

# The Impact of Engineering Innovation and Eco-Design Competition on Environmental Awareness, and Academic Performance: A Global Qualitative Analysis in Europe, Asia, and the Middle East

Mahmoud Abdulwahed <sup>1\*</sup>, Mazen O. Hasna <sup>1</sup>

<sup>1</sup> Qatar University, QATAR

\* CORRESPONDENCE: ✉ [m.abdulwahed@qu.edu.qa](mailto:m.abdulwahed@qu.edu.qa)

## ABSTRACT

Environmental interventions in engineering education are essential to change behaviour of future engineering and awareness towards environment. Such change in behaviour and awareness would lead to future engineers higher consideration of environmental issues in their designs of engineering products and services in their future career. The paper provides a qualitative study on the impact of shell-eco marathon, a design competition focused on producing cars with lowest possible impact on environment, on engineering students environmental awareness. The analysis also explores the approach impact on academic performance and on engineering curriculum. Findings indicates that students environmental awareness have increased as a result of participation in the design competition, their academic performance did not negatively affected, and in many cases instructors opted to enhance their engineering curriculum based on the experiences they had in this competition.

**Keywords:** environmental awareness, sustainability, engineering education, qualitative analysis, innovation

## INTRODUCTION

For couple of decades, focus on infusing environmental awareness in education has been emerging significantly. UNESCO (1978) identified couple of dimensions in which environmental awareness is integrated in education, such as: 1- knowledge, 2- attitude/behaviour, 3- skills, and 4- engagement. Several related interventions have been reported since then, for instance see (Athman & Monroe, 2000; Ballard & Pandya, 1990; Callicott & Rocha, 1996; Gough, 1997; Karimi, 2003; Madsen, 1996; Palmer, 1998).

Shell Eco-Marathon is a design oriented global competition in which students compete on designing environmentally friendly cars with minimum consumption of fuel for preservation of environment (Abdulwahed et al., 2013). In SEM students build knowledge, skills, and actively engage in design projects to minimize environmental impact of cars fuels. The competition originated couple of decades ago, and spread from Europe across the world to USA, Asia, and the Middle East. In the USA the focus is mainly on K-12 students, while in Europe, Middle East, and Asia the focus is on higher education students. SEM is a very much project based oriented, and in many cases in performed in collaboration with industry partners, in particular in Europe. The importance of active learning and design in engineering education has been emphasized in several studies (Abdulwahed & Hasna, 2017; Abdulwahed & Nagy, 2012; Abdulwahed et al.,

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2008; Abdulwahed et al., 2013; Abdulwahed et al., 2016; Hamad et al., 2013). In general, fewer studies have been conducted on the higher education students in terms of environmental awareness as compared with school students (Leeming et al., 1993; McMillan et al., 2004)

The issue of environmental awareness is in particular essential for engineering students, as they will work in the future on designing products and solutions, and these designs if not considering environmental impact may increase negative issues on environment. Integrating environmental awareness through projects in relationship with industry such as SEM has been found effective way to engage students (Dori & Tal, 2000).

## RESEARCH BACKGROUND

Over the years of participation of College of Engineering Students at Qatar University in Shell Eco-Marathon Competition, supervisors and faculty have observed frequently positive impacts on students.

In order to quantify the faculty and students' observation, a research project was proposed and supported to conduct detailed analysis. The research scope widened beyond Qatar University to include comparative analysis on students from various geographic locations, including Middle East, Asia, and Europe.

## QUALITATIVE RESEARCH METHODOLOGY

Qualitative methods were used for sensing the impact of SEM. Interviews were conducted with students and faculty members from different countries, mainly in the Middle East, Asia, and Europe. Content analysis of interviews transcripts and theory of grounded analysis were utilized to get findings, and construct a conceptual model of SEM impact. All interviews were audio recorded and text-based synthesized after that before the analysis.

## RESEARCH GOALS IN THIS PAPER

The qualitative analysis aimed at several research goals, among them was an exploratory goal in which was based on grounded theory to deduct potential impacts. After a thoughtful process of reviewing and organizing the collected data, the final themes, categories and sub-categories that developed or emerged and on which the analysis will be based are as follows:

- SEM & Environmental Awareness
- SEM & Engineering Curriculum
- SEM & Academic Performance

## STAGES OF THE QUALITATIVE RESEARCH

The qualitative research included several stages, first exploratory interviews were conducted with supervisors and faculty from Qatar University. These interviews fed back into developing semi-structured interview protocols to be conducted with faculty and supervisors from other Universities, as well as, participating students from different geographical locations. Interviews then were transcribed and qualitatively analyzed in line with several research goals of the project. Findings of the specific goals for this paper is being reported in subsequent sections.

