Alternative Assessment Models: Assessment through group work and the use of CAS as a self-assessment tool

by

Marlene Torres-Skoumal

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Vienna International School has been using CAS, specifically the TI-92, with select classes in grades 6 – 10 (ages 11 – 18 years) for the past three years. Our class sizes range from 15 - 25 in these grades. This paper suggests a model for the learning and reinforcing of algebraic manipulative skills through the intensive use of group work. Potential difficulties in group-work situations, such as varying language and technical skills and diversity of mathematics abilities and backgrounds, will be discussed with particular attention to using these variables to maximize skill acquisition. Furthermore, this paper suggests a model for assessing students through group work, and fur using the TI-92 as a self-assessment tool.

INTRODUCTION

What students learn depends to a large extent on how students learn it. Hence, the advent of new hand-held technologies, which are able to execute traditional textbook and examination questions in a fraction of the time required by hand, is forcing a re-evaluation of the goals of mathematics education. The emerging consensus among its users is that the graphic display and CAS calculators are offering more opportunities to enrich classroom teaching, enhance and improve students' understanding of mathematical concepts, and increase appreciation for the subject of mathematics by facilitating real world applications. On a practical level, curricula and resources need to be rewritten to implement the new learning objectives and alternative assessment models must be designed to reflect the changes in objectives and learning style. This is emphasized in the NCTM Curriculum and Evaluation Standards for School Mathematics, “Assessment must be more than testing: it must be a continuous, dynamic, and often informal process”.[1]

BACKGROUND

About three years ago, the Vienna International School (VIS) decided to integrate CAS technology into the 9th and 10th grade curricula (ages 14 – 16 years) on an experimental basis. We purposely chose classes without external examination requirements to ensure some flexibility. (The VIS offers the International Baccalaureate (IB) program in the 11th

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[1] *Curriculum and Evaluation Standards for School Mathematics,* National Council of Teachers of Mathematics, 1989.

and 12th grades, and CAS technology is not allowed in the IB external examinations.) The students received a TI-92 on loan for two years at the start of grade 9. To the already existing variables normally present in any average sized international school class, namely mathematical ability and background, motivation, and command of the instructional language English, CAS introduced the added variable of technical skill. As a way of tackling all the above, particularly the latter, we decided to engage the students in extensive use of group work and furthermore to use group work for assessment purposes.

GROUP WORK

In this class there were marked technical differences along gender lines in both motivation and skill. The boys were almost obsessive in using the new technology, and the girls tended to use the TI-92 only under direct instruction. (These gender differences are not observed when we introduce the TI-92 in younger grades, e.g., grade 6, age 11!) It was difficult to motivate the technically strong students to share, willingly and patiently, their abilities with the others. We decided, therefore, to create small equally sized groups of students containing at least one strong "technician" to serve as training sessions to familiarize students with the keystrokes and sequences of the TI-92 within a particular topic. Furthermore, we decided to use their group work for assessment purposes. It has been our experience that when students are allowed to set their own groups, they tend to band together along friendship lines. If they are to be assessed on this work, however, the weak students rally around the strong ones so that the stronger ones receive a disproportionate amount of the workload. To ensure, therefore, some equality and fairness in the assessment process, we also attempted to distribute the “mathematicians” equally among the groups. It was their responsibility to assist students having difficulties with concepts and underlying algebraic structures of the task at hand. Where possible, ESL students were assigned to groups with students having the same mother tongue.

To provide added incentive in all their respective roles, a student from each group was then selected *randomly* to present a solution to a similarly difficult problem using the TI-92. We noted that the weaker students, either conceptually or technically, were far more attentive and motivated in understanding the problem and correctly executing its solution using technology since they knew that they too might be chosen to assume the responsibility for the grade of the group. As Bert Waits from Ohio State University is fond of saying, there is nothing that influences the actions of a student more than the "will it affect my grade” syndrome, and so the average competence and confidence in using the TI-92 increased accordingly.[2]

The task of writing new materials and resources can be so daunting that it may serve as a deterrent to integrating CAS technology into the curricula. For all aspects of the course, therefore, we attempted to use the traditionally assigned textbooks as much as possible. For initial group work, each group received the same worksheet, taken from their

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[2] More detailed background information can be read in the article entitled “Calculator Wars” in *IB World* in the August/September 1999 issue on pages 39-41.

standard textbook[3], for example on simplifying rational algebraic expressions. After the initial group work to introduce a topic, we progressed to intermediate group work where each group received different worksheets with an emphasis on applications, e.g., modeling problems using rational algebraic expressions (appendix A). A task of similar difficulty was selected for presentation, and the group was again assessed in the way described above. The teacher allowed the students to informally assess each other after discussing the assessment criteria (appendix B). At the teacher's discretion, these student assessments were also used as part of each student's ultimate grade.

