# THE TEXT ANALYSIS OBJECT (TAO): ENGAGING STUDENTS IN ACTIVE LEARNING ON THE WEB

[1]David M. Kennedy, [2]Albert Ip, [3]Norm Eizenberg and
[4]Craig Adams

[1]and[2]Multimedia Education Unit, The University of Melbourne, Australia.
email: d.kennedy@meu.unimelb.edu.au
email: a.ip@meu.unimelb.edu.au

[3]and[4]Department of Anatomy and Cell Biology, The University of Melbourne, Australia.
email: n.eizenberg@anatomy.unimelb.edu.au
email: craig.adams@whcn.org.au

## *ABSTRACT*

*At The University of Melbourne, there has been an ongoing effort to place the learning of anatomy within a clinical context by linking anatomical knowledge with clinical practice and diagnosis. This effort has been made in order to overcome the traditional division between structure and application, which characterises much of biological science teaching. In recent times the Faculty of Medicine has elected to move to a curriculum based on a problem-based learning (PBL) approach, modules of which will be deployed on the Web. This is leading to the development of computer-facilitated learning (CFL) modules for medical students.*

*This paper reports the results of a study of the design, development and formative evaluation of an innovative, interactive learning tool, which will be implemented into Web-based modules. The learning tool is an open-ended, short answer, text analysis object (TAO) designed to be used in Web-based courses or incorporated into hybrid Web/ CD-ROM systems. TAO facilitates the development of extended question-and-answer problems which overcome the limitations of the multiple-choice question format – a format which can only represent one of the lecturer's understandings of the correct answer and a selection of her or his views on student alternative conceptions. Using the TAO, a student is required to generate a more meaningful answer by articulating her or his understanding rather than merely recognising the lecturer's representation. The TAO facilitates an iterative approach to developing student knowledge constructions of anatomy from a clinical perspective and provides feedback to student responses by using a key word and key phrase search mechanism.*

*The formative evaluation of the TAO has been completed with students from second year medicine. The results of this evaluation are reported. The examples provided in this paper relate to questions developed for the Department of Anatomy and Cell Biology in the Faculty of Medicine. However, it must be stressed that the TAO is applicable to many other academic disciplines with similar needs for students to develop more complex understanding of specific content domains.*

## KEY WORDS

Text analysis, active learning, Web-based testing, evaluation, medical education.

## 1.    INTRODUCTION

The use of the World Wide Web (Web) to facilitate more flexible delivery of academic courses in higher education has increased considerably in the past three years. Many large course management applications (e.g., WebCT®, TopClass®, and Virtual U®) have been developed which administer student access to courses, log student activity, organise multimedia content (text, images, video, sound) into easily navigable modules and Web pages, and provide an easy-to-use authoring environment for lecturers and teachers. Considerable effort has been invested in the development of course management software. However, only minimal efforts (institutional or commercial) have been made to develop pedagogically sound interactive learning tools that have the potential to engage the student more actively in her or his learning. If there are to be any lasting improvements in student learning outcomes and the success of online courses there is a need to:

•       embed sound educational pedagogy into online courses; and

•       provide interactive pedagogical tools, which are simple for content experts to implement.

The development of the Text Analysis Object (TAO) is part of a wider program being undertaken by the Multimedia Education Unit (MEU) at The University of Melbourne to develop simple generic Web-based learning and evaluation tools (Fritze & McTigue, 1997; Kennedy, Fritze, & McTigue, 1997; Kennedy & Ip, 1998). The MEU is developing a number of generic learning tools for use in Web-based, CD-ROM or Web/CD-ROM hybrid course materials. The TAO is designed to be a generic text analysis tool that enhances student learning in Web-based courseware. The functional aspects of the TAO include:

•       a text box into which students type short text-based answers based upon a question item;

•       a software engine to search for key words or multiple versions of a phrase or phrases defined by the lecturer or content expert;

•       the ability to provide appropriate and meaningful feedback to students based upon the number of key words or words or multiple versions of a phrase or phrases found in the text string typed in by the student; and

•       access to expert answers and a representative student exemplar to any question for comparison and evaluation purposes.

