

Transformative learning in engineering education: the project management ability becoming second nature outcome

Douglas T.K. Tien[†] & Satesh N. Namasivayam[‡]

Taylor's University, Subang Jaya, Selangor, Malaysia[†]

Sunway University, Selangor, Malaysia[‡]

ABSTRACT: In this article, the authors discuss the transformative learning outcome of project management ability becoming second nature. This outcome was realised within an engineering education context. A study was conducted by the authors, whereby four outcomes and three factors related to transformative learning in engineering education were identified [1]. The four outcomes were: improved people and relational skills, project management ability becoming second nature, changes in ways of thinking and increased resilience. The three factors that facilitated them were: the need to break out of comfort zones, the need to have crucial learning experiences, which were experiential in nature, and the importance of staying motivated throughout the entire process of transformation until the process is completed. This present article discusses one of these outcomes in greater detail; namely, that of project management ability becoming second nature. The authors' considerations presented in this article, which constitute a new research contribution, are supported by the interview data from their earlier study [1].

Keywords: Transformative learning, engineering education, project management, project-based learning

INTRODUCTION

A qualitative study was undertaken on transformative learning within an engineering education setting of a private university in Malaysia. Through this study, three contributing factors and four outcomes were identified. The three factors were the need to break out of comfort zones, the need to have crucial learning experiences experiential in nature and the need to remain motivated through the process of transformation [1]. These factors as well as how they were facilitated in the students' experiences were further elaborated in [2-4]. The four outcomes were improved people and relational skills, project management ability becoming second nature, changes in ways of thinking and increased resilience [1].

In addition to technical competencies, it is apparent that non-technical competencies are deemed of equal importance for engineering graduates by various engineering education initiatives, such as the International Engineering Alliance [5], the CDIO Initiative [6] and the National Academy of Engineering's Grand Challenge Scholars Program [7]. This is particularly pertinent in view of the complex challenges that the engineering profession is required to address. It was assumed by the authors that the processes that lead to the attainment of the non-technical competencies could be understood through the lens of transformative learning. This consequently provided both the rationale and the motivation to undertake the study.

Learning that is informative often occurs in classroom settings and usually involves the passive absorption of knowledge. Learning that is transformative on the other hand, requires the active engagement of the learner and results in changes in him or her. Transformative learning has been variously defined. One definition that manages to capture the crux of transformative learning was given by Hoggan: *Transformative learning refers to processes that result in significant and irreversible changes in the way a person experiences, conceptualizes, and interacts with the world* [8].

In this article, the authors elaborate on the transformative learning outcome of project management ability becoming second nature. This was not previously elaborated upon at length by the authors in their previous papers.

Project management may be defined as follows: *Project management is the application of processes, methods, skills, knowledge and experience to achieve specific project objectives according to the project acceptance criteria within agreed parameters. Project management has final deliverables that are constrained to a finite timescale and budget* [9].

Project management ability becoming second nature which was identified as a transformative learning outcome in this study refers to the acquisition and assimilation of cognitive, affective and psychomotor skills (i.e. the knowledge, skills and attitude) required to execute a project effectively from initiation to completion. This is an ability which is much desired of engineering graduates as mentioned in the expectations of the various engineering education initiatives mentioned above [5-7].

In defining this outcome, it is necessary to use the words *become second nature*. This is meant to differentiate it from that of merely learning about project management from a book or in a classroom or by passing an examination. *Become second nature* implies that this ability is somehow integrated into the *way of life* of the interview participant. In a more colloquial language, it can be said that the ability had become *part of their DNA*.

The ability to manage projects successfully is valued highly by employers irrespective of the discipline of study. There are clear indications that this skill, inclusive of soft skills, may be viewed as a key determinant in the hiring decisions of graduates to relevant roles.

Many universities integrate the learning of project management with that of project-based learning. It appears that this is an effective approach. De Los Rios-Carmenado et al described how a project-based learning approach to undertake a real-world challenge was used to teach project management competencies [10]. Rather than being passive recipients of knowledge, the students were given exposure to pre-work experiences through the university's collaborative agreements with external agents. Students could work on real-world projects that required the integration of their present knowledge with new knowledge gained from project work. A high level of competence development and improvement in technical, behavioral and contextual skills were observed [10].

Dominguez et al likewise found that project-based learning applied to real-world scenarios was effective in teaching project management [11]. Their case study was about the experiences of MSc mechanical engineering students who participated in the design and implementation of a professional reintegration plan for the socially and economically disadvantaged who depended on external food supply provided by a non-profit organisation. Positive impact on developing project management, empathy, critical thinking and team-working skills of students were observed [11].

