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Educating judgement

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ABSTRACT: The word *judgement* generally brings to mind serious older men in long wigs, who listen more or less attentively to long, boring, speeches by men and women of various ages in short wigs, and, after all that drama, the long wigs either make up their minds on the evidence or are told by a group, usually 12 ordinary citizens, what conclusion to reach. That is the English system that Australia has inherited, which has been lampooned by W.S. Gilbert and given a generally faithful rendition by J. Mortimor. The Americans do it slightly differently, and the Europeans do it very differently. But that is an outline of the usual application of the word. So where and how does the word fit into engineering? And how does it fit into engineering education? These are two questions that need to be answered. The article will discuss judgement generally, how judgement is used in engineering, and how that might be improved by including some aspects of judgement in engineering education.

INTRODUCTION

The usual application of the word *judgement* is in the legal profession, so we can begin by taking a definition from that source:

> *Judgment the determination of a court of competent jurisdiction upon matters submitted to it; a final determination of the rights of the parties to a lawsuit* [1].

That is a very limiting definition, covering only what a *judge* does, and not allowing for spreading the action into other professions.

At this point, we should check what is known about the *judgement process* more generally; a more liberal dictionary states the following:

> *Judgment: the act of judging; a judicial decision; mental faculty of deciding correctly by the comparison of facts and ideas; penetration; intelligence; criticism; opinion; punishment inflicted by God; the final trial of mankind by God; judgment day* [2].

For the purposes of this article, the last three items in the above definition will not be considered. The third (*mental faculty of deciding correctly by the comparison of facts and ideas*) gives a good indication about how a judgement is made by a human being. The inclusion of the word *opinion* is definitely more liberal, for it allows that judgement may be individual.

THE JUDGEMENT PROCESS

Before proceeding to the use of judgement in engineering, it is worth a moment to consider how the bewigged judges make their decisions. Although the law, whatever it may say about the case, generally makes decisions on evidence, there are two ways by which the decision may be reached, depending on the nature of the case before them. If it is a criminal matter, the decision should be made *beyond all reasonable doubt*; if it is a civil case, the decision may be based on probability, on the preponderance of the evidence. However, both of these ideals can be upset by the English institution of the jury system, hence the criticism against it by W.S. Gilbert [3].

Very many cases, particularly criminal ones, are easily settled by reference to the laws of the land, as passed by either the Parliament in England (laws Australia inherited) or by the Australian Federal or State Parliaments.

The other novel bit of legal mystery Australia has taken from the English system is that termed *common law*, also termed *judge-made law* or precedence, because it is based on decisions made in the past, beginning nearly a thousand years ago, modified as necessary by changing customs through the centuries, so that a body of legal knowledge has been built up progressively [1].

This generally applies to civil matters and, because all of the judge-decisions that form the precedence system have been recorded, it is possible to look up what was decided in a previous similar case in the past and predict, reasonably well, what will happen today.

SOME THOUGHTS FROM THE CLASSICS

Clement Atlee delivered a very neat definition: *Judgement is what is needed to make important decisions on imperfect knowledge in a limited time* [4].

An earlier politician, Lord Salisbury, qualified the following:

> *To defend a bad policy as an* error of judgement *does not excuse it – the right functioning of a man's judgement is his most fundamental responsibility* [5].

A reflection on the voice of majority came from Dryden:

> *Nor is the people's judgement always true,*
> *The most may err as grossly as the few* [5].

William Shakespeare should also be included here: *Men's judgements are a parcel of their fortunes* [5].

A few points can be drawn from those memorable quotes, beginning with Atlee who referred to both *imperfect knowledge* and *limited time*. Those are both important factors in decision-making; when they are present, the judgement may almost be a guess. Reflecting on Atlee's period in British-European politics reminds the relevant generation of the English Prime Minister who signed a no-war agreement with Hitler, only to have war break out weeks later (an example of imperfect knowledge); Chamberlain did not know, could not know, what was on the other side's mind.

From an engineering or management viewpoint (or the two combined), Salisbury's remark fits very well; all we must do to apply it is to read *decision* for *policy*. Making good decisions is one of the strictest responsibilities of any profession, including engineering.

APPLYING JUDGEMENT IN ENGINEERING

First, one would expect members of the engineering profession to agree that there is no doubt that engineering work, at its most basic level, depends upon the use of known facts and the application of mathematical techniques. As an example of the facts we use, we know the safe stress that can be applied to any commonly used material, we know that we should not exceed that stress in practice, so we design components within the safe range.

However, situations can arise in which a stress calculation gives a result that is mathematically correct, but an experienced engineer will know, immediately, that it is not the *right* answer. The *right* answer comes from the engineer doing what the judge does in court: he sifts the information, concentrates on what is appropriate, relates that to precedents, and applies *judgement* to get an answer that makes sense. One may argue, probably unsuccessfully, whether the result comes from beyond all doubt or from the preponderance of the evidence, so the *right* answer most likely comes from a mixture of those two processes.

