Computer Supported Learning. A Large-Scale, Web-based Learning and Assessment System to Support Flexible Education.

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Abstract

With the increase in cost and resources constraints experienced by many tertiary institutions globally, the pressure to find alternative methods to deliver teaching and assessment increases. Whilst mindful of the learning experience of the individual, the need to manage the numbers, resources and assessment provide an administrative overhead and headache to every professor who has ever taught.

With this predicament in mind the Computer Supported Learning System (CSL) is a web-based teaching and learning resource and administration system, developed by the Business Education On - Line Unit of the Auckland Business School, at the University of Auckland (New Zealand). We call it Cecil.

This paper describes the Cecil structure and discusses the potential benefits that a university wide resource management system may have in terms of the educational flexibility and resource sharing.

1. Introduction

The need to maintain and provide ubiquitous and individualized teaching and learning support for staff and students is a growing concern for all tertiary education institutions [1]. This paper looks at the Auckland Business School's (University of Auckland, New Zealand) efforts to address these issues.

The Computer Supported Learning system (CSL) operating at the University of Auckland, or Cecil as we call it, has been developed over a period of five years by the Business Education On-Line Unit of the School of Business. It is a system that enables delivery of teaching, assessment and class administration to occur in one environment. In the 2000 academic year Cecil will provide support for approximately 835 courses and be used by 240 general staff and academics in the University. The take up and use of the system is becoming wide spread. Cecil contains the entire enrolment of the University. In terms of course enrolments it is currently actively supporting more than 146220 students.

This year our web site will be one of the busiest in New Zealand. In 2000 we are experiencing more than three million hits per week and have already serviced more than 350 hits per second. It is a 24 hours a day, 7 days a week operation professionally managed by the University's technology support centre.

This paper discusses the detailed nature of Cecil, its architecture and application in the following sections: section 2 provides a description of the underlying architecture of the system; section 3 presents an overview of the Cecil system; section 4 discusses some of the enterprise management and decision making properties of the system and finally section 5 concludes this paper. A more detailed discussion of the Cecil system architecture is described next.

2. The Cecil architecture

Cecil has been designed and built using a fully documented data model that mirrors administrative systems currently in use at the University and extends it through to academic requirements (Figure 1)

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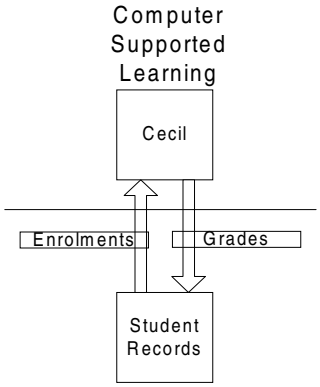

Figure 1. Integrated University functions.

It is comprehensive, thorough and entirely designed for growth. The data model was built with a computer-assisted systems engineering (CASE) software suite and is database independent (Figure 2)

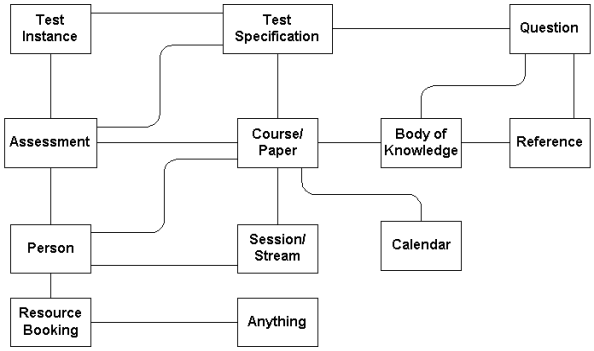

Figure 2. A simplified representation of the Cecil data model.

The architecture is classic n-tier consisting, currently, of a database (SQL Server), object layer (COM), web interface (Active Server Pages), and Windows thick client logical tiers The object layer contains the business rules and is used by all presentation layers (Figure 3).

The database runs on a 4-processor system with a RAID disk array, allowing for redundancy. A secondary replicated database is being deployed to provide reporting, training and OLAP facilities.)

