

A Novel Approach to Build Life-Long Successful Skills for Engineering Managers

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Does learning stop when people leave college? Nor it does or it should. Lifelong learning is defined as the "ongoing, voluntary, and self-motivated" pursuit of knowledge for either personal or professional reasons (Department of Education and Science, Dublin, 2000). The aim of lifelong learning is to improve knowledge, skills, and competence with a personal, civic, social, or employment-related perspective (Yamat et al., 2007). With the ever-evolving work environment and globalization, working professionals many times find the need to learn due to technological advances, personnel/ role changes (willingly or unwillingly), or other unexpected life events. The new Master of Engineering Technical Management (METM) program was launched in 2018, designed for engineers to learn technical and managerial knowledge that helps them exceed at their everyday tasks and soft skills that would benefit them in a lifetime. This paper shares the curriculum design of this program as well as skills and tools it offers, including emotional intelligence, decision-making, communication, negotiation, and so forth, that aim at developing life-long successful skills for working professionals.

Keywords: life-long successful skills, engineering managers, professional graduate program

INTRODUCTION

As managers, especially engineers who are used to handle specs and parts, blueprints and prototypes, when asked to handle new tasks such as managing projects, it is a completely different arena. A project has many aspects, resources, assets, time, budget, etc. And at the end of the day, it's essentially managing and leading people as they are the moving parts of the project. The METM program was created to bridge the gaps between technical skills and critical soft leadership skills with the qualifications of a successful engineering manager in mind.

METM program mission statement states that it is to "provide a unique blend of industry-critical skills in leading people, managing projects, and profitability for engineering and technical professionals to become future leaders in technical management positions, while continuing to work in their companies."

METM has eight overarching Program Level Objectives (PLOs):

1. Demonstrate project management skills
2. Manage resources and assets
3. Develop and practice personal and/or team leadership

4. Communicate clearly and effectively to both technical and non-technical audiences
5. Demonstrate financial and business acumen
6. Negotiate and manage contracts
7. Apply data driven approach to decision making
8. Apply problem solving and critical thinking methods

In addition to technical skills like financial and management knowledge, the PLOs emphasize on lifelong learning skills such as emotional intelligence (EI, inclusion of diversity, handling conflicts, self-management, leadership, etc.), decision-making, communication, negotiation, etc. These objectives are fulfilled by a 21-month, 30-credit hour total, lockstep asynchronous online program. The structure of the curriculum is shown in Table 1, with credit-hour noted in the parentheses.

**TABLE 1
METM PROGRAM CURRICULUM STRUCTURE**

Fall 1 st Year	Spring 1 st Year
TCMT 610 Engineering Personal Leadership* (2)	
TCMT 612 Technology Management Decision Making (3)	TCMT 623 Financial Decision Making (3)
TCMT 613 Technical Project Management (3)	TCMT 624 Managing Technical Teams (3)
TCMT 619 Personal Leadership Coaching (1)	
Fall 2 nd Year	Spring 2 nd Year
TCMT689 Art of Becoming a Senior Leader *(2)	
TCMT 631 Capstone I (3)	TCMT 641 Capstone Project II (3)
TCMT 634 Value Chain Management (3)	TCMT 643 Contract & Risk Management (3)
TCMT 639 Team Leadership Coaching (1)	

* The course is a residency week course, which is offered on campus face-to-face in a five-day workshop style.

METHODOLOGY

Using a descriptive methodology, this paper describes how the life-long learning skills are weaved into the curriculum design of METM program (Table 2).

