New Models in Assessment in Computer integrated Mathematical Instruction - Experiences in the Austrian CA – Projects

Otto Wurnig, Graz (Austria)

Since 1985 more & more teachers in Austria have been in a position to allow students to use electronic calculators in tests, if they had enough practice in class. Teachers of Mathematics at schools which are preparing students for university can choose and formulate their own test problems. Consequently their examples were gradually adapted to the new demands of computer algebra systems (DERIVE, MATHCAD, MATHEMATICA). But it is not easy for the teachers, because in big classes there are *often more students than computers available, not every student has a computer at home and not all lessons can be held in a computer lab.* Therefore three practicable models for tests with the help of computers have developed.

Model 1: ***different examples* for students with/without CAS**
model 2: ***time-sharing on the same computer*** *between two students*
model 3: ***50% team work alternating with 50% single work*** *on the same computer*

1.) **The model with *different examples* for students with/without CAS is a favourable interim model for classes,** where a strong minority is against using CAS in mathematics tests. It is a fact that after some weeks the handling of the computer and the finding of appropriate DERIVE-commands leads to a remarkable difference between those students who have the chance to practise at home and those who do not have this opportunity (Wurnig, 1992). In the tests the DERIVE-users would have had a great advantage over those students not using DERIVE if the latter had not been given a correct interim result with the help of which they could manage to continue their calculations in any case. At the end of the test the books and discs were collected and were printed out at home by the teacher. The time it took to print out the examples was easily made up by the advantage of the prints' good readability as well as the fact that - in case of a correct start and planning - the students' work was without mistakes.

2.) The second model ***time-sharing on the same computer*** *between two students is only sensible if 50% of the test and time can be worked on without a PC and 50% with a PC.* This model was partly used in the **Austrian CA I Project (DERIVE)**. The two students sharing the time of working on the computer, got different examples. Changing turned out to be no problem. The German report of the Austrian CAS I project says,
„After having finished his work on the PC, the student had to save the file and to quit DERIVE, thereby making the PC available for the second student." (Heugl, 1996)

3.) The third model, ***50% team work alternating with 50% single work on the same computer,*** is part of the concept MATHS & FUN with MATHEMATICA It is an educational experiment at the Business Academy I in Graz. Two out of three mathematics lessons per week take place in the computer lab where the students have to work in teams of two and this is the reason why they write their **tests in teamwork,** too. In **1998** this project was also carried out **in two sections** for the **final examination in maths** (A-Levels) for the first time. In the first two hours the students had to solve a problem in teamwork and the next two hours they had to use for their individual work on two different tasks given. If students of a team finished their teamwork before the end of the two hours, they could use all the remaining time for their individual work (www.mathsnfun.ac.at/mf/EnglischeVersion/index1.htm).

4.) But the real goal is one student per computer.

In the German report of the Austrian DERIVE-Project H. Heugl writes**:** *„It would be ideal if every student had a portable CAS-calculator, which could be linked up with the CAS in a computer lab, in his school bag."*

In the Austrian CAS II Project (TI92-Project) **1997/98** the students of the seventy research teachers wrote their tests in mathematics with the TI-92. At their final meeting in August 1998 the teachers collected their most important and sometimes unexpected results:
(Lechner/Wurnig, 1998)

- for solving problems it is very important **not always to insist on the use of the TI-92**.
- students find **new ways with the TI-92** → more work for the teacher
- the problems in tests have to be **more goal oriented** → **text longer** instead of shorter.
- **difficult decision**: What is to be the **minimum knowledge without** the TI-92?
- **difficult decision**: What **minimum knowledge of TI92-**commands is an absolute must?
- **modules** and **programmes** are a good chance **for good students**
  → **a new problem for bad students**.

- TI-92 has no floppy disc → **much documentation** in test book, therefore **fewer examples**.

5.) **The influence of the use of the tool CAS in the exam *situation***
Which is the more valid question? (Heugl, 2000)

Do the new ways of mathematics learning and teaching influence the exam situation?
or
Does the exam situation influence the new ways of learning and teaching?