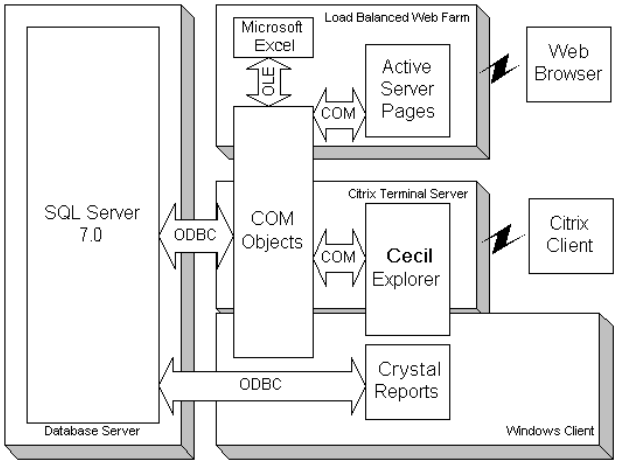

Figure 3. The architectural model of Cecil.

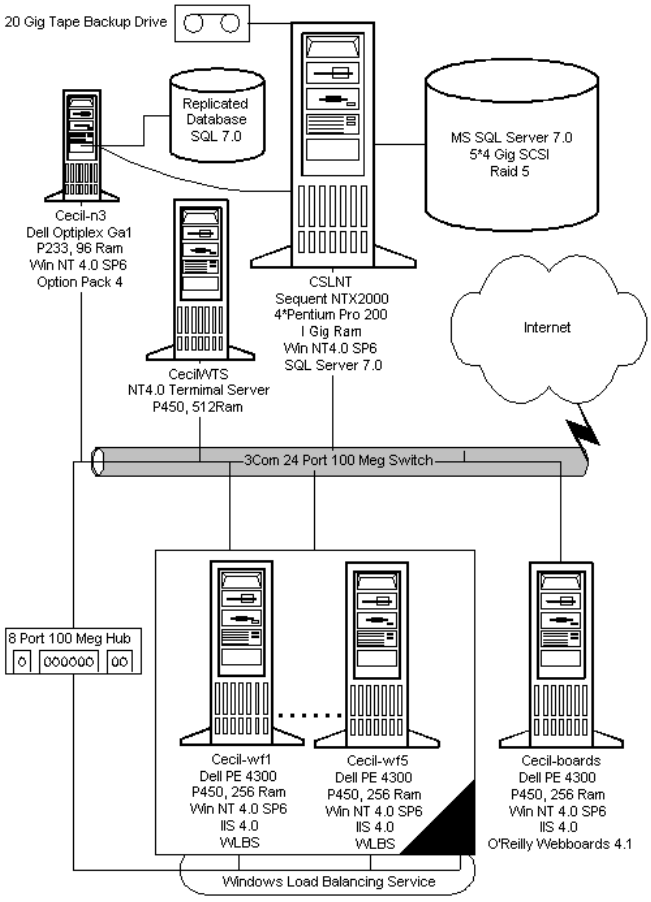

Figure 4. Hardware configuration of Cecil.

The object layer and the web interface run together on a web farm (5 machines that provides load sharing and redundancy. The design allows for the object layer to be placed on an array of object servers when required for increased scalability (Figure 4). The thick client is

deployed to users as a thin client via Windows Terminal Server or Citrix allowing a single point of deployment and access for users of any platform as well as through the web. This architecture, by using RAIS (Redundant Array of Inexpensive Servers), provides both linear scalability (cost vs capacity) and redundancy to guarantee 24x7 service.

Cecil has a number of features that enable its full use in the academic and professional environment. It is internet enabled supporting world-wide access for Internet users using the popular browsers on a variety of common platforms. It has an industrial strength database and server software installed on universally accepted hardware to provide a reliable, responsive, and flexible environment for our work. Every transaction on the system is tracked and recorded in a highly responsive manner. Our design specification calls for pages to be served to the client in less than one second. The security sub-system is extensible and therefore able to embrace all industry standards as they evolve. Secured sockets, encryption and bio-sensing devices can be implemented.

One of the key areas of Cecil relies on its user system interface. This is divided into two main areas the student's and instructor's interfaces**.** The student interface includes user-friendly, easy access to all enrolled papers, Gradebook (marks-to-date), course materials, schedules, on-line assessments with immediate feedback, and communications systems (announcements, email, discussion groups, net-meetings), (Figure 5).

