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The IMPART model - imparting transformation through industry-linked multidisciplinary projects

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ABSTRACT: A gap exists between market expectations and graduate capabilities. In addition to acquiring knowledge, graduates are expected to be well equipped with soft skills, life skills and other non-technical capabilities. Educational objectives should therefore venture beyond *filling the container* to include facilitating *changes in the size and shape of the container (enlarging capacity)* with these being the metaphors for informative and transformative learning respectively. While both are essential, however, greater emphasis is usually given to informative learning. This article documents the attempts made by the author to address this imbalance, attempts that required time to develop into the current practice with valuable lessons acquired in the process. The approach was given the name IMPART as it is the acronym for industry, multidisciplinary, projects, assessment, reflection, transformation. The first five letters of the acronym represent the processes used, while the sixth letter represents the desired outcome. The model employs industry assigned projects, multidisciplinary collaboration, project-based learning pedagogy, 360^0 assessment and feedback, reflection on project experiences and learning from failure to effect transformation. Its implementation, outcomes and lessons learned are presented in this article.

Keywords: Project-based learning, transformative learning, industry projects, multidisciplinary collaboration, reflection, learning from failure

INTRODUCTION

While majority of employers consider analytical and creative thinking as core skills, however, skills in self-efficacy such as resilience, flexibility and agility; motivation and self-awareness; curiosity and lifelong learning along with empathy and active listening and leadership and social influence are also considered by employers as core skills according to the Future of Jobs Report [1]. It is obvious that both hard and soft skills are crucial, and educators need to respond.

With regards to the education of engineers, non-technical competencies have long been regarded as necessary by the various engineering educational initiatives [2-4]. Many of the desired attributes, outcomes and competencies mentioned by them are non-technical. The role of soft skills and non-technical competencies for engineers was already recognised as far back as 1918 [5]. That the engineering community continues to grapple with a similar challenge over a century later underscores their importance, while also suggesting the need for a better understanding of the process that leads to their attainment.

Undeniably, both informative and transformative learning are vital for preparing students for the workforce and for success in life. However, there has always been a greater emphasis placed on informative learning than on transformative learning. Besides acquiring knowledge, students should also be well equipped with soft skills, life skills and other non-technical competencies. Bearing this in mind, education's objective should transcend *filling the container* to embrace facilitating *changes in the size and shape of the container (capacity)*, an illustration borrowed from Kegan [6]. While Kegan's approach to transformative learning is epistemological, his container metaphor is similarly appropriate for the other categories of transformative learning outcomes, i.e. worldview, self, ontology, behaviour and capacity [7].

The effort to develop the IMPART model was motivated by the need to address the imbalance between informative and transformative learning. IMPART being the acronym for industry, multidisciplinary, projects, assessment, reflection, transformation. The model was developed for a two-semester project-based design and build capstone module known as the Mechanical Engineering Group Project (MEGP), which is conducted at Taylor's University, Subang Jaya, Malaysia. Each element of the IMPART model is explained below.

Projects are sourced from the industry (I). Industry as a stakeholder assumes a keen interest in the project outcomes and interacts directly with the students through project briefings, Q&A sessions, providing feedback, assessing the students' artefacts, and sponsoring finances and/or materials for their prototypes. Industry partners have at times loaned test equipment not available at the University. Arranging visits to the industry partners' facilities exposes students to the industry, while helping them gain a more complete context for their projects. Maintaining close collaboration with the industry benefits all three parties; namely, the University, the industry and the students [8].

These industry projects are shared with other schools to create a multidisciplinary learning experience (M) for students from collaborating schools. This enables collaboration opportunity. The intention being to foster understanding and appreciation of other disciplinary perspectives, while also preparing students for the future, as real-world projects are often multidisciplinary in nature.

The project-based learning (P) pedagogy is employed. It is a type of experiential learning that can provide ample opportunities for transformative learning circumstances to be encountered. Furthermore, project-based learning is helpful for realising graduate attributes and industry relevant skills [9][10].