In the past the exam situation always had a great influence on the contents and on the didactic concept of mathematics education. So the emphasis sometimes placed on a specific maths topic can only be explained by the fact that it was easy to construct a suitable test.
Therefore it is understandable that one of the principles formulated by the American NCTM is called the „**Assessment Principle**":

> *Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.*

Some tasks of the Assessment Principle:
- Assessment should be more than merely a test at the end of instruction to gauge learning.
- Teachers should be continually gathering information about their students.
- Assessment should focus on understanding as well as procedural skills.
- Assessment should be done in multiple ways, and teachers should look for a convergence of evidence from different sources.
- Teachers should ensure that all students are given the opportunity to demonstrate their mathematical learning.

Already in our former CAS projects we recognized that the way of assessment was not suitable to the new ways of learning which we observed in our CAS classes.

In traditional mathematics education written exams (5 or 6 one-hour-tests per year) dominate. As far as contents is concerned the emphasis is on calculation skills. This way of testing is suitable to the dominating style of teacher centred teaching, which causes a more reproductive way of learning. Often in two or three of the four examples of a test the same skills are tested - students have to be busy for one hour.

Some significant changes of the learning process in our CAS-classes which strengthen the necessity of changes in the exam situation:

- A more pupil-oriented learning process. More mathematical discussions among the students. The teacher is not the only source of knowledge, he supports the independent acquisition of knowledge by the students.
- Experimenting, the trial- and error method: We seldom find the „algorithmic obedience" where the

teacher shows one way which all the students then accept and follow.

- Working in pairs or groups can be seen much more frequently.
- Besides the teacher there now exists a new, very competent expert - the tool CAS. That means pupils do not always need the teacher for examining the correctness of their ideas and results.
- Phases of „open learning" where the students are individually organizing the speed and the contents of their learning process.
- CAS is not only a calculation tool, students can also store knowledge by defining modules or using the text editor. Therefore it is not sensible to forbid the use of learning media, like books or exercise books during the tests.
- New emphasis on fundamental competence. A shift from calculation skills to other skills.
- Clearer emphasis on problem solving and more application oriented mathematics.
- More frequent cross curriculum teaching.

6.) **The experiences in the CAS-projects require new models of assessment.**

After a meeting of the project management, five topics were chosen for the CAS III Project. 2000 students in 70 experimental classes from grade 7 to 11 took part in this project. It was carried out in 1999/2000. One topic was the influence of CAS on the Examination Practice.

A team of teachers under the leadership of H. Heugl developed **some variants of a new model of assessment** (Heugl/Schirmer-Saneff, 2001). In accordance with the Ministry of Education, experimental studies to test the new models started in 1999/2000.

Model 1: short tests – problem solving tests

Shorter tests (15 to 30 minutes) to examine fundamental competence like calculation competence, visualization competence and abilities of using the available CAS. In some tests the use of any electronic tool, especially CAS, was forbidden, in others it was allowed.

Problem-solving-examinations (50 to 120 minutes) to check the competence of problem solving with more application-oriented examples, more open questions, with more emphasis on argumentation, reasoning and interpreting. During these examinations students are usually allowed to use their learning media like their maths school books or their exercise books.

For this model the idea of the two phases is significant (Heugl, 2000): First laying the foundation by focussing on certain fundamental mathematical competence like algebraic competence and then in a second phase using fundamental competence for problem solving.

Model 2: project work

A certain number of the **classic written exams are substituted by projects** which are partly done during the lessons but the larger part of the work has to be done at home. In some classes every single student has to work on his special theme, in others project work is given to a group of students. This practice can be especially observed in larger classes because the presentation of the project work of every student of the class would take up to much time.

The content of such project work concerns themes for which students have to apply formerly learned contents but there are also fields where the students are faced with new problems and contents on the basis of their project work. Students have to produce term papers which they hand out to the other students of the class after of the presentation of their results.

The assessment takes place in two ways:

- Observation of the learning process: independent activity and ideas of the student, necessary inputs of the teacher.
- Assessment of the results: quality of the term papers, quality of the presentation, competence during the discussion of the results.

The fundamental idea of the **model project work** is to remove the existing separation between written and oral exams and the separation between product-oriented tests and process-oriented oral exams.