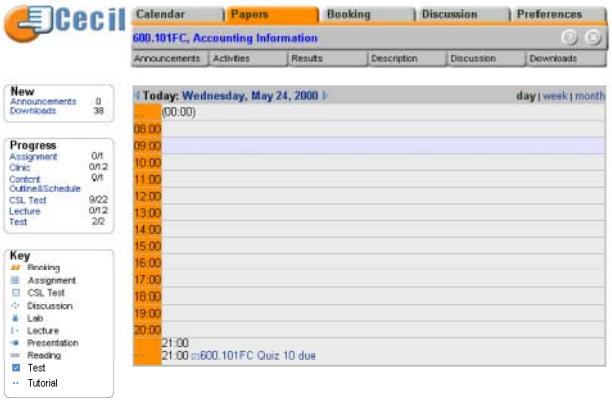

Figure 5. A student's view of Cecil Web.

The instructor's interface provides easy access to relevant students data, their assessments, their photos, and communication systems. An authoring interface provides the tools to build references, test items, diagnostic feedback, course content, and various paper activities (Figure 6). Authors are able to incorporate large item banks from textbook publishers and batch load these questions with a minimum of manual effort.

Cecil is updated from the University's enrolment and registry system on a daily basis with the result that instructors do not need to create and maintain class rolls. Data generated by the University's system for streaming students are also incorporated into the Cecil Gradebook which further assists in the management of large papers (Figure 7).

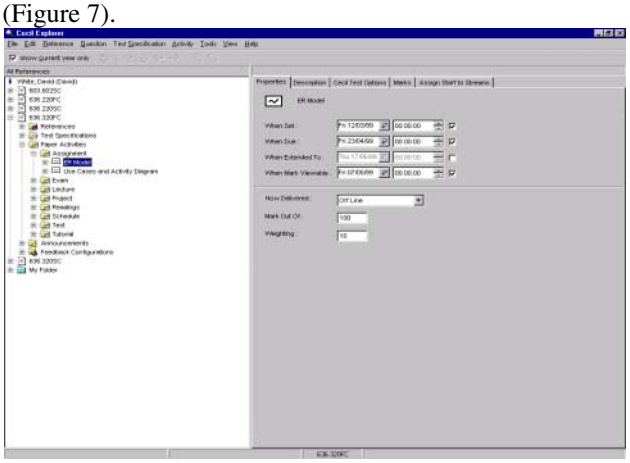

Figure 6. Screen shot from Cecil Explorer

This section has discussed the architecture of Cecil, section 3 now looks at Cecil's features.

3. Computer Supported Learning (CSL) at Auckland University?

This section discusses the functional areas of Cecil from the perspectives of the instructor and administrator, it then discusses the student user's interface, Cecil Web.

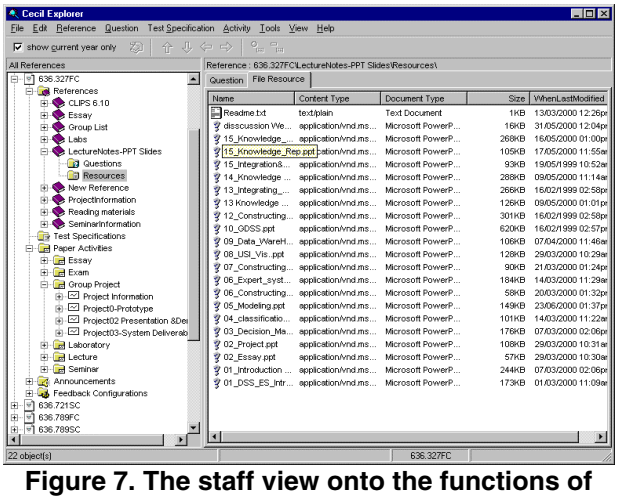

Figure 7. The staff view onto the functions of Cecil via Cecil Explorer.

A staff member interacts with Cecil using a program called Cecil Explorer (CE). Access to CE is normally

provided through a Citrix server. The Citrix server is also web-accessible and some academics use this method. The discussion of the instructor and administrators tools within Cecil Explorer all refer to Figure 7

Cecil is primarily an instructional management and assessment system. A university has an abundance of creative people from a wide range of disciplines who are extremely eclectic in their teaching philosophies and practices. Choosing one educational software solution to satisfy this group would be a major challenge [2].

