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Cognitive computing tools in architectural project management education: approach, process and evaluation

Peer reviewed

Abstract

The teaching of Project and Practice Management to architecture students doing professional masters degree programmes at the University of Pretoria incorporates a variety of aspects related to planning, scheduling, finance, monitoring and control. In an effort to train future professionals in skills for the workplace, the module on Practice Management is using commercial off-the-shelf software (COTS) as cognitive tools for simulating real-world architectural management. This paper reports on and evaluates the process whereby students generate their own framework of inter-linked spreadsheets and scheduling charts and contextually apply it, within their personal thesis projects, to integrate key aspects of management and financial control. The tools are used to manipulate knowledge and their interactivity provides dynamic modelling for decision making and the exploration of alternatives. Use of these cognitive management tools synergistically fosters cognition, reflection and comprehension of project management principles. Students' perspectives on the venture are evaluated, the findings reported and discussed, and minor adjustments suggested for future offerings of the module.

Keywords: architectural education, cognitive tools, commercial software, dynamic modelling, evaluation, practice management, project management

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Abstrak

Die dosering van projekbestuur vir argitekuurstudente in die professionele meestersgraad-programme aan die Universiteit van Pretoria sluit 'n verskeidenheid aspekte in wat verband hou met beplanning, skedulering, finansiering, monitering en beheer. In 'n poging om toekomstige professionele praktisyns vir die werkplek te bekwaam, word kommersieël beskikbare programmatuur as kognitiewe gereedskap in hierdie module in Praktykbestuur aangewend om praktiese bestuur vir argitekte te simuleer. Hierdie artikel doen daaroor verslag. Die proses waar studente eie raamwerke van onderling verbinde spreitabelle en skeduleringskaarte formuleer, dit kontekstueel tot eie skripsieprojekte aanwend om sleutelkonsepte van bestuur en finansiële beheer te integreer, word evalueer. Die gereedskap word gebruik om kennis te verteenwoordig en hulle wisselwerking voorsien dinamiese modulering vir besluitneming en die soeke na alternatiewes. Die gebruik van hierdie kognitiewe gereedskap vir projekbestuur bevorder sinergetiese bewustheid, besinning en begrip vir die beginsels van projekbestuur. Persepsies van studente oor die module word evalueer, verslag word oor die bevindings gedoen en bespreek en verstellings vir toekomstige aanbieding van die module word voorgestel.

Sleutelwoorde: argitektuur onderrig, dinamiese modelering, evaluering, kognitiewe gereedskap, kommersiële programmatuur, projekbestuur, praktykbestuur

1. Introduction and background

Very little reflective research is undertaken on the use of software tools in the training of architecture students in practice and project management, as evidenced by the lack of literature on these issues. Considerable attention is paid to the use of computer-aided planning, design and drafting (de Villiers, 1998), although this is only one facet of architectural practice. Of almost equal importance in the workplace is the need to effectively manage and operate a practice from day to day. In an effort to train future professionals in skills for the workplace, the module on Project and Practice Management in Architecture at the University of Pretoria is using commercial off-the-shelf software (COTS) as cognitive tools for simulating real-world architectural management. Synergistically, use of such tools in an inter-linked manner, is an integrative cognitive methodology, combining various facets of project-, practice- and financial management and control. This educational approach is being developed and refined, and has been empirically evaluated in a survey among students.

1.1 Professional Context

Architectural education in South African (SA) universities is focused mainly on design and construction. However, the practical delivery process of producing buildings in the real world, outside the classroom, also involves legal, management and financial expertise. Theoretical management courses are taught, but are inadequate for the practicalities of running a project in the workplace and for managing people, processes, time and money. Management and control measures involving stakeholders, documentation and finance are under-addressed. The prevailing view is that exposure to practice during the statutorily-required two years after graduation, as 'Architect in Training', is adequate grounding. Yet the profession in SA is experiencing a lack of management expertise, particularly among young architects who may be required to take responsibility and handle complex projects. Financial constraints necessitate control measures to ensure financial viability of the practice. A particular concern is the lack of expertise in cost planning, monitoring and control of projects in the practice. This can lead to costly time overruns, ineffective utilisation of human resources, and inefficient time planning within the scope of available professional fees.

South African architectural practices are generally well equipped with computer-aided design and drafting (CADD) software. However, unlike practice in Europe, the United Kingdom and North America, they do not make extensive use of commercial information technology for administration and management. Although there are systems for managing businesses, accounting and projects, few are customised to the particular requirements of architectural practice and most are unaffordable for the small practices in SA, frequently in the order of three to five persons. Discussions with several large and small practices in South Africa indicate that computing tools such as spreadsheets and scheduling programs are used for independent administration and management applications. The software used tends to be general-purpose systems constructed from COTS but, in smaller practices, expertise is generally lacking for creative and integrated application of such packages for project and practice management.

