

## Integrating emotional intelligence into engineering education

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**ABSTRACT:** Internationally, engineering education is finding that students need more skills with regard to learning, and that graduates require improved skills to function effectively in the workplace. Emotional intelligence (EQ) covers a range of skills, including self-awareness, self-regulation, motivation, empathy and social skills. EQ also makes a considerable impact on communication skills, including that from an intercultural aspect, as well as on the learning abilities of students. However, EQ should not be considered as substitute for intellect, but rather as an enhancer for work skills and employment opportunities. For these reasons, engineering educators should seriously consider the integrating the facilitation of EQ skills in the engineering curricula. Some basic recommendations are made in the article as to how EQ skills can be incorporated into engineering education. Declining EQ skills in students affect their performance and may lead to higher drop out rates; in turn, this affects the calibre of the engineering graduate in the workplace. The article concludes by making a recommendation that universities seize the opportunity to shape the modern engineer and advance the standing of engineering in the new millennium.

### INTRODUCTION

Various surveys, professional bodies and past research have identified that the graduate engineer requires many skills and a great deal of knowledge when entering the workforce. Essential for this are elements such as interpersonal skills, as well as teamwork and a strong sense of motivation. Such skills are particularly relevant in this era of globalisation, which is taking place at an ever-increasing speed and provides an environment in which the modern engineer must interact. Governments and private industry emphasise that international cooperation is important to remain competitive in a global world economy, but it is indispensable in a world that can only survive through global cooperation. This cooperation requires interpersonal and intercultural skills to succeed [1].

University education needs to be able to prepare graduates, not just with engineering fundamentals, but also for success and actual on-the-job skills. Essential for the skills set for an engineer includes capabilities in emotional intelligence [2]. Initially embraced by management, emotional intelligence should be embraced by all professions.

### EMOTIONAL INTELLIGENCE (EQ)

The term *emotional intelligence* (later coined EQ) was first defined in 1990 by Salovey and Meyer [3]. Their work has since been considerably expanded by Goleman in 1995 (eg see refs [4][5]), who identified that IQ is actually less important for success in life and work than EQ – a set of skills that are not directly related to academic ability [6].

Goleman identified five domains of emotional intelligence, namely: self-awareness; self-regulation; motivation; empathy; and social skills. These areas can be incorporated into student education and preparation for professional working life.

A follow up study identified seven core skills, as follows:

- Awareness of personal feelings and the ability to control them.
- Emotional resilience: the ability to perform consistently under pressure.
- Motivation: the drive and energy to achieve results.
- The ability to take other people's needs into account.
- Influence and persuasive skills.
- Decisiveness: arrive at clear decisions and drive them through.
- Conscientiousness: display commitment to an action plan and match words and deeds [6].

This range of skills can be divided into two key areas within an emotional competence framework, namely: personal competences (how a person manages himself/herself) and social competences (how a person manages relationships); these two groups also feature sub-competences [7].

If a person has a high EQ level, then this indicates that the individual is able to experience feelings as they occur. Higher EQ furnishes a person with compassion, empathy, adaptability and self-control. If persons strengthen their EQ, then they also are more able to strike a healthy balance between personal needs and the needs of others [8].

### Moral Neutrality

The emotional skills offered through EQ are morally neutral, similar to intellectual skills. EQ does not provide values that actually govern their use. For example, intellect can generate a cure for cancer or manufacture deadly biological weaponry. Likewise, EQ can inspire colleagues or exploit them [9].

## Communication

It has been estimated that approximately 90% of emotional communication is actually non-verbal [10]. Indeed, when it comes to the appraisal and expression of emotion of the self, this is expressed both verbally and non-verbally.

However, communication can be inhibited depending on the level of self-actualisation of the communicator [11]. This ties in with the EQ elements of self-awareness and self-regulation. Because communication has been ranked as one of the main characteristics that are required by the engineering industry, EQ has an important role to play in augmenting communication skills, notably when certain EQ elements are enhanced in the engineering student [12][13].