Model 3: Cross curriculum tests

One of the main tasks of the school of the future is a greater emphasis on the **training of networked thinking**. One type of exam within the school leaving exam ("Matura" in Austria) is an oral exam connecting two subjects. Only a few students choose this type of exam, because they cannot experience curriculum phases of learning and because cross curriculum testing has not existed at school so far. In comparison with traditional classes we watch a **growing importance of cross curriculum phases** in our CAS-classes and consequently it was reasonable to consider this fact in the exam situation of our research classes.

Using the possibilities of the TI-92, especially CBR and CBL, a connection of mathematics and science is obvious (Laughbaum, 2000). The questions of such cross curriculum tests are based on both subjects and their assessment is included in the final grades of the two subjects.

Model 4: Written group tests

The use of the tool CAS causes a **growing frequency of cooperative learning phases.** Using the new expert, ´CAS´, students more often work in pairs or groups, share their tasks, discuss mathematical problems and explore mathematical themes together. This cooperative way of learning needs a suitable method of assessing students abilities and competence.

As long as every student gets his individual grade, it is absolutely necessary not only to assess the group-competence. **The individual competence must be the central competence for reaching a valid grade**. One rule in our model 4 is that a passing grade can only be obtained by a student if neither the individual competence nor the group competence is negative.

When using the project method as a didactic concept for group work, the learning of the students must obviously checked in a process-oriented way. When having to assess a written group test, however, the individual partner distribution is not obvious and consequently difficult to transfer into a individual mark.

7.) The model of assessment I chose.

I chose to use **a combination of model 1 and model 2** in form 11 (1999/2000):

The fundamental idea of my model variant is to use the pre-set time for written tests in a school year - 350 minutes in form 11 - in different ways (Wurnig, 2001):

For short tests *- up to a maximum of 25 minutes -* ***to check reproductive skills*** *or reproductive knowledge with or without CAS.*

For one longer test per half-term*,100 minutes, -* ***to check problem solving skills****. There should be sufficient time to experiment and to use materials which have been worked out at school or at home.*

For working out a short chapter of mathematics (a little project work) *which has not been dealt with at school. Each student was to prepare his short chapter in written form at home and present it to his classmates at school.*

8.) **Acceptance of the new assessment models as seen by the students.**

At the end of the CAS IV project (2001/2002) the students of all research classes of form 11 had to answer 27 questions concerning the acceptance of the new assessment models. The result is very encouraging (Fürst, 2003).

Nearly 100% of the students recommend the new assessment models and would like them to be part of the normal school assessment.

Short tests are seen as a positive innovation by both boys and girls. (89%).

Problem solving tests are seen more critically. 74% find that they have a high level.

74% think they should get a positive mark in problem solving tests if they are able to solve exercises similar to those done at school.

Concerning the use of auxiliary materials the results are as follows:

Formulary	should be admitted	100%
TI – 92		98%
Exercise/ homework books		75%
Mathematics book		57%

Project work is seen as a very useful innovation (92%), but the students want to decide by themselves in which of their subjects they do the project work (79%).

As to the last question asked, the students had to consider whether and in what way they had personally profited from the new experimental way of teaching with the help of CAS.

Almost all the students were of the opinion they had profited..

Some answers from among my students translated from German into English:

- Girl, best student of the class, Maths not among favourite subjects, but very good mark

"*It's fun working with the TI-92. I was able to reduce my original dislike of the subject. My attitude to Maths changed. It lost the character of a subject for freaks for me when solving application-oriented problems of mathematics."*

- Girl, Maths not among favourite subjects, but a good mark.

"*I got to know modern media and learned to do calculations in a faster way. I like the use of the TI-92 and I appreciate the use of the supporting materials when writing tests.*"

- Girl, Maths rather a favourite subject, average mark.

"It is easier to understand the learning content because of the many short tests. They help to create a readiness to cooperate."

- Boy, Maths among favourite subjects, mark below average.

"*I have learned how to take meaningful notes so as to be able to use them when needed. I have learned to work with the TI-92 and this has helped me to expand my knowledge.*"

- Boy, Maths rather a favourite subject, good mark.