We believe Cecil is uniquely designed to support all of the University's disciplines. It allows instructors to store and organize all of their teaching and research materials in one location and then assign these resources to individual papers. In this sense it becomes a personal body of knowledge (BoK) that can be shared with colleagues and with students. The architecture of Cecil is designed to replicate the BoK from the academic's desktop to the University system and then on to the student's laptop (Bodies of Knowledge are discussed further in section 3.4).

As an assessment system Cecil supports instruction by storing large banks of questions and then selecting, from these banks, questions that meet the instructor's instructional objectives. The questions form an assessment that is presented to the student via the Internet either under supervised or non-supervised conditions. Assessments are immediately scored and the feedback is provided using a protocol established by the instructor. Cecil has been designed for computer-automated testing (CAT). CAT will adjust the difficulty of the following questions based upon the responses provided by the student.

Cecil has enabled students to complete their studies in an efficient manner and also courses to be managed in several ways. Students are able to access all course details and materials via the web either on or off campus. Announcements previously put on bulletin boards or made at the beginning of lectures are now made electronically making changes to programs or important message transfer very effective. Management of papers through Cecil is extremely flexible; academics and tutors can access the system, post announcement, upload materials and use Gradebook features from the web, therefore enhancing the overall-working environment. It has been noted that professors visiting in Europe can instantly inform all their students of the latest developments and tutors regularly mark assignments at home and post the marks via their internet connection. Gradebook has many unique features for paper management techniques and also advanced statistical summary facilities.

Cecil is clearly aimed at supporting academics and their students by providing a highly flexible and reliable system for assessment and feedback. An important aid to successful learning is the opportunity for self-assessment and immediate, guiding feedback. These facilities are discussed in the following sub-sections.

3.1 References and Bodies of Knowledge

Cecil provides other services such as an impressive method of organising multi-media or text based learning materials. The "reference" system enables the instructor to file all relevant information regardless of its source and to drag and drop these references into various class folders. As the "reference" system grows it will become a personal body of knowledge and a useful system for teaching and research alike.

In the Cecil data model all learning is related to what might be called a career, discipline or a body of knowledge (BoK). Many professions such as medicine, accounting, mathematics and information systems have well articulated taxonomies. The New Zealand Qualifications Authority has technical training standards that also form BoKs since they provide a framework for learning and assessment [3].

The body of knowledge (BoK) for information systems has been developed over a number of years and based upon numerous studies by individuals and professional organizations [4, 5, 6, 7, 8, and 9].

In the past, IS'95and IS'97, has been proposed as a model curriculum by the AIS, ACM and DPMA, [9, 10]. This curriculum details hundreds of knowledge elements and classifies them in a variety of ways that includes the use of Bloom's Taxonomy of Educational Objectives [11]. Combinations of the knowledge elements form learning units that in turn form the basis of courses of study in IS. Using Cecil our MSIS Department has modeled the body of knowledge for Information Systems to make a formal link between professional requirements, our courses of study, individual papers, and our assessments (Figure 8).

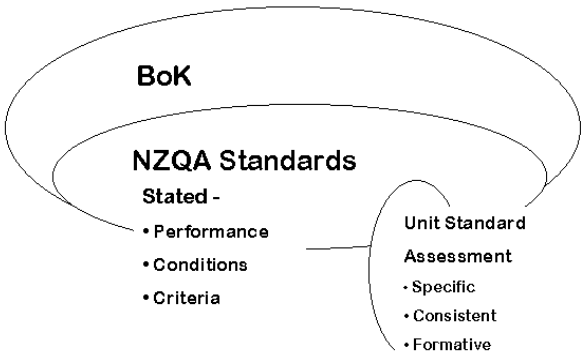

Figure 8. A conceptual representation of the body of knowledge.

Building a link between assessments and knowledge elements has many benefits; one is the student's ability to

plot their progress in their studies over weeks, months, or years. In our design we retain students' achievement data with the result that we can provide a report on what parts of the body of knowledge the students have learned, what remains to be learned for a qualification, and what changes have occurred in the body of knowledge that were not available when they were taking their training. This latter feature is especially useful for planning post-graduate sessions. If post-graduate training or continued education is necessary then the differences between a student's personal accomplishments and their desired goal can be readily provided. In the case of obsolescent knowledge then the new knowledge elements are provided as links from the knowledge elements the student mastered earlier.

Under Cecil students may wish to have their academic record stored at their former institution or at a central site and choose to query the system over the internet. If privacy is an issue an individual may store their academic record on their personal computer and then use the internet to compare their accomplishments with the current standards.