## THE IMPACT OF EQ ON LEARNING

A person's EQ level can have a considerable impact on learning. As such, it is of relevance to any educator and student. Various important elements in utilising emotional intelligence have been noted, including:

- Individuals differ in their ability to harness their own emotions in order to solve problems.
- Emotions and moods can subtly (but systematically) influence certain components and strategies affecting problem solving.
- Positive emotion can affect memory organisation so that cognitive material is actually better integrated and diverse ideas are seen as being more inter-related.
- Emotions and moods may be used to motivate and assist in improved performance at complex intellectual tasks.
- Mood swings may contribute to a wider generation of potential future outcomes.
- Positive moods can facilitate more creative responses.
- Emotional processes can refocus attention and help to reprioritise demands on the person's attention and the reallocation of resources.
- Emotionally intelligent individuals will be able to solve problems adaptively and will be more competent in integrating emotional considerations when considering alternatives [3].

These factors drive to the very heart of the education process and how students are educated and learn. How students are taught relates to one practical application of EQ, although it is recognised that the greatest impact is made at the pre-tertiary level. Importantly, EQ can be nurtured and stimulated.

Neighbouring, relatively parallel cultures can have different EQ levels. This was demonstrated by a recent study that revealed that Canadians generally have significantly lower EQ levels than their counterparts in the USA [14]. However, because EQ is a learnable skill, this is, of course, subject to change. This indicates that education has a prime role to play in enhancing the EQ levels of students that should reflect in the behaviour and improved working abilities of graduates.

## EQ and Intellect

Emotions contribute directly to rational thought; messages to an individual's brain from the eyes and ears first go through the brain structure most heavily involved in emotional memory [8]. Emotions clearly play a major part in helping an individual to

decipher and interact with the surrounding environment. Findings suggest that IQ may be connected to as little as 4% of real-world success as IQ does not measure creativity or a person's unique potential [15].

Indeed, intellect, measured by IQ, can fall short without EQ. A detailed report from a very smart engineer may be close to undecipherable to the manager who makes the final decisions. EQ contributes to identifying the needs of others and to identifying those projects that are more important to the task at hand. In the example of the report mentioned above, the information presented may need to be changed by identifying the needs of a report's readers.

Intellectual accomplishments and social skills can be enhanced through EQ. Notably, EQ can be changed, but an adult's IQ is said to be fairly constant [8]. However, it should be noted that EQ should not be considered as a replacement for knowledge, ability or job skills, but instead that it enhances work skills [16].

## IS EQ FOR ENGINEERS?

It should be noted that EQ is *not* the opposite of IQ. It has been stated that in industry, *IQ gets you hired, but EQ gets you promoted* [10]. For example, a manager at AT&T Bell Labs was asked to rank his top performing engineers. High IQ was not the deciding factor, but instead how the person performed regarding answering e-mails, how good they were at collaborating and networking with colleagues (rather than lone wolf), and their popularity with others (rather than socially awkward) in order to achieve the cooperation required to attain the goals [10].

This example highlights the benefits of high EQ regarding communication skills, time management, teamwork, leadership skills and business acumen. Such important skills flow on from emotional intelligence, like the skilful recognition of others' emotional reactions and empathy to come across as genuine and warm, which will achieve greater cooperation from others, rather than being perceived as oblivious and boorish [3].

Moreover, Goleman has asserted that *emotional intelligence abilities were about four times more important than IQ in determining professional success and prestige*, even for those with a scientific background [5]. Indeed, high IQ appeared to be gained at the expense of EQ skills: *trained incapacity* [5].

Furthermore, the engineer's stereotypical negative image of the socially inept genius can inhibit student recruitment and retention [17]. This may be countered through graduates employing EQ tactics in the workplace, thereby generating an improved image for engineers through interaction. However, these skills must be educated in the engineering students in the first place.

## Employment Opportunities

Practical applications for EQ also relate to hiring practices in business. Graduates applying for the same jobs with the same degrees will prove to be successful not just by intra- and extra-curricular activities, but also by the level of emotional intelligence imparted by such activities, including Problem-Based Learning (PBL). EQ tests may also be involved,

particularly as the field expands; new questionnaires are continually being devised and implemented.

It has also been argued that people with low EQ miss out on promotion, as other workers do not like working with them. Furthermore, a poor working life can spill over into the private life, and vice versa [6].

#### Intercultural Training Competencies

In order to minimise distortions in their communication, students (as future engineers) need awareness and a general understanding about cultural differences. This is particularly relevant, due to increasing globalisation, because many engineers will have to work with people from cultures foreign to their own, or even be stationed in countries beyond their personal cultural boundaries.

