

# Capturing the student learnings from the Solar Decathlon Middle East 2018

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## Introduction

The Solar Decathlon is an international competition organised by the U.S. Department of Energy (USDoE) in collaboration with local hosts (McCarthy, Banfield, Baghi, Faidutti, & McDowell, 2018). It requires university teams to design, build and operate sustainable, stylish and cost effective solar powered net-zero energy homes (United States Department of Energy, 2019). In 2016, the University of Wollongong (UOW) entered the Solar Decathlon Middle East 2018 (SDME). This competition integrated local and regional Middle Eastern characteristics, whilst promoting sustainable and innovative concepts which could be beneficial to all people. The UOW team's aim was to construct a sustainably designed house which celebrated human life in all its diversity, placing a strong emphasis on designing for those living with dementia (Team UOW, 2019). The Solar Decathlon has been described as an intensive and immersive authentic learning experience in a multidisciplinary setting, which encourages students to apply theoretical knowledge learnt, whilst simultaneously developing essential professional and personal skills (Ortegon, 2016).

This study captures some of the learning outcomes and personal development of Team UOW students who participated in the Solar Decathlon Middle East 2018. These outcomes are explored against the University of Wollongong's Course Learning Outcomes for a Bachelor of Engineering (Honours) and Engineers Australia's Stage 1 Competencies.

## Literature Review

The importance of well-developed soft skills in the 21<sup>st</sup> century in university graduates who are entering the work force is well documented (Bloomberg Next, 2018). This importance is attributed to a changing world with continuously evolving technology. Skills such as; adaptability, communication, flexibility and problem solving are deemed to be essential. The value of experiential and authentic learning experiences has now become more significant in higher education due to their ability to aid the development of these soft skills in students (Ortegon, 2016; Whittington, Anderson, & Connor, 2017). Programs such as the Solar Decathlon have a central focus on technological and social issues and possess real-world relevance to develop the skills necessary for success in the 21<sup>st</sup> century (Deloitte, 2019).

Experiential learning can be described as the process where students gain knowledge and develop skills from first-hand experiences which do not occur in a traditional classroom setting. The benefits and characteristics of experiential learning are hailed as 'the future of learning' (eLearning Industry, 2019). Kolb's Experiential Learning Theory defines this as:

*"The process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience."* (Kolb, 1984)

The Kolb Learning Cycle is regularly applied to higher education learning outcomes (Healey & Jenkins, 2000). Kolb's Experiential Learning Cycle shows the four fundamental stages for a learning experience to be considered 'experiential' (adapted in Figure 4).

Authentic learning experiences assist students in developing effective and valuable understandings. Bridging the gap between classroom and practical learning has been identified as a difficulty in university education (Stein, Isaacs, & Andrews, 2004).

Design challenges, such as the Solar Decathlon, bring students an authentic and experiential learning experience solving engineering and social problems relevant to the participants

(McCarthy & Rasekh, 2013). The Solar Decathlon requires students to work in multidisciplinary teams, another similarity to real-world environments (Ortegon, 2016).

Strobel et al. developed a model with 11 key factors and 7 key outcomes which characterise authentic problems (Strobel, Wang, Dyehouse, & Weber, 2012). Factors relevant to describing the Solar Decathlon as an authentic learning experience include:

- Real-world context/Future professional situation
- Interaction among learners
- Decision-making in practical contexts
- Value beyond school
- Provide information/data that is from or mimics real-life or skills
- Complex problem transcending the borders defined by disciplines

The outcomes of authentic problems include; higher-order thinking, disciplined inquiry, active self-knowledge construction, development of professional goals (Strobel et al., 2012).

### **UOW Engineering Course Learning Outcomes and Engineers Australia Competencies**

A learning outcome describes the learning a student has attained and can reliably demonstrate with confidence at the completion of an educational program (Lesch, 2012). The Course Learning Outcomes (CLO) set by the University of Wollongong for a Bachelor of Engineering Degree have been outlined in Table 1 below. These contain a mix of both soft and technical skills. Soft skills are seen in Learning Outcomes 5-9 in Table 1. This suggests that outside the classroom, students are expected to have real-world experiences.