3.2 Assessment and feedback options

Cecil provides secure access to self-assessment options such as multiple-choice questions (including true/false as well as multiple-right questions), questions that use embedded random numbers. Multimedia objects can be inserted into questions that include streaming audio, video, graphics files, and even QuickTime movies. Java applets are also becoming popular and these can also be inserted into our custom questions.

Where assessments are generated within Cecil they become objects in the database. Any assessment presented to a student is capable of regeneration at any time in the future. In other words test items are locked once delivered. The student's responses to the question are stored. No aspect of the assessment can be changed at any time in the future. A tutor can regenerate a test to review it with a student and can indicate the student's response and the correct answer at the same time. Cecil's design respects the due diligence required of traditional assessment methods.

Self-assessment activities are one of the most popular options. Students use Cecil at all hours to check their understanding of the learning materials. The fact that no academic credit might be obtained for doing a self-assessment seems irrelevant so long as the learning content is clearly mapped to the course objectives and examinations.

Increasingly, we see students wishing to receive small simulations that supplement the lectures and allow them to interact with new concepts. Many institutions are working on learning engines, active learning pages, or goal based simulations to complement lectures, tutorials, assignments or laboratory sessions. Cecil has an open architecture that means that Cecil can be adapted to present any new web-based technology.

Model problems with random numbers have been developed in several disciplines. Such problems engage students at a higher cognitive level than is often the case with recall and recognition questions. Shared variable questions (using random values) allow instructors to pose problems of increasing complexity and to step the students through problem solving pathways. Cecil is designed to support computer aided testing. This means that based upon a single answer the system can adapt to the student's response by branching to another problem set or a different level of difficulty.

Many forms of feedback are provided that include: feedback on the each of the possible student's responses, feedback immediately after a response, feedback at the end of the quiz, and/or feedback by email. The feedback message can be either extremely terse or detailed. Naturally feedback messages can include multimedia objects as well as links (URLs) to other useful sites.

3.3 Gradebook

Assessments or self-assessments are organised in the context of the course of studies. The central Cecil application for this is Gradebook, a highly flexible method of tracking student progress. Gradebook has been designed to integrate with the University's Academic Registry. Gradebook is loaded automatically with the latest enrolment data from the Registry. Where a course uses streaming then course streams may be loaded into Gradebook. Instructor's can assign tutors to mark assignments by stream and give them access to selected parts of Gradebook for fixed periods of time. Gradebook activities can be linked to grading criteria (a type of assessment) with the result that essays and other assignments can be marked anywhere, anytime (over the internet) and the student's grades updated, feedback sent by email, and the students enabled to see their marks via the web as well. Gradebook has also been designed to produce output consistent with Academic Registry's requirements.

3.4 Students view of Cecil Web

This section briefly describes the functions that are available to every student who uses Cecil. These features are discussed in relation to Figures 5 and 9. Student users access Cecil through a web interface. Upon access to the system the student user is presented with the Cecil Home

Page. The Cecil Home Page is a "diary" with a view of "today".

At the top of the home page the menu bar displays options for selecting information on enrolled courses (indicated as papers), the resource booking system, the discussion system, or the personal preferences unit. There are further features of Cecil, these show announcements, activities associated with the course, in progress results for the course, a description of the course and the ability to download materials. All of these will be discussed in the following paragraphs.

Students receive notification that announcements have been received at their Cecil home page and access announcements at the home page for each of their courses. New announcements that not read are symbolically represented as a closed envelope, an open envelope icon indicates that the announcement has been read.

Students may also receive email announcements if the instructor wishes to ensure that each student is immediately notified of some course change. This email may be directed to any valid email address the student provides in their "personal preferences" portion of Cecil.

Student users have a number of parameters about themselves and the defaults of the system that they may change. They may change their email address from the default University address to another outside of the University such as their address at work or home. Students may also substitute another photo for the one that is automatically loaded from the University's identification card database. The student can also enter a "preferred" name. Often students from Asia use this option to insert their "westernised" name.

As noted above, the home page for Cecil defaults to today's date (0800 – 2000) and lists all of the tasks due for all of the student's courses. The user can choose to display weekly and monthly views to get a more comprehensive look at what lies ahead.

