Experiences of a critical thinking approach in engineering practice

M J Barr

Maurice Barr is a Chartered Engineer and a Member of IMechE and IET. He has spent the majority of his career in the automotive, rail and power industries. He was a founding Director of Alexander Dennis Ltd in Falkirk and served for 4 years as President of Diamond Power International Incorporated in Lancaster, Ohio, USA. He is a Director of Star Refrigeration Ltd, based in Glasgow

Abstract

The author reflects on how his ability as a critical thinker developed from his early experience as a student working with a manufacturer. He emphasises the need to get engaged with problems, working collaboratively towards solutions.

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Introduction

This paper was inspired by a review that I made of the IES strategy report *The discipline of critical thinking*[1] in which Iain MacLeod emphasises that it is necessary to exercise the development of a suitable mindset to succeed when seeking to solve complex problems. He states:

> "Ethos is the core issue. Critical thinkers need to be students, in the sense 'one who studies', of the thinking modes/ principles that guide their actions. They need to collect guiding principles, and discipline their minds to use them – to avoid, for example, blind acceptance of what their intuition prompts them to do. Most people can adopt such a discipline but it best practised in the company of others and one should learn to adopt it from an early age. Therefore, it should become a discipline in another sense, i.e. a 'branch of learning' in education"

'Ethos' is a very important point. Problem solving needs to be approached with a 'humble confidence'. It is important to 'walk towards the problem' and to engage it rather than position oneself 'away' from the problem. During my early working years, I worked with a Senior Design Engineering Manager who acted as the conduit for all communication from production back to design.

We tended to 'get stuck in' to any concerns that were identified with the hope that we could help to solve or at least improve them, but we observed many others who put energy instead into ensuring that the 'bright light of enquiry' did not or could not shine on them. Ethos matters.

1 *https://www.engineers.scot/office/resources/publications/discipline-ct.pdf*

The point about the need for a high level of expertise when addressing complex problems is also important. There are many people who have the skills and knowledge to solve problems but for some reason just will not engage. Perhaps the fear of being involved in a high-profile team that might not ultimately solve a problem puts people off from offering their expertise. The 'driving in of fear' has been a powerful factor in human behaviour. Consider, for example, a task force appointed to the job of improving the punctuality of the rail service. If the team were to get train punctuality from 88% on time to 99.3% on time then that would be a great improvement, but it is the 0.7% not on time that will be front page news. A member of the task force may feel that his friends will tell him that his team was a failure – do they want that? So 'humble confidence' is important. Get the right people together in a collaborative effort, with no preconceived ideas and a firm belief that a much-improved position can be achieved through the various skills and experiences of the team.

The background to critical thinking

The strategy report places the issue of critical thinking in a historical context by citing several examples including the design of the Panama Canal, the improvement of the Glasgow water supply and the prevention of scurvy in the 18th Century. The scurvy example is particularly interesting – there must have been so many theories as to what scurvy was and why it was there. It is also very interesting that the first use of a form of systematic clinical trial played a part.

I can probably relate most to the example of Deming's philosophy of continuous improvement. I have used most of those tools quite a lot and I find them very powerful and, importantly, trainable (but still needing a disciplined mind). In my role as a production manager within a large manufacturing plant, using the seven-step problem solving process and learning to search for the root cause rather than addressing the next evident symptom was a formative experience. I observed that it took some time for people to realise that they could do something about a problem, because they were culturally conditioned to avoid the bright light of enquiry. However, once they realised that problems were being examined in a 'no blame' environment it unlocked creativity in problem resolution and also set the team up well for realising that these skills could then be turned to continual improvement. This uses the same skillset but it is presented with a different spin. It was quickly evident that the team moved from negative stress to positive stress and utilising the skillset truly became fun.

Another important concept is value added vs non-value added. Problem solvers can sometimes get too consumed with the virtues of waste elimination and leanness which may discourage other types of people from engaging in the process. However, there definitely comes a point once the mists of waste have been cleared a bit by critical thinking, when the benefit of adding value becomes more visible. At this point it is useful for innovators, who are sometimes bored by systematic problem solving, to join the team. It is the value added that the world wants – not the joys of waste elimination and leanness. In other words, it is the illumination not the method of illumination that is valued. When the continual improvers have almost perfected the filament bulb, they can sometimes feel gazumped by the LED innovators. There is a powerful and interesting organisational dynamic in getting improvers and innovators working together.