**Table 1: UOW Bachelor of Engineering CLOs (University of Wollongong, 2017)**

<b>Extract from UOW Course Learning Outcomes for Bachelor of Engineering (Honours)</b>	
<b>5</b>	Communicate clearly and coherently in writing to a range of audiences, with an ability to integrate knowledge, research, data, analysis and critical evaluation.
<b>6</b>	Communicate verbally to a range of audiences using appropriate language in presentations, consultation and negotiation.
<b>7</b>	Work productively as part of a team with the capacity for leadership, recognising the roles, responsibilities and accountabilities of team members.
<b>8</b>	Show respect for the views, values and culture of others in settings involving colleagues, clients, communities and end users, and consider alternate perspectives in design and project management.
<b>9</b>	Make complex considerations in regard to professional ethics and accountability, account for and mitigate risk, and operate with a commitment to professionalism in all work.
<b>10</b>	Appreciate the importance of sustainable engineering design and seek to maximise positive social and environmental outcomes in engineering design, practice and development.

Engineers Australia’s “*Stage 1 Competencies*” consist of 16 mandatory elements of competency which are expected to be demonstrated upon graduating as an engineer from an accredited program (Engineers Australia, 2019). Similarly to the UOW CLOs, soft skills can be identified in the Professional and Personal Attributes in Section 3 of Table 2.

**Table 2: Engineers Australia Stage 1 Competency Section 3 (Engineers Australia, 2017)**

<b>3 PROFESSIONAL AND PERSONAL ATTRIBUTES</b>	
<b>3.1</b>	Ethical conduct and professional accountability.
<b>3.2</b>	Effective oral and written communication in professional and lay domains.
<b>3.3</b>	Creative, innovative and pro-active demeanour.
<b>3.4</b>	Professional use and management of information.
<b>3.5</b>	Orderly management of self, and professional conduct.
<b>3.6</b>	Effective team membership and team leadership.

# Context and Background

## About the Solar Decathlon

The Solar Decathlon has expanded since its first event in 2002 in USA. It is now co-hosted by multiple countries and governments worldwide. The aim of the competition was to raise awareness of environmental practices and innovations applicable to both industries and households. By placing the competition in an educational collegiate setting, academic benefits to students and institutions could also be gained (Ortegon, 2016).

In 2016, the University of Wollongong gained entry to the Solar Decathlon Middle East (SDME), held in Dubai in 2018 co-hosted by the Dubai Supreme Council of Energy, the Dubai Electricity and Water Authority and the U.S. DoE (Solar Decathlon Middle East, 2018).

The Solar Decathlon is an intensive and immersive learning experience. It encourages students to apply theoretical knowledge, whilst developing essential professional and personal skills (Navarro et al., 2014; Ortegon, 2016). Navarro et al found that the main educational value of the Solar Decathlon for participants was (Navarro et al., 2014):

- Improvement in ability to work in multidisciplinary teams
- Development of technical, scientific and social skills
- Increased work motivation

## Solar Decathlon Middle East 2018

SDME 2018 integrated local and regional cultural and climate characteristics. As well as coping with high temperatures, humidity and sand storms, the architecture needed to be suitable in an Islamic context (United States Department of Energy, 2019). Solar energy with battery storage was the only energy source permitted in the SDME 2018. Each house was required to be fully functional in the final phase of the competition at Dubai. The houses were assembled at the Solar Hai (Solar District) 50 km into the Al Qudra desert in Dubai, next to the MBR Solar Park, one of the world's largest solar farms. The construction period was only 15 days. The teams needed precision in the planning and execution of the build. Team UOW, had the added challenge of completing their house 3 months ahead of the other teams to allow for shipping across the world. Each team then participated in ten contests (Figure 1) and also opened their houses to the general public for tours.