A learning model to impart project management knowledge through scaffolding and project-based learning for a project engineering course was proposed by Pokharel [12]. The model included team formation, leadership selection, development of activities and peer evaluation. Application of appropriate project management tools and techniques were required in each part of the model. A survey showed that the students perceived gains in their project management knowledge and skills [12].

Effective project management requires the application of both hard and soft skills. Hard skills are associated with the initiation, planning and execution, monitoring and closing of projects within the constraints of time, cost and quality objectives. On the other hand, soft skills are associated with behaviors, attitudes, and core personality characteristics that affect an individual's ability to manage projects [13]. Ballesteros-Sanchez et al developed an index for measuring soft skills in project management [13]. They found that by employing a project-based learning methodology in training students for project management had resulted in noticeable improvements in the areas of soft skills defined by their index.

Pant and Baroudi argued the need for project management education to include both human and technical skills [14]. The focus of most universities in training students in project management has thus far been placed more on the technical skills considered crucial to project success. These are no doubt easier to teach compared to human skills i.e. soft skills. However, soft skills are also crucial to project success. As highlighted by previous authors, an effective pedagogical tool for teaching project management is by employing the project-based learning method where students work in teams [10-13]. Using this approach, the development of various soft skills was facilitated.

A study by Ortiz-Marcos et al found that the students who played the role of the team leader in a project management course using project-based learning methods managed to strengthen their project management competencies more when compared to those who played the role of team members [15]. Hence, it was recommended that all students be given an opportunity to experience the role of team leader.

The project-based learning method was found to be effective in helping undergraduate students attain various graduate attributes due to its learner-centered and constructivist approach [16]. The efficacy of project-based learning lies in shifting the focus from teaching to learning. The features of project-based learning typically include being student-centered, involved learning while doing, being more process than product oriented, requiring group collaboration and being experiential in nature [17].

METHODOLOGY

As the interest of this study lies in how the interview participants (students and recent graduates) perceived their engineering education experiences, a qualitative research methodology consistent with the interpretivist/constructivist epistemology was adopted. In agreement with this epistemology, the basic qualitative study methodology, the selection of participants through

purposeful sampling and semi-structured interviews were used. Appropriate methods of data collection and data analysis were carried out. This methodology and the corresponding justifications for it were explained to a greater extent in papers by Tien et al [1][2].

The following section describes the participants selected for the study.

Participants

Purposeful sampling was employed to select participants considered as having the best possibility of having undergone the type of transformative learning of interest to this study. The sample size was not pre-determined with the sampling continuing until data saturation was reached. Purposeful sampling involves recruiting participants based on pre-selected criteria relevant to the primary issues of interest to the study. The selection criteria, reproduced from [1] were as follows:

1. Enthusiastic participation in curricular activities, usually evidenced by an above average cumulative grade point average (CGPA) score.
2. Enthusiastic participation in extracurricular activities (ECA) evidenced by their roles and initiative displayed in ECA. It was anticipated that valuable learning may occur in a range of informal learning situations and that this would be especially true with transformative learning.
3. Unafraid to speak the truth.
4. Have good communication skills as this helps very much in interviewing.

Table 1 provides a brief description of each interview participant.

Table 1: Information regarding the interview participants [1].

Interview participant	Programme	Gender	Ethnicity (M/C/I)	Level of study at the point of interview	Reason for selection/remarks
IP1	ME	M	I	Completed semester 7	Outspoken, displays leadership qualities, active in ECA.
IP2	CE	F	C	Recent graduate	Completed TGCSP, showed initiative during TGCSP by organising a study trip to Japan.
IP3	EE	M	C	Recent graduate	Good academically, high CGPA score, yet also very active in ECA.
IP4	ME	M	C	Semester 6	Active in ECA, high CGPA score, President of Student Council, involved in TRC competition during Foundation.
IP5	ME	M	M	Semester 5	Active in ECA, high CGPA score, articulate.
IP6	ME	F	C	Recent graduate, employed	Active in TRT, completed TGCSP, good CGPA and communicates well.
IP7	EE	M	C	Completed semester 8, awaiting results	Recommended by another student due to a miscommunication. His interview was retained to serve as insight into the challenges of non-transformation.
IP8	CE	F	I	Recent graduate	Outspoken and active in ECA, displays leadership qualities, the first president of TRC.
IP9	ME	M	M	Recent graduate	Key leader of the TRT, can communicate well.
IP10	ME	M	C	Recent graduate, employed	Completed TGCSP, one of the top students, can expect honesty from him.
IP11	EE	M	C	Recent graduate, applying for postgraduate studies	Good academically but no ECA. Deliberately selected to have a participant with no ECA.