Three perspectives guided the development of TAO. These perspectives involved:

•       a pedagogical view of teaching and learning;

•       the needs of academic staff engaged in developing online courseware; and

•       the needs of students engaged in learning anatomy.

The pedagogical perspective adopted derived from a theoretical framework that links what is known about sound educational practice with the design of multimedia elements to incorporate into interactive multimedia courseware [Kennedy & McNaught, 1997].

In the initial design and development phase of the TAO, academic staff from the departments of Chemistry, Physics, Anatomy and Cell Biology, Pharmacology and Economics at the University of Melbourne were surveyed to determine some of the requirements for delivering online tutorials. While the needs of each academic discipline were varied, the analysis of text from student-generated answers was perceived to be one element fundamental to the implementation of meaningful Web-based courses to engage students more actively in the learning process – a move away from the click-and-browse interface of many current online courses. Academic staff perceived that a Web-based learning tool that could elicit student responses of complex knowledge rather than merely require recognition as in multiple-choice questions (MCQ) would enhance student learning.

The final view that guided the development of TAO derived from student focus groups (from the Faculty of Medicine). The students were in their first year of clinical practice (year 4). Scenarios were constructed on paper (and displayed using an overhead transparency) to evaluate the basic functionality of the TAO and a number of potential feedback mechanisms. The student focus groups were involved in the design of a meaningful feedback mechanism, and a number of other functional components of the initial prototype of the TAO. The final structure of the feedback mechanism was developed from the specific need to link anatomical knowledge with studies in clinical practice in a way that was meaningful to students. Staff and students (second year) from the Department of Anatomy and Cell Biology then participated in the development, design and formative evaluation of the Text Analysis Object.

## 2. A FUNCTIONAL VIEW OF THE TAO

The basic functionality of TAO required a:

- text field into which a student could type an answer to a question;

- software engine to analyse the student text and provide meaningful feedback;

- method of displaying an expert answer; and

- simple to use authoring environment.

Initially, the TAO has been created as a server-side object – that is, the software engine for analysing the student answer and providing feedback is located on the server. This decision derived from the need to have a short development time, core functionalities could be developed quickly and tested, and the tool could be easily maintained. A functional student view of the current iteration of the TAO is shown in Figure 1.

A problem widely reported is the inability of students to link the pre-clinical knowledge (e.g., anatomical knowledge) with the demands of being a successful clinician (Balla, 1989; Eizenberg, 1988; Eizenberg, 1991). From focus groups consisting of fourth year medical students (in their first clinical year of study), the need for a two-tiered model of question response became apparent. A typical quote from these students was:

> … the difficulty is knowing what is important and what is not important (anatomical knowledge) in making a diagnosis.

> I have forgotten much of what I learnt in first and second year anatomy. … I find myself going home each night and relearning the important concepts (of anatomy).

From the work with the fourth year focus groups, a two tiered model for developing questions and meaningful feedback for students using the TAO was developed. The two tiers facilitated:

- developing a model for writing questions which focused on important anatomical concepts; and

- the development of a software engine that differentiated between important anatomical concepts and what were merely anatomical details (ideas not fundamental in clinical practice).

The first of the two points above led to the development of a schema for writing the questions, expert and student representative answers, keywords and phrases. It also guided the development of the authoring environment.