Culture general knowledge instruction can be given to cover the following aspects, which also touch on areas covered by EQ:

- Developing an understanding of bases of cultural differences (categorisation, differentiation, in-group/out-group distinction, learning styles and attribution) [18].
- Understanding the influences that culture has on communication and associated behaviours.
- Acquiring a level of intellectual curiosity, openness, tolerance and empathy towards foreign cultures and their inhabitants [19].

EQ, through its emphasis on intercultural awareness, empathy, self-awareness and social skills, can strongly aid intercultural communication competences [20].

Furthermore, it has been argued that the learning of other cultures should be an integral element of communication modules that are part of a university curriculum, as this will also support greater linguistic competence and serve to break down student perceptions of stereotypes. Dlaska has affirmed that it will also support *learner motivation, cross-disciplinary integration, learner autonomy*, as well as the institution's academic standing [21].

#### EQ IN ENGINEERING EDUCATION

Given the principles stated above, it becomes quite apparent that encouraging EQ abilities should be a component of student education. This becomes especially relevant given that the skills that employers value include a willingness to learn, flexibility, communication skills, teamwork and other forms of working with others [6]. Because such skills fall into the category of EQ, universities need to be aware of industry demands on graduates.

#### Examples of EQ Integration

In assessing the needs of industry, the Technical University of Czestochowa, in Czestochowa, Poland, identified various practical and psychological elements required of their graduates in power engineering. Emotional intelligence was seen as being of *major importance in teamwork or in the management of a group of people* [22].

A course in computational visualistics at the Otto-van-Guericke University, in Magdeburg, Germany, set out to blend technical

aspects with perspectives from the humanities. Reflection was combined with the traditional technical computer science to cover computer game design; this allowed for something relevant for visualistics that would simultaneously gain a high level of motivation from the students. Some students may initially have rejected the integration of the *soft* fields of competence and claimed that an engineer need not know about the *fuzzy stuff*. Yet the process of reflection was embraced by virtually every student in the subject [23]. This lecture contributed to the EQ of the students through this process of regulation and utilisation of emotion to become more self aware, creative and motivated.

#### Incorporation into Studies

Incorporating elements of EQ learning in studies, rather than as a separate study unit or module, will link learning and work attitudes, including motivation, creativity and interpersonal skills, with the tasks at hand, such as project work. Learning EQ skills seems to be in line with experiential learning and a constructivist approach to studies, as EQ by nature implies an experiential approach. Encouraging students to learn these new skills through project work activities and in student-centred learning will succeed more than would a standalone lecture on EQ; theory without practice does not run very far.

#### Real Engineering and Real Life

The heavy traditionalism of many courses have the perspective of teaching only *real engineering*, ie defining and isolating problems and achieving technical solutions. Exposure to this culture of traditionalist engineering education not only discourages reflection, but also generates future engineers *who both lack and do not appreciate the value of the skills of reflection* [24]. As such, do engineering studies actively discourage the EQ factor by the very nature of the traditionalist style of teaching in this field? Such traditionalist teaching imparts engineering as a discipline rather than as a career.

Certainly, the prevailing traditional stereotype of the engineer suggests a specifically male individual who is not especially emotionally intelligent, but more likely to be manipulated by those who are.

#### The Evolution of Engineering Education

Engineering is progressively becoming less and less of a standalone subject. Other disciplines are influencing and being increasingly incorporated in engineering curricula in order to increase the attractiveness of a university's graduates, thereby responding to industry demands, eg management, business strategy, marketing, philosophy, communication, ethics, environmentalism, sustainability, etc.

Furthermore, the expansion of the number of double degrees on offer suggests that industry and society require that graduates have a fusion of core and non-core engineering skills, instead of just engineering alone. Indeed, double degree programmes are helping to introduce a level of diversity – and not just because of the subject offered; in Australia, for example, it was found that more women were favouring double degree programmes [25].

Engineers' attitudes to the *soft skills* area, incorporating people, ideas and self-reflection, have to be tackled at a fundamental

level. Curricula has to incorporate general skills and abilities that are valued by both universities and particularly employers, including the following:

- Self- and context-awareness.
- Decision-making and action planning.
- Research and analysis.
- Communication skills.
- Critical reflection [24].