Assessment (A) and feedback are 360^0. Students are assessed by the lecturer, the industry and their project team members. Feedback from industry increases students' awareness of industry's expectations. This allows them time and opportunity to make any needed adjustments prior to their entry into the workforce. Feedback from peers helps to validate their strengths and contributions, while revealing weaknesses and blind spots that may require further attention [11].

A weekly logbook is used to record technical and non-technical learning. The logbook includes a section to reflect (R) and learn from project experiences. Reflection is necessary as it is a critical element of transformative leaning [12]. In addition, a learning from failure exercise called *return-on-failure* is carried out twice per semester. The failures analysed are not restricted to technical failures, but would often include those related planning, project management, time management, communication failure, teamwork, personal attitudes, etc.

The desired outcome is the transformation (T) of attitudes and behaviours, even as new knowledge and skills are being attained.

The IMPART model is depicted visually in Figure 1.

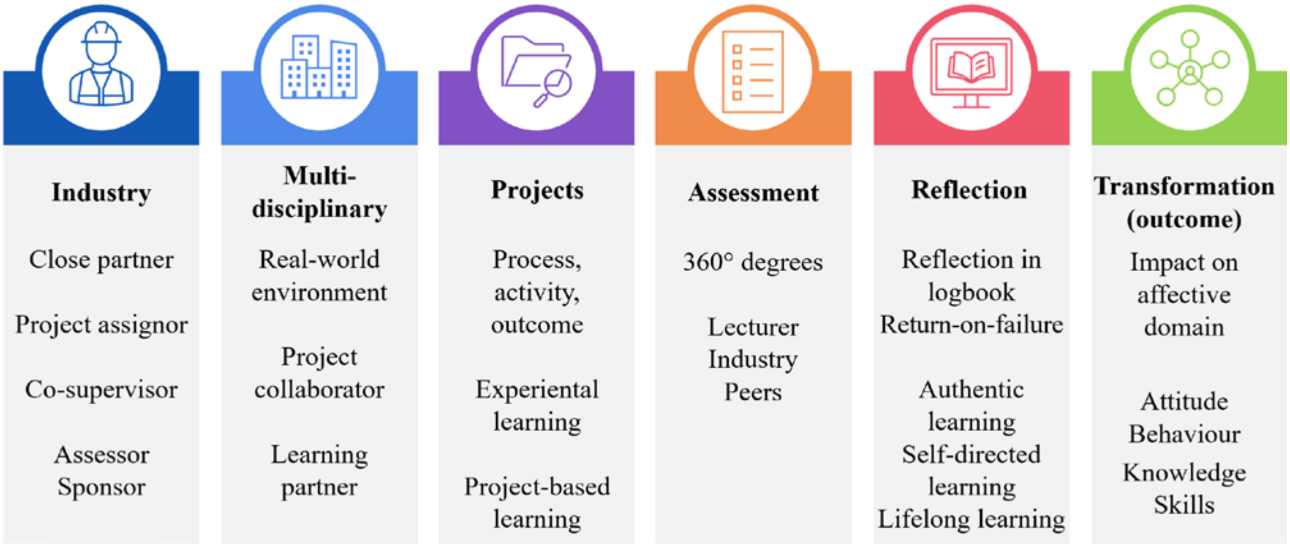

Figure 1: The IMPART model.

From a theoretical perspective, the effectiveness of the IMPART model relies on three factors [13]. These are 1) the need to break out of comfort zones; 2) the need to have crucial learning experiences which are experiential in nature; and 3) the importance of staying motivated throughout the entire process of transformation to prevent the transformative process from being aborted. The need to break out of comfort zones is supported by transformative learning theories. The need to have crucial learning experiences which are experiential in nature relies on experiential learning theories. To enable sustained motivation throughout the process of transformation is reliant on motivation theories.

The IMPART model was not developed in a short time, but needed several semesters to reach its present form. The multidisciplinary learning experience was the last element to be added. The IMPART model was developed for the Mechanical Engineering Group Project (MEGP), a two-semester capstone project that adopts the CDIO approach, where CDIO stands for conceive, design, implement, operate [3]. The first semester (MEGP 1) is dedicated to conceiving and designing, while the second semester (MEGP 2) is dedicated to implementing and operating.

