An Information-Centric View on Decision Making

Brett A. Becker
Griffith College Dublin
South Circular Road, Dublin 8, Ireland
brett.becker@gcd.ie

Abstract

Humans are being exposed to consistently increasing volumes of information with time. Excluding emotions it is a subset of this information upon which all decisions are made, and the way this information is interpreted and utilised affects these decisions. Student ability to adeptly interpret and use all information, not just that delivered in academic settings is clearly valuable in making better decisions. The high-level nature of this view incorporates decisions made across all disciplines.

This paper presents a perspective on what all students should be taught about the process of interpreting information and making decisions. The main goals are teaching students how to filter, interpret, validate, weigh, reject, utilise and present information in a systematic way, ensuring that the information upon which decisions are made is rationally and logically sound, leading to better decisions regardless of the specific problem at hand or problem domain. This is not a complete pedagogical method but a modular component which can be integrated with existing methods.

This perspective is based on the idea that basic decision making can and should be an adaptable and evolutionary tool useful across broad domains, and that all students should be proficient in. This view does not include the teaching of static methods used to solve a specific problem or problem type. The ultimate goal is to benefit the quality of the decision making skills of students in all academic disciplines.

Finally, results of a brief survey conducted to give an insight into undergraduate students' abilites to interpret and filter information and the quality of decisions based on that information are presented.

***Keywords*:** scientific analysis, decision making, problem solving, cross-disciplinary education, critical thinking

Introduction

Regardless of discipline, decision making skills are indispensable, valuable and necessary tools for all students. The decision making process has been well studied but most research focuses on specific disciplines such as science and technology (Bell and Lederman, 2003), or present focused strategies and methods (Saaty, 2008), (Heywood, 1996) and (Triantaphyllou, 2000). Little research has been presented on more broad and universal ideas such as (Gregory and Clemen, 1999).

Perhaps the most prevalent method of teaching is the presentation of problems which are to be solved, and the quality of the decisions made in the solution process then assessed. No problem can be solved without information. In fact the problem statement itself is information and should be treated as such. Accordingly, the problem should be subject to the same scrutiny and analysis that the information used to make a final decision is. This concept is all too often neglected by students.

All students can benefit from better decision making skills, regardless of specific discipline – for comprehensive overviews of work in the study of general decision making see (Costa, 2001). It is students' decisions upon which not only assessment, but the presence and quality of their skill and knowledge is based. Many pedagogical methods either neglect this, take it for granted, or are rooted in a motive which overlooks the importance of general decision making skills.

Naturally, information can be misleading, flawed, biased, or completely incorrect. A discerning glance at any reputable newspaper inevitably reveals headlines reporting results of studies that are extrapolated upon and paraphrased by non-experts, opinion polls presented with little or no statistical validity, and other questionable or pseudo-scientific presentations. All sources of information and all information channels including teaching are susceptible to these problems. As the view presented in this paper is information-centric, dealing with and using all information correctly is of the utmost importance.

This paper consists of two sections. The first proposes an outline of a broad-based view on how students should be taught to make decisions, and highlights areas where the decision making process can break down. This view is based upon the fact that excluding human emotion, all decisions are based on the interpretation, filtering, and absorption of information available to the decision maker. The amount of information available to students is growing exponentially with time. How this

information is interpreted and utilised is essential to good decision making. The second section presents the results of a survey which was designed to give a brief insight to the average undergraduate student's ability to deal with information and the decisions made based upon that information.

In the most general form, the premise of this paper can be described by the following – Just as math is not about numbers, but about quantity (Royer, 2003), decision making is not about solving problems, it is about interpreting and using information.

1. An Information-Centric View on Decision Making

This section presents a set of concepts from which all students can benefit. Combined, they have been designed for two primary reasons. The first is to help any student, regardless of discipline, to make better decisions. The second is for these concepts, as a single modular unit, to be easily incorporated into any other pedagogical methodology without conflict. This is a property shared by teaching theories such as constructivism. For more, see (Fosnot, 1996).