These characteristics incorporate elements of EQ. Indeed, subjects in humanities can play an active role in the education of future engineers who can reflect and display sensitivity to both individuals and society [26].

#### Create the Future

Emotionally intelligent engineers have the opportunity to manifest future change and actively *create the future* [15]. Indeed, Cooper and Sawaf state that:

*... successfully intelligent leaders and managers continually question many of the assumptions that others accept ... [and] they challenge it perceiving the deeper risks and limitations, and in many cases find ways to transcend it ... They know the future is not something we wait for; it is something we must actively help create. And emotional intelligence plays a vital role [15].*

Studies indicate that a single person with a low EQ can lower the collective IQ of an entire group [15]. Engineers must be a part of this active and creative change process to achieve. An engineer with a low EQ will not be of much benefit to anyone, no matter what the engineer's IQ level is.

#### MODE 1 AND MODE 2 LEARNING

Chisholm and Burns recently discussed mode 1 and mode 2 typed of learning [27][28]. Mode 1 focuses on traditional didactic delivery methods, while mode 2 targets *knowledge production in the workplace resulting mainly from involvement in trans-disciplinary projects* [27]. Mode 1 skills are essentially homogeneous, while mode 2 skills are more heterogeneous [28].

EQ skills, notably with regard to flexibility, adaptability, self-awareness and a higher level of motivation to learn, mesh into this form of education. As EQ skills positively contribute to a worker's abilities in the workplace, heightened EQ can enhance the learning experience in the workplace. Both factors will contribute to an easier transition for a student into a workplace after graduation.

Mode 1 pushes knowledge into the student, while mode 2 involves a knowledge pull controlled by the student [28]. Similarly, improving students' EQ levels is also more intrinsically driven for each student, as the goal is for every student to improve his/her self-awareness, aid his/her reflective skills, etc.

#### INTEGRATION

It has been suggested that EQ needs to be *embedded* within an organisational system for it to be effective [29]. So, too, should

EQ be integrated within the educational structure for it to be effective and reinforced in the learners' minds.

Introducing engineering design students to EQ skills at the very start of the course proved beneficial in facilitating student learning at Rensselaer Polytechnic Institute in the USA [5]. The five *simple secrets of success*, as suggested by Goleman at that time, were communicated to students as

- Rapport;
- Empathy;
- Persuasion;
- Cooperation;
- Consensus building [5].

Students engaged in recognition exercises of these aspects in groups [5]. These exercises contributed to increased student awareness of these skills and improved students' teamworking abilities in this example; one key component involved encouraging communication skills between team members.

This shows how EQ can be integrated into a course structure after an initial introduction of the concepts is made to the students. From there, exercises that promote EQ skills can be integrated into the course, examples of which are described further below.

Broadening the scope of the engineering degree will encourage students to view engineering beyond the narrow confines of a technical description. However, isolating EQ education into one subject will not achieve the desired change as much as incorporating EQ elements across the curricula.

#### Some Recommendations

Augmenting communication skills across the curricula, again rather than in a standalone subject, will contribute to students' higher EQ levels by targeting certain elements. This includes the delivery of oral presentations in engineering studies and incorporating communication and presentation skills in the marking structure of reports so that students treat them more seriously. This may involve a restructuring of certain components of subjects and, indeed, the curriculum. Generally speaking, students do not come to university just for the sake of study; they go to universities to acquire and amplify career skills.

Experiential approaches, which involve the student in the actual experience of communication, with opportunities for debriefing and re-application, provide opportunities for the development of self-awareness. Videotape playbacks of oral presentations also stimulate reflection in the student [30]. Constructivist approaches build on past learning and should be utilised to build on students' positive learning experiences to enhance learning and skills development.

Also, role-play will encourage self-awareness, while role reversal will contribute to the student's understanding of empathy, of knowing how *the other side* perceives engineers. Indeed, this need not be confined to specifically engineering concerns. However, such context-specific role-play will help to cement those skills within the engineering framework.

More encouraging feedback to students will help to *create the future* [15]. In this area, it may be the educators who need to be

trained up more in the area of EQ and the importance of positive comments. Negative comments decrease the chance that the student will respond and learn from feedback [31]. Positive feedback encourages the student and builds on strengths. However, student errors should not be ignored; criticism should be applied constructively, rather than in an adversarial manner.