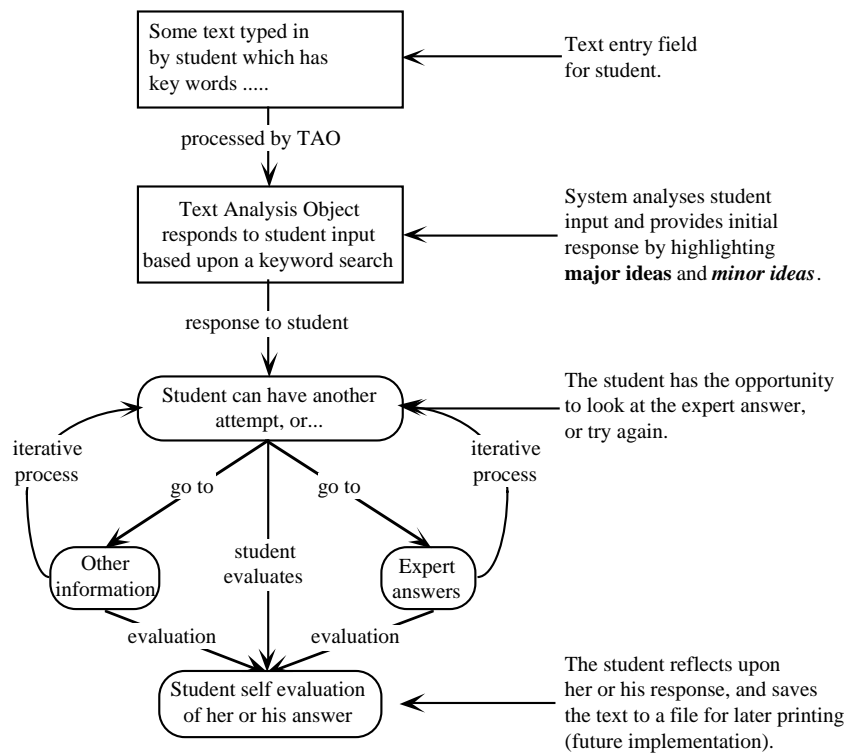Question: Define a term, express an idea, or interpret some information.

| | |
|---|---|
| Some text typed in by student which has key words ..... | Text entry field for student. |

*processed by TAO*

| | |
|---|---|
| Text Analysis Object responds to student input based upon a keyword search | System analyses student input and provides initial response by highlighting **major ideas** and *minor ideas*. |

*response to student*

| | |
|---|---|
| Student can have another attempt, or... | The student has the opportunity to look at the expert answer, or try again. |

iterative process       *go to*       *go to*       iterative process

Other information       student evaluates       Expert answers

*evaluation*       *evaluation*

| | |
|---|---|
| Student self evaluation of her or his answer | The student reflects upon her or his response, and saves the text to a file for later printing (future implementation). |

**Figure 1: A functional view of the TAO object**

## 2.1   *Structuring the authoring environment*

The structure of the authoring environment was critical – because the tool is likely to be used by lecturers with limited computing experience. Design of the authoring environment was guided by work carried out as part of developing Learning Evaluation Online (LEO), an online evaluation tool used in the formative evaluation of TAO (Kennedy & Ip, 1998). The experience gained from the structure of the LEO authoring environment indicated a forms-based approach to be very useful. The authoring environment (question development template, QDT) consists of a proforma (Figure 2) which has fields for the:

- reference code for the question;

- question stem;

- key words and multiple versions of a phrase or phrases based on an important concept or concepts;

- key words and multiple versions of a phrase or phrases based on an detail or details;

- mark to be awarded for each concept (major idea) and detail (minor idea);

- expert answer in point form; and

- exemplar student answer.

The experience of the authoring environment indicated that authors (content experts) with minimal computing skills can format questions easily for the TAO software engine. The structure of each question required the:

- separation of important (clinical) concepts from (anatomical) details;

- development of a number of alternatives for key words and phrases, separated by the pipe symbol;

- organisation of the expert answer into point form which clearly showed the concepts and details (a stated requirement from the students in the focus groups); and