Six concepts are proposed which together address the decision making process from first contact with the problem and accompanying information through to the final step, presentation of the decision(s) made. Those steps are:

1. Problem Definition, Analysis and Tractability
2. Information Filtering
3. Information Validation
4. Information Absorption and Decision Making
5. Decision Validation
6. Decision Presentation

1.1 Problem Definition, Analysis and Tractability

The first thing students need to consider when presented with a problem is – what exactly is the problem definition? This step is often overlooked by many students. Most problems posed in an academic setting inevitably (and possibly by design) leave some aspects of the problem up to student interpretation. It can be argued that almost all real-world problems suffer a greater degree of ambiguity as to

definition, as these problems are not designed for the purpose of an educational exercise, but often arise from natural circumstance. Thus, it is left to the student to determine what the exact problem being posed is and what is being asked.

There is always a second consideration involved before solving a problem – is the problem worth solving? Most real-world problems should not be viewed as being isolated from others; often they are not independent but related in some way. Would a solution to the specific problem at hand help work towards or achieve the overall goal being sought? Wasting time and effort on seeking a solution to a problem that will not help solve other problems is in most cases a problem not worth solving (academic and personal curiosities aside).

After deciding that a problem is worth solving perhaps the most daunting challenge awaits. All problems inherently come with a hidden facet - Is the problem itself tractable? There is no point in trying to solve a problem if the problem itself is not solvable. The existence and prevalence of problems that are not tractable is often not conveyed to students with enough rigor or emphasis.

A popular example of an intractable problem is the travelling salesperson problem (TSP)[1]. The problem may be stated in general form as follows: Given a number of cities with the distances between every pair known, what is the round-trip route visiting each city exactly once (then returning back to the origin) which minimises the distance travelled? The TSP has applications and analogues in many real-world areas including logistics, economics, and electronics to name but a few.

The TSP involving a dozen or so cities is solvable by brute force - all possible routes can be traversed and the optimal solution selected. However if the number of cities is increased to a few hundred the problem becomes strikingly difficult. One advanced technique which attempted to solve the TSP with a problem size on the order of only 13,000 cities is estimated to need over 10 years to solve using 48 computers working in parallel (Applegate, 1998). A single person making one decision *per second* could not solve such a problem (using existing techniques) in a time period less than the estimated age of the universe - about 14 billion years.

Clearly an ability to assess the tractability of any problem, no matter how simple it appears to be is a necessary ability for all students to possess.

[1] The TSP belongs to a class of problems which has not to date been proven to be intractable (or tractable). It is however used to exemplify problems which at present and with current techniques displays all characteristics of being intractable.

1.2 Information Filtering

Once a problem has been committed to the decision process (definition decided and tractability assessed) the next step should be to decide what, if any, information is worthwhile utilising in the process. To this end, all students should be introduced to the concepts and concrete examples of pseudoscience, bias and superfluous information.

The hallmarks of pseudoscience are (but not limited to): the use of vague and/or misleading terms which do not have clear, known scientific definitions and uses (or misuse of those that do); the unwillingness or refusal to present methods, information, and data principal to the argument being presented or defended; the lack of repeatability of results; and presenting information in a way designed to suit a predetermined objective. All information presented in such a manner needs to be treated with the same care and scepticism as biased and superfluous information.

Biased information is simply that provided to the subject with the intent of swaying the decision making process in a particular direction. The warning signs of bias should be taught and methods of dealing with and avoiding bias dealt with.

Superfluous information is that which is either unintentionally provided yet has no bearing to the problem at hand or information which is intentionally provided to distract the subject from the relevant information. There is a subtle difference between this and bias, as superfluous information is not intended to steer a decision in a particular direction, but simply to confuse or distract (or has been provided completely unintentionally). Again students should be made aware of this, and taught how to identify and treat such information.

1.3 Information Validation

Even after a volume of information has been passed through the filtering process, its validity should still be in question and should be treated so. Central to the acceptance of the validity of information is the reliability of the primary source of the information. All students should be taught the importance of both validating references and in providing them (see 1.6 - Decision Presentation).

Obviously all information should come from reputable sources, a topic which is beyond the scope of this paper, but one concept that all students should be made

aware of is distance to source (DTS). The DTS is simply defined as the number of sources between the source providing the information and the primary source. In most popular media sources (such as newspapers) the distance to source is large, and often indeterminable. Any information taken from such a source should be treated with great care and scepticism.

