TEACHING ENGINEERING STUDENTS

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ABSTRACT

Education has a number of vital roles to fulfil, such as the development of constructively and critically thinking students, the empowerment of citizenship towards the creation of a better society, generation of awareness of issues of equality and justice, and finally promoting the vital fact that in a society there are *'responsibilities'* as well as *'rights'*. In addition, education indirectly also contributes to the wealth creation sectors of society providing the vital competitive edge required to survive or thrive in the global market place.

This paper presents some thoughts on teaching engineering students. Interrelated issues of education and training of significance to engineering are considered and basic theories of teaching are briefly discussed from the viewpoint of engineering.

INTRODUCTION

We live in a fast moving world where nations have less and less control over their destinies. There is need for a broader vision of education, the vision of the common social good and the development of human potential to its full capabilities.

'*The global economic reality is one where a sports car which is financed in Japan, yet it could be designed in Italy, assembled in Indiana, Mexico and France, will then use advanced electronic components invented in New Jersey and will finally actually be constructed back in Japan. There will be no more national products and technologies, no national corporations, no national industries. There will no longer be national economies. All that will remain rooted within national borders are the people who comprise the nation. Each nation's primary assets will be its citizens' skills and insights*' [1].

In an educational context, globalisation presents us with a series of challenges:

- Education and training is seen as the principal means of increasing national economic competitiveness,
- Ageing populations and workforces will require expansion of post-compulsory education and re-training,
- More and more voters might not subscribe to subsidizing this trend for lifelong learning.

Education has a key role to play in dealing with many of the societal problems and challenges that face us. However, at least in the short term, it seems that in the developed countries the loss of manual labour intensive markets has been accepted as being inevitable and that there is only one alternative, i.e. to proceed towards the hi-tech niche end of the market. This decision is said to be based on pragmatism but on the educational front it might turn out to be short sighted. The engagement in expensive educational and training programmes, which provide flexible, adaptable and highly skilled workforces that are ahead of the competition from the poorer countries, might be a sure way to keep ahead of the competition, at least in the short term but provide us with reasons about its utility only in economic terms. One must not loose sight of the fact that this is only a part of the overall educational strategy and that enhancing national competitiveness by subordinating all welfare policies to the needs of a competitive economy might lead to social disengagement and strengthen further selfishness in society reinforcing all the trends that were wrong in the selfish society that was promoted in the 1980's.

One must look carefully at the long-term effects of such decisions in the context of the overall efforts to maintain our privileged economic position in the current world order. It is simply not good enough to apply the economic free market principles in formulating educational strategy because any disturbances that are created in the value/ethics system through education will not be ironed out by the laws of supply and demand. Such disturbances not only can have a much longer shelf life and can last for generations, but they are very difficult to remove or alter in the short term.

In our professional capacity we should always try to emphasise this to engineering students; there is the tendency to expect technological progress to get us out of the various messes we find ourselves in and technology usually delivers,

however, technological developments do not happen overnight, they take time and this is where the break down occurs in free market forces models as an answer to everything.

Engineering provision in a modern university cannot be divorced from consideration of the nature and purpose of universities, "what is a university for?" In 1984, Newman addressed this question [2] and some of his ideas are still important regarding contemporary universities. An ambition of this paper is to draw attention to interrelated issues of education and training of significance to engineering. Given the breadth of the topic and the limited space of a conference paper, we only touch selected issues that we consider to be important.

IDEAS & ASSOCIATIONS

The word *technologia* (the origin of the word technology) means making, producing, constructing, and building, having made a detailed account of the matter or question, with explanatory reasons, logical basis and exposition of principles. In the East and West Roman Empires the word *technologia* also used to imply the logical and rational development and application of tools, machines, materials and processes that helped to solve human problems.

In Latin the word *ingenium* (the origin of the word engineering) means skill. Nowadays, engineering means the art and science by which the properties of matter are made useful to man, whether in structures, machines, chemical substances, living organisms and the design of complex systems that perform useful functions. According to the Royal Academy of Engineering and the Engineering Council of the UK, engineering is *the knowledge required* and the process applied to conceive, design, make, build, operate, sustain, recycle or retire, something of significant technical content for a specific purpose; a concept, a model, a product, a device, a process, a system, a technology.

The distinct inputs that are expected of engineering courses and degree programmes offered by tertiary education in advanced countries were highlighted above. It should be noticed that engineers graduate from institutions of higher education that often use the word technology, but not engineering, in their titles, e.g., MIT, ICSTM etc.

Education and training are closer related in early life experiences but diverge more and more as we move higher in education. In universities students study and academics expect them to become more self-directed as they progress in their studies. In engineering education and training a large part of the academic's task must be to equip the student with the means to pursue inquiry on his or her own part, to instigate self-directed study. Modularity was intended to make university subjects student-centred not subject centred.

The word education signifies to be led and thus "points to a subservient relation between those who are being educated and those who are educating them" [3]. The Greek word $\mu o \rho \phi \omega \sigma \eta$ implies "what educates us, forms us". Education is for the whole, the complete, person.

In ancient Greece knowledge is proven to be true only when it is verified by common experience (Heraclitus' "$\alpha \lambda \eta \theta \epsilon \upsilon \epsilon \iota \nu \ \epsilon \sigma \tau \iota \ \kappa o \iota \nu \omega \nu \epsilon \iota \nu$"), only when it is shared with others. This is a direct result of the definition of the man/woman who is a person (= $\pi \rho o \sigma \omega \pi o \nu$), which signifies that s/he has his/her face (= $\omega \psi \iota s$) towards (= $\pi \rho o s$) someone or something: that s/he is opposite (in relation to or in connection with) someone or something. In other words, man/woman exists only in comparison with every other existence, only in relation to, in connection with another person [4].

"It is persons that educate and train", not courses; between academic and student "successful collaborations often arise fortuitously and spontaneously" [5]. The energy embedded in examples and case studies is what educates and trains in engineering.

The mastering of any engineering subject, the getting inside it, is the same as mastering its particular modes of thought. If universities were to reduce thought to just teaching, this would actually stifle thought [6]. There is progress when students are able to continue the intellectual activity that constitutes their subject beyond anything they are taught, or as Newman put it "Gentlemen….you have come, not merely to be taught, but to learn" [2].

The mastering of any engineering subject must include assessment and revisiting. Modularity often threatens the latter. Some parts of a subject can be used in another, but it still needs a different whole to belong to. Skilful course designers ensure that courses have structures that allow key parts to be revisited. Universities are for taking things further. Their engineering students after graduation may go to all lengths of research.

The engineer needs to know (among other things) "hard" facts, truths which, when we know them are, in Newman's terminology, "exhausted" and thus can be securely acted upon [3]. As pointed out by Graham, Newman distinguishes between "education" and "instruction", between "the philosophical" and the "mechanical", the former being characterised by an introduction to "general ideas", the latter with information "that is exhausted upon what is

particular and external". Newman's distinction has to do with the different direction of thought that alternative forms of enquiry take [3].

"Those who engage in learning as opposed to instruction are set upon a course - the investigation of general ideas - which in turn implies a different relation between learning and the mind which learns than the relation implied in a process of "instruction". Newman does not claim, and no one needs to, that education is superior to instruction, only that it is different" [3].

Following Graham, we can replace the language of training versus education with one which contrasts technical with liberal education [3]. "Newman's idea of the university providing a liberal education, even to those training for the professions, e.g., engineers and scientists of every kind, and thus making them even better engineers and scientists , became the idea of the university"[6]. Newman knew that technology and engineering subjects can provide intellectual stimulus; "no one can deny that commerce and the professions afford scope for the highest and most diversified powers of the mind" [7].

Technological and engineering education must "in part be intellectual and affords scope for the highest and most diversified powers of the mind" and the exercise of the powers of the mind that technology and engineering require is not required for its own sake, but for the sake of another end. Intellectual enrichment is a form of wealth [3].

Professionals need an understanding of the significance of their profession. What is it to be a chemical engineer in charge of a petrochemical plant? Why are chemical, mechanical and metallurgical engineers employed in a petrochemical plant? Without some consideration of these questions, the respective practitioners of these professions are mere functionaries, reduced to servers and not formers of social life; "Liberal education embellishes the technical and technological to create the professional" [3].

The education and training of engineers has been affected by the eagerness to engage students with so called useful topics, something that mirrors an earlier fixation with relevance [3]. Engineering topics have to be relevant to something; everything useful must be useful for something.

There is an attempt to eliminate the distinction between education and training by concentrating on skills; "because skills will increase GDP", skills are something you can do something about and something worth the doing.

Academics are often required to provide an adequate explanation of the value of university education. Even though finding arguments to explain the value of engineering training is not difficult, it is crucial to observe the following:

- ⇒ that engineering education is not just the acquisition of skills and
- ⇒ that justification in terms of transferable skills offers no support whatever for the content of subjects; "The error in the appeal to transferable skills does not lie in its falsehood, but in the fact that it attempts to explain value in terms of use" [3].

"Current political rhetoric about the competitive world flatly contradicts the part about transferable skills, for it is often recognised that skills are not transferable, that training in one process will not do anything to prepare you for other processes; we must therefore be ready and willing to re-train" [6].

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There are various theories of teaching as shown in the table below:

Relationships between the four basic theories of teaching [8]		
	SIMPLE THEORIES	**DEVELOPED THEORIES**
The verb 'teaching' is applied to the academic subject. It is likely to be one with a lot of detailed facts to learn.	Transfer theories	Travelling theories
The verb 'teaching' is applied to people. The subjects are related to personal attitudes and skills.	Shaping theories	Growing theories

The basis of the transfer theories is the fact that the subject material is viewed as a commodity to be transferred to the students' minds and successful learning is seen to be the result of well-prepared material, effectively organised and

imparted. Unsuccessful learning is seen to be the consequence of poorly motivated, unintelligent, lazy, forgetful students. The conventional form of lecturing is seen as a classical manifestation of a transfer theory in action. As such, the conventional lecture has been described jokingly as being 'an occasion when the notes of the lecturer become the notes of the students without passing through the minds of either'.

To metaphorically demonstrate the transfer theories we can consider the themes of 'the students being considered as empty vessels to be filled by the teacher', or 'the baby food analogy where the teacher is processing very tough material into more easily digestible nutrients for rather simple minds'. All that is required of the teacher in these theories is the delivery of his nuggets of wisdom, ensuring the purity of the seed.

In a similar way the shaping theories view students, or their brains, as raw material (metal, wood or clay) to be shaped, or moulded or turned to a predetermined and often detailed specification. In the shaping theories the teachers 'develop' or 'produce' engineers, doctors etc. Shaping apparently happens through the sheer force of the spoken word and the authoritative presence of the expert on this controlled, passive raw material. These theories are akin to indoctrination, training and instruction, rather than education (see Figure 1). We must be able to draw the distinction between these concepts because shaping theories have value and can be effective when used in the appropriate contexts of training, instruction and indoctrination.

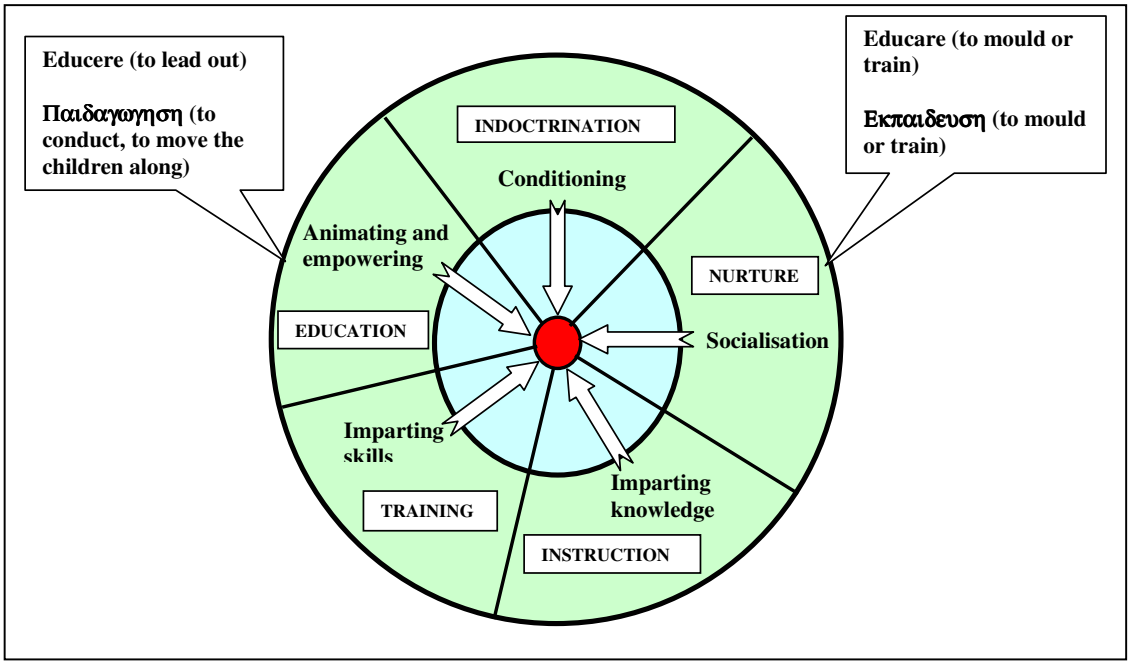

Figure 1. How different aims are associated with the different approaches to learning [9]

There is a plethora of research on Teaching & Learning and it is beyond the scope of this paper to attempt anything more than making this clear. There is an illustrious list of contributors to our understanding of these topics, however, I will try to pull this section together by considering two papers that have direct relevance to the choice of my theme and are influential to my own teaching approach [8, 9].

A hybrid theory, lying between the simple and developed theories, is the Building theory. This theory views the student's brains as building sites where the subject matter is delivered as raw materials, a load of bricks, but then it requires the building of a complex structure (a concept) to be built by suitably arranging the various interrelated building elements. Therefore, teaching involves more than the simple delivery of materials, but it involves building a structure according to a predetermined plan. Although in the face of it this is an advance on the simple transfer theories, it still leaves us with a 'static' model of knowledge and a 'closed' system approach to teaching and learning. If however, we allow the actual construction of the concepts to be carried out by the students in accordance to their own experiences, abilities and motives, thus allowing them to become significant contributors to the direction and efficiency of their own learning, this theory can be on the way to be classified as a developed theory.

The essential element of the simple theories is that the teacher is or should be in full control of the commodity being transferred (transfer theory) or of the shape and size of the final product (shaping theory). The end product in both

cases ought to be predetermined and in this simple relationship between teaching and learning, if something has been taught it must have been learned. The role of the student in these theories is a passive one.

In contrast, the essence of the developed theories is that the students become contributing partners in their own learning. In the developed theories the students become fellow travellers (travelling theory) or they are helped along by the teacher or expert but they also make significant contributions to the process and pace of their learning as well as the direction and the objectives (growing theory).

The job of the teacher becomes that of a 'coach' who uses his experiences and expertise to help students to organise their ideas and utilise their talents in order to appreciate their experience and what is to be mastered ahead of them. The teacher will 'guide', 'point the way', 'lead' on what becomes a joint journey of exploration. The teacher is there as someone who has seen it all in context but he/she is still exploring, being aware of the continuous changing scenery, knowing that there is always something new to learn and happy to share this experience with newcomers. In this scenario, the teachers themselves are open to seeing things from the perspective of their students and often being enriched by the experience of seeing something from a different viewpoint or discovering something totally new. The experience and knowledge of the teachers is of great value in this kind of exploration because it can be used to provide the appropriate feedback on their developing skills and knowledge therefore assisting their continual improvement.