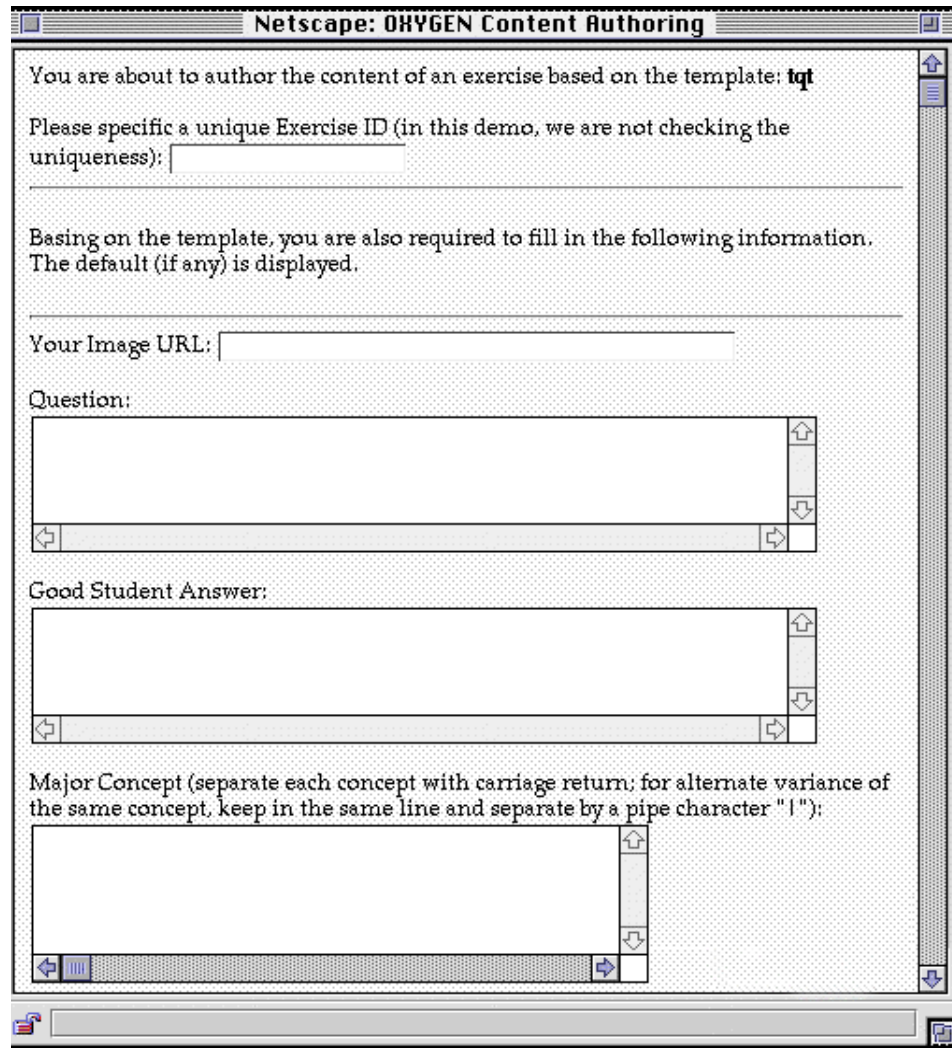- assigning the appropriate mark for each concept and detail (usually 2 marks for a concept and 1 mark for a detail).



**Figure 2: Image of the TAO authoring environment**

Two questions used in the formative evaluation are shown in Tables 1 and 2. In Table 1 the question is a simple one which focuses on anatomical detail. However, in Table 2 the question is more complex and resulted in considerable discussion, debate and collaborative effort in order to answer the question (between each pair of students).

**Table 1**

Example 1: A simple question using TAO

| | |
|---|---|
| Question 0001 | In which surface region of the anterior abdominal wall is the pain of appendicitis usually first experienced? |
| Expert answer | Concepts:<br>Details:<br>The midline region around the umbilicus<br>The pain is experienced in the umbilical region. |
| Student answer | In the midline around the umbilicus. |
| Keywords and/or phrases | Concepts<br>Details<br>umbilical\| umbilical region\| umbilicus\| paraumbilical\| periumbilical<br>midline\| midline region |

## 3.    FORMATIVE EVALUATION

Formative evaluation was undertaken with 25 students (11 pairs and one group of three) over a period of four days. A screen capture of question two illustrating the experience of the students is shown in Figure 3. Each session consisted of approximately one hour for each group of students. The student responses to the use of TAO were generated by:

- recording (audio tape) student conversations using the 'think-aloud' approach as they answered the questions;

- researcher notes of student-student interactions; and

- an online survey containing Likert-style and free text response questions at the conclusion of each session using Learning Evaluation Online (LEO), a Web-based evaluation tool (Kennedy & Ip, 1998).