1.2   Academic context

The target learners are students doing the MArch (Prof) and MLArch (Prof), professional masters-degree programmes in Architecture and Landscape Architecture respectively. The research relates to the module, Practice Management, with themes:

1   Legislation related to the practitioner;

2   Management of architectural or landscape architectural practice; and

3   Employer-employee legislative framework and contractual relationships.

This article mainly addresses the second theme, which incorporates:

•   the architect's management and administration of projects in the practice; and

•   organisation, management and administration of an architectural practice.

Required outcomes are that students should be able to participate meaningfully in the management and administration of architecture practices and be able to set up and run a small practice. The aspects addressed in this paper relate mainly to the practical issues of allocating project staff and determining time schedules within

an appropriate project cost framework. These aspects are then considered in terms of their impact on office cash flow.

1.3 The problem

Practice Management courses in South African architectural schools, while teaching office and financial management do not generally deal with the specifics of planning and monitoring staff, time and costs on individual projects in a practice. These aspects are left to the post-university 'Architect in Training' period in a practice. This is unfortunate, because inadequate expertise in this area in real-world practice can rapidly impact on cash flow, often realised too late.

There is therefore a need for innovative teaching strategies in professional practice management within formal university education – education that is constructive rather than prescriptive – as well as reflective research on the utility of such teaching approaches. This paper describes a 4-year effort to explore the use of readily-available COTS for enhancing the learning of time and cost control of architectural projects and the associated management principles. The findings of a survey among learners provide information for reflective analysis on the cognitive and practical value of the exercise.

1.4 The objective

The aim is to use software packages as cognitive training tools to support students in understanding the underlying financial discipline and inter-related components of professional architectural practice, rather than merely memorising theories, principles and procedures of management. Jonassen & Reeves (1996) define 'cognitive tools' as technologies that enhance human powers of cognition during thinking, problem solving and learning. They suggest that cognitive tools, among others:

- are most effective when applied in constructivist learning situations;

- support learners in generating their own representations of knowledge;

- can promote the deep reflective thinking required for meaningful learning;

- should be applied to tasks defined by learners themselves, under guidance of educators; and

- should be situated in realistic contexts with results that are personally meaningful.

As an example of such learning and problem solving, Reeves, Laffey & Marlino (1997) describe the use and effects of cognitive tools, including spreadsheets and the World Wide Web (WWW), in a situated learning environment for engineering students in the USA.

This study describes how cognitive tools are used by students to re-present and manipulate knowledge, thus stimulating cognition and integrated thinking within innovative management techniques.

1.5 Content of the article

Section 2 sets the context of the study and explains the approach. In Section 3 the learning process is addressed, describing the stages of the work required from the students and the tasks they must produce as deliverables for the module. The effectiveness of this teaching strategy has been evaluated by a student survey, the findings of which are given in Section 4.

2. Approach

The practical component of the module aims to communicate an integrated understanding of the cost control fundamentals that govern project and practice management. Modus operandi has evolved over the years. In 2000 theoretical aspects were taught and computing tools demonstrated in practical exercises, but students were not required to generate computer-based management deliverables. In 2001 students were exposed to very brief stints of internship in established architecture practices, during which they were required to develop or re-use their own constructed management and control tools and apply them to actual projects there. The approach used in 2002 and 2003 was a participative problem-based method. Savery & Duffy, (1995) encouraging student-centered, partially-cooperative learning to develop practical computing skills and generate management tools from COTS packages in a contextualized project situation. Problem-driven learning entails a role-shift of the lecturer from an instructor to a facilitator, who aims to stimulate higher-order thinking and to challenge

learners' cognitive processes. Using their own dissertation projects (explained in the next subsection), students are required to simulate the dynamics of project management and control, and generate reporting mechanisms. Use of their own project makes the learning event personally relevant and helps them take ownership. The skills acquired can be extended and transferred to a variety of situations in practice.

2.1   The students' tasks

Each student selects a hypothetical, yet authentic, building project for research, design and documentation for their dissertation (termed a 'thesis'). As part of integrated capstone learning, students analyse their thesis project for financial- and work-flow planning, against which to measure progress. The tasks they were required to do for the module, involved using COTS such as spreadsheets and project management tools to model flow of work in their thesis projects, so as to set up a reporting structure by which to monitor progress for management action. These real-world simulations are based on parameters such as:

- the cost of the building;

- fees for architectural services (South Africa, 2003) and allowances for overheads and anticipated profit;

- the stages of work (South Africa, 2003);

- the calculated duration of each stage of work;

- interrelationships between tasks, and the impact of change in one variable on other parameters;

- a project and practice cash flow; and

- control aspects relevant to their specific project.