Once again, there is a debate if the journey should be a 'pure exploration' or a 'guided tour'. There are merits in both and we see no great contradiction in a free flowing guided tour. I have been a recipient of such a guided tour in exploring the beauty of ancient Ephesus. Although we had to explore it within certain guidelines, the exploration was interactive and as a result I have both learned something from the guides but I have also taught them few things myself, feeling satisfied that we both had gained from the experience. It could be argued that 'if you do not know your destination how would you know when you got there?' That can be countered by saying that Columbus discovered the Americas by having the idea that China could be reached by sailing West. Clearly he did not reach his planned destination but how many of you can argue that his exploration did not fundamentally change the course of human history? Once again we do not see a great contradiction of having set targets (objectives) but allowing the flexibility to explore outside these.

Although the role of the teacher in the developed theories is a more human and responsive role, and of course the student's involvement and input become a crucial part of the learning process, there is a distinction on the emphasis, i.e. the travelling theory emphasises the subject whilst the growing theory emphasise what is happening to the student as a person. Both these theories place less emphasis on 'teaching methods' but emphasise the 'teaching strategies', 'learning activities' and 'learning experiences'.

ITHAKA

When you set out for Ithaka
ask that your way be long,
full of adventure, full of instruction.
The Laistrygonians and the Cyclops,
angry Poseidon - do not fear them:
such as these you will never find
as long as your thought is lofty, as long as a rare
emotion touch your spirit and your body.
The Laistrygonians and the Cyclops,
angry Poseidon - you will not meet them
unless you carry them in your soul, unless your soul raises them up before you.
Ask that your way be long.
At many a summer dawn to enter
-with what gratitude, what joy-
ports seen for the first time;
to stop at Phoenician trading centers,
and to buy good merchandise,
mother of pearl and coral, amber and ebony,
and sensuous perfumes of every kind,
sensuous perfumes as lavishly as you can;
to visit many Egyptian cities,
to gather stores of knowledge from the learned.
Have Ithaca always in your mind.
Your arrival there is what you are destined for.
But do not in the least hurry the journey.
Better that it last for years,

So that when you reach the island you are old,
rich with all you have gained along the way,
not expecting Ithaca to give you wealth.
Ithaca gave you the splendid journey.
Without her you would not have set out.
She hasn't anything else to give you.
And if you find her poor, Ithaca has not deceived you.
So wise have you become, of such experience,
that already you will have understood what these Ithakas mean.
C.P. Cavafy

A first degree in engineering involves "A course that is broad and structured in a substantive field of knowledge which gives the learner an insight into the limits of knowledge as well as some of its domains. There is a natural tension in engineering between doing tomorrow what was done yesterday and being innovative. The principles cannot be effectively elucidated without a basis of facts and knowledge of engineering systems, so it is not a matter of one thing or another, but of balance, giving engineering students conceptual spectacles through which to view the world" [9].

If we allow ourselves to see the variety in the way we learn, then we can appreciate the need for a variety in teaching approaches. The more flexible one is in their teaching strategies, the better chance they have to accommodate the different ways of learning of their students, which after all is only a reflection of the natural differences in cultural, social, previous knowledge levels, experiences, and all the other 'baggage' we all carry within us as individual human beings.

However, there is one more point to be stressed, it is not only how well intentioned we are in our approach and how well we articulate our aims and objectives, but how well and what the students understand those objectives to be. It is not how well we design assessments to test understanding rather than reproduction, but what our students believe the assessment to be about. Any mismatch between these perceptions and the effectiveness of what we are trying to achieve will be severely reduced. Different students, as all of us, perceive the same context in different ways. If we are lucky enough to establish a rapport with our students and both are on the same 'wavelength' then we can both reap the benefits of the developed theories of learning. However, if any mismatch occurs in the perception of the learning process from either side, there will be frustration and disillusionment all around.

Engineering suffers from too much emphasis on knowledge and teaching and not enough on technology and learning. Assessment needs to be part of the learning process and it should be for the benefit of the student and not for the criticism of the students by staff or the teaching staff by their students. Assessment should be a step model rather than a hurdle, i.e. the growth in students' progress and level of understanding should be achieved through incremental steps that sequentially reinforce their learning rather than expected to occur in an almighty single burst of insight, although that does happen. There are both pedagogical and economic advantages in adopting the Bologna model in engineering education, i.e. a not too demanding first degree with little or no professional pretensions, followed by a more demanding specialist second degree for those selected through motivation. The first degree would be largely tacit knowledge based, utilising the Internet as a teaching tool, with problem based learning, case studies and work placements to construct experiences based on knowledge and skills. The second, professional degree is where the engineering leadership will be moulded through strictly explicit knowledge that reflects the high expectations of the aspiring professional engineers. Although this approach seems to stand everything that we hold so dear in engineering education on its head, it is only an illusion. We have been approaching engineering education mainly on tradition, i.e. it has always been done that way. We must build the professional engineers by immersing them in vast amounts of explicit knowledge, irrespective how much of that knowledge they will use in their professional careers. What this new approach proposes is not doing away with explicit knowledge that is invaluable to engineering, but instead is asking us to allow selective transmission of such knowledge to those in the engineering profession that are motivated to use it. After all an engineer is someone who finds creative solutions to problems [10].

Teaching is all about creating the appropriate 'environment' for learning to take place. If we are given the serious task of educating or influencing minds (young or old), the least they deserve is the commitment from us that we will do our best to facilitate the process of learning. Of course that takes us back to the issues of 'What constitutes education/learning?'

Should education be about the development of the individual, or should education focus in meeting the requirements of society? Should education manifest itself as the development of the individual or as a set of skills and knowledge that will get the individual employment? There is clearly a dichotomy of purpose and this dichotomy manifests itself through the various curricula. However, although the social and individual needs are not the same, they do clearly overlap. There is need to see the commonalities of purpose as the base of an education that fulfils both tasks at the same time. It must be understood that education is multifaceted and it must serve a number of purposes. In addition,

rather than viewing the educational purposes as neat little linearly connected boxes, they could be envisaged as part of a 3-dimensional continuum all interconnected, each having an influence on the others and vice versa [11]. In our search for a meaning, we might be forced to step back and reflect before jumping onto whatever bandwagon is fashionable in educational circles (that does happen).

Teachers, like anybody else nowadays, must be allowed to draw back occasionally, to concentrate on things that really matter. Being buried under bureaucratic paper mountains is not conducive to reflecting on the world that we are occupying or the purpose of why are we here? Teachers must be allowed the **freedom** not only to ask the question 'Why Teach?' but given the **time** to seek the answers and the **space** to act on their answers.

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'DEVELOPMENTS ON THE DELIVERY OF NON-TECHNICAL MODULES TO ENGINEERING MATERIALS & BIO-ENGINEERING STUDENTS'

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ABSTRACT
Like everything else in life, in business we have to deal with people. A successful manager will have to 'Plan, Organize, Lead and Control'. Each of these four aspects of management requests dealing with people. In the practice of management it will always be 'You' and 'Them'.
To be a successful entrepreneur one requires a number of skills but success will not be forthcoming without 'networking'. Successful networking needs communication skills.
Teaching management to engineering students requires the development of their 'soft' skills. They need to be made aware of not only who they are as persons, what makes them tick and what their moral stand point is but also how to interact and communicate with others.
This paper will give you a flavour of a module created to impart these kinds of skills to students of Engineering Materials and Bio-Engineers.

INTRODUCTION
Recently, Neil Glover, Project Manager University Research RR plc was asked 'What do engineering employers want from our graduates? His answer is summarized in bullet form below:

- Evidence in real interest in solving practical engineering problems
- People who can think around an issue and apply their knowledge to unfamiliar circumstances
- Evidence of applying learning through project work and planning to hit deadlines
- Bright and enthusiastic people who will fit into the team.
- Less concerned with the extent of the candidate's taught knowledge

Clearly today's engineering employers request that our graduates should be able to hit the ground running, possess complex creative problem solving, team working and communication skills, together with adequate knowledge and understanding of business/management issues.
The challenging task for us is to seek the right balance in addressing the demands of modern industry whilst retaining our focus on the student's intellectual developmental needs.
At the Department of Engineering Materials of the University of Sheffield we have developed two modules, soon to be merged into one, that espouse exactly this challenge; MAT388 'Creativity, Innovation, Enterprise, and Ethics', developed by the author and MAT381 'Management for Bio-Engineers' developed by Prof. R. Short and currently also taught by the author.
This paper will provide a short description of how these modules operate, what they hope to achieve and how the students are assessed.

The modules - γνωθι σ'αυτον - know thyself
"If you are not a viable unit in the ordinary world, you will not become one elsewhere. If you have poor capacity for making human contacts, we cannot offer you the substitute of a community where 'we understand one another'. That belongs to play-life, what some, of course, generally call real life."
From: *Learning how to learn, Idries Shah*.

The starting point for both modules is providing the students with the opportunity of exploring their personal learning and thinking styles [2, 3]. As individuals we are all different and we tend to have different abilities, strengths and ways of solving complex problems. The idea is to get the students to appreciate the differences that exist between themselves as well as help them identify and strengthen their weaknesses in their learning. Work done back in the 1960's at Harvard has demonstrated that two students with nearly identical intellectual capacities can have markedly different abilities in problem solving or intellectual discourse [4].
The graphs shown at the end of this paper provide you with a flavour of the data collected. It can be seen that in general engineering students appear to be well rounded students. Of course the point of the exercise is not only to achieve personal recognition of strengths and weaknesses in our learning in order to be able to work towards future improvement more effectively but to realize that we are different and these differences can be something quite positive in team work as we all contribute different strengths to the group process.
Other researchers [5] have shown that student developmental growth relies on experiential learning opportunities coupled with reflective observation and judgment. During this part of the process the students are introduced to

Kolb's experiential learning cycle [1] and are asked to reflect and discuss their findings as part of a personal portfolio that they will compile over the course of the module. At the tail end of this work an introduction is given as to what do engineers do.
Once this introspective part of the process has been achieved, the students are introduced to the concepts of creativity, innovation and entrepreneurship. The approach is interdisciplinary, thematic and holistic. There is a 'vision' set out for the complete module instead of the traditional specific disciplines. Individual concepts are explored through the use of lectures, group activities, case studies and presentations by practitioners such as economists, industrialists, entrepreneurs, venture capitalists and bank managers. The structure of the module is based on interconnected themes that allow flexibility in the programme without loss of cohesion. Throughout the module the students are provided with background factual information on the financial, accounting, project management, product quality, human resources and managerial aspects of running a business in a holistic manner having spent time on introducing systems and systems thinking. The modules are rounded off by discussing ethics and ethical dilemmas through the use of case studies.

"You can learn more in half an hour's direct contact with a source of knowledge (no matter the apparent reason for the contact or the subject of the transaction) than you can in years of formal effort"
From: *Learning how to learn, Idries Shah*.

The assessment

As already alluded to earlier each student works on a personal portfolio throughout the course of the module. That forms 60% of their assessment. In order to further develop their communication and team work skills, the students are split into groups of four, maximum five and are asked to develop a business plan for a new product or company. The groups are asked to keep minutes of all their meetings as they progress through their group projects and develop a group portfolio. In order to avoid positive or negative discrimination within the groups, members are asked to assess each other's performance and provide explanations and reasons for their assessment. At the end of the module each group makes a presentation of their project to a panel of experts who act as potential venture capitalists who might want to invest in the group's unique ideas.
Team work and the introduction of an element of competition between the groups seem to work very well as motivators. However, we intend to introduce some extra incentives next time round by having actual prizes for best presentation, second and third place via sponsors who are either individual entrepreneurs or industrial organizations.

The result

Feedback obtained by the various cohorts taking these modules has been in general quite positive and the modules have been continuously evolving over the years. We believe that: learning is enhanced when learners are personally engaged in the learning process and they can see the relevance of the subject to themselves and their careers; all learners are different; creative and critical thinking skills are essential for today's global market; learning is a life long process; the need to develop their ability to transfer and apply learning to multiple situations; reflection is very important for assimilation and that the use of technology can enhance the learning process.
We are confident that the modules incorporate the complete experiential learning model proposed by Kolb and that the students are able to hone their communication skills and work cooperatively within their groupings realizing the value of team work in visualizing and implementing solutions to complex problems; the modules provide relevant, interesting and challenging learning experiences giving the students ample opportunities suitable to their particular style of learning; different aspects of learning are synthesised across multiple contexts providing the students with the opportunity to synthesise and the provision of a variety of assessing techniques allows them to take some ownership of the process.
Although students are encouraged to recognise their own learning styles and preferences but these preferences are not used to pigeonhole them in these styles but rather to reinforce the individuality of particular modes of learning and thinking. The value we see from such exercises is that the students reflect on how they learn and they use these findings as a springboard to improve on learning styles that are less comfortable with. Experimenting outside their comfort zones increases their learning experience and helps them become more rounded learners. Analyses of the 'kite' learning profiles of the students can act as a starting point for the lecturers by providing insights as how to best interact with their students. This is useful information for adopting teaching approaches that are suitable for the maximum number of students and also the basis for planning learning opportunities that would cater for those in the minority, e.g. small-group brainstorming activities are extremely effective for experimenter (active) learners, or brief intervals in teaching to allow the students to think through what they have been told allows the reflective thinkers to gain the benefits. Of course this work has a positive effect on staff by making their experiences more rewarding, interesting, fulfilling and valuable. Education is both and art and a science and we believe that engaging in educational research as part and parcel of the teaching/learning process yields rewards for both learners and teachers, as well as the wider academic fraternity.
The use of a group 'real-life' project under tight time limits and the pressures they exert proves to be very rewarding for the students. They find the experience both frustrating and rewarding – a reflection of reality. The group project manages to bring forth all the management elements we would like to emphasise: group formation, conflict, motivation, leadership, negotiation, criticism, cooperation.
The planning of personal and group portfolios help to emphasise the project planning, communication and presentational skills. Product development or business planning brings to the fore the knowledge required for

brainstorming novel ideas, divergent and convergent thinking skills, incubation (reflection), evaluation of solutions and finally verification.
Students have an intrinsic desire to learn and they learn more effectively if they believe that what they are being taught will matter in their lives [6, 7, and 8]. The programme, in its latest iteration, is to introduce more interactive presentations and mixed-team learning activities with a competitive element dispersed throughout the modules, culminating with short, 5 minute group presentations to peers and staff. Emotions are known to have a strong, some say dramatic, impact on learning [6]. The use of group case presentations in front of judges outside their 'comfort zone' raises the stakes as does the element of inter group competition. The emphasis here is on teamwork, integrity and dedication. Motivation and pleasure are the basic ingredients here; there are intrinsic rewards associated with the learning process itself but the intention is to also introduce extrinsic rewards (e.g. prizes) in the future.
Finally the assessment process provides the students with ample opportunities to express their learning in a creative non-prescriptive manner by allowing them freedom of expression. The personal portfolios are exactly what the title states 'personal'. Although all students are given instructions as to what areas their portfolios should cover, each portfolio is different, reflecting the individuality of its owner. That sometimes creates problems for the 'external' examiners who would like to see more uniformity and clearly identifiable scoring scales, but after all these are modules on creativity and creativity is not uniform, it is chaotic. Another useful part of the assessment exercise is that of the students having to assess each other and providing the reasons for their choices. This is a test of what behavioural and ethical skills and awareness the module has imparted. The intention of these modules is to instil new mindsets in the students cultivating fondness for creativity and learning, in addition to building up their confidence, enthusiasm and abilities to communicate and collaborate effectively with others.
For future developments what we would like to be able to do would be more systematic analyses of the learning style and thinking style indicators data by using them at the beginning and at the end of the course and looking for any significant shifts in the patterns, as well as combining them with questionnaires of pre- and post-course surveys about the modules. Such data will provide indications as to any gains derived by the students as well as useful information on any learning pattern alterations.