In the IMPART approach, it is crucial to cultivate mutually beneficial, long-term relationships with industry partners. These partners should be made aware of the module requirements and what they can expect. Likewise, the school's expectations of industry partners should be clearly communicated. There were several industry partners, but two were very supportive over an extended period. Both are multinational corporations, with one from the tire industry and the other from the air conditioning industry.

The mechanical engineering students have collaborated with multidisciplinary partners from different schools within the University such as:

1. The Design School @ Taylors
2. School of Computer Science
3. School of Management and Marketing
4. School of Accounting and Finance

Apart from the schools mentioned, the Electrical and Electronic Engineering (EE) programme and the Robotics Design and Development programme within the School of Engineering have been vital partners.

Partnering different schools can often be challenging as each school has their own module requirement, assessment timelines and nature of deliverables. It is advisable for a module collaboration agreement to be drafted between academics of partner schools to foresee and account for these challenges. Educators should ensure that their students are able to grasp the rationale and the potential benefits available from a multidisciplinary learning experience. This is because the students are often required to accommodate the needs of their multidisciplinary partners and *vice versa*. The ability to appreciate the larger picture when faced with unexpected inconveniences provides the motivation to persevere.

RESULTS AND DISCUSSION

The intention of this article is to share some lessons learned and outcomes attained from adopting the IMPART model. Hence the discussions to follow will be more practitioner oriented than research oriented.

Reflection

Reflection is an essential element of transformative learning [12]. The logbook where each student records his/her project activities include a section for weekly reflection. Students reflect on their project experiences and what they have learned from them which would culminate in key takeaways. It is essential for students to understand the benefit of this exercise. Project experiences may be either *good* or *bad* but are often beyond their control. Nevertheless, learning from such experiences is worthwhile and reflection offers perspective. Excerpts from students' reflections revealing their key takeaways are presented below:

Although the decision to redesign the collector structure had caused my workload to increase dramatically, I did not express any disagreement but quickly started the redesign work so that the team was able to be on track as soon as possible. From this event, I learnt that sometimes it is worth to sacrifice for the team in order to achieve a better outcome. Besides, I also learnt that complaining will not get the things done, so it is always better to start working rather than complaining all the time. - Student 1

During this week, I was told that an extra load cell component would be required to sense the presence of the rubber sample through weighing. This was not planned during the conceiving and designing stages of the CDIO framework, but an additional feature that was found necessary during the actual implementation and operating stages. From this event, I learnt that it is important to always be prepared for any extra work that is necessary. Besides, it is important that an engineer should possess the ability to improvise, adapt and overcome any unexpected issue. - Student 1

Although this week's progress was not much for the MEGP, I was reminded that sometimes it is not just the people, and their skill levels that can affect a project but also other external factors such as the ones previously mentioned. However, we should not be discouraged due to these factors as we have no control over them. What we have control over is our attitudes and emotions towards these external factors, take them as a lesson and always look on the positive side of things. - Student 2

In my view, failure is not the end; it is a stepping-stone to learning and growth. The insight that the only real mistake is the one where we learned nothing *by Henry Ford emphasises the importance of deriving lessons from our setbacks. This resonates with my philosophy that failure should not be feared but welcomed as an opportunity to gain new knowledge. I firmly believe that we must not shy away from stepping out of our comfort zones and attempting new things, even if the possibility of failure looms. The quote that stuck with me,* if you do not fail, you are not even trying, *holds immense truth. It applies not only to my studies in mechanical engineering but also to the various other roles and responsibilities I juggle each week*. - Student 2

Apart from reflection on project experiences, there is also a section to reflect on team development according to the Tuckman model [14]. Working in a team on a complex project with tight deadlines and faced with competing priorities from other modules is undoubtedly challenging. This is even more so if all or most of the team members have not worked together as a team prior to the current project. Navigating the complexities of evolving team dynamics is aided by using the Tuckman model. The Tuckman model helps students recognise the stages of team development, i.e. forming, storming, norming and performing (adjourning is not relevant at this juncture). The goal is for each team to reach the performing stage because ultimately their project success is heavily dependent on good teamwork.