The entries in the calendar view have icons that identify if the event is a booking. If the student "clicks" on any of these events s/he is taken directly to its detailed description or activity. Students select a specific course from a list of current courses via a pull-down menu. Each paper has associated with it announcements, activities, results, discussions, and downloads. As noted in Figure 9, two summary tables are provided. One indicates what is "new" such as the number of unread announcements, and number of learning materials available but not yet downloaded by the student. The second "progress" table lists the course activities and their status. Since each course can use Cecil in slightly different ways the list of activities can vary. In general, the list includes all of the assessed and non-assessed "events" within the paper and against each a summary of those completed and in total. For example, (Figure 9), in the paper shown there may be 22 CSL Tests of which 2 have been completed hence 2/22. There may be 12 lectures and the delivery date has passed is 0, hence 0/12.

Like many large institutions, The University of Auckland has very large enrolments in its first and second year courses. In order to provide seminars, laboratory experiences, projects and tutorials to small groups of students, they are "streamed" by the University's registry system. Inevitably the students with work and home commitments find themselves placed in impossible situations and need to be moved.

Fortunately Cecil provides these students with self-streaming options so that they can shift themselves around to more convenient timeslots if some are available. When all else fails the students see the course coordinator! This streaming feature has saved students much hardship and course coordinators several days work each semester.

Lectures are associated with a specific date and may have assessed or non-assessed status. In other words, there could be an attendance credit associated with a lecture. If the student selects a specific lecture then the date, time, location and duration of the lecture are provided. The learning materials associated with the lecture may be made available, at the discretion of the lecturer, before or after the lecture. These learning materials can be in a wide range of file formats including: Microsoft Office products, Visio, ERWin, Adobe Acrobat, QuickTime, Real Audio, Real Video, and Lotus ScreenCam. The Business School produces a CD ROM each semester with updates to the internet browsers as well as all of the plug-ins to the browsers that students may require.

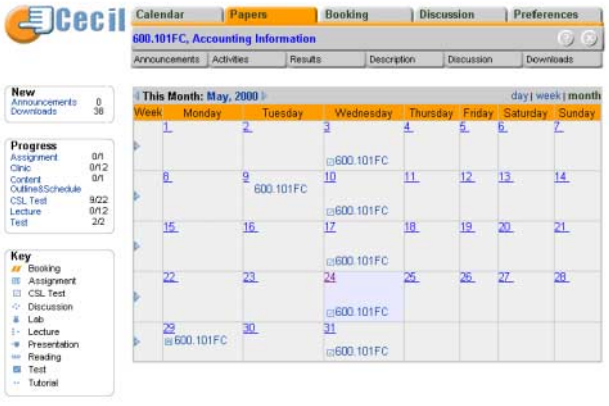

Figure 9. A Calendar view of Cecil Web.

Many courses use Cecil quizzes. Most of the Cecil quizzes are provided for formative assessment. In other words, the student may take them to determine if they are mastering the material. In some cases the quizzes must be taken before the associated lecture. In this way the diligent student will have reviewed the lecture material

and determined areas of potential weakness. Quizzes may be supervised or non-supervised.

The collaborative work area termed "Discussion" is, in fact, a third-party application called WebBoard produced by O'Reilly & Associates. Cecil Discussion provides threaded discussions as well as synchronous chat rooms. The WebBoard interface has been configured so that it provides a visually seamless transition to and from the Cecil home spaces. Cecil Discussion provides threaded discussions as well as synchronous chat rooms. It appears to fill the current teaching and learning requirements and has been profitably exploited by many Departments.

3.5 Evidence of Success

There is evidence that students at the University are motivated to participate in learning activities for several reasons. For credit where an activity is assessed, where an individual feel that participation is useful and also for general serendipitous intrigue.

Evidence from several observations and studies in the University have noted improvements in learning outcomes, perceived usefulness of on-line learning tools and use of tools. There are several reports of the use of on-line learning tools for no credit, purely as a learning exercise as to test understanding.

In 1997 after 1 semester of operation student responses were sought on the ease of use and perceived usefulness of the site. The results in table 1 show a positive response to the system. The results have been drawn from two identical questionnaires given a total response rate of 42%, the response rate for the first round being 24%. [12].

Table 1. Summary results from Cecil survey.

