# Computer-based testing for assessment of medical and dental students on the higher levels of Bloom's taxonomy

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## Introduction

The School of Medicine, Faculty of Health Sciences at the University of Pretoria (UP), follows an outcome based, horizontally and vertically integrated, community based, problem-oriented curriculum. Various types of assessment are used to assess the medical and dental students through the five to six years of study.

Computer-Based Testing (CBT) is used extensively for objective assessment. In the first year of study, testing of knowledge and insight (levels 1-2 of Bloom's taxonomy) is primarily used in assessment. As the students progress through their studies more emphasis get placed on clinical content assessment that consits of the higher levels of Bloom's taxonomy (levels 2-6), which includes analyses, syntheses and evaluation of clinical cases (see Table 1) (Bloom, 1956). The aim of the school and faculty is to direct all assessment (including objective assessment), already from first year, on a higher cognitive level than just knowledge and the challenge is to apply CBT in such a way that it will promote deep learning.

**Table 1: Bloom's taxonomy (Bloom, 1956)**

| Level | Key words |
|---|---|
| 1. **Knowledge:** Recall data or information. | defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states. |
| 2. **Comprehension:** State a problem in one's own words. | comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives examples, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates. |
| 3. **Application:** Applies what was learned in the classroom into novel situations in the work place. | applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares produces, relates, shows, solves, uses. |
| 4. **Analysis:** Distinguishes between facts and inferences. | analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates. |
| 5. **Synthesis:** Put parts together to form a whole, with emphasis on creating a new meaning or structure. | categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes. |
| 6. **Evaluation:** Make judgments about the value of ideas or materials. | appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports. |

In 2005 a new CBT system with enhanced features was developed for UP, which could enable a facilitator to assess students on higher cognitive levels. The Department of Anatomy in the School of Medicine, participated in a pilot study in 2006 and started to use all the different question types as a first phase of implementation in 2007. Questions were created to test on higher levels of cognitive skills and a redesign of their whole database of questions was done.

Although the main focus of this department was on the level of assessment, it was part of a software process model which UP followed during development and implementation of the new CBT system. The process model UP followed is similar to the Catherine wheel model - a generic model applicable to both summative and formative assessment developed by Zakrzewski and Steven in 2000 (Zakrzewski & Steven, 2000). The Catherine wheel is a spiral model designed to utilize a step-wise approach to assessment design and implementation. It has five segments namely Planning, Risk Analysis and Management, Assessment Design, Evolutionary Development and Evaluation. During the implementation and subsequent analysis of the new CBT system, each of the above-mentioned segments was revisited in sequence.

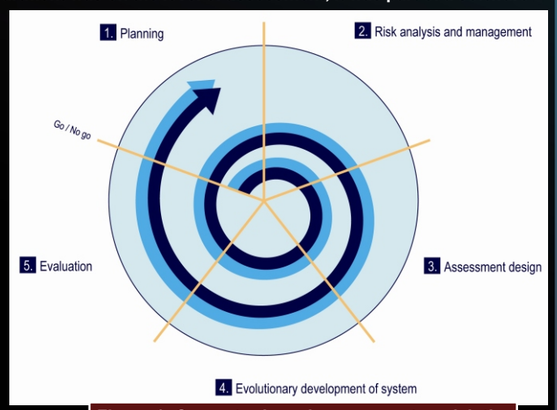



**Figure 1: Computer-based assessment model: the Catherine wheel**

## Aims

The first aim of this study was to evaluate the implementation of the new CBT system for UP with the option to test students on higher cognitive levels (higher levels of Bloom's taxonomy) with the aid of the Catherine wheel model.

The second aim was to reflect on the success of the new assessment model by means of a questionnaire completed by both students and lecturers.

## Materials and Methods

### Model used to evaluate the new CBT system

UP followed their own design and implementation process which correlates with the Catherine wheel model. In developing the new testing system for UP the process started at the centre of the spiral and worked its way through all five segments of the Catherine wheel. At the end of 2006 the lecturers reflected on the success of the pilot study and problems identified were addressed.

### Target groups, role players and instruments used for this study

First year and second year medical and dental student groups from two different modules in the curriculum, Block 1 (Molecule to Organism) and Special Activity 4 (Anatomy Dissection) were identified to participate in this study. Block 1 and SA 4 were also part of the original pilot study done in 2006. With the benefits of the new CBT system, the Department of Anatomy aimed to redesign their entire assessment portfolio for these two modules, for which they have a strong involvement in and act as course coordinators.

