



# Metacognition and Information System Students: How To Improve Outcomes Without Lowering Standards

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## ABSTRACT

*This paper considers the impact that instruction in cognition and metacognitive skills has and on student outcomes in one Information Systems course over three years. Some conditions and constraints regarding the teaching of Information Systems in the Australian universities sector are examined and discussed. Student performance data over a six semester period are analysed in order to assess the effect that changes to teaching practices and the inclusion of instruction in basic memory, cognitive style and processing has on student outcomes. It is strongly suggested that Information Systems curricula should change to include such metacognitive aspects.*

## INTRODUCTION

Many Australian academics are under pressure to achieve more with fewer resources. Increases in class sizes and decreases in government funding have occurred whilst the number of academics has remained relatively stable. The introduction of performance management and quality controls combined with the need to raise revenue from teaching has increased this pressure.

Educational theory would state that the learning processes are most effective when they are tailored to the cognitive style of the student. There are many instruments for assessing the cognitive style of students. Some of these such as Myers-Briggs, address personality as a factor (Dewar & Whittington, 2000) while others such as Sternberg-Wagner (Benson & Standing, 2001a) focus on processing styles. However the more sophisticated the instruments are, the more unwieldy they are in practice. No lecturer can afford the time and effort to present the curriculum from several perspectives and it would be a logistical nightmare to divide the class into smaller parts. Consequently many lecturers do not take cognitive style into account in their teaching practice.

## ACADEMIC TEACHING STYLES

A teaching qualification has been a prerequisite for many academic appointments made in the last ten years. Most Australian universities provide in service courses for lecturers and these include theories of learning and teaching. However, many academics are "time served" in that they have many years teaching experience but no formal or accredited training. The evaluations carried out in most universities and faculties do little to measure the effectiveness of teaching and become instead measurements of lecturer and subject popularity. Many academics were appointed on the basis of research and publication. Good researchers do not necessarily make good teachers.

A distinction needs to be made between pedagogy and teaching style, the latter depends on a number of personal factors and is often idiosyncratic since personality plays a major part in curriculum delivery. Informal interviews with 20 academics showed that the greatest influence on teaching style had nothing to do with teacher training or education. Instead, academics developed teaching styles and approaches based on their own experiences at college and university, basing their teaching practice on academic role models which they had found personally appealing, whilst avoiding practices and styles used by lecturers whom they had found boring, ineffectual or inept. All had some awareness of personality types and cognitive styles but only two used this in their own teaching. It would seem that the remaining members were teaching to classes which they imagined to be predominantly like

themselves with significant potential for teaching/cognitive style mismatch.

## IS THE MINDSET OF INFORMATION SYSTEMS ACADEMICS APPROPRIATE?

By the early 1970s information systems was beginning to appear in the curriculum of major American universities. As an emerging discipline it was neither pure science nor social science and its paradigms and infrastructure were ill-defined (Benson & Standing 2002, Weber, 1997). In a monistic view of science the boundaries of the discipline are usually clear, there is a paradigm (system of working) and infrastructure (journals, committees, etc.) that provide coherence (Banville and Landry 1989). While the research and publication areas of the emerging discipline of Information Systems owed much to the social sciences, its practice relied heavily on scientific, mathematic and engineering disciplines. Software was closely associated with the underlying hardware, indeed detailed knowledge of the underlying architecture and operation was essential if efficient programmes were to be written. As business began to use computers to process and filter huge quantities of data the demand for systems and their developers increased exponentially. The impact on computer technology in engineering and manufacturing had reduced the number of skilled people who were required. Many of these people migrated into Information Systems bringing with them a mindset that was grounded in logical thinking, rigour and mathematical notation. While the skills required by Information Systems (IS) graduates has been a frequently studied topic (Latham, 2000; Snoko & Underwood, 1999, Standing & Standing, 1999) (The debate usually centers on the relative importance, of technical skills, interpersonal and communication skills, and the depth of business knowledge and skills), little has been written about the skills required by information systems lecturers.