The students adapted very easily to the screen design and the method of using the tool. In each session students completed approximately 4 to 6 of the 8 questions. This led to the unusual phenomenon (in the first author's experience at least) of the majority of the groups of students requesting to stay in the computer laboratory to complete all of the questions (which they subsequently did).

**Table 2**

Example 2: A complex question using TAO

| | |
|---|---|
| Question 0002 | Explain the anatomical basis for the pain of appendicitis being usually first experienced in the umbilical region. |
| Expert answer | Expert answer |
| | Concepts: |
| | The appendix is an unpaired viscus. |
| | The appendix is supplied by visceral afferents. |
| | Visceral pain is poorly localised and is referred. |
| | Unpaired viscera refer pain to the midline because they receive a bilateral nerve supply. |
| | The appendix develops from the midgut. |
| | The midgut refers pain to the umbilical region. |
| | Details |
| | The nerve supply for the appendix is associated with the tenth thoracic spinal cord segment or spinal nerve, T10. |
| | The umbilical region is supplied by tenth spinal cord segment or spinal nerve, T10 dermatome. |
| Student answer | Student answer |
| | The appendix is an unpaired viscus derived from the midgut, which is supplied by T10 spinal cord segment. Pain is referred to the midline in the T10 dermatome. |
| Keywords and/or phrases | Concepts |
| | unpaired viscus\| unpaired viscera\| viscus\| viscera |
| | visceral afferents\| visceral afferent nerves\| visceral sensory nerves\| midline |
| | midgut |
| | bilateral nerve supply\| bilateral nerve\| bilateral nerves\| bilateral referred pain\| referred\| refer |
| | Details |
| | tenth thoracic\| T10 |
| | dermatome |
| | spinal cord segment\| spinal nerve |



**Figure 3: Screen-capture of question 2**

The formative evaluation indicated a strong acceptance of the TAO as an effective learning tool. Representative written comments from the online survey asking "What was the best feature of this multimedia program?", are shown.

> It is very clinically oriented which is brilliant since books do not often highlight important principles.

> … the distinctions between concepts and details in the question are critical, therefore very relevant.

> The fact that we could type in our own answers and for the program to analyse what we got right instead of us choosing from a number of given answers.

The use of pairs of students enhanced the learning experience by promoting a collaborative approach. Students were strongly engaged in debate and argument about the inclusion or exclusion of anatomical concepts and details. Most pairs of students tended to refine the first attempt a number of times before having the response analysed. The concern expressed by some academic staff that a student would merely access the expert answer almost immediately was unfounded for two reasons. The first reason was student motivation – when asked why they didn't look at the expert answer immediately, students stated that doing so was a 'waste of time' because it wouldn't help them learn. The second reason is more pragmatic – TAO requires a student to click on a submit button in the first iteration of an answer before providing access to the Get Answer button (Figure 3).

A similar lack of concern was expressed in regard to the lack of a spell checking mechanism – they believed they should know how to spell the terms. Not all comments were positive and some of these responses have resulted in changes in functionality of the TAO.

In response to 'What was the worst feature of this multimedia program?', students stated the following.

> No indication of how much is expected in answering a question.

> Having to sift through (expert) answers to find what you hadn't included (in your own answer).

> Maybe at times being too pedantic about details.

> There is no half way between your incorrect answer (and you not knowing how to improve it) and the correct answer (ie there were no hints to guide you through coming up with a correct answer).

In response to 'Any more comments or suggestions for improvement?', students stated the following.

> Providing hints at second attempts and . . . having a help file with a list of anatomical terms which can be accessed.

> Just enhance the text analysis flexibility – sample a wide proportion of possible answers.

> Highlight the number of marks per question so we can judge the amount of detail required.

In response to these comments two changes are being made to the TAO software engine. The mark for each question is displayed with the question stem to provide a guide for the relative complexity of the answer required (sometimes students would answer a *why* question when a *where* answer was required, see Table 2 and Table 1). The second change is more fundamental. The TAO is to be incorporated into a Web-based course – providing access to hints and online help to support student learning.