For example, the author recalls a situation in which an aspiring draftsman calculated the weight of a pipe to be supported and then the size of the support, which worked out to be the diameter of a 16 gauge wire (about 1.5 mm). So he specified that and was somewhat overcome when the senior engineer pointed out *that's not done, there are standard pipe clips which we use for this purpose*. The junior person was, sadly, quite *correct* with his calculation, but his judgement was wrong.

Now, if it is agreed that this is the way an experienced engineer works, we come to the second question: how do we include that in engineering education? Before that, is anything in engineering education presently to tell students that they will, occasionally, have to discard their nice, neat, mathematical answers and solve problems by some other means?

Experience at one university has suggested that there is currently nothing. Against this, there is the impression from that establishment that telling students they will have to work in such a way is expressing the grossest heresy. Perhaps all that can be done is mention that judgement will be needed, sometimes, more of which follows in a later section.

FOLLOWING FROM THAT

There is an unfortunate follow-on from the observation that engineers use judgement. Although much engineering work is performed by using judgement, that is a process or practice that is not truly reliable and provides an opportunity for error. This can be illustrated by reference to judges in court: there have been cases where the judge's judgement-decision has been wrong. The same can happen in engineering: engineers can make mistakes. Indeed, a research project has shown that there are several often-occurring, quite *normal* conditions that readily cause mistakes, and has exposed some of the reasons why intelligent and well-intended people will make wrong decisions [6].

Here is another example from the author's past: a junior engineer who had fallen behind in progress with a project he was managing, around A$50,000 in today's terms. The reason for slipping was, of course, he was not only learning engineering, he was learning self-management and efficient use of his own time. With the best of (self-preservation) intentions, he faked a couple of monthly reports so that the senior engineer to whom he reported thought all was well: progress was occurring as planned.

But something happened quite by chance: the senior found out less than a week before the finishing date and confronted the junior, who confessed, almost in tears, which is embarrassing for any adult male, and certainly was for those on both sides of such a conversation. The senior was faced with two decisions: what to do about the project? And what to do about the junior? There was also a third question: which of these has the higher priority?

Getting the job finished was *numero uno*. Strings were pulled, debts were called in, other debts were agreed, and the work was finished on the scheduled day. Then came the other decision. The senior thought back over his own past, thought about the junior's future, thought over what little he knew of someone who had been with him for only a couple of years (imperfect knowledge) and the need to act swiftly now the job was done (limited time), then *made a decision based solely on judgement.* He settled for giving the junior some reflective advice.

Was that good judgement? It could have been bad. Like many management decisions, the correctness of the decision can only be determined by the outcome. The junior engineer improved his work efficiency and effectiveness, left the firm a few years later, went into marketing with an international engineering firm, and became an area manager with that firm.

JUDGEMENT, GENERALLY

So, it appears that some decisions in many walks of life cannot be made entirely by the use of objective techniques and require

the use of the mysterious element termed *judgement*. This is not what is pronounced in a court of law by a judge, based on evidence presented by lawyers and witnesses, some expert and some lay, the balance of probabilities, beyond all possible shadow of doubt, rather it is what a manager uses when facing a decision with imperfect knowledge and limited time or, alternatively, a truly unprogrammed decision. He/she utilises a *judgement technique* that may be perfectly rational to him/her but may, or may not, appear to be rational to others.

The type of decision-making in which an individual's judgement is required has been called *judgement call*, a phrase originally from the USA military that has now been taken up by business [7]. Expressing the need for such a type of decision is often indicated by another person saying to the decision-maker: *It's your call*.

How is a judgement-call-decision defined? It is a choice in a high stakes environment between two or more poorly identified options. The choice must also be based on ambiguous information while facing conflicting goals, often with a close time horizon.

What are the characteristics or parameters of judgement calls? First, here are some typical situations that identify those decision elements to be weighed up:

1. To shoot or not to shoot (clearly a military example), or to go ahead or to not go ahead.
2. To stay or to quit.
3. To retain present security or to seek future possible gain.
4. To accept risk or to retain security (related to 3 above).
5. To indulge in chance or to maintain control (combining 3 and 4 above) [7].

Regarding the fourth set states above: a person should bear in mind that risk is expressed pseudo-mathematically as the product of consequences (damage or injuries caused by an undesirable event following a decision) and the probability or uncertainty (of the event occurring). Some low-probability (very unlikely to occur) events have serious consequences (and may occur, although improbable).

The following understanding elements will assist decision action in determining how to answer a judgement call:

- Find the cause of the problem (which may be difficult if time is short).
- Choose a frame of reference (how does the cause relate to the situation?).
- Use reason rather than emotion (but recognise that feelings may be helpful) [7].

It is the author's opinion that these elements are very good and make sense, but if we lack information, how sure can we be of the cause of the problem? How sure can a person be that any selected frame of reference is appropriate? How can we separate our brain-level reasoning process from our gut-feeling sense of what may be *right*, even if a rational analysis makes it appear to be *wrong*.

With all that covered, the nine steps that should help in any decision-making situation can now be reviewed:

1. Be sure of the desired goals or objectives.
2. Observe a need or a deficiency in the path towards those goals or objectives.
3. Ask the question: does that present a problem?
4. If so, identify and express the problem clearly.
5. Generate options to solve the problem.
6. Assess and evaluate the options.
7. Choose an option (strategy) and decide what to do (tactics).
8. Implement and act.
9. Monitor progress and results [8].