**TABLE 2
METM PROGRAM COURSES BY SKILL SETS**

Semester	Course Name, Credit Hours	Emotional Intelligence	Leadership	Communication	Decision-Making	Negotiation
Fall 1st Year	TCMT 610 Engineering Personal Leadership* (2)	X	X	X	x	x
	TCMT 612 Technology Management Decision Making (3)	x		X	X	X
	TCMT 613 Technical Project Management (3)	x		X	X	x
	TCMT 619 Personal Leadership Coaching (1)	X	X	X		

Spring 1st Year	TCMT 623 Financial Decision Making (3)			X	X	x
	TCMT 624 Managing Technical Teams (3)	x	X	X	x	
Fall 2nd Year	TCMT689 Art of Becoming a Senior Leader *(2)	x	X	X	X	X
	TCMT 631 Capstone I (3)	X	X	X	X	X
	TCMT 634 Value Chain Management (3)			x	X	x
	TCMT 639 Team Leadership Coaching (1)	X	X	X	x	
Spring 2nd Year	TCMT 641 Capstone Project II (3)	X	X	X	X	X
	TCMT 643 Contract & Risk Management (3)			x	x	X

Note: Uppercase **X** indicates the skill is a major focus, lowercase x indicates the skill is a minor focus of the courses.

Emotional Intelligence (EI)

EI has become a highly valued skill set in leadership training in recent years (Cherniss & Roche, 2020; Heimann, 2020; Rasuloova, 2020). As opposed to using high IQ as a hiring criterion, more companies are listing high EI score as an important indicator of a qualifying candidate (Poskey, 2013); according to a recent CareerBuilder survey, “seventy-one percent of employers say they value emotional intelligence over IQ” (Career Builder, 2011). In an interview with Harvard Business Review, psychologist Daniel Goleman who popularized EI in the 1990s, commented that “the most effective leaders are all alike in one crucial way: They all have a high degree of what has come to be known as emotional intelligence. It’s not that IQ and technical skills are irrelevant. They do matter, but...they are the entry-level requirements for executive positions” (Landry, 2019). Nowadays, EI is what every leader uses to make pivotal decisions, plan projects and initiatives, solve problems, interact with clients, set performance expectations, communicate feedback, and interact with colleagues of all levels.

There are five domains of emotional intelligence (Goleman, 1998): self-awareness, self-regulation, motivation, empathy, and social skills, all considered critical soft skills that METM students should learn and practice throughout the program, as well as after their graduation into their journeys ahead. Because the METM students are working professionals, EI competencies such as self-regulation, motivation play an important role in helping them manage their emotions, use their time efficiently, and find motivations to navigate between school work, family responsibilities, and work tasks.

Upon entering the METM program, the first course students learn is TCMT 610- Engineering Personal Leadership. Due to the nature of the course, it’s offered in a face-to-face setting, so instructor-student as well as student-student interaction is maximized. During a one-week residency, students will learn EI models and develop cognitive, emotional, and behavioral capabilities that an effective leader would have. Students take an EQ-i 2.0, Emotional Intelligence Assessment for Leadership and get a detailed report with explanations and actions to take for further improvements (Figure 1). Course activities include a series of lectures based on the five elements of EI, group discussions that associate with students’ own experience, writing assignments that focus on in-depth personal reflections on topics including role model, personal motivations, (emotional) trigger points, empathy, and reflection on guest speaking events.

FIGURE 1
FIVE CATEGORIES OF EI COMPETENCIES WITH 15 SUBSCALES



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 Based on the original BarOn EQ-i authored by Reuven Bar-On, copyright 1997.

After students grasp the concept of effective leadership EI competencies and develop a clear awareness of which EI competencies they shall improve, they continue this journey in the first year fall semester, during which they take TCMT 619-Personal Leadership Coaching as an extension of TCMT610: students work with an experienced coach who have great expertise in the EI field to develop a customized personal EI leadership development plan. A student might work on a few EI competencies identified during the residency week, for instance, empathetic listening, and self-regulation, motivations. A development plan will be created, including action items, accountable stakeholders, practical milestones, etc. Through video and written reflections and face-to-face coaching sessions, the student will consult, implement, revise existing goals.

During the same semester, METM offers two technical courses, TCMT 612-Technical Project Management and TCMT613-Technical Decision Making (Table 2). Although students learn mostly on their own, these two courses also have group projects. Students are assigned into groups of four to five people and complete group projects that require a high level collaboration- because METM students are from different states (or even countries), the differences in geographic location and time zone make teamwork very challenging (e.g., when a group of students need to meet online for weekly discussion), the EI competency trainings obtained from TCMT 610 & 619, for instance, stress management, time management, etc., lay a good foundation for these two courses and set a tone for future semesters as well.