As near as it may be established the average age of an Australian Information Systems academic is 53 years. An informal analysis of the backgrounds and qualifications of Australian Information Systems academics shows that the overwhelming majority have qualifications in other disciplines and have migrated to Information Systems in later life, many from computer science. Information Systems curricula show a heavy dependency on 1980s and early 1990s thinking. The traditional systems life cycle view, derived from engineering disciplines, is no longer appropriate for many Information Systems projects. In particular Web commerce development projects require much shorter timelines and ability to respond to rapidly changing requirements than older projects. Newer systems also require different skills and thinking styles and it is hard to see where these are being engendered in university curricula.

Lecturers are unlikely to change their mindset and are insufficiently resourced to customise the curriculum at a micro level. The only practicable approach is to give students the resources they need to customise the curriculum to suit their own cognitive styles.

## DEVISING AN INITIAL METACOGNITIVE PROGRAMME FOR STUDENTS

To be effective any metacognitive programme would have to consist of three parts

- a) a self diagnostic tool
- b) education in thinking styles, memory and adapting strategies
- c) continuing access to suitable resources as metacognitive awareness increases

It should be noticed that diagnosis is the first phase. Consultations with psychologists suggested that students might incorrectly self-label if education preceded diagnosis, and this would lead to inappropriate metacognitive strategies. Obviously any diagnostic tools would have to be as simple as possible whilst retaining usefulness. Taking these components in turn.

## DIAGNOSIS

Myers-Briggs Type Indicators were rejected as being too complex and potentially unreliable, a view shared by many practising psychologists. Similarly schemes which incorporated personality types with cognitive styles were rejected since their outcomes were too diverse to be useful to individual students at an early stage of metacognitive development. Harrison and Bramson (1999) identified five main modes of thinking. These modes are typified by the philosophers Hegel, Kant, Singer, Leibniz and Locke. The Hegelian and Kantian modes are substantive/value oriented thinking and knowing styles as distinct from the analyst/realist style represented by the Leibnizian and Lockean modes. Harrison and Bramson (1999) noted that approximately 50% people prefer to think in a single style and that 35% are able to use two related styles. This confirms the view expressed by Benson and Standing (2001) and Stenning, Cox and Oberlander (1995) the underlying preferred thinking styles are relatively immutable but a minority of people (approximately 12%) may prefer several modes equally. While Harrison and Bramson's (1999) framework is useful, the need to incorporate a history of contemporary thinkers and schools of thought into the programme was an acceptable overhead. Reverting to work carried out by Ornstein (1997), a simpler classification scheme of left and right brain thinking was adopted (this has been discussed in Benson & Standing, 2001a). NB. This division uses the terms left and right as cognitive styles, neurologically speaking functions may be distributed in either or both hemispheres of the brain (McCrone, 1999, Kelly et al., 1998). Ornstein's divisions give the following:

- Left brain cognition - sequential analysis: systemic, logical interpretation of information. Interpretation production symbolic information: language mathematics abstraction and reasoning. Memory stored in a language format
- Right brain cognition - holistic functioning: processing provides a "holistic" picture of was environment. Visual special skills. Coordination of holistic activities such as dancing and gymnastics. Memory is stored in auditory, visual and spatial modalities

In individuals, a very small difference in right and left brain ability is usually sufficient to guarantee 100% selection for the preferred mode. Work by Benson & Standing (2001a) showed a right brain bias in IS students.