The point of departure for such analysis comprises the information which, in the workplace, would be regarded as the architect's brief. Students then go beyond these basic requirements and incorporate human resources factors, such as allocation of staff to projects, projected man-hours and provision for actual hours worked. Each student's problem has its own distinct set of requirements and management factors, and its tasks are assessed accordingly. While each student's work is different in terms of the data generated, their

tasks were assessed on the way in which management principles and practice were applied using the available software within the context of the particular project. The learning process and its effectiveness in terms of learner knowledge, understanding and cognition could be objectively assessed by investigating how well they applied management principles in their tasks and deliverables. Marks were also allocated for innovative use of the software.

2.2   The tools

From consultation with local architectural practices and noting the software available to students, it became clear that Microsoft Office was appropriate as a generally-available, affordable toolset. Most students are familiar with MS Word, whose framework and interface conveniently provide familiarity, consistency, and predictability (Dix, et al., 1998) to users newly encountering Microsoft Excel for the purpose of spreadsheets. MS Project – although not part of the Microsoft Office suite – is also used and is easily learnable, due to its similar format. The laboratory in the Department of Architecture is equipped with these, and many students acquire them personally.

3.   The learning process

3.1   Method

Dynamic software modelling of financial aspects provides a framework for planning, monitoring, control and reporting. Computing sessions are conducted in the laboratory and although co-operative work is required for other activities, this is an individual project. Manual preparation of material is required prior to each session, involving documentation and specification of the problem and task.

Cognitive theories and models of learning (Winn, 1990) focus on the mental processes involved in learning. Theoretical principles and procedures of project management are taught earlier in the course, and are now practically actualised in the context of analysis and exploration of a major problem. The experience stimulates mental processing, as students 'do' rather than 'remember'.

Stage 1: Schedule of accommodation to determine total project cost – spreadsheet

The Microsoft Excel spreadsheet is introduced for the purpose of preparing a schedule of accommodation. However, the generation of multi-parameter spreadsheets can be demanding and complex. Vygotsky (1978) proposes a "zone of proximal development" – a condition of cognitive readiness for learning and problem solving. This level of cognitive ability can be fostered by guidance from a facilitator and consultation with peers. Students are walked-through their first draft spreadsheets under guidance from the lecturer, who explains each function and entry. As illustration, he demonstrates the development of simple prototypes on the digital projector in the laboratory. This guidance enables them to concentrate more on the operation of a spreadsheet than on data entry. Text, numbers and formulas are entered, copied or replicated and edited and the required results generated. Following this introduction, learners produce their own schedules, which serve as the interlinked baseline from which further management tools are prepared. Figure 1 is an example of a student's schedule, which should incorporate at least:

- a list of spaces;

- surface area of each space;

- the number of spaces of each description; and

- the total area for each individual space type, which is calculated by entering the relevant formula.

- An approximate cost per m^2 is entered for each space type; so that

- the total cost for each space type can then be determined.

The space and cost columns are totalled to determine the net area and cost for the whole building, after which adjustments can be made to reach budgeted gross area and cost. On completion of this stage, the learner is familiar with basic spreadsheet functionality.

LINGUISTIC CENTRE SCHEDULE OF ACCOMMODATION					
SPACE DESCRIPTION	NUMBER OF SPACES	AREA/SPACE	AREA (TOTAL)	COST PER SQ. M.	COST
LIBRARY	1	200	200	2,150	430,000
reference section					
binding and printing					
staff facilities					
returns					
LECTURE ROOMS	6	50	300	2,150	645,000
STAFF OFFICES	6	16	96	2,150	206,400
THEATRE SPACE	1	180	180	2,150	387,000
RECEPTION	2	40	80	2,150	172,000
SOUND RECORDING	1	100	100	2,150	215,000
TOURIST INFORMATION	1	25	25	2,150	53,750
DELI / RESTAURANT	1	250	250	2,150	537,500
TRAINING KITCHEN	1	90	90	2,150	193,500
ABLUTION FACILITIES	3	40	120	2,150	258,000
INFORMAL TRADE	8	50	400	2,150	860,000
STOREROOMS	2	18	36	2,150	77,400
COMPUTER ROOM	1	100	100	2,150	215,000
BOOKSHOP	1	150	150	2,150	322,500
TOTAL	35	1,309	2,127		4,573,050

Figure 1:   Schedule of accommodation, space and cost

Stage 2: Income, stages of work and time allocation – spreadsheet

Architectural fees are based on project cost. Hence the cost determined in Stage 1 is used to determine budgeted income. Project income is then subdivided over the various stages of work as per the recommended SAIA scale of fees (South Africa, 2003). This is illustrated in Figure 2.

The integrated nature of this project is achieved by linking the spreadsheets. For example, project budget from the Stage 1 spreadsheet is automatically carried through to the next spreadsheet by a formula referring to its cell on the first sheet. Due to this interactive connection, adjustments to the first spreadsheet to correct it or to explore alternative values are automatically reworked into subsequent calculations. The appropriate SAIA fee formula is entered to calculate the budgeted income. The columns include:

- stage description;
- the percentage fee for each stage; and
- calculation of income for each stage.