Leadership and Communication Skills

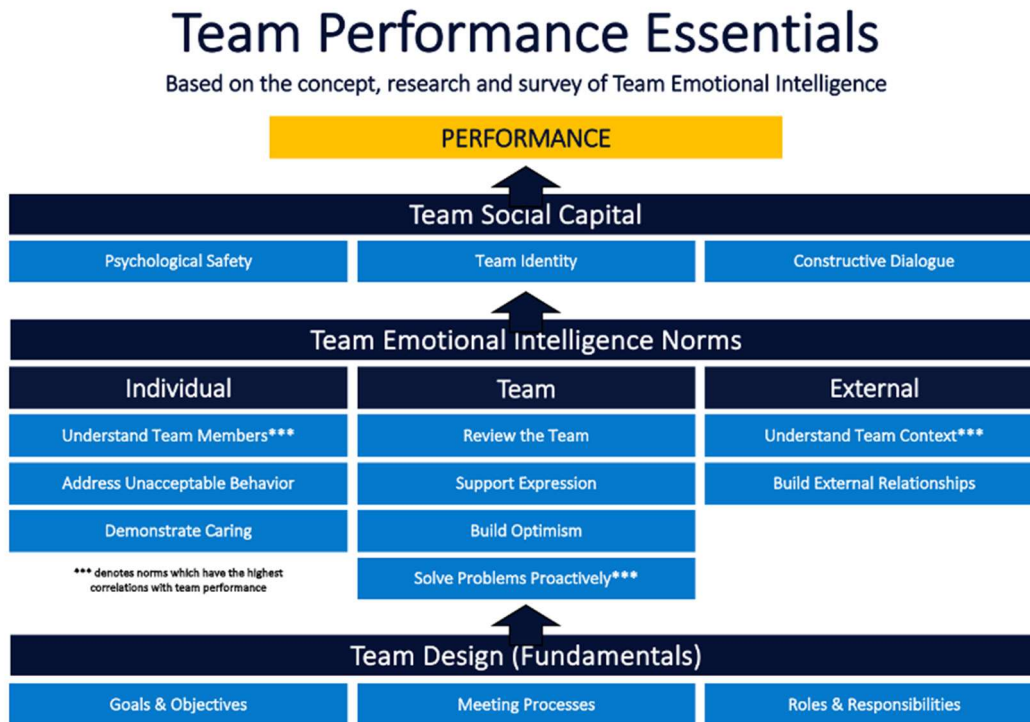
In a non-isolated life, individuals communicate with one another almost every day, whether it's a synchronized conversation (physical or virtual face-to-face), or asynchronous conversations like email correspondence, text messages. In a work environment, an engineering manager's job description may include but definitely not limit to hosting meetings, delegating tasks, giving presentations, reporting to higher level management, building relationships with internal and external stakeholders, etc., all of which require communication skills. What sets a good engineering manager apart from ordinary ones is how well

she/he communicates with different types of audience. For example, a technical machine operation manual would be greatly different from a proposal to purchase that new equipment to a higher-level supervisor (who might not have a technical background). It is one thing to be able to read the parameters in process flow charts, but another thing to explain the financial impact of operating on a new equipment might bring to the department.

As seen in Table 2, during the first-year spring semester, students take TCMT 623-Financial Decision Making along with TCMT 624-Managing Technical Teams. While TCMT623 focuses on technical knowledge of financial statements and tools to conduct return on investment (ROI) analysis, time value analysis, etc. that would aid an engineering manager's decision-making process, TCMT624 has a great emphasis on how to lead technical team(s): it starts off talking about characteristics of a transformational leader (including Idealized Influence, Inspirational Motivation, Intellectual Stimulation, and Individualized Consideration), which are also connected to EI competencies taught in the first semester. Students work in teams, through discussions, case studies, mini group presentations, they learn methods to identify dysfunctional teams and/or behaviors, manage conflicts, provide solutions based on specific scenarios, as well as skill in leader communication, delegation, providing feedback, organizing and balancing work among team members. This course offers tools including the "7 Cs of Communication" (Clear, Correct, Complete, Concrete, Concise, Consideration, Courteous), how to build trust, power identification (position and person types of powers), etc., so that students can apply these methods in their course work and real life work environment.