Peer reviews, with initial advice on how to structure comments constructively, can have a positive learning effect on students. The student receiving the peer feedback also recognises others' viewpoints, encouraging empathy, but also helping to generate self-awareness, key elements of EQ.

Building opportunities for reflection will also contribute to greater EQ understanding as the students become more self-aware. Another study in software engineering found that reflective essay tasks generated gains in student development activity, the students saw the impact of their practices and began to connect practices with potential improvement strategies. Furthermore, the students could also articulate the influence of their own work and motivation on the quality of output, thereby engendering a deeper understanding of the subject [32]. In this example, incorporating a greater emphasis on communication activities served to enhance EQ aspects, including more active participation, greater self-control and awareness, heightened motivation and a better understanding of course material. Furthermore, exercises in reflection were found to enhance the learning experience and communication skills of engineering students [33].

Teamwork and cooperation will help engender EQ qualities and are particularly important skills given the high level team-based environments in industry [8]. This will include negotiation skills between teamworkers. Encouraging a proactive, rather than reactive, attitude is also a valued work skill associated with EQ that can be educated in the university student. Other skills can be applied in the university environment from Ref. [8].

#### Applications in the Workplace

EQ skills can be applied across different work environments. EQ skills improve teamworking skills, especially with regard to communication between team members. Furthermore, the context of the receiver of the communication, whether it be written, non-verbal or oral, is taken into account through empathy and self-awareness. This is important whether the context be cultural, educational, professional, social or otherwise.

Open, honest and candid communication in the workplace is, mostly, more welcome in companies of today, as it helps in the identification of problem areas earlier. EQ skills contribute in area as well, as high-EQ people will be more receptive and better able to tackle negative, as well as positive, news and assists in the sharing of pertinent information, fostering better communication linkages [5].

#### Issues for Universities

Goleman identified that EQ skills are declining in students and affecting performance (eg student drop out rates) [5]. This will also affect their abilities to perform on the job as engineers, including their communication skills. This emphasises the need

to integrate EQ skills in modern education; improving such skills will in help students to become better communicators, teamworkers, and reflective and empathic practitioners of engineering.

Ultimately, EQ skills can be integrated into university teaching, whether it is at the basic instructional level, in a work-based learning structure or as a part of PBL education. Enhanced integration of EQ skills will in turn enhance the work skills of graduates, particularly with regard to communication skills.

#### SUMMARY AND CONCLUSIONS

Emotions seem to have been largely left a distant second place in comparison to rationality and intellect. However, recent studies have indicated that these are more closely bound together, that emotional intelligence is a prime factor in the success of the individual.

As a graduate engineer's required skills base continues to expand and evolve beyond the basic technical engineering knowledge, universities need to recognise that the skills base now needed in the knowledge era has extended to greater emotional awareness. Several recommendations have been forwarded that will contribute to the education of this next generation of engineers. This list is by no means complete, but it is, perhaps, the first step in the greater recognition of student capabilities.

EQ offers more than just learning tools for the engineering student, but also career skills for the engineering graduate. Emotional intelligence is not some standalone fad, but rather an element that can have a significant impact on a student's education and his/her future career [12]. EQ significantly contributes to the measure and influence of non-cognitive factors in the workplace and education [7].

Furthermore, the globalisation of private industry and other organisations will continue at increasing levels. Consequently, the professionals involved in international business will need to be equipped with new and expanded competences and skills from an intercultural perspective. Technical skills alone are no longer sufficient in this brave new world of advancing engineering education and globalisation; intercultural awareness and EQ skills are prime components that will facilitate the adaptation of future engineering graduates.

By providing the right curricula contents, universities should seize the opportunity to contribute in shaping the required modern engineer at the start of the new millennium, evolving understanding and contributing to global understanding for the next generations of engineers [20].

Goleman has stated that *engineering education has ignored this range of skills in the past*, skills that incorporate communication and collaborative abilities, teamwork, selling an idea, accepting criticism and feedback, learning to adapt, and leadership [2]. He further states that when engineers are promoted to leadership positions, they often lack the requisite leadership and managerial skills [2]. Such EQ-related skills need to be integrated urgently into engineering curricula for engineering to regain relevance in education, across disciplines and in society. This means that students, educators and managers of tertiary institutions need to be educated in this burgeoning field.

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