## EDUCATION

A minimalist programme was devised in order to fit into the existing curriculum without compromising content or standards. A total of 3 hrs was allocated, a 40 minute introduction and four 20 minute mini-presentations. Since the object was to improve student outcomes, the programme focused on knowledge and techniques that

would be immediately useful to students. This resulted in the following composition:

- a) basic personality types (introvert, extrovert, judge, perceiver and control/emote responses) – this allowed students to make a swift assessment of themselves in terms of their broad behavioural patterns, attitude to deadlines and motivation. This also enabled them to make a similar assessment of their lecturers. Simple motivational strategies were offered and the importance of leisure and enjoyment to learning were explained and emphasised.
- b) basic left and right brain cognitive styles, auditory, visual and kinesthetic learning - an introduction to the nature of knowledge and Constructivism.
- c) an introduction to memory and its relationship to learning styles, the primacy-recency effect and its relationship to note taking/revision practices. The conscious/subconscious divide and making use of associative memory and mind mapping for recall. An introduction to problem solving states and the IPRAM model (a simple conceptual framework for establishing one's intellectual maturity with respect to a particular knowledge domain) developed by Benson and Standing (2001b).

Since greater exposure to metacognitive resources and increasing self-critical awareness would allow more motivated students to add to their metacognitive tool set, URLs were posted onto the unit website and these links gave students access to web based resources for learning, metacognition and memory techniques e.g., [www.brain.com](http://www.brain.com), [www.intelegem.com](http://www.intelegem.com) etc. A relevant bibliography was made available.

## CHANGES TO TEACHING PRACTICE

Although lecturers do not have the time to present the curriculum from multiple perspectives, it is quite feasible to present material from left and right brain perspectives. It has been seen that abstract thinkers (left-brain) perform better than concrete thinkers (right-brain) under certain conditions. This is most notable when the subject have no prior experience of the subject area, left brain thinkers are able to theorise and so make more rapid initial progress (Benson & Standing, 2001). By contrast, right-brain thinkers cope less well with abstraction and require examples and experienced to ground their knowledge. Taking the example of teaching normalisation in a database course, left brain thinkers are able to accept a highly theoretical and abstract presentation of the concepts using set theory and are able to apply their knowledge reasonably quickly. Presenting material from both perspectives was the only concession made to learning styles. However, both right and left brain thinkers require practice and repetition for retention.

Regular reinforcement of the metacognitive training programme concepts was given during the course. This took the form of brief examples of study practices and suggested activities. In particular, students were referred to social constructivism (vonGlaserfeld, 1993, Ernest, 1995) and were encouraged to discuss their assignments with other students. In order to accommodate students who had a low social-need strength, assessments were constructed so they could be completed on individual or group basis. A clear statement of objectives was given for each lecture. This statement was revisited at the end of each lecture to confirm that the objectives had been met. The number of objectives was restricted to 7 or fewer to correspond with Miller's (1956) thinking. In earlier lectures, students were given suggested strategies to help them remember the subject matter. Subsequently students were encouraged to develop and use their own methods.

Modifications were made to the timing of subject matter delivery in order to maximise the primacy-recency effect. Students require breaks and the longest time to lecture should proceed without interruption is approximately 45 to 50 minutes. It is inadvisable to focus on a single task for extended periods since neurochemical depletion reduces learning productivity. An attention span of 7/8 minutes was assumed and suitable activities, diversions were introduced on their expiry. Extensive use was made of humour and drama triggers. Forward and backward referencing were used and where possible the subject matter was grounded in familiar real-world examples.

A 50 minute examination preparation session was given to at the end of the course. This focussed on technique rather than content, in particular the task of relating question selection, ordering and answering to learning styles

Although this seems an extensive alteration to teaching style and practice, the total work involved was less than 16 hours for a 42 hour, single credit course. The extra work was incorporated into the annual update of the course and has since provided a useful framework for the development of other courses.

**EVALUATION**

Table 1 below shows student perceptions of the course for three semesters before and after the introduction of new teaching practices. The figures are drawn from the same single credit course, each enrolment had a minimum of 55 students.

Items 1 & 2 are based upon the entire evaluation instrument with student assessment factored in. The remaining items relate to specific questions within the instrument. Some changes were made to the wording of the instrument in the second semester of the new practices in relation to items 5 and 6. While the wording was broadly equivalent, the author took a sample of 16 students and asked them the same questions in the same words and obtained similar results.