"The role of the teacher is to provoke capacity in the student, to provide what there is when it will be useful, to guide him towards progress. It is not to impress, to give an impression of virtue, power, importance, knowledge or anything else".
From: Learning how to learn, Idries Shah.

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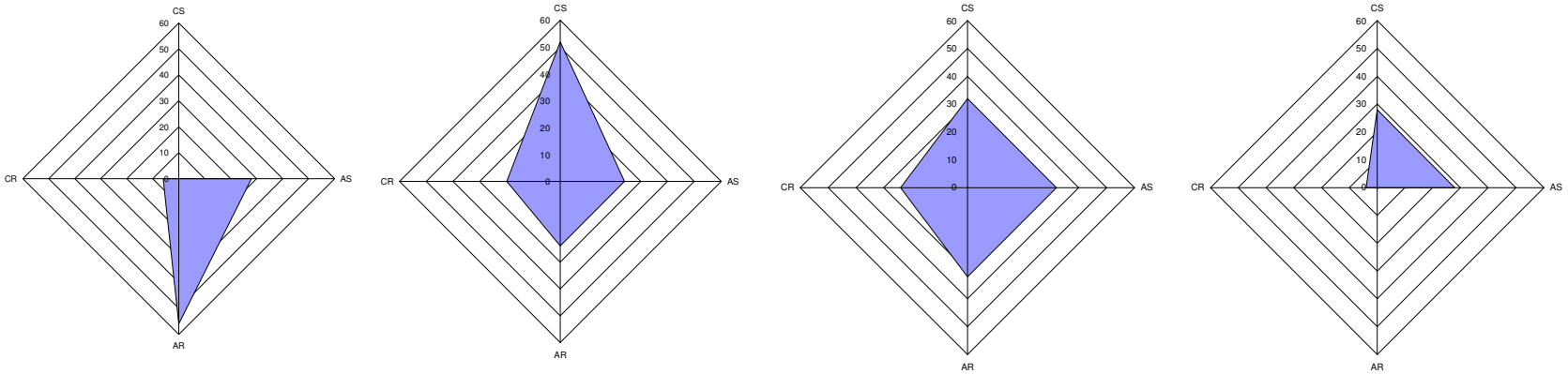
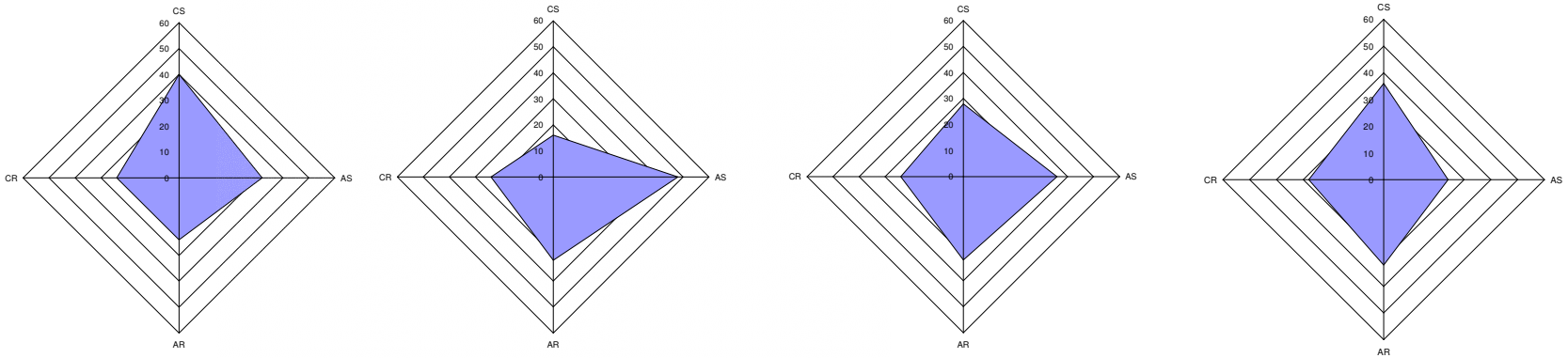
Realist



Experimenter

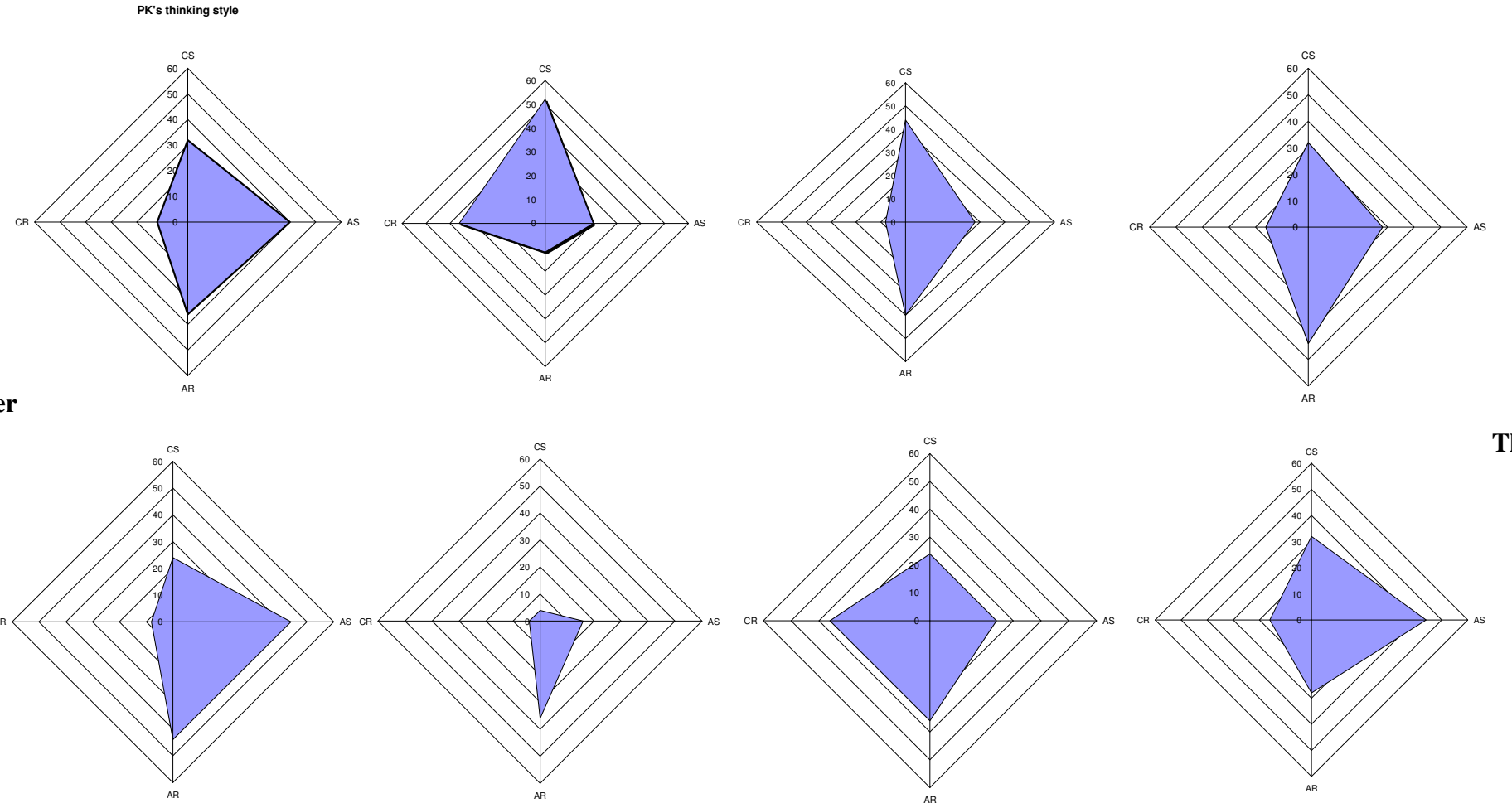
Theorist



Reflector

CS – Realists, **CR** – Experimenters, **AR** – Reflectors & **AS** - Theorists

Realist



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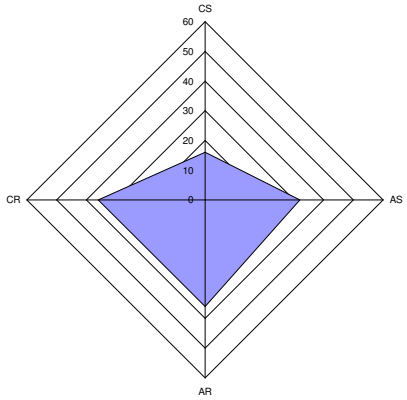
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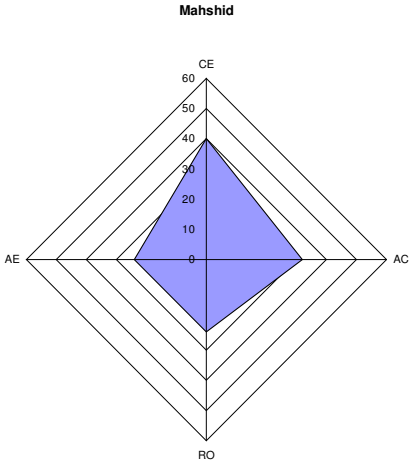
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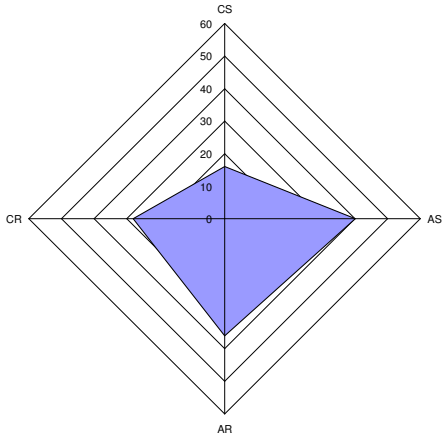
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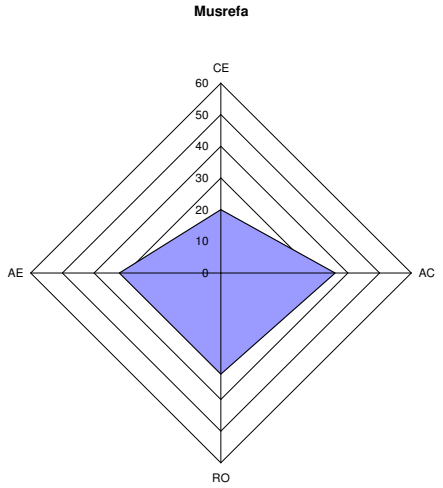
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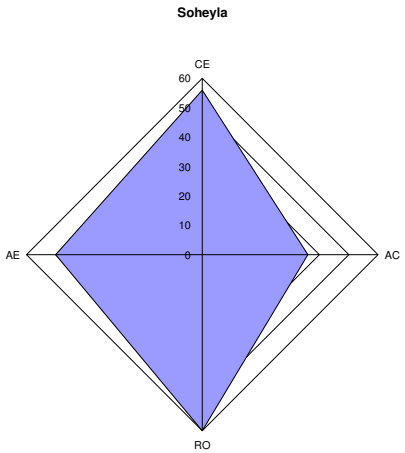
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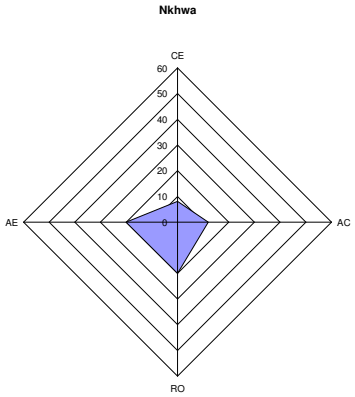
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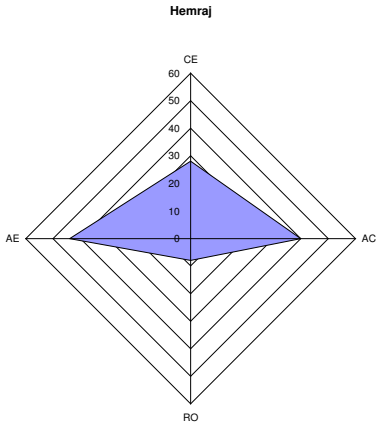
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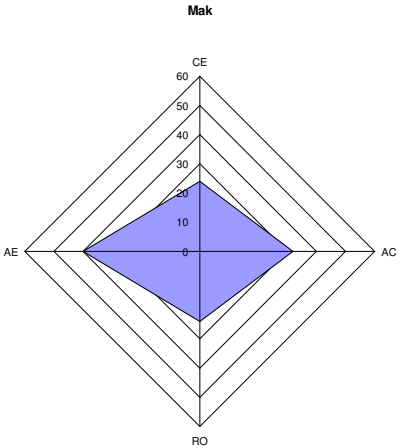
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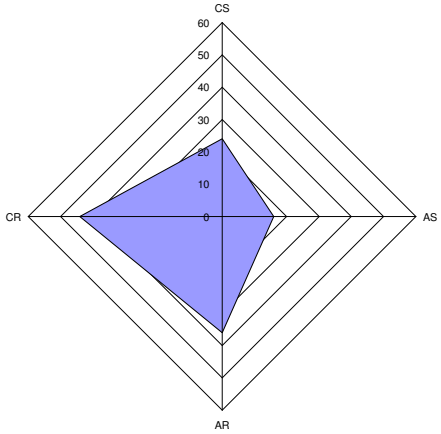
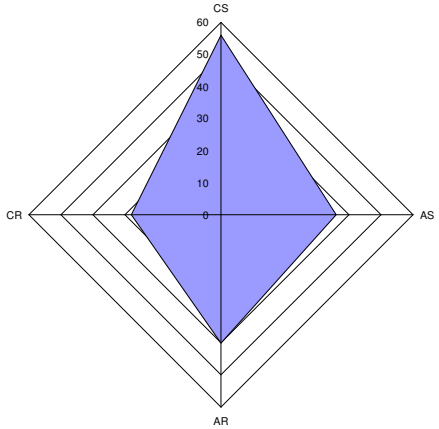
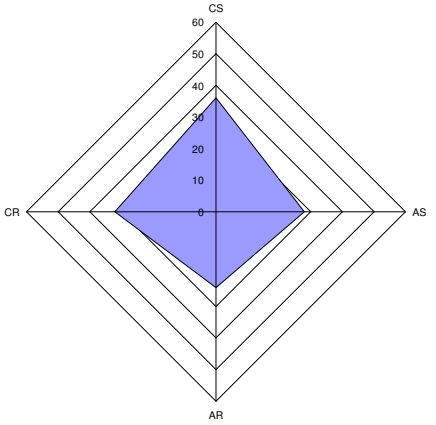
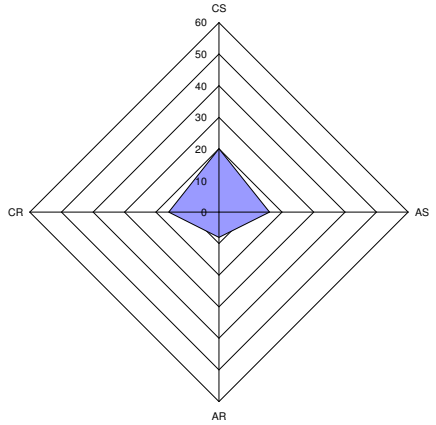
Realist