To determine realistic time estimates, a cost per man-hour (including allowance for overheads and profit) is required to calculate the number of hours available for each stage of work. Earlier in the course, the students were provided with time-and-cost guidelines. The next column is therefore:

- cost per man-hour; followed by
- man-hours available.

With man-hours budgeted for each stage, this spreadsheet can be used as a monitoring tool against which to measure progress. Provision is made in the following columns for:

- man-hours used;
- percentage used; and
- remaining man-hours.

PROJECTS BUDGETING

LINGUISTIC CENTRE

PROJECT ANALYSIS

AREA OF BUILDING	R 2127
ESTIMATED COST PER M. SQ.	R 2150
ESTIMATED BUILDING COST	R 4,573,050.00
PROFESSIONAL FEES	R 342,978.75
ESTIMATED DISBURSEMENTS	R 22,865.25

SUBDIVISION OF FEE FOR VARIOUS STAGES OF WORK

PROJ COST	R 4,573,050.00		PROF FEES	R 342,978.75								
Stage	Stage	Percent	Fee/Stage	Cost/ Man Hr	Hrs Avalaible	Hrs Used	% Used	Remaning	Staff	Days	Weeks
1	Inception	5.00%	R 17,148.9	R 180.0	95.3	0.0	0.0	95.3	1.0	11.9	1.7
2	Design Concept	15.00%	R 51,446.8	R 150.0	343.0	0.0	0.0	343.0	2.0	21.4	3.1
3	Design Development	15.00%	R 51,446.8	R 150.0	343.0	0.0	0.0	343.0	2.0	21.4	3.1
4	Documentation	40.00%	R 137,191.5	R 150.0	914.6	0.0	0.0	914.6	4.0	28.6	4.1
5	Administration	25.00%	R 85,744.7	R 200.0	428.7	0.0	0.0	428.7	2.0	26.8	3.8
TOTAL		1.0	R 342,978.8		2124.6	0.0		2124.6		110.2	15.7

Figure 2:   Professional fees, staff allocation and time

In simulating real-world activities where a client might view the projected fee with dismay, students can use their suites of spreadsheets as tools for exploratory decision-making and reflection (Schön, 1987). Models can be manipulated, increasing and decreasing values so as to optimise 'client' affordability and 'office' standards. Changes on one sheet interactively update the others, affecting their resultant values. For monitoring and control purposes, the column for 'man-hours used' can be completed on a weekly/monthly basis, using data from time sheets. The final columns relate the time available for each stage to days or weeks, considering the number of staff allocated to each stage, as input for project time scheduling.

Stage 3: Project programme of work – Microsoft Project

This more advanced stage addresses the integrated scheduling of all activities, including tasks undertaken by other professional disciplines. Time must be allocated to all projected tasks and their interrelationships considered in terms of sequence and overlap. Graphical representation by a Gantt Chart helps students visualise the schedule and explore alternatives.

The last two columns of the Stage 2 tabulation provide the architectural design-time data as input for Stage 3. Students complete the rest of the programme by including other stakeholders, as displayed in the Gantt Chart (Figure 3), listing tasks and allocating a duration to each. The software automatically generates the relevant bar lengths. Tasks can be linked, overlapped, grouped, or in parallel. Start and completion dates are automatically generated or may be given as input.

Once entered, the data may be viewed in various formats and time intervals. Microsoft Project can handle complex scheduling applications and management reporting. Some students venture beyond the basics to include staff numbers, names and costing details and once-off costs for cash flow purposes. Progress can be monitored by indicating work completed. In this way students design the workflow for all participants and determine the combined time scale of integrated activities for the various stages of work. This information is needed for determining project cash-flow in Stage 4.
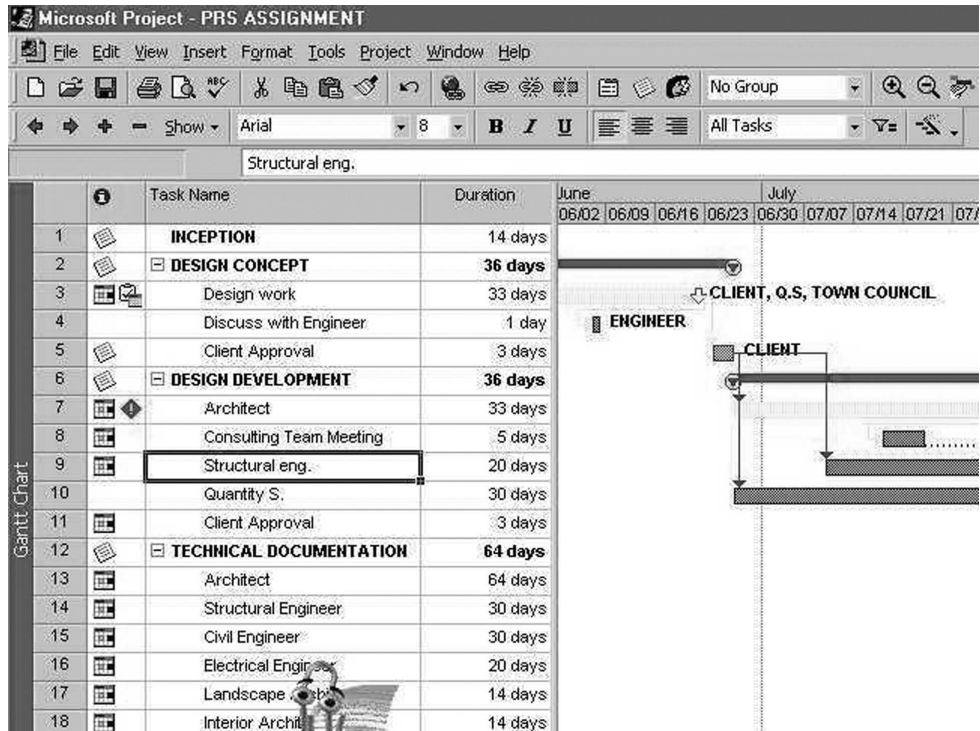
Figure 3:   Gantt chart view of programme of work