Besides TCMT624, TCMT639-Team Leadership Coaching (taught in the next semester) also offers lectures on continuous EI applications and leadership training. Topics include team design (i.e. team goals & objectives, team member roles & responsibilities, meeting processes), team EI norms on individual, team, and cross-boundary levels that are correlated to team performance based on previous research (Druskat, et al., 2003), and team social capital, i.e. benefits of well-executed team norms (Figure 2). This course is built upon the two first-year EI courses (TCMT610 &619), which are focused on an individual level. Students are expected to develop inspirational and meaningful personal leadership goals and a leadership development plan; it also acts as an auxiliary course to TCMT 634- Value Chain Management that's offered in the same semester, in which students work in the same teams to complete group assignments and case studies.

FIGURE 2
TEAM PERFORMANCE ESSENTIALS
 (GRAPH TAKEN FROM TCMT639 LECTURE SLIDES)



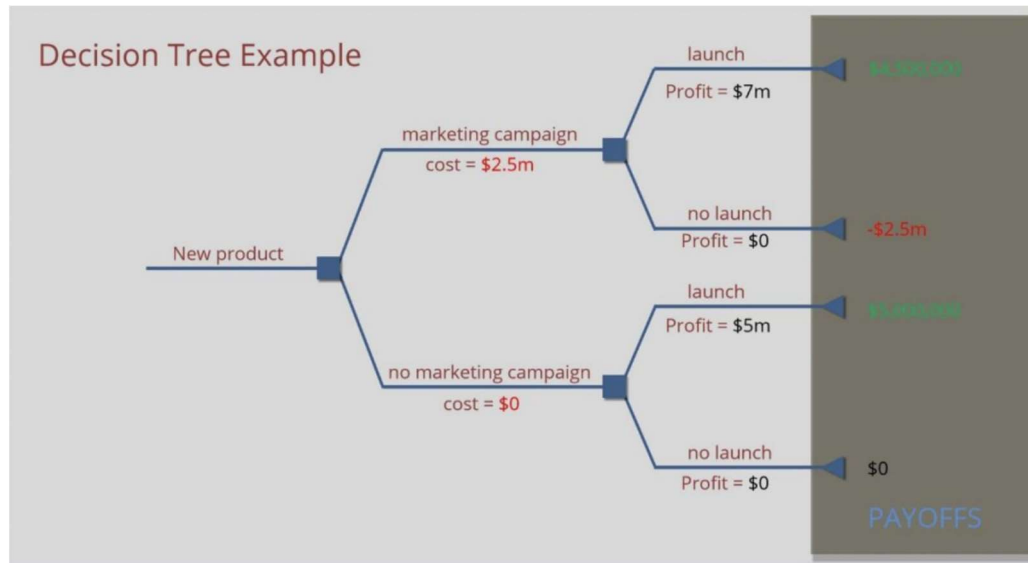
Decision-Making and Negotiation Skills

From “what’s for dinner?” to “what gift should we get for mom’s birthday?”, we make decisions every day. Some decisions are obvious and easy to make, but to an engineering manager, the greater magnitude (scope) the problem has, the more difficult it is to come to an optimal solution. Should you choose Project A over Project B? Purchase a new set of equipment or fix the old one? Invest more in marketing campaign #1 or both campaign #1 and #2? What if the current budget does not make the cut? How to make a strong case in order to convince stakeholders to get the additional resources (money, personnel) that you need?

Decision-making and negotiation are vital skills in order to solve a problem, which involve a series of meticulous “calculations” such as assessment of current situation, evaluation of alternatives, execution, re-evaluation, etc. Although not all the students are currently in the positions to make executive decisions, the METM program is designed to offer all the necessary knowledge throughout the 21 months of the program, to shift students’ **mindset** to strategic planning, so that students have the tools at their disposal when called upon to make a managerial or executive decision.