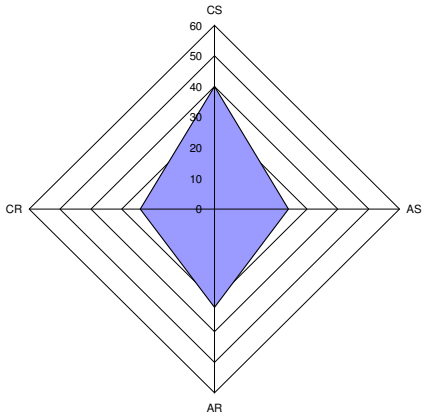




Experimenter

Theorist

Henderson



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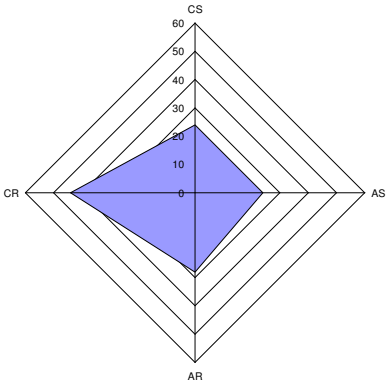
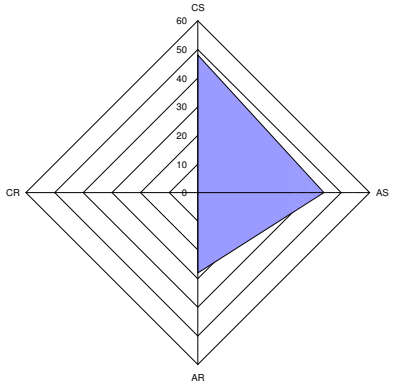
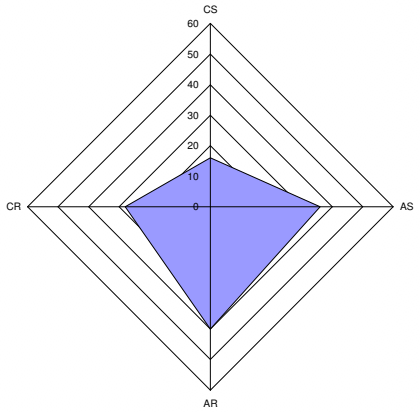
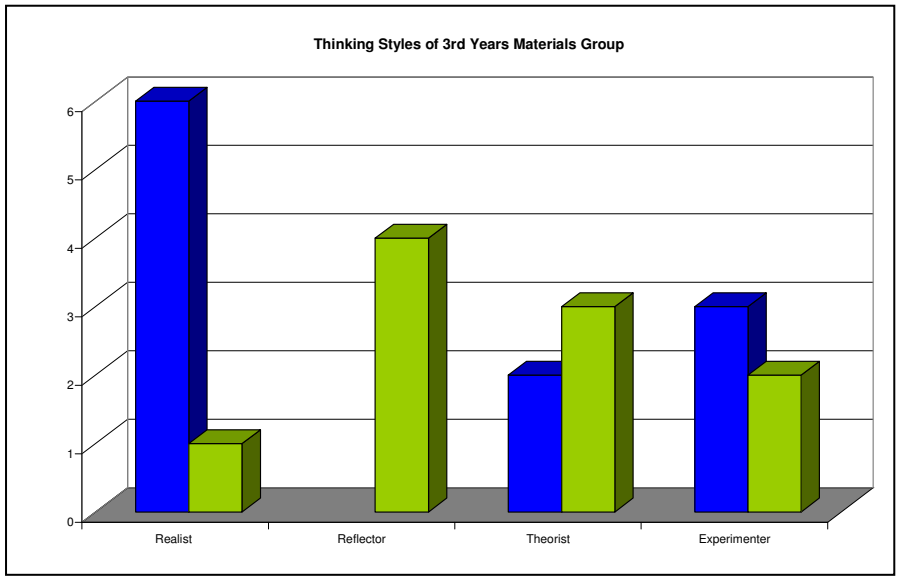






Reflector

CS – Realists, **CR** – Experimenters, **AR** – Reflectors & **AS** - Theorists


Thinking Styles of 3rd Years Materials Group
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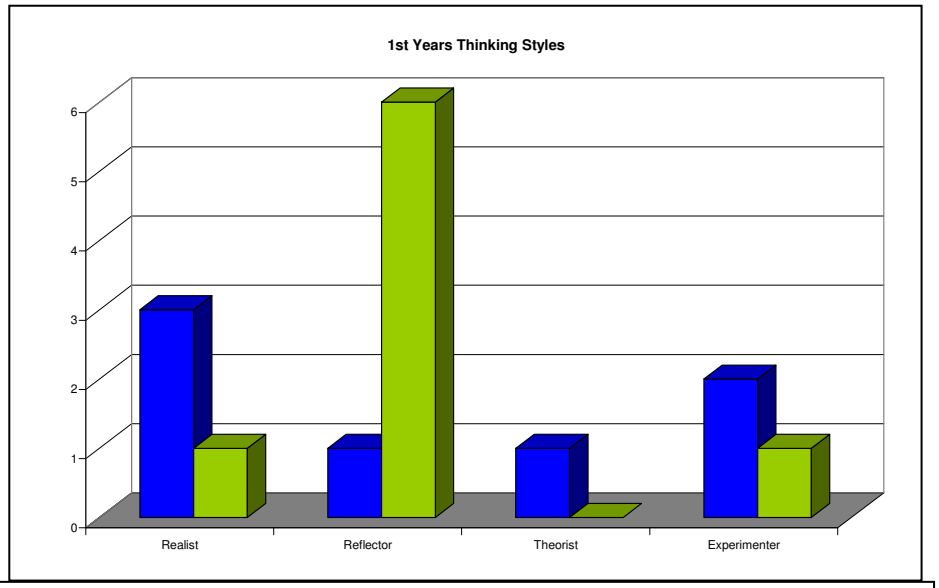
4
5
6
Realist
Reflector
Theorist
Experimenter


1st Years Thinking Styles
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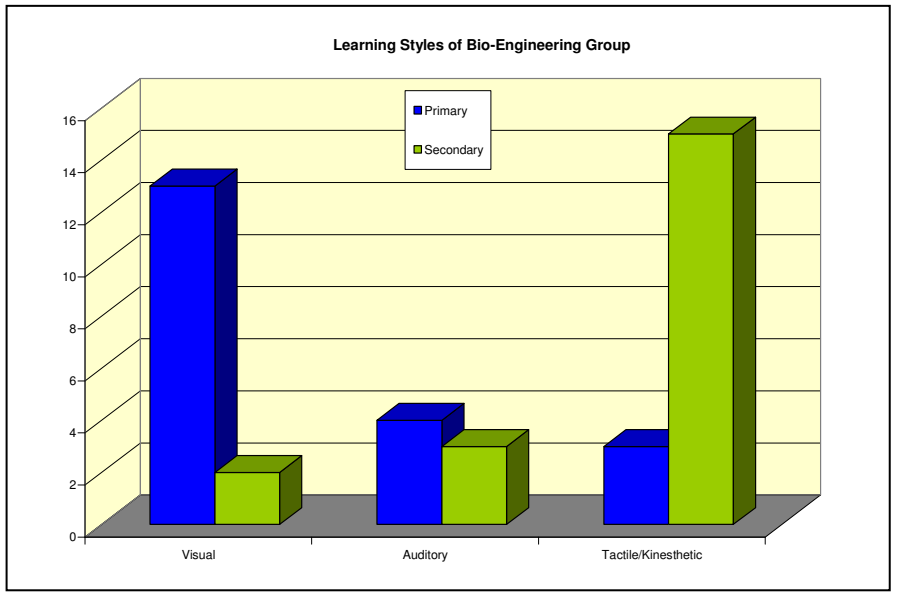
Realist
Reflector
Theorist
Experimenter


Learning Styles of Bio-Engineering Group
Primary
Secondary
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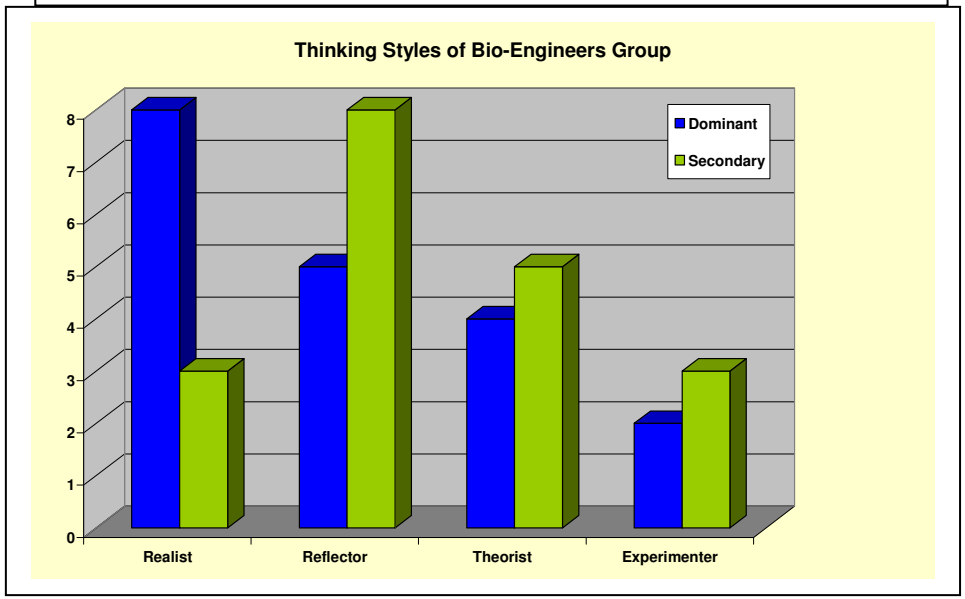
4
6
8
10
12
14
16
Visual
Auditory
Tactile/Kinesthetic


Thinking Styles of Bio-Engineers Group
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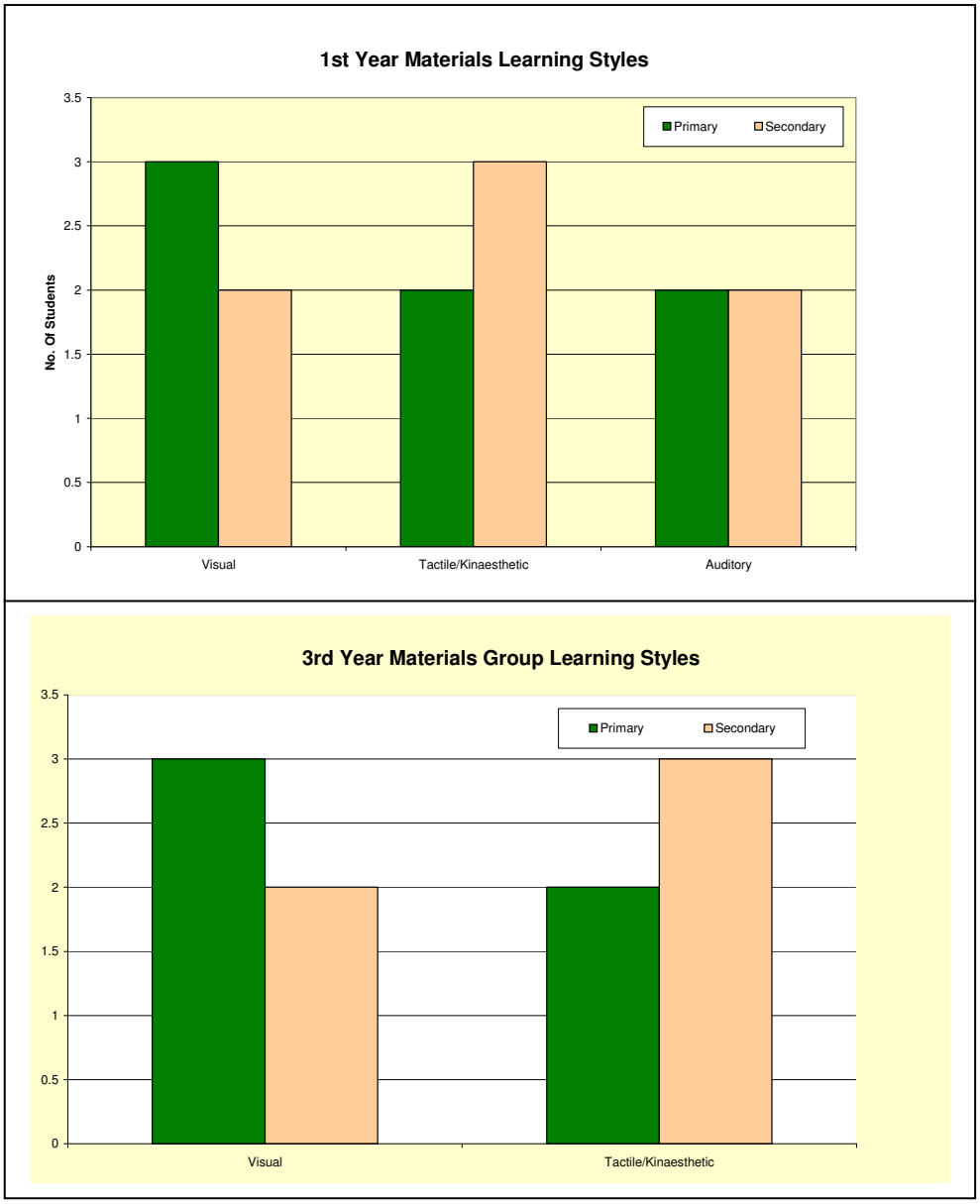
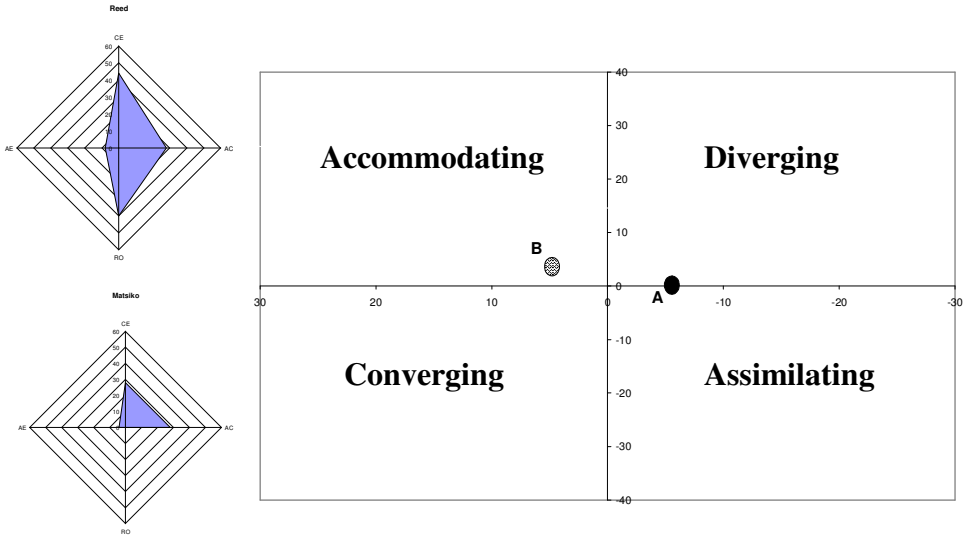
Realist
Reflector
Theorist
Experimenter


1st Year Materials Learning Styles
No. Of Students
Primary
Secondary
Visual
Tactile/Kinaesthetic
Auditory
3rd Year Materials Group Learning Styles
Primary
Secondary
Visual
Tactile/Kinaesthetic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21ST CENTURY TEACHING & LEARNING

KOLB CYCLE & REFLECTIVE THINKING AS PART OF TEACHING, CREATIVITY, INNOVATION, ENTERPRISE AND ETHICS TO ENGINEERS

P. Kapranos

International Symposium for Engineering Education, 2007, Dublin City University, Ireland

The University Of Sheffield.