In addition to the extended comments (above), the student responses to bipolar Likert-style questions (which focused on the potential educational value of TAO) were analysed. The responses are shown in Table 3 (the responses were scored: 1, strongly disagree; 2, disagree; 3, no opinion; 4, agree; and 5, strongly agree).

**Table 3**

Example Student Responses to Likert-Style Questions

| Likert-style question | Response |
| --- | --- |
| The TAO helped emphasise important and relevant concepts | 4.7 |
| The TAO helped identify key concepts and provided insights | 4.6 |
| The TAO helped provide feedback which was meaningful to me | 4.3 |
| As a result of using this multimedia I was stimulated to reflect on what is important for me to understand | 4.4 |
| As a result of using this multimedia my intention to achieve an understanding of this subject was enhanced | 4.4 |
| Overall I found this multimedia program to be worthy of extension to develop new modules with similar uses of the TAO | 4.7 |

The responses in Table 3 indicate that issues, important to student understanding are being addressed by the TAO learning experience.

## 4. FUTURE DEVELOPMENT

The TAO will be incorporated into a Web-based course in the new Problem-based Learning (PBL) medical course at The University of Melbourne in 1999 – problem based courseware that focuses on anatomical concepts called *The Body*. In response to current student feedback a number of changes to TAO will be made. The changes are:

- a mark for each question will be displayed with the question stem rather than after the first student iteration;

- improvements to the authoring environment (it will be simplified to include the appropriate URL);

- each question will be generated in a separate window rather than using frames (as in the current implementation);

- integration of appropriate video and sound resources to provide multiple perspectives of the clinical problem (already carried out to a limited extent in three of the questions); and

- incorporation of the TAO into meaningful courses.

The use of TAO is being investigated with other content areas including undergraduate physics and language studies. In the next stage of implementation, TAO will be redeveloped for a CD-ROM environment in the DeMystify project. Formative and summative evaluation of student learning outcomes in both the Web and CD-ROM environments (using TAO) will continue in 1999.

## 5. REFERENCES

Balla, J. I. (1989). Changing concepts in clinical education: The case for theory. In J. I. Balla, M. Gibson, & A. M. Chang (Eds), *Learning in Medical School.* (pp. 3-18). Hong Kong: Hong Kong University Press.

Eizenberg, N. (1988). Approaches to learning anatomy: Developing a program for pre-clinical medical students. In P. Ramsden (Ed.), *Improving learning: New perspectives.* (pp. 178-198). London: Kogan Page.

Eizenberg, N. (1991). Action research in medical education: Improving teaching via investigating learning. In O. Zuber-Skerrit (Ed.), *Action research for change and development.* (pp. 179-206). Avebury: Aldershot.

Fritze, P., & McTigue, P. (1997). Learning Engines - a framework for the creation of interactive learning components on the Web. In R. Kevill, R. Oliver, & R. Phillips (Eds), *What works and why, ASCILITE97.* Proceedings of the Australian Society for Computers in Learning in Tertiary Education Conference. (pp. 200-206). Curtin University of Technology, Perth: Academic Computing Services.

Kennedy, D. M., Fritze, P., & McTigue, P. (1997). An interactive graphing tool: The meeting of pedagogy and technology. In R. Kevill, R. Oliver, & R. Phillips (Eds), *What works and why, ASCILITE'97.* Proceedings of the Australian Society for Computers in Learning in Tertiary Education Annual Conference. (pp. 331-337). Curtin University of Technology, Perth: Academic Computing Services.

Kennedy, D. M., & Ip, A. (1998). Learning Evaluation On-line (LEO): A customisable Web-based evaluation tool. In C. Alvegård (Ed.), *CALISCE '98.* Proceedings of the Fourth International Conference on Computer-aided Learning and Instruction in Science and Engineering. (pp. 255-262). Chalmers University of Technology, Göteborg, Sweden: Chalmers University of Technology.