1.4 Information Absorption and Decision Making

After filtering and validating the information that is to be used to make a decision, the issue of absorption and decision making itself should be dealt with. These are intrinsically cognitive and at times heuristic processes which do not lend themselves greatly to qualitative analysis. Indeed much of this stage may forever remain out of the reach of educators, at least directly. Nonetheless the human qualities of decision making can not and should not be ignored. It is in this step of the process that students should be taught and encouraged to subject the problem and information at hand to a scientific process of theoretically proposing a decision, assessing the implications of the decision, and hypothetically reasoning about the results that the proposed decision will bring about. Failure at any of these steps allows for the possibility of a less than optimal decision to result. Although this step in the information-to-decision process remains the most challenging to define and handle from an educational point of view, one possible inroad is to teach good practise in this area through repeated examples, both correct and incorrect in outcome.

1.5 Decision Validation

Once a decision has been reached the decision itself, like the information used to make the decision, has to be validated. Validating a decision is inherently different to the validation of information used in the decision making process. Namely a decision, unlike raw information, constitutes an act, and causes effect. Decisions change the current state of matters. A decision made today can affect another made tomorrow. These effects should be repeatable. A solution which has different effects at different times (under reasonably controlled environmental circumstance) is of little or no use. If the decision has been made to achieve a well defined goal from a well defined problem, repeatability is important.

At this point the main theme of this paper and its relationship to the Scientific Method becomes apparent. A full discussion of the validity of applying the Scientific Method across the curriculum is unfortunately beyond the scope of this paper; however a central feature of the Scientific Method is the repeatability of an experiment (or decision). In the case of a decision, thought-experiments should be undertaken, the purpose of which are to ensure that the desired goal can be achieved from the proposed decision, and that the decision has repeatable effects. If the decision that has been made leads to significantly differing effects under the change of small yet feasible changes in circumstance, the decision itself should be questioned, and possibly re-tooled, starting from the beginning.

1.6 Decision Presentation

All steps in the information-to-decision process discussed above deal with the interpretation and validity of information. At this point, even if a sound decision has been made it is of no use if the decision and its supporting factors can not be properly presented. Not withstanding the previously discussed factors there are still several more that must be considered when presenting a decision or the results thereof. Chief amongst these is error.

The error in a qualitative decision is difficult to assess, and perhaps for this reason is often ignored. However in presenting such a decision, a student should have a concept of the fact that their decision may not be completely correct, and the reasons and factors involved in that possibility need to be recognised, and preferably presented with the decision. This not only shows that the decision maker is open to outside opinion, but that they have thought about their decision thoroughly and not interjected their own bias.

No decision or solution which is quantitatively presented is meaningful without one of two things: a declared error factor or a statement describing why an error factor is not necessary, or has been omitted. A simple example can demonstrate this. Suppose a political poll reveals that 25% of people have voted for candidate *A*, with an error of +/- 5%. A second poll says that 19% of people have voted for candidate *A*, but has not reported an error or a reason for not doing so. The lack of an error factor or explanation for the lack thereof renders comparing the two polls practically meaningless. If an error of even 1% exists in the second poll there is a

possible overlap in the results meaning that both polls could be both correct and in agreement with each other.

Students should also understand the difference between two broad types of error that can appear both in the information used to make a decision and in the decision itself – random and systematic. A random error is not due to the nature of the information or decision itself, but due to outside factors that cannot be controlled or eliminated. A systematic error is due to a factor in the decision making process itself, and therefore without correction will lead to the same effects every time the same process is followed. Students should know about these errors, their effects, and how to identify and handle them.

Another very important topic not commonly taught and explained to students is that of precision and accuracy. It is entirely possible for a decision to lead to results which although very precise, are not accurate at all, and vice versa. Students need to understand this delicate relationship. An excellent source for more on the topics briefly discussed in this section is Taylor (1996).

2. Survey Results

To gather some evidence of the information processing and decision making abilities of typical undergraduate students a small cross sectional survey was conducted in June 2008 on a frame of 100 full-time undergraduate students. The method was simple random sampling. Two questions from the survey are presented here. Question 1 was designed to be unambiguous and since it has a definitive answer can lend some insight into the more difficult to ascertain aspects of decision making, including those discussed in 1.4 above.