I also recall from my 'lean' days, the 50:50:50 approach. This definitely builds on the continual improvement philosophy. The idea here is to reduce the 'harm' by 50% rather than eliminate it. Once this is achieved then a further 50% reduction is targetted, and so on until the residual harm is no longer seen as significant. The group can then keep going with continual improvement and value-added innovation.

Taking the previously mentioned example of train punctuality at 88% (12% short of perfect), the first goal would be a reduction of 6%. This is a very suitable project for the seven step problem solving process, as

techniques such as Pareto and brainstorming tend to spit out collaborative consensus on the first things to address and enable actual performance change to be achieved rapidly. This is the so-called "low hanging fruit" but even at this stage there will still be a boffin in the corner developing the perfect algorithm to cure everything. When the first 50% goal is achieved, punctuality will now be above 94%, so the gap is now 6% and the next goal is a 3% reduction. Funnily enough Pareto and brainstorming will again give significant pointers to the next step and actions can once more be implemented quickly. Meanwhile the algorithm is almost finished in the corner. Punctuality is now 97% so the next goal is 1.5% improvement and when the team achieves this we are now at 98.5%. The next 50% goal is 0.8% and this takes us to 99.3% – a big improvement from 88% punctuality, generally achieved quite rapidly.

This is a strong example of continual improvement beating postponed perfection. I used this approach a lot in reliability improvement and in warranty cost reduction – where sometimes the search for best becomes the enemy of better. It is often found when the first 2 or 3 '50%s' have been completed that it is then possible to build a much simpler algorithmic model which can take you close to 'perfection'.

The strategy report moves on from these examples to consider the question of critical thinking in the political sphere. This is outside of my experience but it is evident that politics is about power and this seems to induce a corrosive rather than a collaborative approach, where blame seems to thrive. It is obvious that this corrosive approach is a failure in industry, so it seems unreasonable to expect any better result when it is applied in the political arena.

Principles for critical thinking

The report describes the different approaches that can be employed for problem solving, based on the ideas of Daniel Kahneman in his book "Thinking Fast and Slow" (Kahneman, 2012). Kahneman identifies two modes of thought, drawing an analogy of a computer with two operating systems; a fast one for snap decisions based on intuition and simple rules and a slow one for judgments based on evidence and logic.

I have a level of intuition in certain topics. I can remember, and I have tried to learn from, being criticised for 'just knowing the right things to do' in certain circumstances. The criticism was that I did not or indeed could not share my logic in coming to that assessment. My colleagues were, quite rightly, frustrated by that.

I have also spent hours diligently working through a problem and reaching the conclusion that the 'intuitive' person had come to at the get-go. This made me feel foolish but I took some solace from having 'tested' the intuitive proposal to some extent.

It is hard to know when the intuitive person 'just knows it', and unless one is strong minded and disciplined then intuition spoken loudly and confidently from someone with an intuitive track record can win the day but be harmful to the desired outcome.

I would certainly agree that well taught, critical thinking would give the skills to ensure that intuition was at least diligently tested, and hopefully evaluated against another selection of solutions derived through a structured problem-solving process.

I did not learn the full suite of problem-solving approaches at university. I learned a lot on industrial placement and as a Graduate Trainee through being allowed a free hand to watch hours of 'Lean Manufacturing' material and being encouraged to practise it with multi-disciplinary teams.

I became confident through experience that 'Continual Improvement beats Postponed Perfection' and that 'Best is the Enemy of Better'. I am comfortable and confident in not having a fully perfect solution. I am fairly OK with someone identifying small flaws in my solution – these are the next opportunities for improvement. One has to be strong minded not to shelve the 'better' because it is not yet perfect. In any case, by the time it has been made perfect, the innovators will probably have changed the game by then.

My time working for the Senior Design Engineering Manager gave me an early introduction to project-based learning. We could not be sure why what was wrong was wrong – we just knew that something was wrong. We did not know if it was the base design, the capability of the supply chain or an error in the assembly process. We worked in a 'political' environment where much effort was being applied to avoiding blame rather than embracing every concern as a learning opportunity. So whilst not at the level of vitamin C and scurvy, we still had to navigate uncertainty and untravelled waters.

This worked out well for me so elements of my education must have helped at that time, but I feel sure that the approaches to Education for Critical Thinking suggested in the report will be very beneficial and effective for the next generation of engineers and for society as a whole.