Excerpts from a student's logbook revealing ongoing evolution in his team's development is reproduced below:

For the second week of the MEGP 1 module, the team is still in the forming stage of the Tuckman's model because the group was just newly formed and the proper introductions were made together with the MLE (multidisciplinary) partner too. The icebreaking session was also done during the meeting so that the team is more comfortable with one another. The group leader was also selected with very little objections. The group still has high enthusiasm and thus can be considered the forming stage. - Student 3

For the seventh week of the MEGP 1 module, I would say that the group showed signs that unfortunately may still be in the storming stage. During the discussion, there will be disagreements and the group sometimes struggle to reach a unanimous decision on the decision matrix weightage. This has led me to assume the team is still in the storming phase. - Student 3

In week 10, the group is in the norming stage where each member knows their role and does their task proactively and is also able to check each other's work so that we know the progression and if the group member needs help to do the work. The group's discussions are more open to share disagreements as we understand that disagreements are not personal but for the benefit of the project. - Student 3

Learning from Failure

An exercise known as *return-on-failure* (ROF) is carried out twice a semester. This expression is a play on the words *return-on-investment*. As with an investment, students may have often invested heavily in their failure, investing their time, effort and emotions. Consequently, what returns can they expect from it, i.e. what lessons have they learned from their failure. The failures in this context are those occurrences which are unexpected and unforeseen.

Students may sometimes include predictions about the failure modes of their designs and how these can be mitigated through redesign. However, they need to be reminded that the ability to predict and mitigate failure in advance, before it even happens, is not a failure, but the embodiment of good engineering. Failures defined in this exercise are those that are unforeseen and unexpected. These need not be limited to technical failures, but can include failures related to planning, project management, time management, communication failure, teamwork, personal attitudes, etc. Being conscious of providing psychological safety is vital for this exercise as psychological safety is associated positively with learning from failure [15].

The ROF form has five sections intended to guide the students to reflect. The sections are:

1. Description of the failure.
2. *Five whys* (*5 whys*) exercise to identify the root cause. (Which can be more or less than 5 whys but what is important is to identify the root cause)
3. Other possible causes besides the root cause.
4. Corrective measures to eliminate or minimise recurrence.
5. Key learnings from this failure.

Multidisciplinary Learning Experience

The most challenging element of the IMPART model to implement is the multidisciplinary learning experience (MLE). Students from one engineering discipline often appreciate collaborating with students from another engineering discipline, for example: mechanical engineering (ME) students with electrical and electronics engineering (EE) students.

The difficulty appears when they need to collaborate with students from other schools. The different disciplinary mindsets, background knowledge, nature of the deliverables, and possible misaligned module assessment timelines present unique challenges. However, this also offers valuable opportunities for students to be taken out of their comfort zones and be prepared for the challenge of working in multidisciplinary environments.

A survey undertaken on MEGP students regarding their level of satisfaction with the MLE on a scale of 1 to 5 is presented in Table 1.

Table 1: MEGP students' satisfaction with the MLE.

Satisfaction level	1	2	3	4	5
Percentage	0%	5%	25%	60%	10%

While the majority were satisfied, there were minor concerns. From student feedback, there was a request to have MLE partners from the same school across all project groups. A preference to work together *technically* with their MLE partner was also expressed, but this is only possible with programmes within the School of Engineering. There was also a concern that while the MEGP is a two-semester module, the MLE partners' modules tended to be one-semester. These concerns can be addressed by providing a clear explanation at the commencement of the module regarding the purpose and benefits of the MLE along with what challenges can be expected when working with their MLE partners. Notwithstanding the minor concerns, a sample of positive feedback regarding the MLE is given below:

It has been very beneficial for me because I was able to gain more knowledge and exposure from other students' disciplines. - Student 4

Broadens my view……I was able to look at the project from many different lenses. Furthermore, the MLE also provides a good preparation for me to pursue my future career. - Student 5

It really does simulate real life working environment and gives me an early exposure to working life. - Student 6

A survey conducted among ME students revealed that 90% of the respondents would recommend the MLE to other students.

