CONTS

# Assessment Issues in the introduction of a CAS pilot in the International Schools

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This presentation will discuss assessment issues concerning the introduction of computer algebra systems enabled (CASE) technology in mathematics courses at the International Baccalaureate Organization (IBO). I will give a brief description of the IBO programmes, outline the pilot course then discuss some issues we have identified in the planning and starting phases of the pilot.

The IBO, founded in 1968, has a non-profit educational mission. It offers to schools three programmes: the Diploma Programme (DP), the Middle Years Programme and the Primary Years Programme. There are 1,355 schools authorized to offer IB programmes. These schools, known as IB world schools, offer a total of 1,579 IB programmes in 116 countries to approximately 200,000 students.[1]

The DP is a demanding pre-university course of study that leads to examinations. It is designed for highly motivated secondary school students aged 16 to 19. The programme has earned a reputation for rigorous assessment, giving IBO diploma holders access to the world's leading universities. The DP's grading system is criterion-referenced, which means that each student's performance is measured against well-defined levels of achievement. These are consistent from one examination session to the next and are applied equally to all schools. There are four different mathematics subjects available within the DP usually taught over two years: mathematical studies standard level (SL), mathematics SL, mathematics higher level (HL) and further mathematics SL.

The history of the use of the graphics display calculator (GDC) in the UK is not impressive. Indeed, is can be said that until recently "there is no coordinated support for secondary mathematics teachers learning to use graphic calculators as part of their mathematics teaching."[2] In the last few years some notable progress has been made in the UK but there is a long way to go. This has a bit of a knock-on effect in international schools as they tend to be slightly eurocentric in pedagogy. In addition, the international school setting has severe limitations when it comes to requiring technology in courses and this may be similar to limitations of some national systems. IBO world schools represent a wide variation in schools and pedagogies, a wide spread of economic groups, varied access to technology according to geographic, social and political limitations, have a tendency towards traditional pedagogy and are resistant to changes in pedagogy.

From the international school perspective, the IBO introduced the GDC in the mid nineties and has committed many resources in supporting GDC use. With the completion of the last curriculum review in the mathematics subjects, the GDC is now required in for each of the

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1www.ibo.org, 6 May 2004.

[2] Monaghan, j. 2001. Graphic calculators in Leeds high schools: summary report of a collaborative research project from a team of Leeds secondary mathematics teachers and Leeds University mathematics education staff, Leeds Graphic Calculator Project, University of Leeds.

examination papers set for each mathematics course. Currently examiners set examination questions with the expectation that students will have access to a GDC but not any technology capable of **symbolic manipulation**. This obviously includes CASE devices but, surprisingly to many people, also includes a number of programs available on a regular GDC. Other subjects in the Diploma Programme, notably the sciences, also permit the use of a GDC in examinations, but cross-curricular work related to technology does not seem prevalent in our schools. The IBO is working on ways to further encourage technology use in the teaching and assessment of science subjects and cross-curricular considerations.

Many of our schools make regular use of technology including innovative inclusion of CASE in technology. In the assessment component called “the extended essay”, there are no restrictions in technology and there have been a few essays that demonstrate excellent use of CASE technology.

The mathematics HL CASE pilot course

The underlying philosophy of the use of technology in the Diploma Programme is the concept of enabling learning through technology, promoting good practice in teaching and assessment. As part of the commitment to evolving and introducing appropriate technology, the IBO has committed itself to an international pilot using computer algebra systems enabled (CASE) calculators. The planning stage included a number of key points.

- determining the major goals of the project from the organizations perspective
- organizational commitment
- analyzing examiners ability and perceptions
- choosing devices
- choosing schools

The main aim of the pilot course will be to explore the feasibility of supporting and assessing courses that include CASE technology on all examinations in an international setting. The pilot course starts September 2004, with examinations May 2006, with four IBO schools located in Norway, Switzerland, the United Kingdom, and the United States. Students will have access to the TI-89 Titanium on all examination papers that make up formal assessment.

An early decision was made to follow the new mathematics HL course (240 hours over two years) with the same assessment model, permitting direct comparisons between a CASE and non-CASE course. The IBO is one among many systems / boards experimenting with the parallel course model in the introduction of CASE technology. As Kissane[3] suggests, this option does allow a way forward for schools/boards nervous about CASE technology and it is better than total inactivity in the short term. More importantly, is will serve as a decision-making model for future courses. The thinking is to adjust or “tweak” mainstream questions making them CASE neutral or active as appropriate to meet the needs of the assessment.

[3] Kissane, B. 2000. New calculator technologies and examinations. In W.-C. Yang, S.-C. Chu & J.-C. Chuan (Eds.) *Proceedings of the Fifth Asian Technology Conference in Mathematics.* (pp 365-374) Chiang Mai, Thailand. (ISBN 974-657-362-4)

We had felt a strong organization-wide interest and pressure to investigate CASE technology. Indeed, our examiners believed that writing CASE questions and exams would not be a challenge and did not pose problems. In reality, evidence indicated that examiners did not always write good GDC questions. The organization had to make a commitment to developing an understanding of the technology organization-wide when such a commitment was still potentially controversial with colleges and universities. We expected an inundation of interest from schools wanting to participate but schools remain extremely wary of changes. In the end, only a handful of schools were prepared to commit to trying out new technology. Factors that schools reported as critical for their reason not to participate included staffing issues, negative feedback from some universities and the mismatch of timing of a new course with other projects and courses the schools was offering.