Stage 4: Project cash-flow – spreadsheet

Inputs from the Figure 2 spreadsheet in terms of building costs and fees are automatically transferred by formula links into the cash-flow spreadsheet of Figure 4. Income to-date can be filled in, so that remaining fee income can be determined. This outstanding amount is distributed over the ensuing months according to the income due for the various stages and the month in which each is completed, as indicated in the programme of work.

The cash-flow model helps students grasp the relationships between income, disbursements and overhead costs. It provides a basis from which they can model their own solutions, extend the scope of the spreadsheet and increase its utility by, for example, generating fee and disbursement accounts.

3.2   Discussion of the approach

Bloom's (1956) Taxonomy of Educational Objectives identifies 'synthesis' as one of the major learning forms – putting parts together to form new wholes. Situated cognition (Winn, 1990) proposes that learning occurs most effectively when contextualised in realistic settings, not de-contextualised and isolated. The integrated nature of this documentation series implements both these notions, modelling several aspects of management: client requirements, predicted income, costing of work processes, project schedules and duration, cash flow, human resource deployment and management, and co-ordination of other professional consultants, such as quantity surveyors and engineers.

This venture implements tenets of 'constructivist' learning (Bruner, 1994; Hannfin, 1992), namely, active participation and experiential learning of real-world project monitoring and control. Under constructivism, knowing and understanding are viewed as processes, not as products or events. The learning approach described above involves step-by-step follow-through, as students incrementally generate their sequence of spreadsheets. Moreover, learning is personally meaningful, as they construct knowledge in the context of their own research and design. Open learning occurs, since there is not one single solution, but rather multiple paths to be explored.

PROJECT AND OFFICE CASH FLOW

PROJECT Description	Building cost	Fees and disbursements	Budget	Received	Remaining	MAY Fee	Disb	JUNE Fee	Disb	JULY Fee	Disb	AUG Fee	Disb
LINGUISTIC CENT	R 4,573,050.00	Fees	R 342,978.75	R 0.00	R 342,978.75	R 17,148.94		R 51,446.81				R 51,446.81	
		Disbursements	R 22,865.25	R 0.00	R 22,865.25		R 2,286.53		R 2,286.53		R 2,286.53		R 2,286.53
					R 0.00								
PROJECT 2		Fees	R 0.00	R 0.00	R 0.00	R 0.00		R 0.00		R 0.00		R 0.00	
		Disbursements	R 0.00	R 0.00	R 0.00		R 0.00		R 0.00		R 0.00		R 0.00
					R 0.00								
PROJECT 3		Fees	R 0.00	R 0.00	R 0.00	R 0.00		R 0.00		R 0.00		R 0.00	
		Disbursements	R 0.00	R 0.00	R 0.00		R 0.00		R 0.00		R 0.00		R 0.00
					R 0.00								
TOTALS DISBURSEMENTS			R 22,865.25	R 0.00	R 22,865.25		R 2,286.53		R 2,286.53		R 2,286.53		R 2,286.53
TOTALS FEES			R 342,978.75	R 0.00	R 342,978.75	R 17,148.94		R 51,446.81		R 0.00		R 51,446.81	
OVERHEADS						R 17,000.00		R 17,000.00		R 17,000.00		R 17,000.00	
BALANCE						R 148.94		R 34,446.81		-R 17,000.00		R 34,446.81	