Industry Feedback

Students' work is assessed by the industry partner at the end of the semester contributing 20% of the total module marks. Apart from the assessment, the industry partners are expected to introduce their projects, meet the students for progress updates, provide appropriate feedback and be available for *ad hoc* Q&A, if needed. Overall industry feedback has been positive. Feedback from the two key industry partners is reproduced below:

Cross-function working team has been the norm in industry. MLE resembles some of that cross-function style… …Highly valued elements expected from MLE are the project management skill and teamwork - the non-technical part of the project…. These soft-skill related parts, we think, are essential for talent to master especially with cross-functional or working-with-stranger environment. High skill talents master people skills like communication, networking, managing conflicts, diversity inclusiveness, emotional strength, etc - which are higher priorities, if not highest, criteria in our recruitment. - Industry partner and sponsor for a project that involved the collaboration of ME, EE and Computer Science School students.

Thank you for the opportunity to participate with the students on this MLE. It was a wonderful experience to have three different points of view for the same project, i.e. engineering, business and design. This is the first time that we have been involved in such an activity. There was one engineering team who thought out of the box vs. conventional designs. The design was rather impressive, though it has some technical flaws which need to be corrected. On the whole, I think this MLE project was successful. Now, I look forward to seeing the actual prototype made by the engineering students. - Industry partner whose project was undertaken separately by ME and Business School students and ME and Design School students.

Employment and internship opportunities have resulted not only for the ME students but also for their multidisciplinary partners. One of these is the Design School.

I was impressed by the presentation made last week by your Design School students. They are capable of doing market survey and develop the user persona and product journey maps. These skills are similar to what we are currently doing through our Industrial Design (ID) team. Such talents would be in high demand by us. We are interested to engage with your students for future employment. In view of that, would it be possible to get them to join us for internship? Looking forward to your advice on this. - E-mail excerpt from an industry partner of MEGP to the MLE collaborating lecturer from the Design School.

Peer Assessment

Peer assessment is conducted at the end of each semester. Students rate team members numerically on predetermined criteria and give two types of written feedback, i.e. positive and room for improvement. The numerical ratings contribute 5% of the total module assessment, while the written feedback is shared anonymously. The anonymity of peer feedback is intended to foster greater honesty. Students are advised to keep an open mind about the feedback received because such feedback can often play an important role in their personal development [11].

CONCLUSIONS

In this article, the author introduced the IMPART model. It is an approach developed to meet the transformative learning needs of engineering students. It was employed in an undergraduate mechanical engineering capstone project module and found effective in reaching its objectives. Several lessons learned and outcomes achieved were presented.

The IMPART model was developed for project-based learning, hence it can be potentially applied to any course that employs project-based learning. This may include courses in computer science, architecture, design, business entrepreneurship, and others where projects are used pedagogically.

While the full benefits are likelier if the projects are from industry and if they also included multidisciplinary collaboration, nonetheless, industry-only or multidisciplinary-only or projects without both can still benefit from the approach by adopting 360^0 assessment and feedback, as well as having students reflect and learn from their project experiences and from their failures. In essence, it is about creating transformative learning opportunities through crucial experiential learning and making provisions for breaking out of comfort zones. These factors can engender transformation if the motivation to complete the transformative process is sustained. Motivation exists when the basic psychological needs of autonomy, competence and relatedness are provided [16].

The IMPART model won the gold medal for the Science of Learning Award at the QS-Wharton Reimagine Education Awards 2022 [17]. Prior to that it was submitted to the Honourable Minister of Higher Education (Malaysia) Special Award (AKRI 2022), where it emerged as a finalist under the transformative teaching category. While recognition is appreciated, however, the author does not consider the IMPART model to be a destination reached, but as a milestone by the road in the ongoing journey to better effect transformative learning among students.

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BIOGRAPHY

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