Response content.	Response rate 24%	Response rate 42%
Access from home always	7 %	13%
Access from home sometimes	17%	65%
First access to Cecil found to be V. easy to OK	97%	90%.
Students would use Cecil as a study aid for no credit.	90%	85%
Students would use Cecil to look at their marks in other papers	97%	89%
Students would like to take Cecil tests for their other papers	67%	(71%).

Paynter and Frazer [13] document the comparison of Cecil with two other computer learning sites of a similar nature using a WAMMI questionnaire. A WAMMI is a Web usability questionnaire (Web site Analysis and MeasureMent Inventory).

This is a tool that can be used to allow your users help you improve the effectiveness of your web site. Their survey found that on a scale of 1 - 5 where 1 is the best and 5 is the worst the current Cecil system scored 1.8, where as the best of the other systems scoring 2.3.

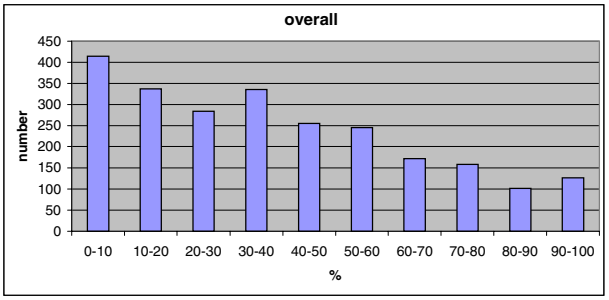

Figure 10. Grades distribution for Biology pre Cecil support

Evidence from another faculty has shown that 68% of students attending the course said that Cecil pre-test had increased their level of understanding of the lecture. 85% of this student group found the on-line tests a useful diagnostic while 92% responded that the on-line materials were useful.

The School of Biological Science also analysed the grades for a paper against the previous history of the course and found that there was a significant increase in the scores of individual students on the paper (Figure 10 and 11).

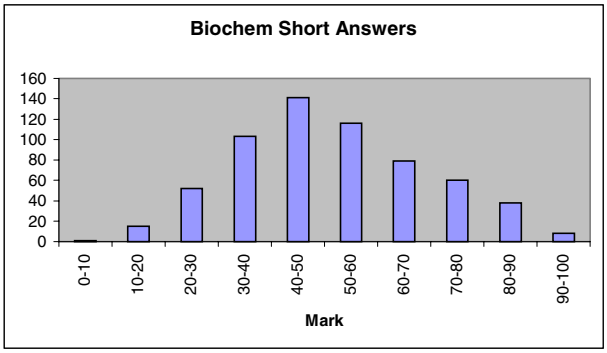

Figure 11. Grades distribution for Biology post Cecil support

There is significant evidence to support that students both perceive the system to be useful and gain practice

with their studies. Many of the technical abilities of the system must be attributed to the openness of the Architecture. This is discussed next.

3.6 The Advantages of an Open Architecture

Given our support for an "open architecture approach to web-based products", it is our view that course content creation and management is best left to the marketplace. Many sophisticated web site authoring and management tools will eclipse the offerings of educational software vendors. Our academics require state-of-the-art solutions to rise above our competitors.

CSL has been built using state-of-the-art design tools, the latest internet server software, and a very reliable database engine. It is installed in the University Information Technology Support Staff (ITSS) centre on a multi-processor computer with fail-safe secondary storage. ITSS maintain operators on site 24 hours a day. In mid 2000 CSL asked and marked over 100,000 questions. CSL has a remarkable record of reliability.

4. Enterprise-wide decision making

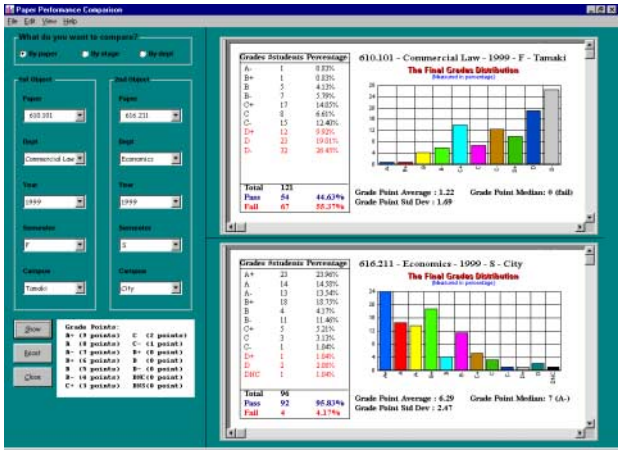

Figure 12. Prototype data mining tool using Crystal reports.