SEP Fee	Disb	OCT Fee	Disb	NOV Fee	Disb	TOTAL Check	REMAINING Fee	Disb
				R 137,191.50		R 240,085.13	R 102,893.63	
	R 2,286.53		R 2,286.53		R 2,286.53	R 16,005.68		R 6,859.58
R 0.00		R 0.00		R 0.00		R 0.00	R 0.00	
	R 0.00		R 0.00		R 0.00	R 0.00		R 0.00
R 0.00		R 0.00		R 0.00		R 0.00	R 0.00	
	R 0.00		R 0.00		R 0.00	R 0.00		R 0.00
	R 2,286.53		R 2,286.53		R 2,286.53	R 16,005.68		R 6,859.58
R 0.00		R 0.00		R 137,191.50		R 240,085.13	R 102,893.63	
R 17,000.00		R 17,000.00		R 17,000.00		R 119,000.00		
R 34,446.81		########		R 120,191.50		R 121,085.13		

Figure 4:   Project and practice cash-flow

4.   Evaluation and findings

A questionnaire survey was undertaken among all of the 25 students who took the course in 2003 to determine their perceptions of the practical computing component of the module and its value, both as a means of professional education and as a cognitive tool. After investigating prior experience with COTS, the questionnaire elicited the students' impressions of using an interactive management model to represent their thesis projects. It focused both on peda-gogical aspects of the approach and on its perceived future value in the workplace. There were Likert scale questions, multi-option questions where more than one option could be selected as well as open-ended questions. Students took the evaluation exercise seriously, giving considered answers and motivating their answers. Both quantitative and qualitative data was therefore obtained.

4.1   Prior experience

Twenty students had formerly used computers; 19 had been 'ex-posed to' MS Excel and six were 'familiar' with it; and only one had used MSs Project. The responses in Table 1 regarding software indi-cate more experience of design and graphics programs than of technically-oriented software.

Table 1:   Familiarity with software

Responses to the open question: 'I am familiar with: ...'		Number of students (n= 25)
MS Office general		5
MS Word		4
MS Excel		6
WWW software		1
MS Project		1
Computer-aided design and drafting	AutoCAD	6
	3D Studio Max	4
	Other CADD software	4
Graphics and drawing packages	Corel Draw	4
	Unnamed graphics/drawing programs	4
	Photoshop	2

4.2   Use of computers to support cognition

Responses on the single strongest impression gained from using the interactive model were categorised. Seven students particularly appreciated the additional perspective on their dissertation projects in terms of time and cost, and seven acknowledged the value of visualising real-world information in the context of interrelated issues and events. Other strong impressions were the impact of changes on deadlines and profit, the interactive value of linking spreadsheets, and the value in the workplace of tools that are easy to create and easy to manipulate.

These findings highlight the added value of interactivity and data visualisation. When they perceived facts and figures within context, i.e. 'situated cognition' (Winn, 1990 – see Section 3.2), the students understood the true impact of decisions and changes.

4.3   Pedagogical aspects

A primary aim of the research related to the pedagogical and cognitive worth of the experience. All 25 respondents agreed that the hands-on learning experience helped them construct their own knowledge about Project Management procedures and 24 found that it supported construction of knowledge regarding their own thesis projects. This simulation of events and figures in an active experiential learning process is in line with 'constructivist' learning (Bruner, 1994; Hannfin, 1992 – see Section 3.2).

The data obtained from Likert-scale questions has been thematically categorized (Miles & Hubermann, 1994) and is presented in Table 2. The contextualised approach, using self-defined projects (Section 1 of Table 2) made it easier for students to learn how to use spreadsheets and gave added value.

The instructional approach, as outlined in the previous section, entails explanation and demonstration of MS Excel and MS Project, together with the introduction of management techniques and open discussion. There after follows the incremental generation of individual spreadsheets and charts. Theory and practice of both management and the software are thus linked to the student's familiar project. Students simultaneously construct professional knowledge and learn the software.

Table 2:   Pedagogical aspects

Thematic Grouping	Statement	Number of students				
		Strongly agree	Agree	Maybe	Disagree	Strongly disagree
1. Contexualized learning: Personal thesis study as a context	Using my familiar thesis project made it easier to learn how to construct spreadsheets as management tools.	11	11	1	2	0
	Working with personalised examples added value and meaning to the exercise.	15	9	1	0	0
	Reflecting on the variables within my project made it easier to understand the complexities of managing time, money and people.	7	16	1	1	0
2. Integration: Simultaneous learning of Practice Management and computer systems	The management theory and concepts we were learning were hampered by all the calculation considerations when building the spreadsheets.	2	1	10	9	2
	Spreadsheet management and data-handling unnecessarily complicate the simple logic of project management	0	3	3	16	3
	The step-by-step buildup-up of management thinking in the spreadsheets helped me to understand the management principles better	Really helped	Made no difference	Put me off	Forced me to work in a way I might not choose	
		21	3	0	1	
3. Instructional approach: Sequential learning process	The step by step demonstration on the data projection screen was an adequate introduction to building useful spreadsheets.	8	15	1	1	0
	More management theory prior to the construction of computer management tools would make more sense of computer tools	1	3	11	9	1

The researcher's concern was that in learning both, one might detract from the other, possibly to the detriment of both. However, responses in Sections 2 and 3 of Table 2 indicate generally positive reactions to the interactive, integrated approach, although some students were unsure. The sequential, stepwise demonstration of the project management process within professional practice was positively received.