Department of Engineering Materials

September 2007

- Twenty-first century engineers should be well-rounded, well-balanced individuals who are capable of relating to people from a variety of backgrounds. They should not be driven by monetary reward alone but by the pride, satisfaction and enjoyment that comes from doing things that are particularly useful. Although their day-to-day work might involve solving very specific technical problems, they should be aware that their work is part of a 'bigger picture'.

M. Chang, "Engineers in the 21st century," IEEE Journal on Selected Topics in Quantum Electronics, vol. 6, no. 6, 2000.

Learning and teaching styles

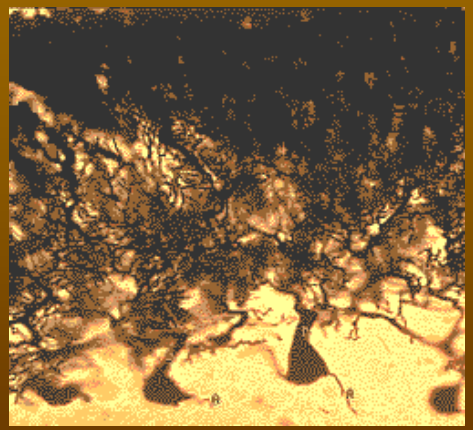
"I am someone's son or daughter, someone else's cousin or uncle, I am a citizen of this or that city, a member of this or that guild or profession, I belong to this tribe, that clan, this nation.

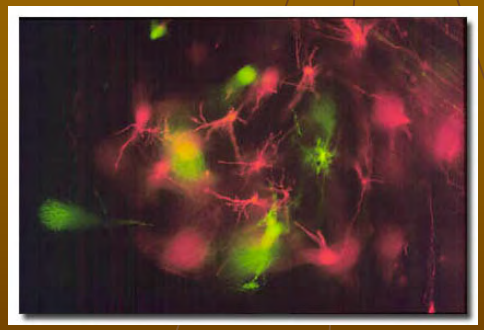
I inherit from the past of my family, my city, my tribe, my nation, a variety of debts, inheritances, rightful expectations and obligations.

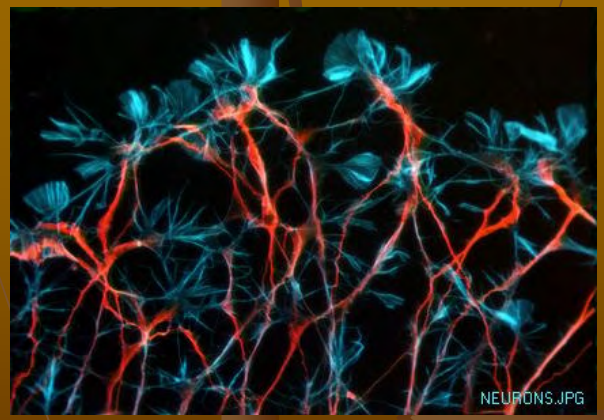
These constitute the given of my life, my moral starting point. This is the part what gives my life its own moral particularity"

Alasdair MacIntyre

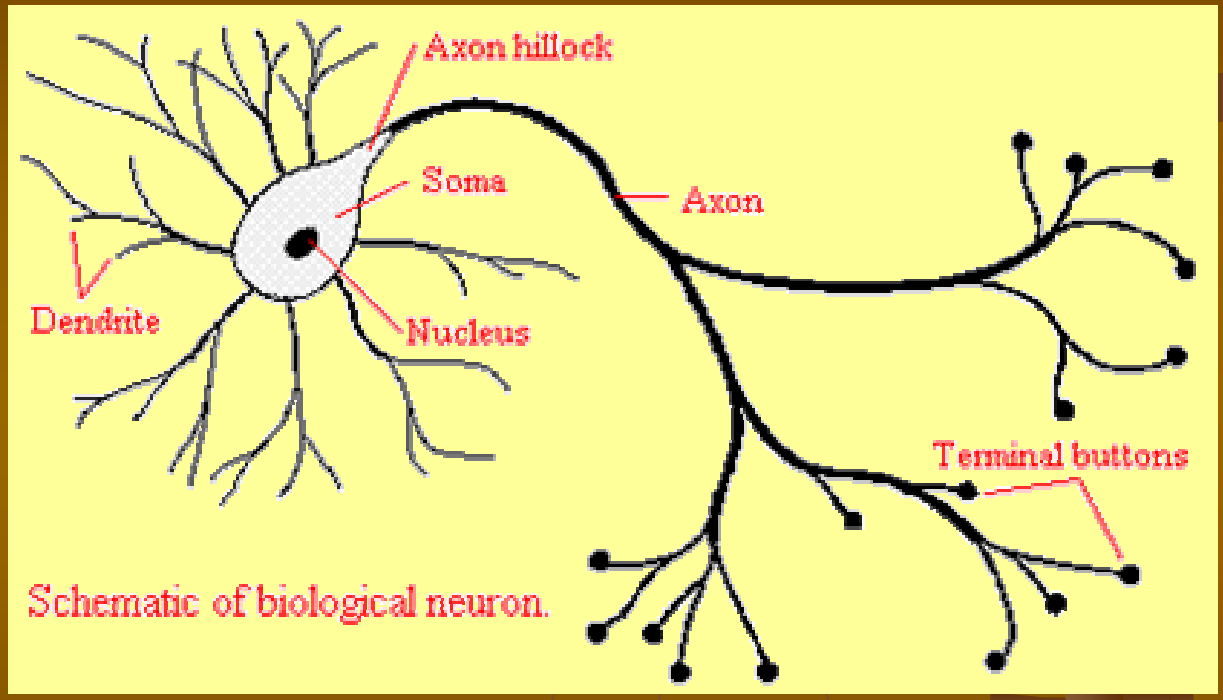
Brain: the most complex thing in the Universe (Sir Robert Winston)

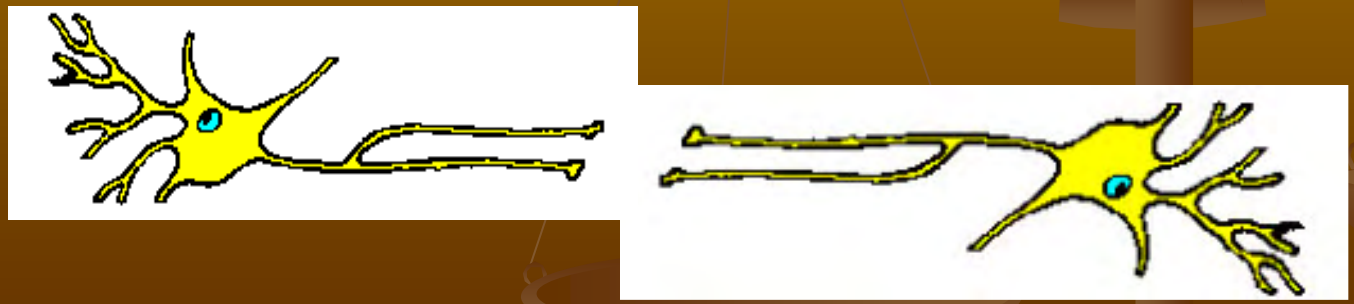






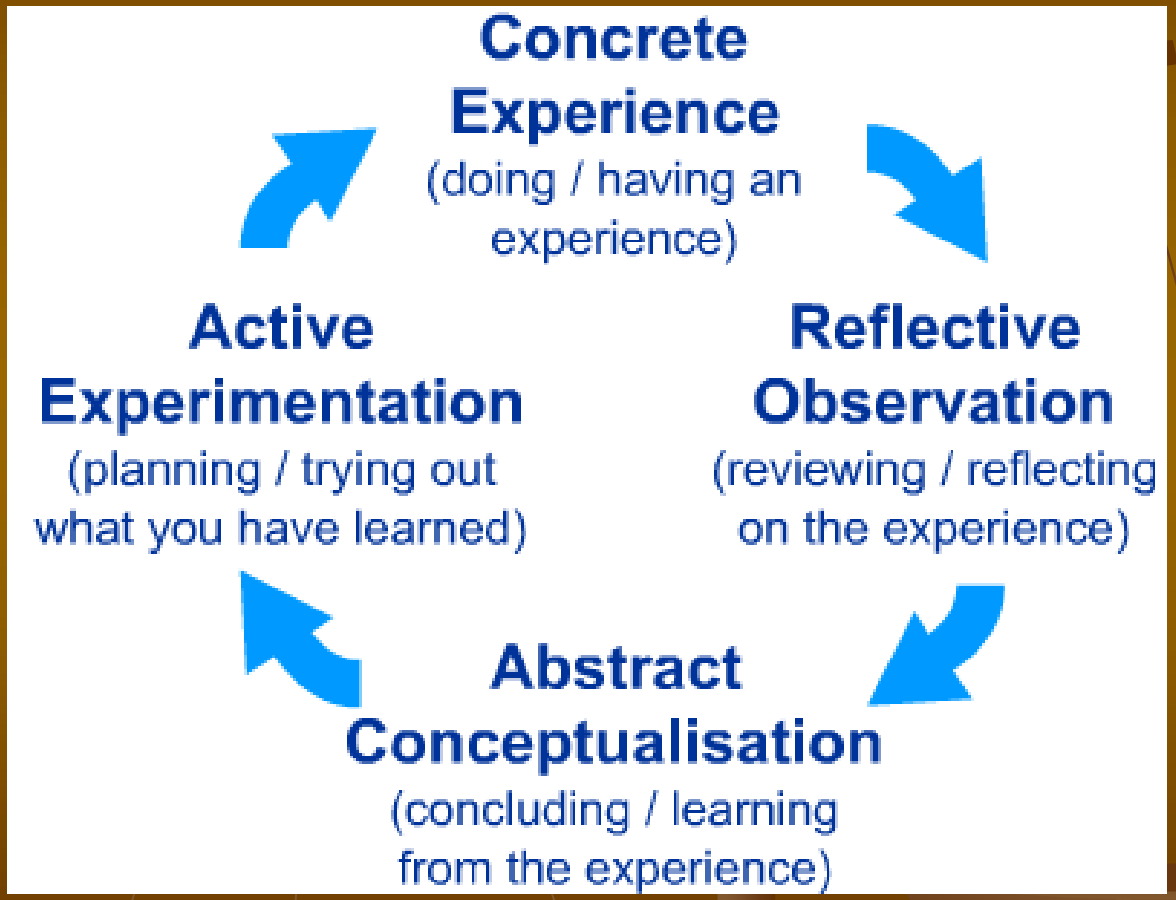
The brain contains 100 billion neurons



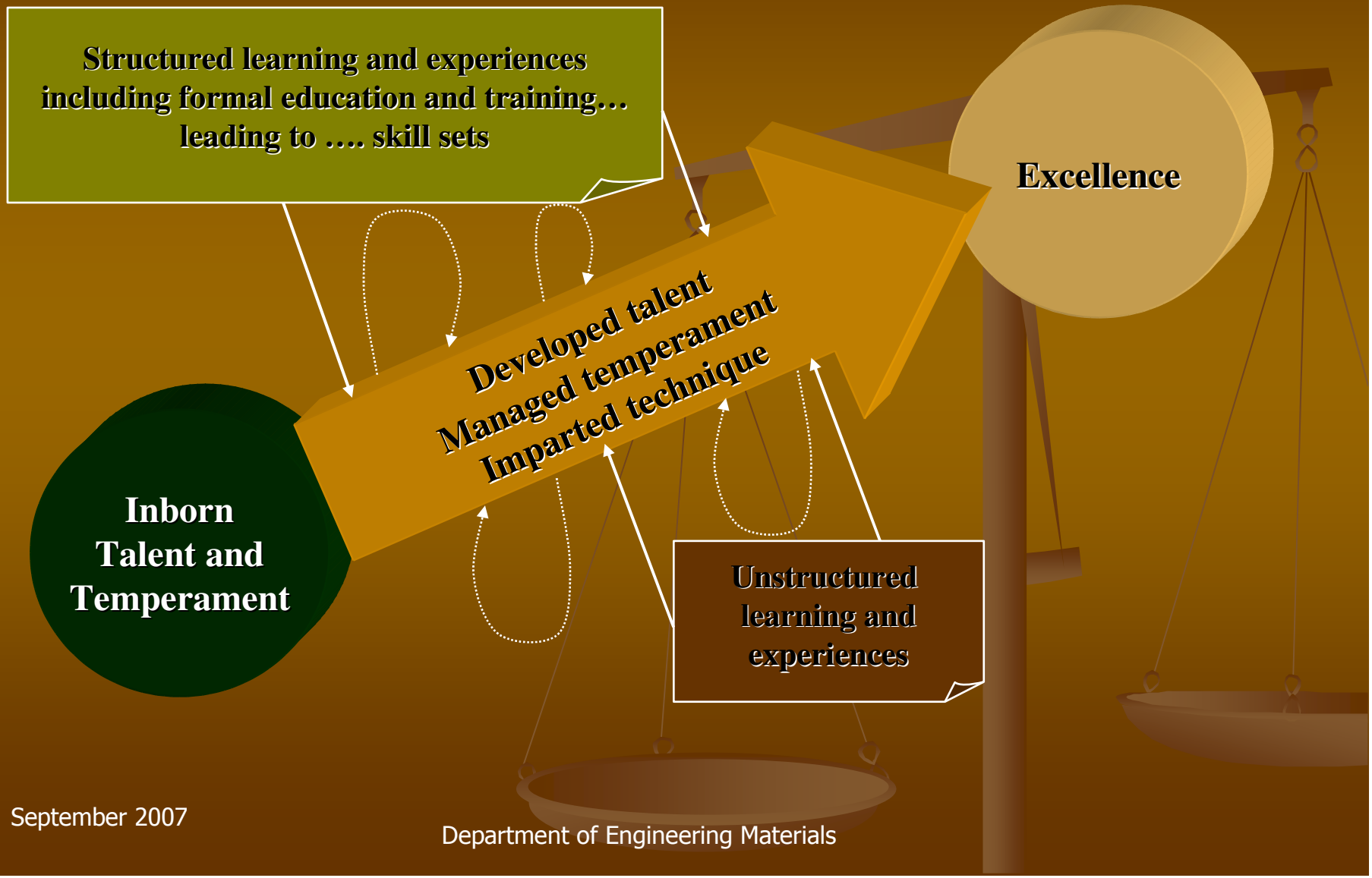


Kolb's experiential learning model

- We learn by experience, and
- Our individual experiences colour the way we perceive our world



Nature-Nurture model



Students learn by:

- Seeing
- Hearing
- Reflecting and acting
- Reasoning logically or intuitively
- Memorizing
- Visualising
- Drawing analogies
- Building mathematical models
- Steadily and in fits and starts

Teaching methods also vary:

- Some of us 'lecture'
- Others demonstrate and discuss
- Some focus on principles and others on applications
- Some emphasise memory and others understanding

- How much the student learns is governed by their abilities, preparation but also by compatibility between their learning style and our teaching style

Learning style models:

- What type of information does the student preferentially perceives: *sensory* or *intuitive?*
- Through which sensory channel is this information most effectively perceived: *visual, auditory, other* ?
- Which organisation of information is the student most comfortable: *inductive* or *deductive*?
- How does the student prefers to process information: *actively* or *reflectively* ?
- How does the student progress towards understanding: *sequentially* or *globally* ?