Figure 1: The Ten Contests of the SDME 2018 (Adapted From: (Solar Decathlon Middle East, 2016))

## Team UOW and Desert Rose House

Team UOW, comprised of three supporting institutes: University of Wollongong – Australia, TAFE NSW and University of Wollongong Dubai. This provided a multidisciplinary cohort including vocational students such as plumbers, carpenters and even a trainee chef. Over the two years, about 250 students participated, with about 50-60 being active at any one time. Approximately 70% were engineering students while 30% came from all other faculties of the university. 41 students took part in the final phase in Dubai (Figure 2).



Figure 2: Images of Team UOW with the Desert Rose House in Dubai (Team UOW, 2019)

## Methodology

Student blogs published on the Desert Rose (Team UOW) website (Team UOW, 2019) and survey responses have been critically analysed for value statements, word frequency and sentiment using a software tool, NVivo (QSR International, 2017).

NVivo helps to determine the sentiment of sentences in large text files. It analyses this by finding expressions of sentiment in text-based documents. Words possessing sentiment have a pre-defined score in the software which corresponds to a 4-node scale for sentiment, shown in Figure 4 with 'Neutral' as an additional node for words which do not possess sentiment. The score can change if words have a modifier such as "more" or "much" added.

	A : Very negative ▼	B : Moderately negative ▼	C : Moderately positive ▼	D : Very positive ▼
1 : Internals\Desert Rose Blogs ▼	41	76	253	150

Figure 3: NVivo sentiment scale

## Desert Rose Blogs

Members of Team UOW posted over 75 individual diary entry style posts to their public blog on the Official Desert Rose website throughout the entire competition over two years (Team UOW, 2019). NVivo was used to identify repeated phrases, overall sentiment and meaningful text which capture the personal development and learning outcomes of the participants.

## Surveys

Online surveys were distributed via email to all 250 students involved in the SDME2018 to gain an insight into the varying personal experiences and learning outcomes. This method is useful for documenting the perceptions, attitudes, or knowledge of a defined group of individuals (Paradis, O'Brien, Nimmon, Bandiera, & Martimianakis, 2016).

The 25-question survey consisted of a combination of different style questions, including; multiple choice, Likert scale, text input, checkboxes and matrix grid. This allowed the participant to develop valuable, diverse and thoughtful responses. A number of the questions were targeted specifically towards UOW Course Learning Outcomes, Engineers Australia Competencies and soft skills identified as essential for engineering graduates. The survey also asked demographic questions and aimed to identify evidence of experiential and authentic learning. An anonymous survey link and a password was provided.

## Results and Discussion

### Evaluation of Desert Rose Blogs

Both staff and students contributed to the 75 blogs, equating to over thirty-two thousand words, on the experiences of the participants. It was found that 77.5% of statements possessing sentiment were moderately or very positive. This suggests that those who contributed to the blog posts had a positive attitude towards their experiences as part of the Solar Decathlon. Results which presented negative sentiment were reflective on progress, describing improvements which students had made. The enthusiasm of some of the participants was

revealed upon review of the statements which presented a 'very positive' sentiment, some examples include:

- "Probably the **coolest** and **most innovative** task that I am currently working on is a brand-new design: the Solar Sail."
- "I had **such a fantastic** experience that I **wanted** to do it all over again!"
- "My teammates are **incredibly** hard-working and all did their part to make sure the day was a **success**."

## Survey Responses

At closure a total of 31 students participated in the survey with an average of 28 responses per question. There were 50 active students at the end of the project, 41 of these students went to Dubai as part of their involvement. 20 respondents wrote that they went to Dubai. Given this data and a confidence interval of 95% a margin of error of 12% was calculated.

### Demographic Data

- 71.4% of student respondents study an engineering degree (single or double degree)
- 85.7% were Domestic Australian students
- 42.9% identified as female and 57.1% identified as male
- 75% were Undergraduate UOW Students

### Motivation

Based on the survey responses there were three primary reasons students were motivated to become involved in the Solar Decathlon with Team UOW:

- A new challenging experience
- Interest in sustainable design
- Apply their knowledge/ studies to a real-world project

### Skills Developed through Participation

By analysing the mean value of responses on a 5-point Likert scale matrix question the most developed personal skills were identified as; *teamwork, innovative thinking, creative thinking and communication*. These skills were followed by; *problem solving, attention to detail, work ethic and decision making*. Many students alluded to being confronted by new concepts and challenges, but ultimately developing new technical and personal skills from the experience.