Taylor's Grand Challenges Scholars Programme (TGCSP); Taylor's Racing Team (TRT); Taylor's Robotics Club (TRC)

The interview participants were recruited from all three engineering programmes offered by the School of Engineering; namely, mechanical (ME), chemical (CE) and electrical and electronic (EE) engineering. They comprised the three main ethnicities found in Malaysia, i.e. Malay (M), Indian (I) and Chinese (C). Both genders were included.

There were seven Chinese, two Malay and two Indian participants. This breakdown corresponded approximately with the composition of the Malaysian students' ethnicities in the School of Engineering. A decision was made to focus on Malaysian students as they comprised the huge majority while other nationalities were much fewer and quite diverse. There were also more ME participants selected because ME students made up the School's majority.

Data saturation began to be observed at the 6th participant. However, to confirm if the data were truly saturated, the interviews continued until the 11th participant. The continuation of sampling to the 11th participant was not only meant to establish data saturation, but it was also intended to maintain the mix of ethnicities, programmes (ME/CE/EE) and gender should there be any variation in the outcomes because of these differences, but none were observed. The emergent themes applied across ethnicities, programmes and gender.

Two participants who did not meet the selection criteria were also included mainly for additional insight. They were participants 7 and 11. It is also possible to learn from extreme or deviant (outlier) cases and there is a type of purposeful sampling associated with this [18] although it was not the intention of this study to adopt this type of sampling.

RESULTS AND DISCUSSION

The specific project management skills acquired by the interview participants that had become second nature to them include the following: preparedness for eventualities, time management, thinking systematically, a structured approach to projects, resource planning and management, and attention to details. These relate primarily to the transformative outcomes in worldview, epistemology, self and behavior [8]. A sample of the participants' interview responses are analysed below.

Interview participant 5 (IP5) considered learning project management through his project-based learning experience to be among those experiences that had impacted him most.

I think it teaches something that is so instinctive to me I guess, when you have to manage something from A to Z, you got to make sure that you have enough resources for every step along the way. Not just resources, [but] resources, time, money, it teaches me the fact that everything you do, every decision you make has a certain cost to it, whether it is monetary, energy or physical objects or even time, it really makes me see that everything I do needs to be planned out well, so that everything can be done from A to Z. And let us say [if] things do not work out, you should have [a] backup plan to it, or should have you know, plan A, plan B, plan C. It just teaches me to be more prepared for things, makes me less naïve. - IP5

This had affected both his worldview and his behavior. Through this experience, he internalised the need to be always prepared for eventualities. According to him, he has continued to adopt this mindset for his project-based modules each semester since. Hence, it is reasonable to expect that he will carry this mindset with him into his future career.

Interview participant 3 (IP3) was another respondent who shared the same sentiments as IP5 with regards to the need to have a backup plan and in being prepared for eventualities. He also included close monitoring and support for his team members. These can be considered vital project management skills, in terms of both hard and soft skills.

You would think that things would always go according to plan, but the fact is, it is not. So ...you must be prepared yourself, be prepared from the [start]. ...For all times, you must be prepared.

...because there are a few semesters where the project went wrong, went very bad, because like some ...we could not fully blame [this] on the team member, but the team member said he will get it done but dragged, dragged, dragged, so eventually it was not done. Then, we have like a piece of our part of project is not fulfilled. So, during the presentation some elements ...could not be presented out, which caused a bit of [disruption to] our team.

Always have a backup plan. Do not fully push everything to one person, and always keep track of the person, whether if it is done or does the person need any help. - IP3

For interview participant 10 (IP10) it was resource planning and management. This took the form of idea generation, time management and fabrication of the product. This had become internalised for him to the point that it had become his default mode of thinking. He has already graduated but he continues to apply the same approach at his present place of employment.

In project management you need ideas, you need time, a lot more time, you need to think about how to fabricate it. So, without projects you will not learn any of this, just like how do you pass the test. So, projects help a lot in that way. - IP10

Despite being a fresh graduate who had just started work as a design engineer, IP10 was able to consider beyond the mere design of a product to an appreciation of the overall requirements of the prototype. This was due to his undergraduate project experiences.

I not only think about the design side of it. I also think about can we get this material, can we purchase this, is this in our budget, can the fabrication do so, something like that. It is not just, oh this is the required [values - referring to the values inserted into a formula] and I just put it in the drawing then that is it. I think by the end of the projects [experiences at university] I was able to think from all sides of it, like fabrication, it is not just inputting the required values. - IP10

Interview participant 6 (IP6) was initially overwhelmed by open-ended complex projects but was eventually able to overcome her initial sense of inadequacy. Over time, with project opportunities afforded to her every semester, she became well acquainted with a structured approach to managing these projects.