4.4 Value of integrated computing tools

There were highly positive responses regarding perceived value of the computing tools, as well as the utility of integrating tools. These are shown in Table 3. It is notable that while 21 students recognised the value in their own thesis project, all of them (25) saw value for the future workplace, emphasising the worth of this teaching approach for future professional development.

Table 3:   Perceived value of the computing tools

'The project management computer tools are of value in: '		
My thesis project	The future workplace	Personal life (e.g. finances)
21	25	16
'I can see great value in using integrated computer tools for: '		
Planning and organising management information	Decision making tools: what-if scenarios	Monitoring and control: comparing actual with planned
24	15	21

An open-ended question enquired into the 'greatest' perceived benefits. Table 4 categorises these responses, which relate mainly to the value of COTS in comprehending situations, as enabling tools in the workplace, for financial control, and their predictive value in decision making. These responses pinpoint the holistic nature of

the information obtained by using COTS tools in an integrated way. This is in line with Bloom's (1956 – see Section 3.2) 'synthesis' – putting parts together to form new wholes.

Table 4:   Areas of greatest perceived value

Comment		Number of occurrences
A skill/enabling tool/control system for use in the workplace/practice management		9
Ability to construct/comprehend/compare scenarios; decision making tools		4
Financial and management components of architecture (relationship between cash-flow, time, money etc.)	Comprehension and awareness of these aspects of practice	6
	The role of computing tools in time, money and resource management	6
Detailed thinking for all the stages of design and documentation		2
Visual representation of information		2
Represents the uniqueness of each project in terms of time, cost and phases		1
A tool for use in concept stage of design		1
Time and cost saving tool		1

4.5   The students' likes and dislikes

In reflective educational research, it is useful for the facilitator to know which parts of a course, students enjoy most and which they enjoy least. Table 5 depicts these, ranked according to most liked. They were permitted to make more than one selection.

Table 5:   Most-liked and least-liked module components

Module component	Most-liked	Least-liked
	Number of learners	Number of learners
Time & cost analyses	13	1
Cash flow	8	10
Project scheduling	6	4
Schedule of accommo-dation	6	5

It is interesting that one of the concepts more familiar to architec-
ture students (schedule of accommodation) was not the most liked.
By contrast, what more than half (13 out of 25) enjoyed most, were
the numeracy-related aspects of time and cost analysis, where
they learned new concepts and skills. On the other hand, a large
number (10) liked the cash flow aspect the least. It is surprising that
while cost analysis was liked, there was a dislike of cash flow, which
is also a financial aspect. This indicates a problem. From the reasons
given, it was clear that insufficient time was spent on cash flow, for
example: 'it was not done thoroughly', 'too little time', and 'explan-
ation inadequate'.

4.6   Computing tools in professional practice

The class was unanimous that the spreadsheet and scheduling exer-
cises helped them grasp project management principles better.
Of particular value was its contextualisation within their thesis pro-
jects, and its reflective worth. They all intended to use spreadsheets
in their future working environments. They were asked to describe
their own conception of how these tools could be used for creative
management in professional practice. Their spontaneous, un-
prompted responses, shown in Table 6, were analysed by the
researcher and grouped into twelve categories within the themes
of Strategic top-level management, Time analysis, Cost analysis and
Human resource aspects.

Table 6:   Students' ideas for using software tools for manage-
            ment in professional practice

Categories		Occurrences
Strategic, top-level manage-ment	Simulations: scenario planning and analysis	3
	Helps to see the total project picture	1
	To organise tasks for management	1
	A tool for decision making	1
	Comparison of different projects	1
Time analysis	To optimise time and prioritise activities	4
	For time-based analysis of progress	1
Cost analysis	Budget and plan ahead for the financial year	2
	Cost projections	2
	Monitor cash flow, leading to a profitable office	2
Human resource aspects	Staff allocation for each project	2
	Programme schedules, so all staff can see the total picture and monitor progress	3

The general contribution of Table 6 regarding potential use can be
summarised as follows:

• for upfront project modelling to improve conceptualisation,

• for planning ahead,

• for prioritising work,

• for optimising time and cost, and

• in monitoring and managing progress.

The students had previously been exposed to common and con-
tract law, building contracts, and the operation of the building
industry and related professions, but this was their first encounter
with details of running and managing projects. Their responses
regarding the impact of the module on their attitude to future pro-
jects fell mainly into three categories, shown in Table 7, with ex-
amples of students' comments.