### Connections with Learning Outcomes and Competencies

Using a 7-point Likert scale matrix question format, students were asked to reflect on their experiences and select to what extent they agreed or disagreed with an eleven separate of statements. These statements all had direct connections with UOW CLOs (Table 1) and Engineers Australia Stage 1 Competencies (Table 2).

All statements received mean scores between neutral (4) and strongly agree (7). Statements which received a mean value higher than agree (6) were:

- This experience has shown me the value of working in multidisciplinary teams. (6.52)
- This experience has shown me the value of working in a diverse team. (6.44)
- My understanding of the significance of sustainable engineering design has improved. (6.44)
- My capacity to work productively as part of a structured team has developed. (6.04)

This suggests that a number of the UOW CLOs and Engineers Australia Stage 1 Competencies were indeed developed in students who participated in SDME 2018.

### Challenges

88% of respondents confirmed that their involvement in the Solar Decathlon caused them to withdraw or sacrifice other commitments, hobbies, study, sports etc. When asked to elaborate, study, family and relationships were major themes. During Autumn and Spring University semesters in 2018 the mean hours of commitment per week for students were 24.54 hours

and 26.96 hours. 20% of respondents indicated that their subject grades declined since becoming involved in the competition, 36% selected that they stayed the same and 20% said their grades improved.

**Key personal challenges faced:**

- Time Management
- Balance between workload and project
- Personal Organisation
- Facing conflicting perspectives

**Key professional challenges faced:**

- Time constraints and deadlines
- Meeting expectations
- Conflict resolution
- Technical Knowledge
- Effective Communication

*Personal Outcomes*

Students were asked: “From your experience participating in the Solar Decathlon, to what extent do you agree or disagree with the following statements”, the following mean values were established (1 = strongly disagree and 7 = strongly agree).

**Table 3: Personal Outcomes**

Statement	Most Selected Option	Mean
The competition encouraged me to step out of my comfort zone.	Strongly Agree	6.50
The Solar Decathlon enabled me to think creatively.	Agree & Strongly Agree	6.31
I feel that I have become more confident.	Strongly Agree	6.00
In future, I feel that I would be more willing to volunteer for leadership positions.	Agree	5.67
I am now more comfortable about entering professional life.	Strongly Agree	5.88

There were 23 responses to “How has the Solar Decathlon helped you in your career ambitions for the future?”, all responses had a positive sentiment. They also showed indications of authentic learning, soft skill development and reflective practice.

Students wrote:

- “It has given me experience in a **leadership** role, and given me **real world** experience, more than I gained from my professional work experience ever did”
- “It has provided me with a **practical project** to develop both **technical and non-technical engineering skills**”
- “It has given me great knowledge and insight into **sustainable housing** and shown me what it is like working with a **diverse team** and the unique nature of volunteer projects.”

In response to “What has been the most valuable part of participating in the Solar Decathlon?” 23 written statements were analysed. Overall, the responses all had positive sentiment, indicating that students viewed participation in SDME 2018 positively. Making friends and working in multidisciplinary teams were two major themes identified.

**Overall Findings**

Overall, despite the challenges identified, 95.83% of all respondents agreed or strongly agreed with the statement: “Overall, participating in the Solar Decathlon was a worthwhile experience.” When asked for further comments NVivo revealed an overall positive sentiment. Students wrote that participating in the Solar Decathlon was a ‘one in a lifetime’, ‘priceless’, ‘unique’ and ‘unforgettable’ experience.

Connections between the participating in the Solar Decathlon Competition and Kolb’s Experiential Learning Cycle have been established (see Figure 4). Student responses and the blogs confirmed that they had experienced all 4 stages of the learning cycle.