It can now be seen why a judgement call decision can be difficult! It is because in an unprogrammed decision, a judgement situation, Steps 1 to 6 involve uncertain, possibly conflicting, goals, a lack of accurate information, as well as time constraints, with a background awareness that getting it wrong may have serious consequences!

The one serious consequence from this decision situation is an intermediate condition, prior to the ultimate consequence; it is what happens as soon as the Cooper's *commitment to action* occurs [8]. It is also when the decision-maker reaches *the point of no return* [7]. It is like stepping on a banana skin or a patch of oil on the pavement: once the step has been taken, opportunities for recovery are severely limited and most often do not exist.

And *that* is why a judgement-call-decision needs to be a correctly-made decision. There is, almost always, no second chance to allow going over and correcting what was done. It is rare when the rewind button of life can be pressed and a person can rerun the event to correct whatever went wrong. These rare occasions when such a thing is possible are the result of sheer luck, another mystery-management quality.

Nevertheless, many managers make judgement-call-decisions successfully. How? By practice? By *cheating*, falling back on perhaps-ill-remembered incidents from the individual's past? Or, like judges in court, by precedent, from previous cases provided by others? Or is it by some negative-selection reason, because those who are successful are the managers who do not avoid making such decisions? There is scope for research in this.

EDUCATING JUDGEMENT

Even if experienced practicing engineers agree with the author that some engineering decisions are make by using judgement, there is (as remarked earlier) an impression from academic life that judgement is a heresy.

So how can we teach engineering students to use judgement, particularly when nearly all engineering is taught in number-related terms, and where there is little, if any, scope for judgement?

Perhaps we can be advised by this never-ending syllogism:

Judgement cannot be learned or taught.
It comes from experience.
Experience is gained by making mistakes.
Mistakes are made because of poor judgement.
Which is because judgement cannot be learned - - -
And comes from - - -

That syllogism brings to mind G.B. Shaw's saying: *youth is wasted on the young*; from which it may be deduced that the young engineer's viewpoint is: *experience is wasted on maturity*.

All this leads to a couple of ideas that might be used to help students learn about judgement. One is to offer literature on engineering mistakes, such as by Kletz, Lancaster and many others, which would be using other people's mistakes (aha!) from which student can learn [10][11]. Against that desirable outcome, unfortunately, it can be argued that even well-instructed people can find new and ingenious ways of making old mistakes in fresh contexts.

Another suggestion is to bring into some classes, with design probably the most apt, experienced engineers who are prepared to admit to and talk about mistakes they have made. That may be difficult, easier in the third person than the first.

As an example of what could be presented, there is, at present, litigation proceeding between several parties over a design (which cannot, of course, be detailed here with the matter in progress), which, now that it has failed in several ways, has some *absolutely obvious and fundamental* errors from the very beginning. Yet the owners, developers, builders, the team of consulting engineers and the fabricators went ahead blithely and produced something quite useless.

The intention is to focus on mistakes made by poor judgement. It would be good if students could be allowed, even persuaded or led, to make mistakes so that they can learn from them, but a core problem in that is the entrenched concept in tertiary education that *we are there to teach*, even though the concept of *learning* has been flogged for years, and teaching how to make mistakes goes against the grain.

The only subject in this author's experience that permitted, even encouraged, making mistakes was one designed to teach engineering students the basics of management. In that subject, students were given a series of ten assignments through a semester in which they had to make decisions; if they made poor decisions early, they had the opportunity to recognise and correct their decision-making as the weeks progressed.

The subject's aim was to prepare students for being managers in the hope that they would make enough mistakes in class to prevent them making mistakes as managers, as writers like Hartley have presented [12].

Can we teach judgement in engineering subjects? Perhaps, even to a small extent. The suggestions given above might be tried by an audacious heretic.

CONCLUSION

There is sure to be debate on whether we can reach agreement on the use of judgement in engineering. However, there is reasonable evidence in practice and in the literature that some human activity called *judgement* exists and is used in some professions.

It may be *instructed guesswork*. It may be *cheating* by using what has been learned by experience. Sometimes, it may be taking a bold leap into the unknown and just happening to get the right answer or result. It may be an ability to discriminate between alternatives and choose the right one.

The success of those people who have to indulge in decision-making in their profession does not appear to depend on knowledge of the formal processes of how to reason through a problem, but rather on some other quality that helps them *be right more often*. So this factor is dubbed *judgement*, and if their *judgement* is good, the results of the decisions will be good.

That *other quality* that helps managers to be right more often is, of course, the factor called *experience*, which is time-related, and that, also of course, is why it is not generally, usually, present in most fresh graduates in the younger age group. Thirty-plus years ago, when the author was teaching technical college students, many of those in a class were mature-age and had enough experience to discriminate by using judgement.

Nowadays, as most students come into tertiary study soon after high school, they lack that experience. As such, lecturers should act to instil the mysterious quality called, perhaps for want of something more precise, *judgement*.

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