"*My learning has become more independent and more problem oriented. I no longer copy mechanically, I now solve my problems individually.*"

REFERENCES

Aspetsberger, K:/ Fuchs, K. (Eds.): *The AUSTRIAN DERIVE Research Project*. The International DERIVE Journal, 1996, Vol. 3, No. 1.

Bürger, H./Fischer, R./Malle, G.: *Mathematik Oberstufe 3*, Verlag Hölder-Pichler-Tempsky, Wien, 1991

Etchells, T./Browne, R./Ellis, W./Townend, St./Wurnig, O.: *Assessment*. In: Berry, J./ Monaghan, J. (Eds.): The State of Computeralgebra in Mathematics Education, Chartwell-Bratt, 1997.

Fürst, S.: *Schülerbefragung zur Akzeptanz der neuen Modelle*. In: Endbericht für das ACDCA Projekt IV, ACDCA, (2003).

Heugl, H.: *New Emphasis of Fundamental Algebraic Competence and its Influence in Exam Situation*. In: Kokol-Voljc, V./Kutzler, B./Lokar, M./Palcic, J. (eds.): Exam Questions & Basic Skills in Technology-Supported Mathematics Teaching, bk teachware, Hagenberg, (2000)

Heugl, H.: *New Emphasis of Fundamental Algebraic Competence and its Influence in Exam Situation*. ACDCA Homepage: http://www.acdca.ac.at

Heugl, H./ Klinger, W./Lechner, J.: *Mathematikunterricht mit Computeralgebra-Systemen*. Addison-Wesley, Bonn 1996.

Heugl, H./ Schirmer-Saneff, I., *Leistungsmessung/Leistungsbeurteilung*. In Endbericht für das ACDCA Projekt III, ACDCA, (2001).

Herget, W./ Heugl, H./ Kutzler B./ Lehmann, E.: *Indispensable Manual Calcu lation Skills in a CAS-Environment*, In: Kokol-Voljc, V./Kutzler, B./Lokar, M./Palcic, J. (eds.), Exam Questions & Basic Skills in Technology-Supported Mathematics Teaching, bk teachware, Hagenberg, Austria, (2000).

Hill, R.: *Using DERIVE in Teaching Calculus Geometric Maximum and Minimum Problems*. In: Heugl, H./

Kutzler, B. (Eds.): DERIVE in Education - opportunities and strategies, Chartwell-Bratt, 1994.

Klinger, W.(Hg.): *Der Mathematikunterricht im Zeitalter der Informationstechnologie*, CD-ROM, ACDCA, 1998.

Laughbaum, E.: *Using Data Collection to promote Mathematical Understanding*. Kokol-Voljc, V./ Kutzler, B./Lokar, M./Palcic, J. (eds.): Exam Questions & Basic Skills in Technology-Supported Mathematics Teaching, bk teachware, Hagenberg, Austria, (2000)

Lechner, J./Wurnig, O.: *Schularbeiten, 5. Klasse*. In: Klinger, W.(Hg.): Der Mathematikunterricht im Zeitalter der Informationstechnologie, CD-ROM, ACDCA, 1998.

Wilding, H.: *Interaktive Lernumgebungen im Unterricht. Das Lernsystem Math School Help 98*. In: Kandunz, G. u.a. (Hg.): Mathematische Bildung und neue Technologien, Teubner, Stuttgart, 1999.

Wurnig, O.: *Mathematikschularbeiten mit DERIVE - Erste Erfahrungen*. In: Böhm, J. (Ed.): Teaching Mathematics with DERIVE, Chartwell Bratt, Bromley, Kent, 1992.

Wurnig, O.: *From the first use of the computer up to the integration of DERIVE in the teaching of mathematics*. The International DERIVE Journal, 1996, Vol. 3, No. 1.

Wurnig, O.: *New Ways of Assessment in CAS-oriented mathematical Education - New Experiences, First Results.* In Etchells, T.C., Leinbach, L.C., Pountney, D.C. (eds), Proc. of the 4th int. DERIVE & TI-92 Conference (Liverpool 2000), bk teachware, Hagenberg, Austria, (2001).