## SHELL ECO-MARATHON AND ENVIRONMENTAL AWARENESS

The main aim behind launching SEM couple of decades ago was to enhance environmental awareness. Students' designs of cars should response to certain environmental regulations, with fuel efficient characteristics to reduce impact on environment. One main aim of the qualitative analysis was to investigate potential impacts of SEM on environmental awareness.

In general, students' responses reflected enhancement of environmental awareness as a result of participation in SEM experience, see for instance quotes below:

*"It just makes you realize how so many different ways of consuming energy, and how people are usually not adopting those ways, so in a way ya you just give it a part sometimes, so Ya it is a yes."* MENA Student

*“Ya, it increases. The main idea of the project is to make an environmental friendly vehicle where for sure you need something about how the fusel fuel contribute to the damage of ozone layer and these stuff, so you had to learn this things to know why we are doing that. And before I didn't know about it Not really”.* MENA Student

*“I am interested in environmental problems and this project showed me that I can do many thing with different technologies and it was informative regarding environmental issues”* EU Student

*“I definitely learned about new high-tech ways and high efficient ways can be gained”.* EU Student

*“Environmental awareness has enhanced, because now here we are quite careful about the cleanliness about the safety things because it has award for this thing.”* Asian student

The extent to which students feel that their environmental awareness has increased as a result of participation in SEM is different from one student to the other. Some of students expressed that they didn't even know or understand what the effect of eco cars is before SEM and hence the awareness has developed greatly since then.

*“Honestly before this project I didn't know that much about this aspect but now at least 30-50 years we will start to face problems with petrol and other energy resources. While working on the project, I had to do some search about these issues and find solutions regarding problems we faced in this regard”.* EU Student

*“It did sure because I didn't know that the huge effect about the eco cars, and now a days I know the damage that the fuel the burn fuel for the environment.”* MENA Student

On the other hand, some participants (n=4 from Europe and n=8 from Middle East and n=9 from Asia) felt they were already aware about the environment from university courses or other resources but the desire to become more environmentally friendly has developed further due to SEM.

*“I'm usually aware of the environment but I became more interested in being more environmentally friendly seeing how big this eco shell thing is”* MENA Student

Students were motivated to learn such topic due to a couple of reasons. For instance, instructors played a role in getting the students interested about the environment by having frequent discussions and encouraging them to learn more about the environment.

*“I learned this from my conversations from the Instructors. Plus I had searched so many things about the eco word.. so ya as part of my participation”.* MENA Student

Another main reason in raising environmental awareness is an environment award that requires students to prepare some posters and do some research about the topic.

*“Maybe to a small extent because as part of the event they ask some teams to prepare some posters and info graphics which requires on research so, may be to that extent. Because you can apply for award based on that so may be to that extent but not so significant.”* MENA Student.

## SHELL ECO-MARATHON AND ENGINEERING CURRICULUM

The interviews with supervisors in particular have revealed some curricular impacts of SEM experience. For instance, below are summary of reported curricular issues are result of SEM experience:

- Participating in SEM and learning developed from the complex design of eco-friendly cars have highlighted some gaps in the engineering curriculum courses and topics that needed to be bridged
- Some institutions started to utilize SEM complex design as a curricular integrating platform
  - o Integration through sub-projects in various courses
  - o Integration cross-departments
- Some institutions started to offer engineering curriculum credit for participants in SEM
- Some institutions started to increase the practical/hands-on experience in engineering curriculum after observing the significant impact of the hands-on experience of SEM on students understanding of engineering fundamentals
- Some institutions started to participate in another complex design competitions as a result of the positive impact of participation in SEM, e.g. in robotics, in civil engineering, etc.

Below are some quotes of supervisors in regards with curricular related impacts of SEM:

*“for example I noticed that we need to include automotive engineering as we only have mechanical engineering so either opening that as a department or include.”* MENA Supervisor

*“SEM help on emphasizing hands on project experience for students”* MENA Supervisor

*“By making senior projects in which they can get academic qualification of the work they are doing”* Asian Supervisor

*“we got the inspiration of this; the need of shaping and training students for this kind of project , this was before an argument to decide on to go forward or not”* EU Supervisor

*“I am the supervisor for some integrated projects in mechanical engineering, so I feel that it is a source of inspiration for such integrated topics”* EU Supervisor

*“We included in some subjects of the curriculum some practical work/tasks with the required projects. With the courses/projects, we tried to integrate some of the applications they need to develop and apply.”* EU Supervisor

## SHELL ECO-MARATHON AND ACADEMIC PERFORMANCE

Interviewees were asked about potential impact of SEM experience on academic performance, in particular the measure of GPA was indicated as a main academic performance factor to report on.

### Students Perspectives

Some students thought that it has positive impact and enhanced their knowledge while fewer have reported non-positive perception; however, the vast majority of interviewees reported neutral stand on the impact of SEM experience on academic performance.