The pilot course feeds directly from the curriculum and assessment model of the Mathematics higher level course and requires students to have access to CASE technology in all examinations.

Impacts so far

Just considering and developing a CASE pilot has had a very positive effect on mainstream examination writing in terms of awareness. In the process or reviewing and preparing for new technology, we have re-discovered the difficulty of training examiners in writing good examination questions. Examination authoring must result in questions that are either CASE active/neutral without changing the level of difficulty or creating "artificial" questions. We have built on the experience of other innovators in CASE use, especially the Victorian Curriculum and Assessment Authority's (VCAA) experiences in introducing CASE in their Victoria Certificate of Education program. The exposure has resulted in better questions GDC active, rather than just GDC neutral.

Hypersensitivity in terms of calculator issues has resulted in awareness organization wide. Among the positive results we have seen an improvement in the identification of "problem" questions in mainstream examinations and applications and the prioritization of technology in both curriculum development and assessment. The development of communication and "partnerships" with manufacturers to meet the training and resource needs of the IBO has been another positive results. On the slightly negative side is the responsibility that results from awareness and the resulting in time and financial commitments.

We have learned that using CASE in examinations results in significant increases in alternative solutions / approaches to set tasks, even in what seems the most obvious question. Classification for an examination question fit into the following categories:

- Questions that are "CASE" neutral and do not need to be changed.
- Questions that must be "tweaked".
- Questions that remain the same but the markscheme requires significant re-consideration.
- Questions that are still appropriate but that ask a markedly different question in a CASE environment.
- Questions that are no longer appropriate.
- Questions that are now possible to ask: "CASE active"

**Example question 1**

The polynomial $f(x) = x^3 + 3x^2 + ax + b$ leaves the same remainder when divided by $(x-2)$ as when divided by $(x+1)$. Find the value of $a$.

| Method 1 (CASE) | Method 2 (By Hand) |
|---|---|
| Define $f(x) = x^3 + 3x^2 + ax + b$<br>Solve $f(2) = f(-1)$ for $a$.<br>Hence $a = -6$ | When divided by $(x-2)$, the remainder is<br>$f(2) = 8 + 12 + 2a + b = 2a + b + 20$<br>When divided by $(x+1)$, the remainder is<br>$f(-1) = -1 + 3 - a + b = 2 - a + b$<br>Remainders are equal when $2a + 20 = 2 - a$<br>Hence $a = -6$ |

The use of CASE in this example does change the nature of the response but still results in essentially the same type of mathematical thinking in the question response. It would not be essential to revise the question for use in an examination.

**Example question 2**

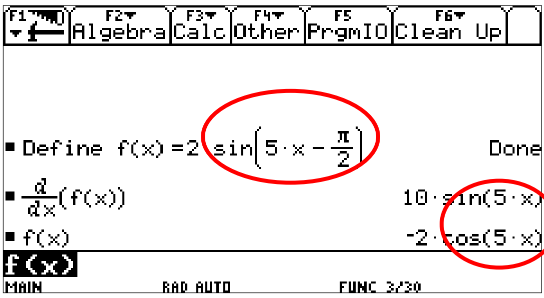
The function $f'$ is given by $f'(x) = 2\sin\left(5x - \frac{\pi}{2}\right)$

Write down $f''(x)$.

The intended method would have been

(a) $f''(x) = \left[2\cos\left(5x - \frac{\pi}{2}\right)\right]5 = 10\cos\left(5x - \frac{\pi}{2}\right)$

But consider this screen shot from a TI-89/92.




The CASE device has re-written the trigonometric function in the devices' default, i.e. the shift of $\sin\left(x - \frac{\pi}{2}\right)$ to $-\cos(x)$. This notational step introduces an unexpected complication compared to what was intended in the original question. This question would needs to be altered to avoid this complication, perhaps by choosing to use the function 2cos (5x).

**Example question 3**

Prove that $(\sin x + \cos x)^2 = 1 + \sin 2x$

| | | |
|---|---|---|
| Method 1 (By Hand) | Method 2 (CASE) | Method 3 (CASE) |
| $(\sin x + \cos x)^2$<br>$= \sin^2 x + 2 \sin x \cos x + \cos^2 x$<br>$= \sin^2 x + \cos^2 x + 2 \sin x \cos x$<br>$= 1 + 2 \sin x \cos x$<br>$= 1 + \sin 2x$ | Input: $(\sin x + \cos x)^2$<br>Output: $1 + 2 \sin x \cos x$<br>Tcollect (Answer)<br>Output: $1 + \sin 2x$ | Input: $(\sin x + \cos x)^2$<br>Simplify (Answer)<br>Output: $1 + \sin 2x$ |

This final question demonstrates that the “old stand-by” method of trying to neutralize technology by simply asking for a proving question will not work well in the CASE environment. This question introduces a number of possible solutions that are fully appropriate and quite interesting, but these would be difficult to mark in the traditional examinations setting. In this case it is the response or markscheme that needs careful thought and adjustment.

This last example brings into sharp relief some of the important questions we are now considering.

- What do we really want our students to know?
- How do we want to see students demonstrate what they know?
- How then should we formulate assessment questions to tease out what students know?

Our experience so far is that schools are still not ready for a complete incorporation of CASE but would welcome the option of using CASE in both teaching and assessment and thus the most likely future is two separate courses one with CASE and one without. These are the questions we now need to consider as we continue to develop this pilot course to meet the needs of tomorrow’s students.