Table 2 below shows time series data on marks distributions for the same unit over a three-year period. While a minimum mark has remained relatively constant, the average mark has increased, the percentage of students performing well has increased only attrition rate has decreased.

NB. Some filtering was undertaken to remove students who withdrew from or failed for non-academic reasons. This may introduce a small element of subjectivity into the assessment of the attrition rate.

**DISCUSSION**

Demonstrating a direct causal link between changes to teaching practices and providing training in metacognition with changes to student outcomes is not possible in the absence of a strictly controlled experiment. Possible objections might include:

- a) The lecturer might have made the course, assessments and examinations simpler in order to increase the number of students receiving good passing grades.

- b) The students are aware that they are part of an uncontrolled experiment.
- c) The improvements could be explained by increases in the quality of the student intake.

Taking these in turn (a) above may be countered by the fact that the examinations over a have been peer reviewed for consistency in style and level of difficulty. Samples of examination scripts and assignments have been similarly peer reviewed.

Despite being unable to counter (b) absolutely, it is argued that the exercise been beneficial. On balance of probability it is apparent that the changes introduced are in accordance with good educational strategy. Changes to subject matter have been minor and the assessment methods have been subject to control and scrutiny. The improvement in student outcomes began when the changes were effected and has continued. The overall sample sizes are statistically significant and the use of the tracking facility in WebCT has enabled the author to see that students who have availed themselves of the metacognitive resources provided have tended to perform better in assessment and examination.

With regard to (c), the same course and practices were carried out over an eight trimester period at a private college whether materials were subject to additional scrutiny and control. Here the survey of student perceptions was not carried out, however the changes to student outcomes closely paralleled those described above.

**CONCLUSIONS**

Should the underlying hypothesis of the work be vindicated, there are obvious implications for Information Systems curricula and Information Systems lecturers. An informal survey of 30 on-line information systems curricula of USA universities failed to reveal any which addressed metacognition and thinking styles. While this is insufficiently rigorous to draw firm conclusions, the author would argue that that it is indicative of the general state of affairs.

In order to develop a fully convincing case it will be necessary to carry out a controlled experiment with a larger sample. Campus reorganisations at the author's University will provide such an opportunity in 2002. It is anticipated that the data obtained from this experiment will provide the basis for long-term, longitudinal study. It is hypothesised that students will continue to develop metacognitive

*Table 1: Differences in student opinions of lecturer before and after the introduction of metacognitive education and changes to teaching practice.*

Criterion	Before new practices n=165	After new practices n=194
1) Good teaching rating	66.0%	76.6%
2) Overall lecturer rating	58.8%	84%
3) Helped to motivate the student	66%	75%
4) Helped to develop analytical skills in the subject	65%	66%
5) Helped to develop general problem solving skills	50%	76%
6) Lecturer understood student learning problems and worked to overcome them	60%	86.6%
7) Lecturer was extremely good at explaining things	63%	100%

*Table 2: Student outcomes before and after the introduction of metacognitive education and changes to teaching practice.*

Criterion	Before New Teaching , averaged over 3 semesters n=184	After New Teaching Practices, averaged over 3 semesters, n=207
Average Grade	59.0%	68.0%
Standard Deviation	12.0%	19.7%
% students scoring >80%	6.58%	20.8%
% students scoring 70-80%	19.4%	28.2%
Maximum mark	76.6%	93.3%
Minimum Mark	40.1%	41.0%
Average attrition rate	12.3%	7.0%

awareness and skills resulting in a profile of continue improvement in terms of outcomes. (It is also suggested such students would perform significantly better in employment than their metacognitive unaware counterparts.)

Even in the absence of such an experiment, the author is sufficiently convinced of the value of the exercise to seek to continue with the new work practices. Over the period that the metacognitive training and changes to teaching practice and delivery have been in place, the author has seen a substantial improvement in student outcomes for a marginal investment in time and effort.

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