Positively students thought that SEM project enhanced their theoretical knowledge, for instance SEM urged students to have more conversations with lecturers about what theoretical aspects related to the design of the car.

Some students reported that management skills they gained through SEM helped them better manage their academic matters. Also some of the European students pointed to the utilization of what they have learned during SEM to raise their grades.

*“I could use my experience to raise my grades and expand my knowledge”* EU Student

*“Actually my GPA increases Fall because I have time management, and in this course I to commit to do something”.* MENA Student

*“We sometimes missed classes. The project was extracurricular activity not credit, GPA didn't decrease they increased 1.6 maybe I managed it quite well because I used to think that shell is extracurricular activity but I was quite interested in that but I had to maintain my GPA.”* Asian Student

On the non-positive perception on academic performance, Students thought that SEM slightly reduced their GPA, but they valued that the overall gains out of SEM experience are highly positive.

*“My grades were affected a little bit because we spent a lot of energy and time on this project but gains were more than the loses; grades are grades and it is all about skills that would definitely help in job market”.* EU Student

On the Neutral Stand, planning and time management were the main reported reasons for ability to balance between academic performance and SEM design demands.

*“For me because I have the correct time management I don't think it does impact much.”* Asian Student

### Supervisors Perspectives

Supervisor reported similar perceptions on potential impacts of SEM experience on academic performance of students.

Instructors who agreed that SEM had a positive impact on the students' performance reported that knowledge and practice have added to the students' performance.

*“Mostly positive impact. Now these students are the best students with excellent academic performance and high qualifications”.* EU Supervisor



**Figure 1.** Model inducted from qualitative findings on the impact of SEM on environment and education space

*“They become professional as they got the skill then apply it, so they can easily understand engineering theories by practical application.”* Asian Supervisor

On the non-positive impact on academic performance, two instructors have agreed that SEM may have reduced students’ grades lightly due to the intense and demand needs of SEM design. One instructor believes that the experience compensates the deduction in GPA and that students can easily bounce in the coming semesters, while the other believe that SEM impacts their spirits positively which is more important than the GPA.

*“Their GPA is impacted reducing their GPA a little bit”* Asian Supervisor

*“I can say that sometimes it affects their grades negatively but their spirit positively”* MENA Supervisor

Many instructors reported neutral stand of SME experience on students’ academic performance. One believes that it depends on the students themselves, whether get encouraged and motivated by the experience to do better in their academic careers, or let themselves get overwhelmed by the demanding nature of SEM to the point where they let it affect their academic performance. And as the way he described it, “the average is zero”

*“Because you have people who get encouraged by the fact that they participated and in the opposite, you have people who look too much in the project and affect their performance later.”* EU Supervisor

*“For sure this project need from them time management but I think it doesn’t affect them negatively”* MENA Supervisor

*“When it comes to grades not necessarily, probably positive yes in labs I would say it should have impacts in labs.”* MENA Supervisor

## DISCUSSION AND FUTURE WORK

The SEM found to have impacts on engineering education and on environmental awareness. Instructors in some institutions started to have modifications in their engineering curriculum as a result of observations and experiences gained in SEM. Last but not the least, SEM persistent with its original aim have found to raise environmental awareness of engineering students. **Figure 1** shows a visualizing model of SEM experience and its various impacts, arrows in wider size refer to estimated levels of SEM impacts, directions of the arrows refer to flow of impact.

The model implies that utilizing active learning interventions approaches for environmental awareness enhancement, e.g. such as Shell Eco Marathon, is an effective tool for realizing the awareness among students. The model suggest that engineering curriculum should be updated accordingly to optimally accommodate the intervention.

Future work recommended out of the study is to work with engineering schools on increasing such active learning interventions. Also, work more on integrating different disciplines together. Comparative analysis of

environmental awareness enhancement through active learning approach such as SEM vs. lecture based approach would be of interest of further investigation.

## CONCLUSION

Qualitative analysis have shown in-depth insight on SEM experience impacts. Significant amount of interviews have been conducted with EU, Asian, and ME students and supervisors, most interviews were conducted during the competition duration. Interviews have revealed convergence reporting among interviewees on a number of investigated and emerging themes. These themes are: environmental awareness, engineering curriculum, and academic performance. Overall, SEM reported to leave significant positive impacts, which have been visualized in a representative model. Through deduction from the interviews transcripts, SEM has contributed to enhancement of environmental awareness, and several engineering academics have improved their curriculum based on their experiences in the competition. Finally there was not negative impact on academic performance of students despite that significant part of them have been taking this as voluntary activity, and despite the fact that it has been significant time consuming process.

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No potential conflict of interest was reported by the authors.

## Notes on contributors

**Dr Mahmoud Abdulwahed** is Head of Technology Innovation & Engineering Education, Qatar University.

**Dr Mazen O. Hasna** is Vice President and Chief Academic Officer, Qatar University.

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