Students indicated that they had experienced developments in multiple personal and technical skills by being involved in a competition which had a real-world context. This result suggests that a number of the UOW Course Learning Outcomes and Engineers Australia Stage 1 Competencies were developed and fostered in students who participated in the Solar Decathlon Competition, with notable improvements in areas involving soft skills.



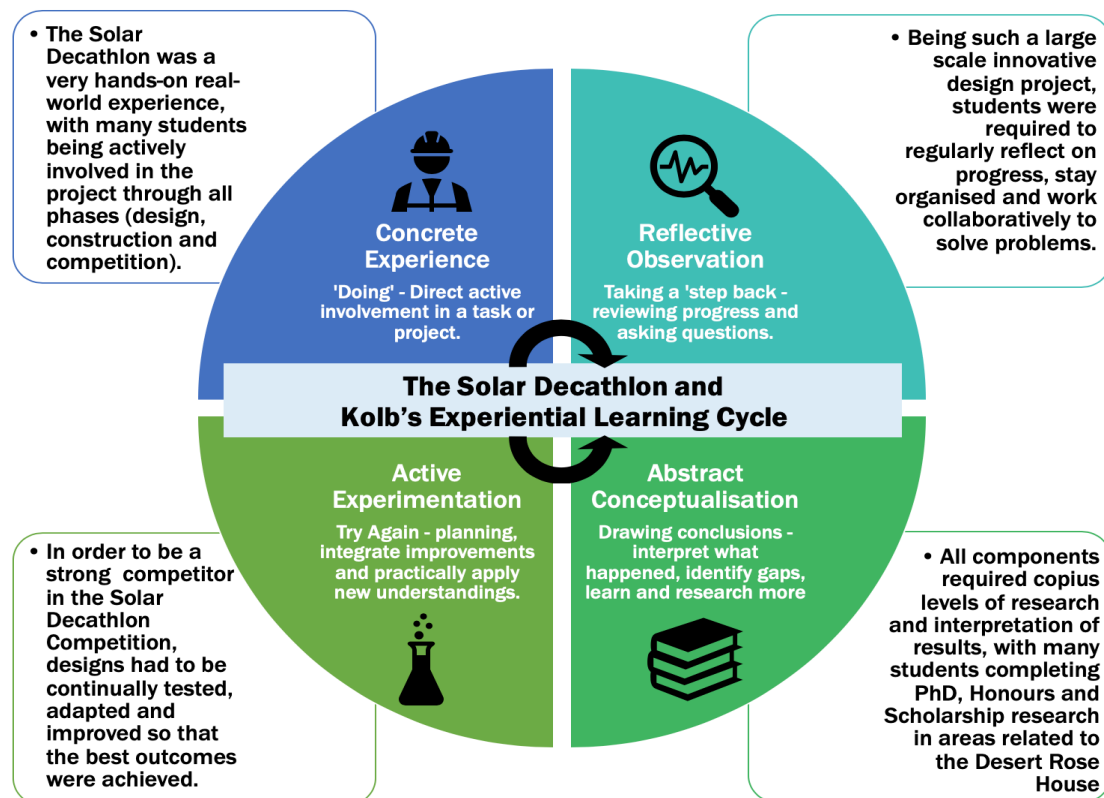


Figure 4: Kolb's ELT and Solar Decathlon adapted from: (Healey & Jenkins, 2000)

## Conclusion

Through the analysis of blog posts and survey responses which required students to reflect on their experiences and self-identify areas of personal development, it can be concluded that the Solar Decathlon meets the criteria of learning models developed by both Kolb and Strobel. Thus, qualifying participation in the competition as an enriching experiential and authentic learning experience for students. The learning outcomes from participating in the Solar Decathlon Middle East 2018 are also eligible to meet a number of the UOW Course Learning Outcomes for a Bachelor of Engineering (Honours) and the Engineers Australia Stage 1 Competencies. This indicates that a future with increased integration of experiential and authentic learning experiences, alike to the Solar Decathlon Middle East 2018, into modern engineering curriculums could be beneficial to the professional development of students and their academic outcomes. Equipping students with a more well-rounded set of skills to assist in meeting the requirements to be a successful engineer in the 21<sup>st</sup> century.

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