Teaching style models:

- What information is emphasised by the teacher: *concrete* or *abstract* ?
- What mode of presentation is stressed: *visual* or *verbal* ?
- How is the presentation organised: *inductively* or *deductively* ?
- What mode of student participation is promoted by the presentation: *active* or *passive* ?
- What type of perspective is provided for the information being presented: *sequential* or *global* ?

What does that mean for us:

- There are 32 (2^5) classroom learning style combinations in the proposed framework
- Most of us would be intimidated by the prospect of trying to accommodate 32 diverse styles in a given class
- FORTUNATELY, engineering education adequately addresses five categories (intuitive, auditory, deductive, reflective and sequential), and use of effective teaching techniques can substantially overlap the remaining categories.
- It would seem valid to say that with the addition of a relatively small number of teaching techniques in our repertoire we should be able to accommodate the learning style of every student in our classes.

Sensing and intuitive learners

- Sensors like facts, data and experimentation; intuitors prefer principles and theories
- Sensors like solving problems by standard methods and dislike 'surprises'; intuitors like innovation and dislike repetition
- Sensors are patient with detail but do not like complications; intuitors are bored with detail and welcome complications
- Sensors are good at memorizing facts; intuitors are good at grasping new concepts
- Sensors are careful but may be slow; intuitors are quick but may be careless

Visual and auditory learners

- Visual learners remember best what they see, if something is said to them they probably will forget it; auditory learners remember much of what they hear and more of what they hear and say
- Auditory learners get a lot out of discussion, prefer verbal explanation to visual demonstration, and learn effectively by explaining to others
- Most people of University age and older are visual learners
- Most HE teaching is auditory (lecturing) or a visual presentation of auditory information
- TEACHING/LEARNING mismatch!

Inductive and deductive learners

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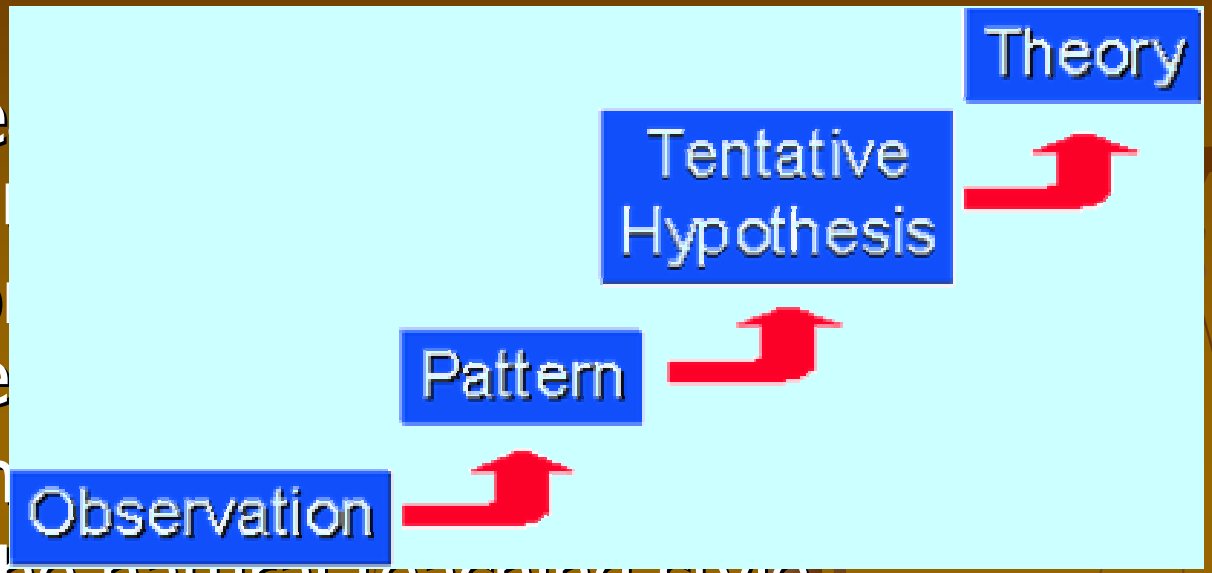
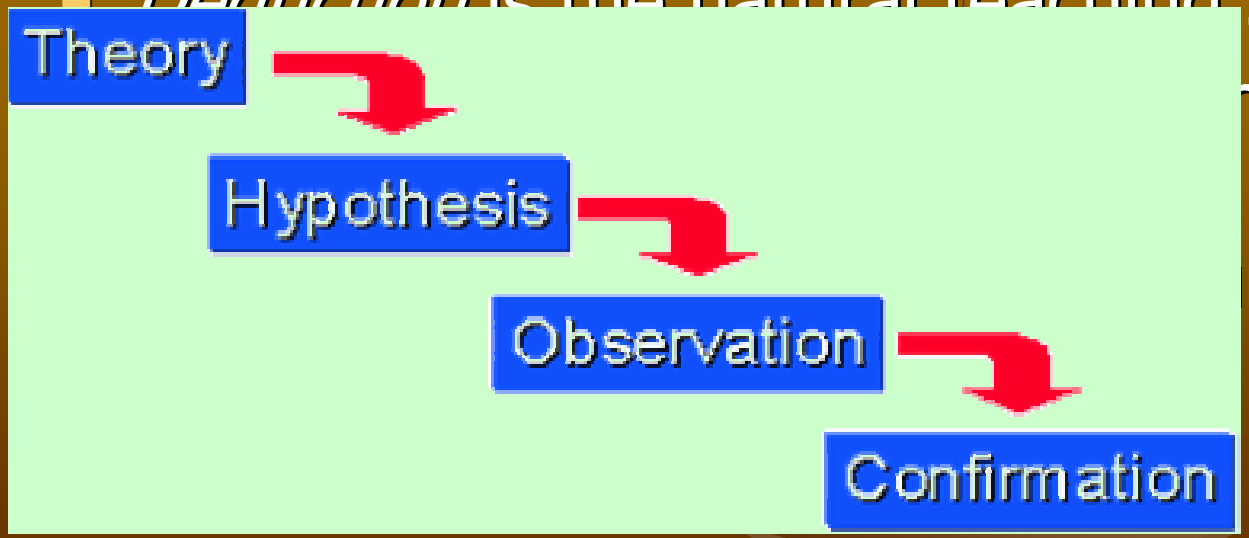




[illegible] themselves as

[illegible] rely deductive

Active and reflective learners

- An 'active learner' is someone who feels more comfortable with, or is better at, active experimentation than reflective observation, and conversely for a 'reflective learner'
- Indications are that engineers are more likely to be active than reflective learners
- Active learners do not learn much in situations that require them to be passive (most lectures) and reflective learners do not learn much from situations that provide no opportunity to think about the information being processed (most lectures)
- Active learners work well in groups; reflective learners work better on their own or at most with another person
- Active learners tend to be experimentalists; reflective learners theoriticians

Sequential and global learners

- Most formal education involves the presentation of material in a logically ordered progression, with the pace of learning dictated by the clock and the calendar.
- Some students learn sequentially, mastering the material more or less as it is presented, others learn in 'fits and starts'
- Sequential learners follow linear solving problem methodologies; global learners make intuitive leaps
- Sequential learners may be strong in convergent thinking and analysis; global learners can be better at divergent thinking and synthesis
- Sequential learners prefer a steady progression of complexity and difficulty; global learners sometimes do better by jumping directly to more complex and difficult material

Teaching techniques to address all learning styles

- Motivate learning - Inductive/Global
- Provide a balance of factual information and abstract concepts – Sensing/Intuitive
- Balance practical problem solving methods with fundamental understanding – Sensing-active/Intuitive-reflective
- Provide illustrations of intuitive patterns and sensing patterns and encourage students to use both – Sensing/Intuitive
- Make use of pictures, schematics, graphs, simple sketches liberally before, during and after the presentation of verbal material – Sensing/Visual

Teaching techniques to address all learning styles cntd.

- Show films, video clips – Sensing/Visual
- Provide demonstrations – Sensing/Visual, hands on if possible – Active
- Use computer assisted instruction – Sensing/Active
- Do not fill every minute of the lecture by writing on the board; provide brief intervals of student interaction – Reflective
- Use short brainstorming activities – Active
- Assign exercises to provide practice on what is being taught – Intuitive/Reflective/Global

Teaching techniques to address all learning styles cntd.

- Provide open ended problems and exercises that call for analysis and synthesis – Intuitive/Reflective/Global
- Provide option for student collaboration whenever possible – Active
- Applaud creative solutions, even incorrect ones – Intuitive/Global
- Talk to students about learning styles. Students will be reassured to find that any academic difficulties may not be part of personal failings – All types
- Explaining to the students how they can learn more effectively can reshape their learning experience – All types

Research has shown that: (Stice J.E.)

- Students retain:
  - 10% of what they read
  - 26% of what they hear
  - 30% of what they see
  - 50% of what they see and hear
  - 70% of what they say
  - 90% of what they say as they do something!

Teaching for all – A study in Balance

- Using a combination of Kolb's experiential learning model, together with reflective thinking of our practice and adding some variation of teaching styles to accommodate the different learning styles of our student audiences can have a potentially dramatic effect on their quality of learning!

'Creativity, Innovation, Enterprise & Ethics'

'Παν Μετρον Αριστον' -

'Balance & Optimisation'