Appendix 1.1 shows the breakdown of results. On average 42% of students answered the question correctly. One conclusion that can be drawn from this is simple – the basic problem solving skills of typical undergraduate students is lacking. Where those students answering incorrectly broke down is a difficult question to answer, but it is for this purpose the methods proposed in this paper are designed. These results only serve to highlight the lack of problem solving skills which exists in the given student population. Further analysis is the subject of future discussion.

Question 1

You want to buy a packet of crisps, ensuring that you get the best value for money. Only one brand of crisps is available but two different promotions are running.

Packet 1 – labelled weight: 100g; list price: 1 euro; promotion: 50% off list price

Packet 2 – labelled weight: 100g; list price: 1 euro; promotion: 50% more than labelled weight free

Which packet offers the best value for money?

A.) Packet 1 offers better value for money
B.) Packet 2 offers better value for money
C.) Both packets offer the same value for money

Question 2 was designed to assess the ability of students to interpret and filter information, and then to make decisions based on that information. The headline in Question 2a is from *The Daily Mail* (MacRae, 2008). The corresponding article was based on a study conducted by the World Cancer Research Fund. The headline is fraught with information filtering and absorption problems including but not limited to the following:

1. The headline is deceitful/biased, because it turns out not to be "your" risk of cancer that is increased, but *the* risk of cancer (WCRF, 2008).
2. The article is missing information such as the length of time one would have to eat "one sausage"[2] a day in order to increase the cancer risk.
3. It is not mentioned that the study results depend upon *everyone* eating one sausage a day for the same undisclosed amount of time.

Appendix 2a displays the results of Question 2a. The results are not surprising, as answer B is the obvious "safe answer" and may have been largely chosen because of that. However it provides an interesting and necessary segue into Question 2b, and some surprising results.

Question 2b was presented to respondents after they read and answered Question 2a. Question 2b purposely rules out the issues raised by Question 1a listed above. It poses a more analytical problem which has a *best* answer (B). Since the

[2] The article eventually discloses that "one sausage" is 50g of processed meat

overall incidence rate of bowel cancer in the UK is about 5% (CRUK, 2008) an increase in *the* rate of bowel cancer of 20% would contribute another 1% to that total. However this is dependent on all people eating one sausage a day *every day* for an undisclosed period of time. Surely the real answer is less than a 1% increase, but as the question is stated, the *best* answer is 1%.

Given the additional information in Question 2b, only 15% of respondents gave the *best* answer. The question could perhaps be rephrased as 'What is 20% of five?' which is very straightforward. It seems that the presence of superfluous and biased information, despite a statement which clarifies the overall question (by telling respondents to ignore any other questions they may have) leads to a confusion which prevents the simple question being asked from being apparent. It seems that perhaps it is not the answer which is elusive but the problem definition itself.

Question 2a.

A recent newspaper headline read "Why eating just one sausage a day increases your risk of [bowel]† cancer by 20 per cent".

Which of the following best describes what you think after reading the above headline:

A.) Eating one sausage a day increases your risk of bowel cancer by 20%
B.) Something other than the above

† information in square brackets added to headline in survey for clarity.

Question 2b. (given to respondents after answering question 2a.)

The answer to question 2a is not A. The study being reported on revealed that eating one sausage a day increases *the* risk of bowel cancer by 20%. At the time this study was done the chance of the average UK resident getting bowel cancer was 5%.

Based only on this information and taking it to be true (ignoring other questions you may have), which of the following *best* describes what this new information means to you?

A.) Eating one sausage a day increases your risk of bowel cancer by 20%
B.) Eating one sausage a day increases your risk of bowel cancer by 1%
C.) Eating one sausage a day increases your risk of bowel cancer by 5%
D.) Eating one sausage a day increases your risk of bowel cancer by 6%

A surprising result derived from this study is that 14% - almost the same amount who answered correctly – gave the same answer (A) in Questions 2a and 2b. This is after being told that the answer to Question 2a *was not* A. Even more interestingly, in 80%[3] of these cases, the *same* respondents account for those who did not change their answer. In other words, 80% of those who chose A as the answer to Question 2a gave the same answer to Question 2b, despite the additional information presented in Question 2b *and* being told that it was the incorrect answer. Again, further analysis is subject to discussion.