From a management information systems (MIS) perspective the term "enterprise" means a perspective that includes a consideration of all of the organisational units, functions, processes and data elements [14].

A number of systems, similar to Cecil are on public offer to academics and their departments. [15]. Very few of these systems have been adopted on a School-wide basis and then exploited for their enterprise wide benefits. The installation of a stable user friendly system may facilitate more than the collation of marks and the provision of feedback to students, it enables the closer collaboration of staff at any scale within the organization (Figure 12).

Historically the need to provide a working solution to problems has lead individuals to purchase and administer their own systems. Often the implementation and administration of these systems have been subject to several pitfalls. Whilst the individual implementation may be sound there are increasing security risks associated with the proliferation of these systems. These risks may over time compromise the organisation's information systems security and the privacy of the client's data. Simple and essential functions such as backups and thorough administration may be unavailable luxuries for the individual's system. The short-term reliance of these systems also on one or two staff to provide maintenance will become a longer-term liability as the consequence of staff departure become apparent.

These issues can be addressed, in many universities compromise and compound systems have been forged. The inability to share and transfer data and teaching resources between administrative units and departments is, however, a major loss. This must be measured both in terms of the costs incurred in data translation and duplication and the frustrating time loss each finds at differing places of the system. A recipe for chaos and data corruption is apparent [16].

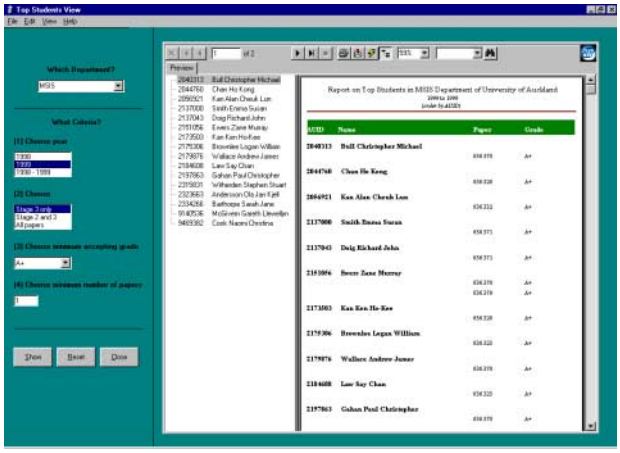

Figure 13. Complex reporting through Crystal

Given these hazards an enterprise solution has been developed. A dedicated team of developers and support staff enable the continuing success of Cecil as well as allowing assessment and resource management. But CSL gives more. CSL has the ability to facilitate the professor and administrative units to mine the statistical data stored within its database. Such data mining may be used to gauge the performance of a cohort of students, or look at the effect of changes in teaching and learning both in present and trend analysis [17, 18]. From small

beginnings Cecil has begun to produce management reports and comparisons reports for student grades and also for resource usage. Staff members may produce status reports to prompt their teaching activity, managers may compare departmental grades across the faculty, and postgraduate coordinators may select from the data base all those students who have satisfied a number of criteria for invitation to higher degrees (Figure 13). Currently plans exist for the support of OLAP tools and a server but currently all data extraction from Cecil is completed using Crystal reports. It is noted that the use of such reporting techniques is extremely useful in terms of overall direction and also in terms of labour savings.

5. Conclusions

This paper has outlined the Cecil system, its architecture, overview and application. It is noted that this system has provided many benefits in terms of teaching learning and administration. It is available to the whole University of Auckland teaching staff and students. The uptake and usage of Cecil has shown significant benefits to the individuals who use the system. The benefits from the sharing of data and resources are high and merit the development and maintenance costs for the University.

This paper has discussed the pitfalls of individualised solutions proliferating through out a university information system. Cecil provides an enterprise solution to University problems associated with the storage, collation of teaching and learning resources, administration and student learning management. It has addressed privacy and organisational issues from the outset of its construction and now provides a stable, secure school and University wide system. Additional features that enable the collation of statistical data facilitate data mining and further in-depth examination of the way papers and students perform is a valuable resource.

With the successful manner in which this system has been utilised within the School of Business at the University of Auckland, further developments are planned to expand the range and nature of support that this system affords its users.

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