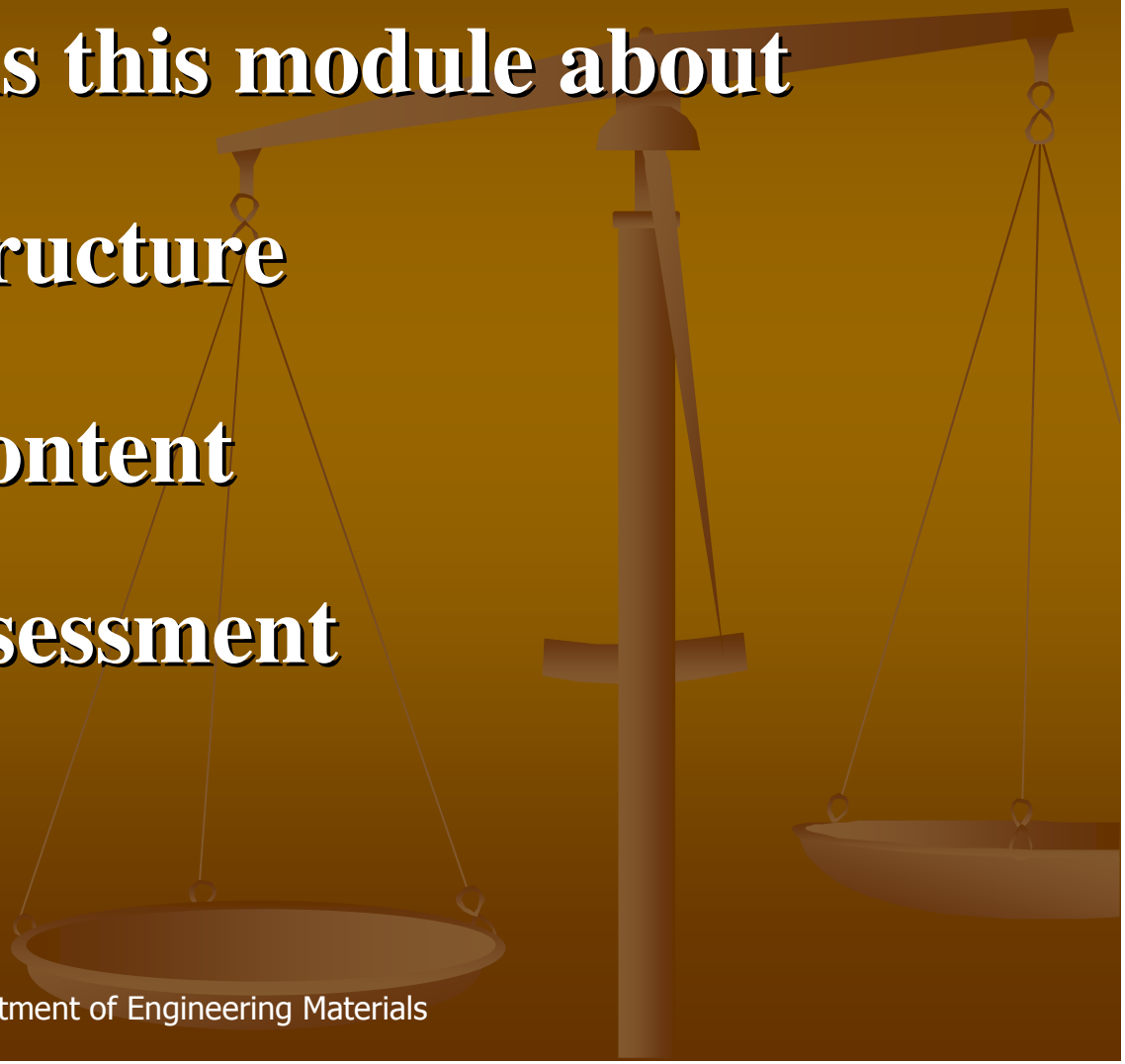
Plato Kapranos K4

2007

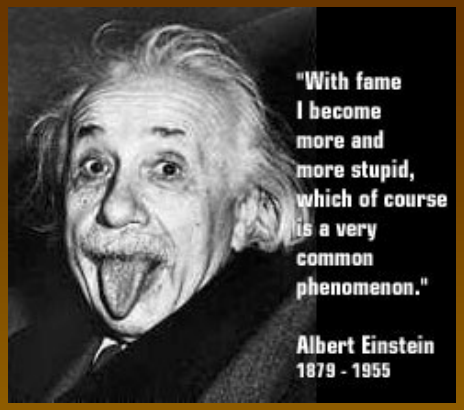
Module 388

Outline

- What is this module about
- The Structure
- The Content
- The assessment



What is this module about



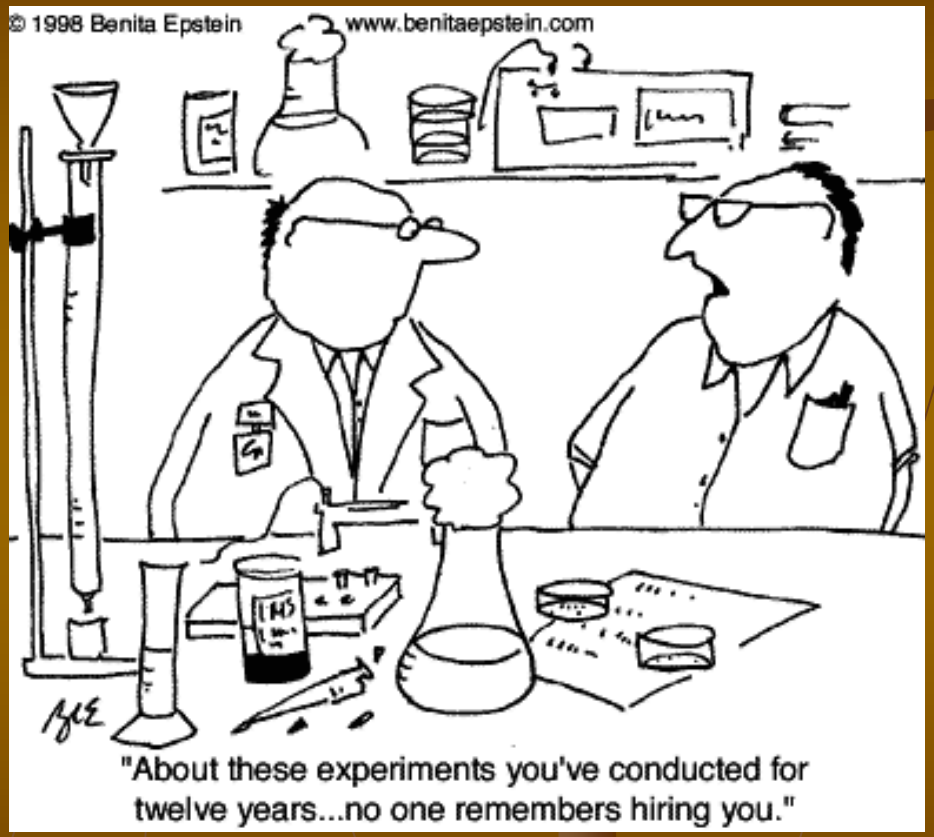
- What engineers and scientists do

- The role that Creativity, Innovation, Enterprise and Ethics play in their jobs

A Scientologist

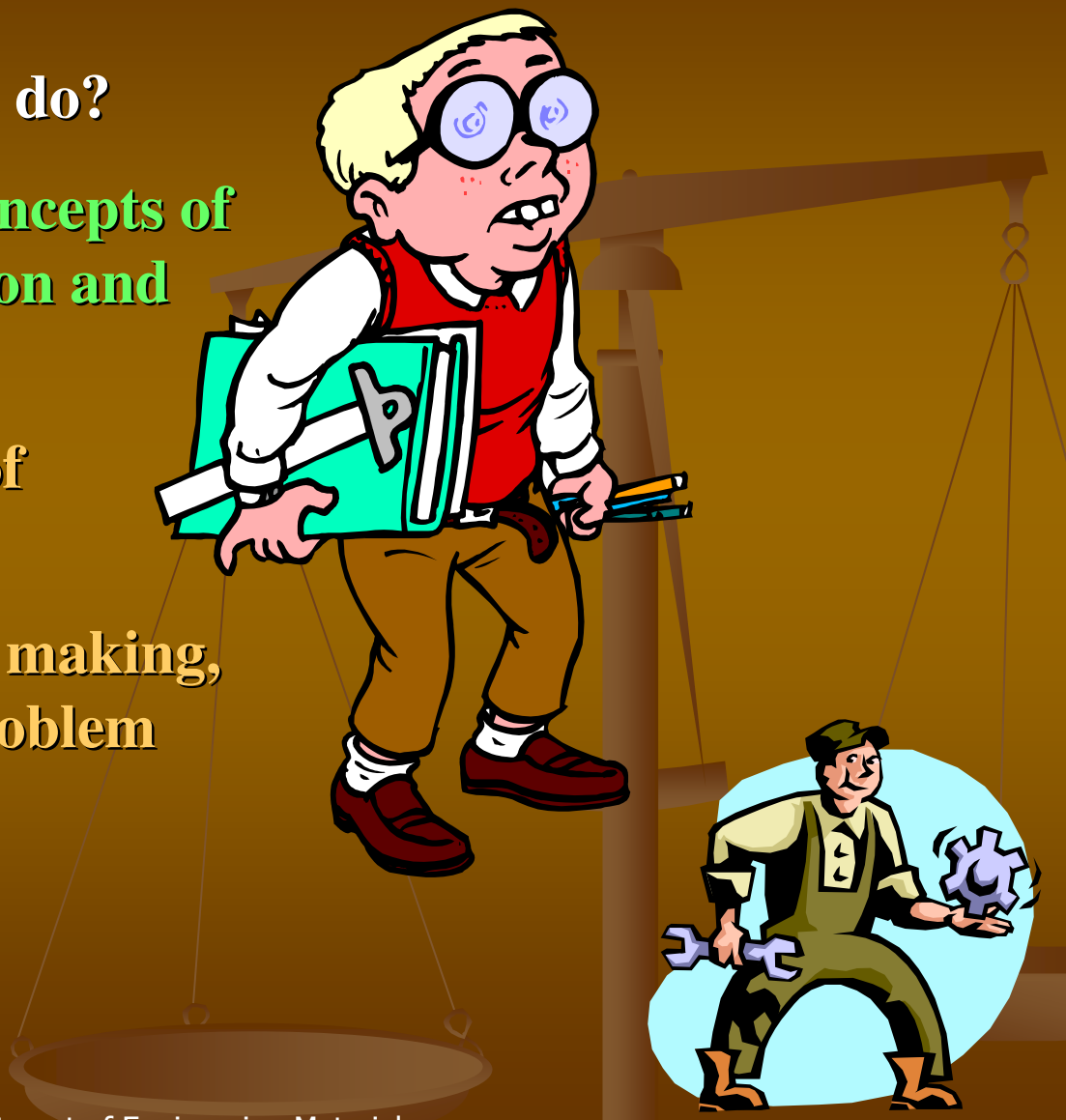
The Structure

- The module consists of series of 24 lectures
- My lectures are supported by the use of external speakers on specific topics
- There will be a written assessment at the end of the module & a group case study



The Content

- Overview of the module
- How do we learn?
- What do Engineers do?
- Introducing the Concepts of Enterprise, Innovation and Creativity
- Economic aspects of Technology
- Introduce Decision making, Risk analysis and Problem solving
- Introduce TQM
- Engineering Ethics



The module assessment

- Will be in the form of:
  - Group presentations: You will develop a business plan for a UK based company
  - Written Assessment: You will be asked to individually tackle a number of problems taken from various parts of the module

(NO Exam)

In the hope that the module will make you see things from a different perspective

I wish that for just one time
You could stand inside my shoes
And just for that one moment
I could be you……

Bob Dylan (Positively 4th Street)

engineers are no different than anyone else, they search for the best possible solutions whilst balancing a number of conflicting demands

'Παν Μετρον Αριστον' -

'Balance & Optimisation'

Acknowledgements

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go raibh míle maith agat

21ST CENTURY TEACHING & LEARNING: *KOLB CYCLE & REFLECTIVE THINKING AS PART OF TEACHING, CREATIVITY, INNOVATION, ENTERPRISE AND ETHICS TO ENGINEERS*

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ABSTRACT
In teaching we deal with people, diverse and ever changing. Not everyone learns the same way or equally readily about all types of material. Both the discipline and level have influence on learning.
There are no easy answers to such questions as 'How do we learn?' and 'How we as teachers can bring about learning?' Our knowledge about teaching and learning is still incomplete, but we know enough as to what types of action may be helpful in enabling learning. It is recognized that both *motivation* and *assessment* play a major part in student learning in H.E.
The use of '*Kolb's learning cycle*' as a model required for complete learning and the principle of continuous '*Reflection in Action*' are two approaches that can help us deal with the difficult task of teaching and learning in the 21st century.

Marco Polo describes a bridge, stone by stone.
"But which is the stone that supports the bridge?" Kublai Khan asks.
"The bridge is not supported by one stone or another," Marco answers, "but by the line of the arch that they form."
Kublai Khan remains silent, reflecting. Then he adds: "Why do you speak to me of the stones? It is only the arch that matters to me."
Polo answers: "Without the stones there is no arch."
Invisible Cities – Italo Calvino

INTRODUCTION
We live in a fast moving world. The quotation of the Ionian philosopher Heraclitus "Τα παντα ρει και ουδεν μενει" – everything changes and nothing remains – could aptly applied to describe our modern life experiences. The fact that we live in a world of continuous flux is nothing new, irrespective to which Creation theory we espouse, things have been moving forward ever since the beginning. What has drastically changed within our lifetimes is the rate of change which at times can assume quite frightening pace. Of course change can be viewed from different perspectives and on the one hand it can be viewed as a positive driver of continuous improvement, with all the accompanying benefits, whilst on the other it can have devastating and debilitating effects on those who cannot keep abreast of it.

In the last decade of the 20th century, especially after the demise of the communist system of the Soviet Union, we have experienced the inexorable growth of capitalism in the form of globalization and in the current state of affairs it looks that either nations sign up to it or are left behind.
On present evidence, there can be little doubt that education is being affected by the assault of globalization. With the continual increase of global markets and more and more powerful global multinational companies, more and more nations try to adopt their educational systems to cater for the needs of these global multinational economic giants. The result is the creation of educational systems that are geared more towards economic and technical requirements, neglecting the contribution to the creation of a better social order. *Nation states are in danger of becoming the servants of global markets with their educational systems providing the human resources to feed them* [1].
In this time of enormous and rapid changes not only the average voter, but the average nation appears to have less and less control over their destinies. Nevertheless, in my opinion there is need to keep in front of us a richer vision of education, the vision of the common social good and the development of human potential to its full capabilities.

Teaching and Learning
It seems sensible that before one attempts to teach, one should make an effort to understand how people learn. Teaching and learning are hard to pin down elusive concepts but for sure different people learn in different ways. In addition, there is no doubt for the need of the learner to be actively engaged in the learning process in order that they benefit from it. Everyday experiences in our lives confirm it. For the older persons such as myself, there are no better examples than trying to use new technologies such as programming a video player, using a computer or trying to get to grips with a mobile phone; I find all much easier by *doing* things myself rather than trying to follow vague instructions, either from my daughters or the various manuals. Unless I get actively engaged I do not really '*learn*'.

As humans we tend to enjoy a task better when we have control over it, i.e. it is of our own choosing rather than one that is imposed upon us, even if it results in some extrinsic reward. In fact research suggests that extrinsic rewards not only undermine intrinsic ones, they seem to promote poor learning. In contrast, tasks that are intrinsically rewarding are associated with higher levels of motivation and active engagement. The more responsibility the learners have for their learning, the greater their intrinsic reward is likely to be [2].

We should, and good teachers have always been doing it, not only try to actively engage our students in the learning process and make the learning process intrinsically rewarding, but we must also ensure that the students are provided with the appropriate working models to understand the meaning of what we try to teach them. In other words it is quite important, especially in today's modularization and interdisciplinary nature of courses, to ensure that our students are given the appropriate background information on which to associate the new information we try to impart. Unless they have a working model in their heads or are exposed to situations through which they can build such a model through their experiences, learning will not take place or it will be incomplete if it does. Of course it is important for the students to know the facts, however, unless these facts can be put together in meaningful patterns they will not be of great use. Facts get their meaning from the way they fit into a particular context. When we speak to them of a good theory, we should be able to demonstrate to them how the various seemingly disparate facts of a topic are put together and make sense. The fitting of various facts into a coherent whole supports the active engagement we seek to impart on our students as well as being conducive to '*deep*' forms of learning (holistic approach).

If we think of the various facts that the learner has to absorb as building blocks, then in order to make these blocks fit together in the right pattern, the learners should be given the outline of the complete topic, i.e. how the various bits in the topic hang together. Given the complete outline at the beginning of a series of lectures they will be able to fill in the pattern that emerges as they go along. The emergence of this pattern is the emergence of meaning and when students see it, they will begin to understand the facts; they will have achieved insight.

The student's perspective to learning is highly colored by the way they perceive the value of the process to themselves. It is therefore very important that we know or at least try to understand the way the students perceive what we try to achieve through our particular way of teaching rather than just rely on how effective or appropriate we judge our teaching method to be.

Kublai asks Marco, "When you return to the West, will you repeat to your people the same tales you tell me?"
"I speak and speak," Marco says, "but the listener retains only the words he is expecting. The description of the world to which you lend a benevolent ear is one thing; the description that will go the rounds of the groups of stevedores and gondoliers on the street outside my house the day of my return is another; and yet another, that which I might dictate late in life, if I were taken prisoner by Genoese pirates and put in irons in the same cell with a writer of adventure stories. It is not the voice that commands the story: it is the ear."
Invisible Cities – Italo Calvino

Education should train one's powers of '*reflective thinking*'. Genuine freedom, according to Dewey, is intellectual; it rests in the trained power of thought, in the ability to '*turn things over*', to examine problems in depth.
Reflective thinking is based on five steps between recognition of a problem and its solution [3, 4, 5, and 6]:

1. Suggestions of a solution
2. Clarification of the essence of the problem
3. The use of hypotheses
4. Reasoning about the results of utilizing one of the hypotheses
5. Testing the selected hypothesis by imaginative or overt action.

Mere imitation, dictation of steps to be taken and mechanical drill may give quick results, but they may have the adverse effect of strengthening traits likely to be fatal to reflective power. True learning of skills necessitates their acquisition as the result of the use of the intelligent powers of the mind.

There is a beautiful description by Michael Polanyi of the learning experience of medical students attending a course in the X-ray diagnosis of pulmonary diseases [7] and a number of factors emerge from it have been summarized [8]:

- The discovery that we need to know something that we do not know,
- Immersion in the problem,
- Puzzlement,
- Active engagement; obtaining information and testing of hunches,
- Repeated exposure to the learning situation,
- The presence of an expert who sets up the situation, acts as a model of competence and answers questions,
- The inherent capacity of the human mind to understand,
- Periodic insights,

- Pleasure in gaining insights,
- Doubt that one will ever really understand, and
- Faith that one will eventually understand.

Looking through the above list one can see that there is an absence of a teacher '*teaching*' and also that quite a number of items refer to the way the students feel. Polanyi goes further in fact and suggests that especially in practical lessons one cannot convey a lot of the information learned by '*telling*', simply because such knowledge cannot be specified in words. He calls this '*tacit*' knowledge. I believe that the major problem of teachers in the conventional classroom situation is not one of language but one of attitude. If the teachers have a sense of empathy and put themselves in the positions of their students, i.e. take on the perspective of their intended learners they will communicate in a way that their learners can understand.

Explaining to students is a challenging task. They may not see the connections that seem so obvious to us. It is an easy assumption to make that facts, which seem so obvious to us that are not worth mentioning, are not equally obvious or could be totally out of the experience of our students. Communicating ideas involves much more than just knowing about them. Meaningful learning and retention are influenced by the substantive content of a learner's structure of knowledge and the organization of that structure [9]. Having '*appropriate background knowledge*' of concepts and principles is essential in problem solving. '*Meaningful learning*' involves the acquisition of '*new meanings*' that will allow the learner to relate the new material to their cognitive structure and to integrate the essence of the new experiences to existing patterns.

The above discussion suggests that the main ingredient of comprehensive understanding of any topic is that the learner can see all its details as an integrated whole. Details of any topic become coherent only when they '*fall into place*'; they integrate with the whole, making the '*picture*' complete. Does this fact affect the setting of rigid objectives? Does the fact that we recognize the goal only when we get close to it affect the determination of such goals beforehand? Are we able to specify goals before we reach them?

In a fast paced world of conflicting demands we need to evolve a dynamic, flexible curriculum as modelled in Figure 1.

