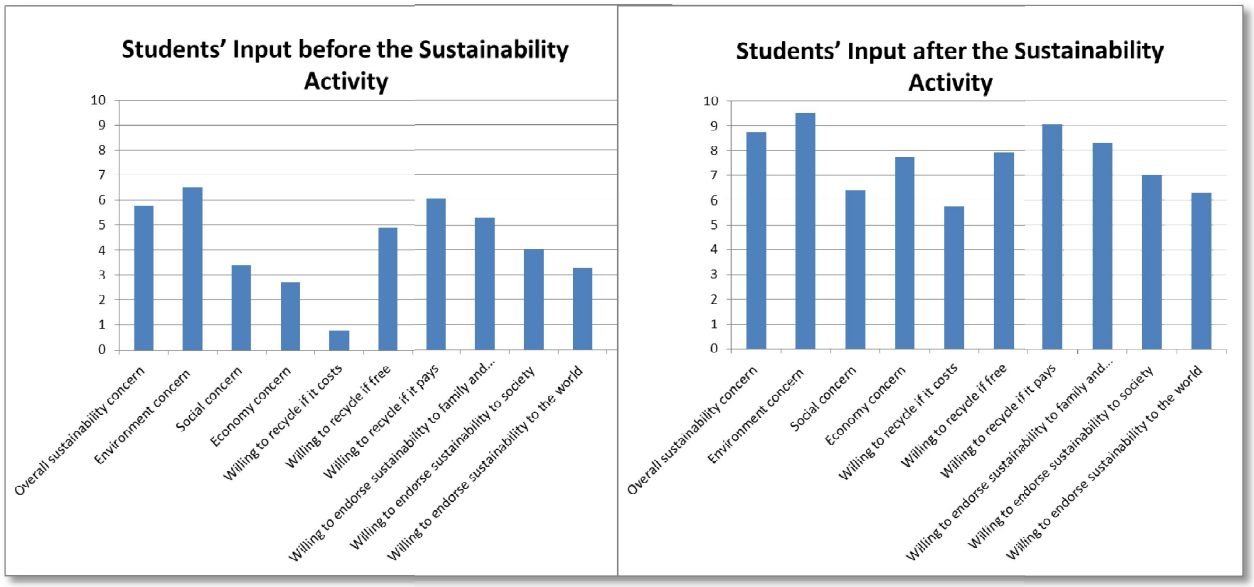

Figure 7: Students' reflections on sustainability changed after carrying out the activity which drove them to understand sustainability and appreciate its consequences.

Showing in Figure 7, the student's appreciation for sustainability has improved in multiple dimensions that include environment, social and economic appreciation. Also showing, the students are more willing to adopt good sustainability practices with and without conspicuous incentives.

CONCLUSION

This work proposes a valid approach to help the engineering students gain better understanding of sustainability and its magnitudes that reflect on their society's needs and worries. The approach suggests that one of the best means to learn and trust in sustainability is to apply solutions to the problems faced in their region and time. In order to have the students believe in sustainability impacts, they are assigned to perform research to uncover the correlation of sustainability on the environment. Environment research oversees the likelihood that mother earth will still be a safe haven to the upcoming generation. Not only the environment is sought to be appreciated in this work, the students also come to realize that sustainability play major roles in enhancing the social ties and individuals' respects. Furthermore, the students learn that the economic advantages are linked to the people adherence to the sustainability guidance. One of the best methods to tackle such multi-dimensional problem is by using computer aided engineering tools which allows for numerical analyses, data base capabilities and modeling. Students' reflections are recorded before and after the implementation of the proposed methodology. The results show that the students' prospective on sustainability has improved with more consideration and care.

REFERENCES

Anderson, K. (1996). Social Policy Dimensions of Economic Integration: Environmental and Labour Standards, doi:10.3386/w5702.

Basiago, A. D. (1998). The Environmentalist, 19(2), 145-161. doi:10.1023/a:1006697118620.

Brinkmann, R. (2016). Introduction to sustainability, Chichester, West Sussex, UK: Wiley Blackwell.

Dernbach, J. C., & Mintz, J. A. (2011). Environmental Laws and Sustainability: An Introduction, Sustainability, 3(12), 531-540. doi:10.3390/su3030531.

Gauthier, C., & Daudigeos, T. (2015). Sustainability Education, The International Journal of Sustainability Education, 11(2), 27-33. doi:10.18848/2325-1212/cgp/v11i02/55291.

Grange, L. L. (2017). Environmental Education after Sustainability, Post-Sustainability and Environmental Education, 93-107, doi:10.1007/978-3-319-51322-5_7.

Ittiravivongs, A. (2012). Recycling as Habitual Behavior: The Impact of Habit on Household Waste Recycling Behavior in Thailand, Asian Social Science, 8(6). doi:10.5539/ass.v8n6p74.

Khoshnava, S. M., Rostami, R., Valipour, A., Ismail, M., & Rahmat, A. R. (2016). Rank of green building material criteria based on the three pillars of sustainability using the hybrid multi criteria decision making method, Journal of Cleaner Production. doi:10.1016/j.jclepro.2016.10.066.

Lang, A. (2014). Business and Sustainability: A Synopsis, Business and Sustainability and Innovation, 179-192. doi:10.1007/978-3-319-07239-5_10.

Pye S., Skinner I., Meyer-Ohlendorf N., Leipprand A., Lucas K. Salmons R. (2008). Addressing the social dimensions of environmental policy - A study on the linkages between environmental and social sustainability in Europe, Report commissioned by European Commission, DG for Employment, Social Affairs and Equal Opportunities.

Schildt, H. (2009). C♯ 3.0: the complete reference, New York: McGraw-Hill Companies.

Seyajah, N. (2015). An Investigation on Sustainable Design Index and its Implementation within the CAD Environment, Cad15. doi:10.14733/cadconfp.2015.137-142.

World Bank Open Data. (n.d.). Retrieved December 13, 2017, from https://data.worldbank.org.