Table 7:   Perceptions of impact on future management of projects and practice

Themes – with examples of comments	Number of occurrences
Business implications of practice: It helped me to see the actual implications of projects. Architecture is more than just design and drawings We must be realistic as well as idealistic.	14
Utility of software tools for modeling: This is another skill I can offer my employer. Using programs hands-on has made me more interested in these aspects of practice. … the positive effect of the tools for easier and better management …	6
Impact of time over-runs: … essential to finish a project as soon as possible to make a profit. I now realize the importance of staring and finishing the phases on time. Important to remain within project income and budgeted costs. Cost and time must be monitored to see if things are out of hand.	5

The perceptions shown in Table 7 indicate that students gained real benefit from the knowledge and skills taught. However, twenty felt the module should not be presented in the last quarter, but earlier in the year for increased value to the concurrent thesis. A few asked for separation of the theoretical and practical (computer laboratory) components and ten asked for expansion and enrichment of the practical. Suggestions were: more lab time, spread over a few weeks, handouts of worked examples in advance, and more opportunities for explanation and practice since many were using the software for the first time. It became clear to the researcher, who is also the module lecturer that more time should be given to certain concepts of the module and to the practical component as a whole.

5.   Conclusion

The students in Architecture Practice Management responded positively to the use of COTS for integrated management exercises. The software served as cognitive tools in line with Jonassen's & Reeves' (1996) suggestions given early in this article. Students appreciated the practical experiential value, the ability to construct and manipulate scenarios, and the potential utility for the workplace.

The evaluation indicated shortcomings regarding the timing of the course and its integration with concurrent final year studies. In response, the school recognised the need to run the module earlier in the year at a time more appropriate for integration with design thesis research and documentation. Supplementary laboratory sessions were held for students weak in technical computing skills.

The students not only learnt principles and methods, but developed skills to deal with the complexities of management and workflow. The framework of interactive documents they generated resulted in enhanced comprehension of time and cost control principles and fostered cognition of their impact on project viability. Students made creative use of readily-available software to represent knowledge and should be able to transfer this skill to other applications. A further real-world professional value is that the software artifacts students developed, can be taken into the workplace.

Integrated scenario modelling provided a constructivist learning experience as students built tools contextualised to tasks within their own theses. They were encouraged to become reflective practitioners (Schön, 1987), as they simulated real-world architectural projects by holistically considering client requirements, time scheduling, personnel planning, project costs and overall co-ordination. The tools offer predictive value as test bases and cognitive decision support systems, in that the impact of dynamic manipulation of parameters, schedule changes or modifications to spatial or quantitative requirements can be visualized and assessed.

The students should be able to enter their two-year period of 'Architect in Training' with greater insight and understanding of practice than former candidates. The value gained from this practical experience at a formative stage should benefit their professional careers.

References

Bloom, B.S. 1956. *Taxonomy of educational objectives. Handbook 1: Cognitive domain*. New York: David McKay.

Bruner, J. 1994. Constructivist theory. [online]. Available from: <http://tip. psychology.org/bruner.html>

De Villiers A.J. 1998. The introduction and growth of CADD and graphics in South Africa. *Information Technology in Construction*, 1, p. 49.

Dix, A., Finlay, J., Abowd, G. & Beale, R.1998. *Human-computer interaction*. 2nd editon. Hemel Hempstead: Prentice-Hall Europe.

Jonassen, D.H. & Reeves, T.C. 1996. Learning with technology: using computers as cognitive tools. In: Jonassen, D.H. (Ed.) *Handbook of research on educational communications and technology*. New York: Macmillan.

Hannafin, M.J. 1992. Emerging technologies, ISD, and learning environments: critical perspectives. *Educational Technology Research & Development*, 40(1), pp. 49-63.

Miles, M.B. & Hubermann, A.M. 1994. *An expanded sourcebook: qualitative data analysis* (2nd edition). Sage Publications.

Reeves, T.C., Laffey, J.M. & Marlino M.R. 1997. Using technology as cognitive tools: research and praxis. [online]. Available from: <http://www.ascilite. org.au/conferences/perth97/papers/Reeves/Reeves.html> (Accessed: 5 August 2004).

Savery, J.R. & Duffy, T.M. 1995. Problem based learning: an instructional model and its constructivist framework. *Educational Technology*, 35(5), pp. 31-38.

Schön, D.A. 1987. *Educating the reflective practitioner*. San Francisco: Jossey-Bass Publishers.

South Africa. 2003. Board Notice 133 of 2003. *Government Gazette*, 14 Nov. Pretoria: Government Printer.

Vygotsky, L. 1978. *Mind in society: The development of higher psychological processes*. Cambridge MA: Harvard University Press.

Winn, W. 1990. Some implications of cognitive theory for instructional design. *Instructional Science*, 19(1), pp. 53-69.