### Evaluation of implementation of the new CBT system

The success of the new assessment strategy was assessed by means of a questionnaire completed by the students (see Table 2) as well as the lecturers that participated in this study. The lecturers' questionnaire was different from the one given to the students (see Table 3).

**Table 2: The 5-point Likert-scale questionnaire completed by students after completion of Block 1 and SA 4**

| Nr | Question |
|---|---|
| 1 | Preparing for CBT tests is the same as for written tests. |
| 2 | This type of assessment enhanced my learning experience. |
| 3 | The questions matched the objectives of the module. |
| 4 | The sampling of questions was representative of the work covered in this module. |
| 5 | The instructions per question were clear. |
| 6 | To receive immediate feedback helped me to understand the work better. |

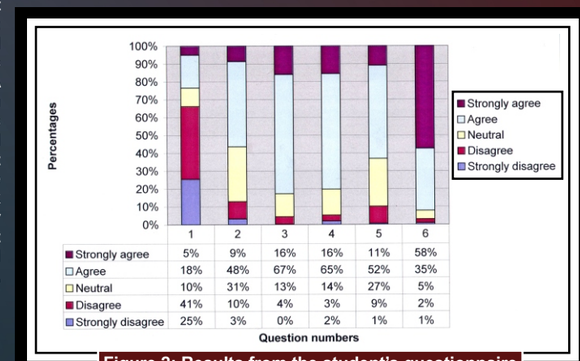
Likert-scale:
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree

**Table 3: Questionnaire completed by lectures after completion of Block 1 and SA 4**

| |
|---|
| 1. What do you see as the biggest advantage of CBT? (Open question) |
| 2. What do you see as the biggest disadvantage of CBT? (Open question) |
| 3. Do you see CBT as a tool to test on higher cognitive levels? (Yes/No) |
| 4. Do you think CBT is used successfully to enhance deep learning in your module? (Yes/No) |
| 5. Which question type(s) do you perceive to be the most appropriate to test on higher cognitive levels? (Multiple options) |

## Results and Discussion

With the implementation of the new CBT system together with the rollout of new hardware and operating platform, the following risks were taken: technical malfunctions, unhappy students, system integrity, and the following assessment prerequisites were kept in mind: validity, reliability, educational impact, compatibility as well as cost, resources and logistics. A reflection after the pilot project in 2006 showed that it was successful and it lead to the full implementation and deployment of the system in 2007. The evaluation of the possible risk factors at the end of the first year full implementation, showed that the methods that were used and the process that was followed, were successful.




| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Strongly agree | 5% | 9% | 16% | 16% | 11% | 58% |
| Agree | 18% | 48% | 67% | 65% | 52% | 35% |
| Neutral | 10% | 31% | 13% | 14% | 27% | 5% |
| Disagree | 41% | 10% | 4% | 3% | 9% | 2% |
| Strongly disagree | 25% | 3% | 0% | 2% | 1% | 1% |

**Figure 2: Results from the student's questionnaire**

### Feedback from the students:

The questionnaires were incorporated into a MS Excel™ worksheet and statistically analysed. The results of the questionnaires (total n=477) for both Block 1 (n=194) and SA 4 (n=283) are summarised in Figure 2.

### Feedback from the lecturers:

The eleven lecturers that are involved in the two modules completed the questionnaire.

Most of the lecturers believe that CBT can be used to test on higher cognitive levels, but depends on how the questions are structured.

The question types that the participants felt testing students on higher cognitive levels the best are (from most to least): Free Format (FFQ), Matching Questions (MAT), Multiple Response (MRQ), Hot Spot Questions (HSQ). Lecturers also felt that well constructed Multiple Choise Questions (MCQ) could test on higher cognitive levels.

We feel that with time and with an increase of questions in the question databank that test on higher cognitive levels, the students will have to learn on a deeper level in order to perform adequately.

## Conclusion

The new implemented CBT system was successfully evaluated using the different stages of the Catherine wheel model. Risk analysis was done, problems identified were addressed and effort has been put into the assessment design.

It is important to note that testing on higher levels of Bloom's taxonomy, using CBT's requires development of well structured and thought out questions. This has been made easier with the new CBT system as more question types are available.

A favourable relationship between the cost, resources and logistics was also evident when using this format of assessment.

Taking into account the scope and versatility of this new system, its potential to be used by any discipline in a tertiary institution, and its potential to test students on higher levels of Bloom's taxonomy, makes the new system an ideal assessment tool that allows for valid and reliable assessment of large groups of students.

## References

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