...because we were learning at the first semester of university, we were learning so many things new for the first time. And then in that way we did not have [open ended challenges], you know, especially in our education system [the Malaysian school system], we are so used to like, giving you a direct [way], this is how you do it. - IP6

I remember Dr L was like [saying], you just figure out how you are going to do [it] yourself, and then we were not comfortable with that ...we went back to him, how are we supposed to do this, like how are we supposed to get through this obstacle, can you help us? And then we realised he was not going to give us the answer, it was scary, I remember because we felt like we could not accomplish the task. - IP6

But because we were so used to that kind of situations, second semester was the same, nobody could help us, like into detail. So, we came up with the solution ourselves and after the third semester, it is kind of like okay, we need to figure it out ourselves ...in the end we get used to the process. - IP6

Having a very structured way to go about the projects really helps ...how we are going to break down this huge thing into manageable morsels. ...The first semester it was kind of like still learning you know. Second semester it was like, okay, you kind of get how you are supposed to do it after some trial and error in the first semester. Then [semesters] three and four, it was kind of like getting used to it. By [semester] five it is just like it is part of you already. - IP6

Like some people when they get into a challenge then they get scared, but like for us, okay, we have a challenge, can we do something, yeah. That kind of feeling, yes. - IP6

This appeared to be a change in her epistemology, in how she constructed knowledge and formulated solutions, as well as a change in her sense of self as reflected in the last excerpt above. The entire list of individual codes under this category of project management ability becoming second nature covers *time management, preparedness for eventualities, organising skill, resource planning and backup plan, general project management, structured approach to projects, systematic thinking, attention to details, ideation and practical skill*.

The interview participants' responses indicated that the changes they had experienced have met the criteria of stability, depth and breadth that was elucidated by Hoggan to be regarded as transformative learning outcomes [8]. Depth refers to the degree to which a transformative learning outcome was affected. Breadth regards the number of contexts in which the change is demonstrated while relative stability indicates a lasting change. It is worth mentioning that the curriculum that the interview participants undertook had a project-based module in each semester, from semester 1 to semester 6. These were team projects. However, in semesters 7 and 8 they undertook a two-semester final year project which was an individual project.

This article focused mostly on the acquisition of the hard skills of project management. For a more extensive discussion of the soft skills acquired through managing projects from project-based learning experiences, kindly refer to another publication [19], which is an elaboration of the people and relational skills outcome observed in the same study.

CONCLUSIONS

A qualitative study undertaken by the authors found that engineering students experienced transformative learning outcomes in the areas of improved people and relational skills, project management ability becoming second nature, changes in ways of thinking and increased resilience [1]. The factors contributing to them and the ways to facilitate these factors, which were the breaking out of comfort zones, crucial learning experiences experiential in nature and staying motivated through the process of transformation, were elaborated in previous articles [2-4].

This present article highlights in greater detail one of the transformative learning outcomes observed in the study, i.e. that of project management ability becoming second nature, explaining what it is and how the interview participants have experienced it. Therefore, it may help add to the insight on the transformative learning phenomena that the study had uncovered.

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BIOGRAPHIES



Douglas Tong Kum Tien is a Senior Lecturer in the School of Engineering at Taylor's University, Malaysia. He received his BEng (Hon) in mechanical and production engineering from the National University of Singapore, his MEng in manufacturing from University Malaya and his PhD in engineering from Taylor's University. His research interest is in engineering education. Douglas is an experienced educator with over two decades in academia and several years in industry. He is a Chartered Engineer, a member of the Institution of Mechanical Engineers and a professional engineer registered with the Board of Engineers, Malaysia.



Satesh Namasivayam has over a decade's worth of experience in higher education. He has held several academic leadership positions where he has played an instrumental role in the execution of various strategies that have helped in positioning academic schools. As a third-generation mechanical engineer, he was formerly a Fellow of the Institution of Mechanical Engineers and a Chartered Engineer, registered with the Engineering Council, United Kingdom. He is also a professional engineer with a practicing certificate, registered with the Board of Engineers Malaysia. Dr Namasivayam is an evaluator with the Engineering Accreditation Council, Malaysia, and has been involved in evaluating engineering degrees for accreditation in the country. He is also the only Malaysian member on the International Steering Committee for the Global Grand Challenges, National Academy of Engineering, USA. Dr Namasivayam was formerly Editor-in-Chief of the Journal of Engineering Science and Technology, a Web of

Science and Scopus indexed journal, which also published engineering education related research. He possesses a first-class honours degree in mechanical engineering and a PhD in thermo-fluids engineering, both degrees awarded to him by the University of London.