During the first year of METM program, many decision-making and negotiating tools are taught through a series of technical courses. For example, TCMT612-Technical Decision Making, introduces models of intuitive versus data-driven decision making, optimization tools such as decision-making trees (a graphic representation of a decision problem as a series of branching options) (Figure 3), sensitive analysis, Analytic Solver (an Excel add-on) to link technology and engineering decisions with the enterprise’s business performance in mind. At the same time, TCMT 613-Technical Project Management puts students in a project manager’s shoes to inspect many aspects in order to create and present a holistic project- scope, schedule, budget, and resources and tools to evaluate risk factors and mitigation strategies.

FIGURE 3
DECISION TREE EXAMPLE (GRAPH TAKEN FROM TCMT612 LECTURE SLIDES)



As students enter the second year of METM program, they will learn TCMT689-Art of Becoming a Senior Leader, TCMT 634-Value Chain Management, and TCMT 639-Team Leadership Coaching (discussed in previous section). TCMT 689 is taught by an industry c-level executive; it targets engineering managers who are aiming for a c-level or v-level position in their companies. Course topics consist of organizational structure design, building a personal brand, professional networking, motivating teams, acquiring talents, negotiation techniques, etc., all from an executive’s perspective. Lectures are delivered in a workshop style during the second residency week, and discussions, in-class exercises, and reflective writing assignments are used to provoke thoughts and assess learning outcomes.

TCMT 634 teaches students technical knowledge regarding the structure of product(s) value chain, financial impact of information (value of communications), inventory policies, how to choose a profitable supply contract based on the market demand, and tools such as inventory analysis, demand forecasting, etc. It is a higher-level technical course that’s built upon other concepts and tools taught in TCMT 612,613,623 discussed above. All courses combine lectures, real world business cases (e.g. Harvard Business Review case studies), discussions, quizzes to help students transfer technical yet practical knowledge to immediate application.

The last semester consists of two courses, TCMT 641-Capstone II and TCMT 643-Contract & Risk Management. While designing the METM program, the need for a law-related course was evident and became natural as the courses flow: as engineering managers review alternatives, make decisions, sign a supplier contract, what are some key pieces of information that a manager should pay attention to? Can you claim the rights to a piece of intellectual property or does your company own it? Who should you contact when an issue occurs and how does it affect business agreements (e.g., in a breach of contract on your side or the other side of the contract)? As one of the concluding courses, TCMT643-Contract & Risk Management covers subjects such as characteristics of different types of contracts, subcontract management, competitive negotiation techniques, contract financing, and cost reimbursement. This course is taught by an experienced industry lawyer who has an engineering background, and the cases picked as real-world examples are curated to benefit engineering managers.

The Capstone courses are the culmination of the METM program, for which students must utilize all the subjects and tools they have learned throughout the program to identify and implement key steps in a large-scale practical technology industry focused project. Eligible projects could be a general business challenge or opportunity; new source of business value; project and/or process management, optimization;

technology products innovation, etc. In order to complete this project, they will need to use comprehensive skills like leadership, communication, decision-making, etc. to conduct data collection, data analysis (financial analysis, market analysis, etc.), justify their choices/solutions with compelling data and critical thinking, and present their findings to faculty, industry sponsors and invited guests in a professional manner.

RESULTS

At the conclusion of the METM program, graduating students took an exit survey, which includes demographic questions, Likert type scale questions, rankings questions, etc. The objective is to capture students' perceptions of their satisfaction with the program and learning outcomes as they graduate from the master's program. The program just had our first cohort of METM graduates and are still in the process of data collection, analysis and plan to report the results later.

CONCLUSION

In conclusion, an industry focused professional master's degree is designed and offered successful to over 150 professionals since 2018. The program will enable engineers and technologists to consider leadership position in their company with the knowledge, practice, and lifelong learning skills that they have gained in the Master of Engineering Technical Management. The program plans to extend its outreach to other states and global market for 2021.

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