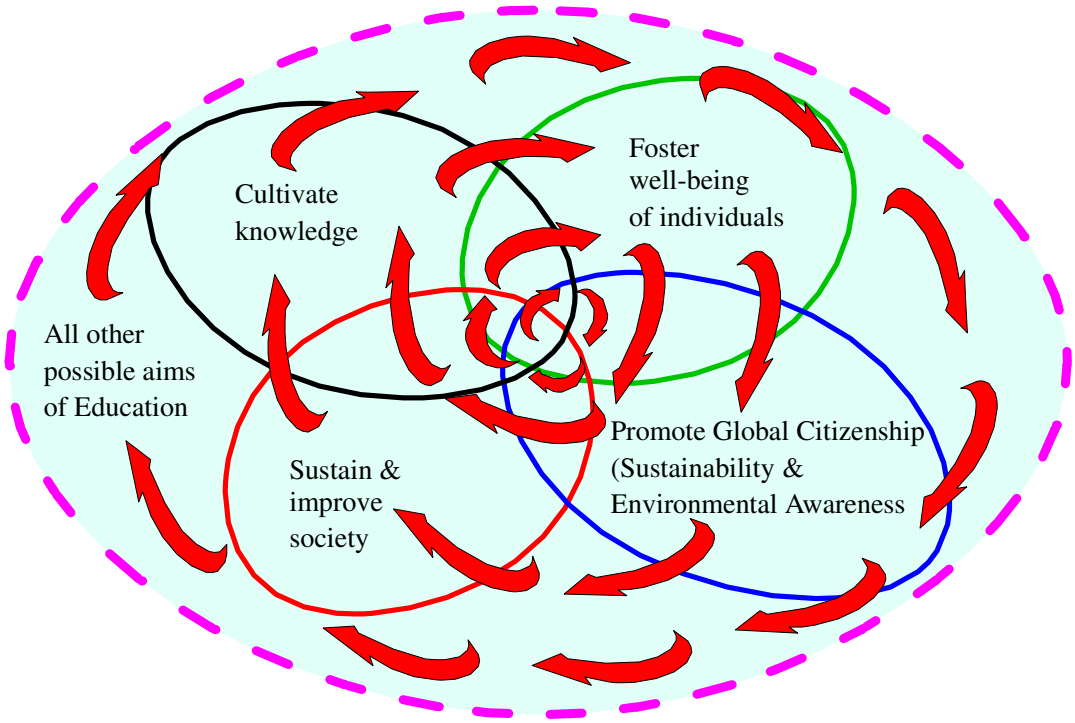

Figure 1 Model showing how a balance can be achieved between contending aims by targeting the common elements in the set of aims. Working from the intersection of the different sets of aims and by continuing to work through common points between the sets we can we can develop a consensus through a democratic process that accommodates the sincere differences and contesting interests. They key to this process is to realise that the purpose of education is not monolithic or static and that the continuous shifts of educational aims provides the potential of dynamism in the real world of continuous flux. Even the most tenuous consensous can act as a focal point from which the process of building a sound educational programme can begin.

The activities we have been discussing above are not of course set in vacuum. They are part of the curriculum and as such they can generate positive or negative effects on the way the students will approach their studies and they will also

help to shape their learning strategies. Overcrowded timetables, overloaded syllabus can affect the way we teach. We might be willing to take our students in a trip of exploration but we most probably will end up speeding through prescribed material at a gallop leaving our audience breathless and possibly lost in the process. All these, coupled with an assessment approach that is geared towards examination and the recall of facts and you end up with the classical symptoms of '*surface'* learning. All these adverse effects are consistent with the simple theories of learning we have already touched upon. We need '*plasticity*' in the curriculum that reflects changes either of substance or perspective in technology, metamorphoses in subject content, changes in landscape, i.e. the changing of boundaries.

However, there is one more point I would like to stress, it is not only how well intentioned we are in our approach and how well we articulate our aims and objectives but how well and what the students understand those objectives to be. It is not how well we design assessments to test understanding rather than reproduction, but what our students believe the assessment to be about. Any mismatch between these perceptions and the effectiveness of what we are trying to achieve will be severely reduced. Different students, as all of us, perceive the same context in different ways. If we are lucky enough to establish a rapport with our students and both are on the same '*wavelength*' then we can both reap the benefits of the developed theories of learning. However, if any mismatch occurs in the perception of the learning process from either side, there will be frustration and disillusionment all around.

Engineering is a subject heavily loaded with explicit knowledge. Engineering suffers from too much emphasis on knowledge and teaching and not enough on technology and learning. The teacher's role is to structure knowledge, to make knowledge accessible, to facilitate learning (not to impart information), and to manage the learner's interaction with knowledge, whilst the learner's role is to assimilate, organize and apply knowledge.

What are the employers looking from our graduates and what are the career expectations that our graduates have? Employers take as granted that the graduates should have appropriate technical skills. Graduates are also expected to possess good communication, decision-making, problem solving, team building, and negotiating skills. A report by the Association of Graduate Recruiters has shown that although graduates may have top qualifications they do lack important working skills. Large companies perceive that graduates leave universities lacking initiative and without the ability of effective communication. Nearly half of the firms surveyed in the same report expressed the belief that graduates are not good in decision making, whilst a third are not impressed with their problem solving or team-building abilities. Nearly 80% said that employees with such soft skills would find it easier to move up the corporate ladder. The majority of graduates think that they have completed the learning process when they graduate and they do not want to take on job functions that they perceive to be beneath them. Their salary expectations appear to be ~£10,000 higher than the prevailing rates! What can the professional teachers do to assist in bridging this perception gap that exists between the two camps?

Now Kublai Khan no longer had to send Marco Polo on distant expeditions: he kept him playing endless games of chess. Knowledge of the empire was hidden in the pattern drawn by the angular shifts of the knight, by the diagonal passages opened by the bishop's incursions, by the lumbering, cautious tread of the king and the humble pawn, by the inexorable ups and downs of every game.

The Great Khan tried to concentrate on the game: but it was the game's purpose that eluded him. Each game ends in a gain or a loss: but of what? What were the true stakes? A checkmate, beneath the foot of the king, knocked aside by the winner's hand, a black or a white square remains. By disembodying his conquests to reduce them to the essential, Kublai had arrived at the extreme operation: the definitive conquest, of which the empire's multiform treasures were only illusory envelopes. It was reduced to a square of planed wood: nothingness….

Then Marco Polo spoke: "Your chessboard, Sire, is inlaid with two woods: ebony and maple. The square on which your enlightened gaze is fixed was cut from the ring of a trunk that grew in a year of draught: you see how its fibres are arranged? Here a barely hinted knot can be made out: a bud tried to burgeon on a premature spring day, but the night's frost forced it to desist."

Until then the Great Khan had not realised that the foreigner knew how to express himself fluently in his language, but it was not his fluency that amazed him.

"Here is a thicker pore: perhaps it was a larvum's nest; not a woodworm, because, once born, it would have begun to dig, but a caterpillar that gnawed the leaves and was the cause of the tree's being chosen for chopping down…

This edge was scored by the wood carver with his gouge so that it would adhere to the next square, more protruding…"

The quantity of things that could be read in a little piece of smooth and empty wood overwhelmed Kublai; Polo was already talking about ebony forests, about rafts laden with logs that come down the rivers, of docks, of women at the windows….

Invisible Cities – Italo Calvino

THE 21ST CENTURY TEACHER

"Which mask shall I wear today?" asked the teacher looking in the mirror.

"It all depends what day it is!" the mirror replied….

"Is it Short Courses-day, Committee-day, Lecture-day, Examiners meeting day, TQA-day, COST-day, Paper submission deadline-day, External funding bodies meeting-day"? *P. Kapranos*

Every year I spent a lot of time on improvements to the various undergraduate modules I teach. This is done through reflection of what I do and on the feedback from students and colleagues. That means that I have to spend more TIME on updating and changing notes, sometimes even drastic changes such as the possible introduction of interactive case studies. However, I feel that teaching is all about creating the appropriate '*environment*' for learning to take place. If we are given the serious task of educating or influencing minds (young or old), the least they deserve is the commitment from us that we will do our best to facilitate the process of learning.

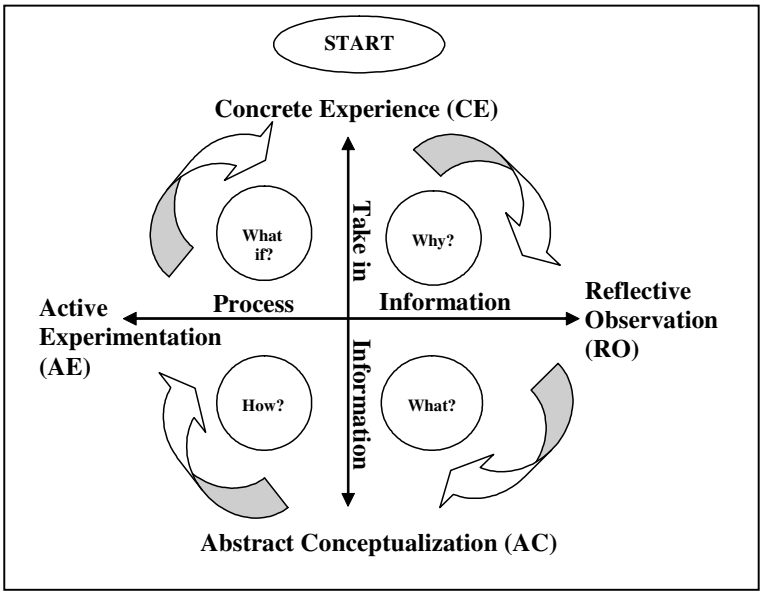

Figure 2. Kolb learning model [10]

Effective teachers are by definition reflective practitioners. Continuous progress in their practice, the search for novel and better ways of engaging and challenging their students as well as themselves are second nature. They have been trained to analyse their performance as communicators and to objectively look for ways to make the difference, i.e. reflective practice is an established part of the teaching/learning culture or is it?
I fear that not many teachers in academia are 'qualified' as teachers. Depending on the nature of the establishment many see teaching as something of secondary importance to research if not as a direct hindrance to it. Reflecting practice is a time consuming process and TIME is a commodity that academics do not have in abundance.

Nevertheless, if teaching is to be a meaningful activity, every teacher must be allowed the luxury of TIME and TOOLS to step back and assess their individual part within the educational context. This clearly will be a struggle and every struggle embodies a dilemma to which a balanced but optimised solution **must** be sought. It is only by reflecting on our own experiences that we can make the necessary changes; clarifying the vague, breaking through barriers, changing through positive experiences, gaining insight, learning, engaging our creativity, allowing our potential to flourish.
I subscribe to the notion that ideas are not fixed or unchanging elements of thought but are formed and re-formed through our 'experiences'. I therefore decided that since my approach to teaching and learning revolves around the Kolb learning cycle it would be appropriate to report on my experiences through teaching my undergraduate students in an action research set-up (Figure 2).
Motivation is highly dependent on personal involvement in the successful completion of various tasks. If one has a personal stake in something, as well as being interested in it, chances are that they will be much more motivated in getting on with it rather than if it were imposed on them from outside (intrinsic as opposed to extrinsic rewards). I give my students 'a stake' into what I am doing and the result is that I almost get full cooperation with responses to my questionnaires, contrary to the expectations of many of my colleagues.

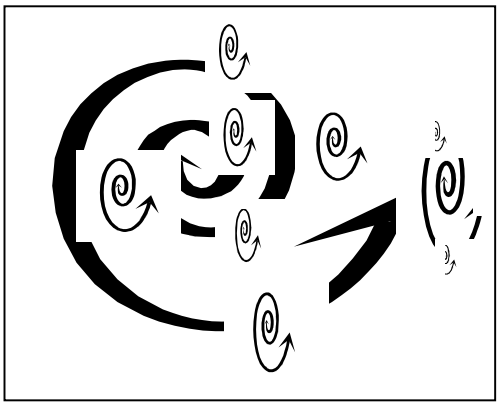

Figure 3. The unlimited cycles in the 'reflection in action spiral' after McNiff [1984].

Of course this process is a spiral one, the iterations continue every time the cycle is repeated resulting to what I hope is an improvement to my practice. This '*recursively improving practice*' is well described as a cycle of cycles by McNiff [11] and shown in Figure 3, where each individual cycle consists of: identification of problem – imagination of solution – implementation of the solution – evaluation of the solution – modification of practice. Each such cycle may be taken as the germ of a system that generates an unlimited number of cycles that operate in a similar fashion.
Of course that takes us back to the issues of 'What constitutes education/learning?' [12]. Should education be about the development of the individual or should it focus in meeting the requirements of society? Should education manifest

itself as the development of the individual or as a set of skills and knowledge that will get the individual employment? There is clearly a dichotomy of purpose and this dichotomy manifests itself through the various curricula. However, although the social and individual needs are not the same, they do clearly overlap.

There is need to see the commonalities of purpose as the base of an education that fulfils both tasks at the same time. It must be understood that education is multifaceted and it must serve a number of purposes. In addition, rather than viewing the educational purposes as neat little linearly connected boxes, they could be envisaged as part of a 3-dimensional continuum all interconnected, each having an influence on the others and vice versa (see Figure 1). In our search for a meaning, we might be forced to step back and reflect before jumping onto whatever bandwagon is fashionable in educational circles (that does happen).

If we perceive, and democratically convince others, that there is underlying unity, then there is scope for a potential working consensus however tenuous, imbalanced or adversarial that may be. We must first establish values that are commonly agreed upon across society and not whether there are any values that should be agreed upon across society. Agreement on such values can be compatible with different interpretations and applications of them. If we perceive the differences in educational aims (the strains in the model) as a potentially healthy source of dynamism in a continuously changing real world that might allow us to focus on the need for adaptability to our perpetually changing needs, purposes and values. When things get out of balance because of change, we can expect that by adapting our views accordingly the imbalance in the system can be corrected (alleviation of the strains in the atomic model).
Of course the real problem in the curriculum is how to proceed when there is a continuous state of flux in our aims and priorities. How can effective educational programmes are built on unstable and shifting ground. This is more a practical and political problem rather than a philosophical one.
The grand aims of education are clear*: 'We should aim at the transmission of knowledge, the good of society and a good life for the individual'*. The key question is how do we proceed when these aims are or appear to be in conflict?
One way forward, without the risk of aimlessness and further elaborate procedural rituals, is that we must strive in building a consensual basis on the aims of education upon which in a spirit of ***tolerance*** *and through* ***critical examination*** *and* ***open debate*** *can hope to arrive to a convergence of conclusions. Hope lies in the perpetual process of understanding and reaching reasonable accommodations rather than the attainment of any final solutions.*

Nothing is simple, linear or predictable in human affairs. Teaching, is above all, an intensely human and interactive activity, if not, it is not done correctly. There are different learning styles, a plethora of educational aims, a variety of curricula, a profusion of communication techniques, different skills to be taught and learnt, negotiations, administrational duties, philosophical aspects, professional aspects, psychological aspects, practical aspects, institutions, funding bodies, and a myriad of other factors to be considered by the teachers in their daily duties. Above all, there are the human interactions, with students, colleagues and outside agencies.
Therefore, first of all the teacher must be able to juggle; keep all these balls up in the air; a tough act to follow!

It is all too easy for the conscientious teacher to take the total responsibility of learning on their shoulders, after all teachers often speak of their work as a vocation. Teaching often becomes synonymous with a calling distinguished by selfless service to students and educational institutions. To imagine that the performance of their students is directly related to theirs and their failings are their failings, we move into the teacher-martyr-wreck syndrome.
Ensuring that the students realise their responsibilities in the learning process does not translate to the shedding of responsibility but the sharing of responsibility. It is a partnership that has to be negotiated and nurtured in order to bear fruit and it certainly proves much more productive than the one-sided martyr syndrome.

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