Conclusion and Future Work

All human decisions are based on information. Even the problems that provoke and demand decisions should be treated as information. This paper presents an information-centric view, which if communicated to students the author believes will benefit the decision making skills of all students. Students need to treat and handle all information appropriately – scientifically, systematically and rationally. This view seeks to lay the foundation for a modular teaching component which can be incorporated into any teaching method.

The survey presented in this paper is only intended to give a small insight to the abilities and shortfalls of the decision making abilities of the average student. Future work will involve a larger, more thorough and detailed survey designed to assess in much more depth the decision making characteristics, abilities, and shortcomings of students.

[3] Figure rounded to next greatest integer

References

Applegate, D. et al. (1998). On the Solution of Traveling Salesman Problems. *Documenta Mathematica*. (Extra Volume) pp. 645-56.

Arthur L. Costa (Ed.). (2001). *Developing Minds: A Resource Book for Teaching Thinking*. Alexandria, VA, USA: Association for Supervision & Curriculum Development.

Bell, L. and N. Lederman. (2003). *Understandings of the nature of science and decision making on science and technology based issues*, Wiley Publications, Journal of Science Education, Vol. 87, Issue 3, pp. 352-377.

CRUK (Cancer Research UK): UK Bowel Cancer incidence statistics (2008). Available from: http://info.cancerresearchuk.org/cancerstats/types/bowel/incidence/#source6 [Accessed 28 May 2008]

Fosnot, C.T. (Ed.). (1996). *Constructivism. Theory, Perspectives, and Practice.* New York: Teacher's College Press.

Gregory, S and R. Clemen. (1999). *Improving Students' Decision Making Skills.* Available from*:* http://faculty.fuqua.duke.edu/~clemen/bio/DMSkills.pdf [Accessed August 24, 2008]

Heywood, J. (1996). *An Engineering Approach to Teaching Decision-Making Skills in Schools Using an Engineering Heuristic.* 26th Frontiers in Education Conference, Vol. 1, Issue 9 pp. 67-73

MacRae, F. (2008). Why eating just one sausage a day increases your cancer risk by 20 per cent. *Daily Mail (UK)*, 31 March, 2008. Available from: http://www.dailymail.co.uk/health/article-550729/Why-eating-just-sausage-day-raises-cancer-risk-20-cent.html [Accessed 30 May 2008]

Royer, J. (Ed.). (2003). *Mathematical Cognition*. Charlotte, NC, USA: Information Age Press.

Saaty, T.L. (2008) *Decision making with the analytic hierarchy process* International Journal of Services Sciences, Vol. 1, No. 1, pp.83–98.

Taylor, J. (1996). *An Introduction to Error Analysis.* Salsalito, CA, USA: University Science Books.

Triantaphyllou, E. (2000) *Multi-Criteria Decision Making Methods: A Comparative Study*. Springer

WCRF (World Cancer Research Fund): Press Release (2008). Available from: http://www.wcrf-uk.org/press_media/releases/31032008.lasso [Accessed 28 May 2008]

Appendix 1 – results of Question 1 in survey. * represents the correct answer.

School	Number of students surveyed	Answers			Percentage answering correctly
		A*	B	C	
Arts and Celtic Studies	25	8	7	10	32
Business and Law	11	4	4	3	36
Human Sciences	20	10	3	7	50
Life Sciences	13	6	5	2	46
Engineering, Mathematical and Physical Sciences	16	7	5	4	44
Average percentage answering correctly:					**42**
95% confidence interval:					2

Appendix 2a – Results of Question 2a in survey. Confidence intervals were not calculated due to the qualitative nature of the question.

Answer	Percentage
A	16
B	84

Appendix 2b – Results of Question 2b in survey. * indicates *best* answer. Confidence intervals were not calculated due to the qualitative nature of the question.

Answer	Percentage
A	14
B*	15
C	35
D	36