In this year's grade 10 class (age 16 years) we are introducing advanced group work, where each group receives different mathematical modeling problem and is responsible for assigning sub-tasks within their group. (The students will also be encouraged to research and design their own mathematical modeling problems!) Each group will present their model with each student presenting the assigned subtask. All groups will assess the presenting group formally using the assessment criteria described in appendix B. The grade awarded will consist of the average of the groups together with the teacher's assessment. The students will be assessed on the following categories: content, communication, presentation, proper use of technology, results, conclusions, and the suggestion of possible extensions to their work. For each category, the grades awarded will be 1, 2, or 3, for a maximum possible overall grade of 21 points. Students will already be familiar with the assessment criteria beforehand and are explicitly aware of the conditions necessary to receive full marks. Through the transparency of the assessment procedure we expect students to be better prepared to assess their peers objectively and fairly.

RESULTS AND OBSERVATIONS

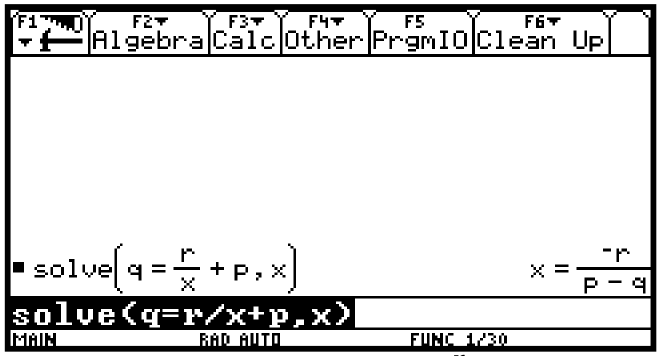
In our early work with grades 9 and 10, the use of intensive group work had many observable benefits other than training purposes. Students became more skilled in discussing and explaining mathematics through the frequent use of making presentations. They developed an increased awareness of their own strengths and difficulties by having to formally explain their solutions. (As educators we know there is no better method for learning than teaching!) Through the transparency of the assessment criteria for their group work, they developed an increased appreciation for assessment procedures, and were better able to assess themselves more realistically. Through the random selection of the student to be assessed, they developed a sense of responsibility for each other's learning. Finally, there was a definite improved rate of assimilation of ESL and new students through the need to work cooperatively.

SELF-ASSESSMENT

In addition to group work, we discovered areas to introduce students to the notion of self-assessment. When using the TI-92 as a pedagogical tool, it sometimes renders algebraic expressions back in a form not immediately recognizable as equivalent to those obtained

[3] The standard texts for this class were Modular Mathematics Pure Maths 1 and 2 by Bostock and Chandler published in 1990 by Stanley Thornes Publishers, Ltd.

using paper and pencil. Hence, the first time one tackles rearranging algebraic formulas, for example, using CAS can prove to be more troublesome than the ensuing confusion is worth. In consolidating manipulation of algebraic formulas in a later grade, however, it can provide an excellent opportunity for self-assessment (appendix C). For example, in



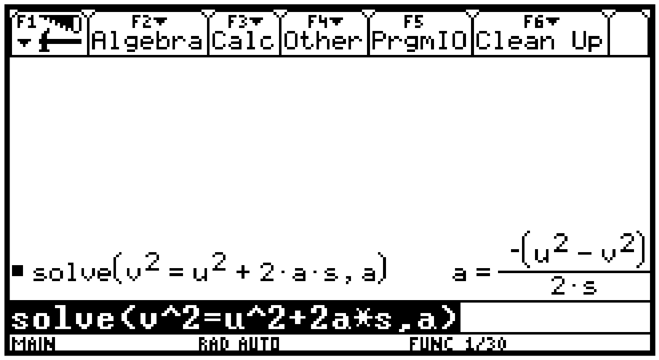
solving (11) by hand, one would probably obtain $x = \dfrac{r}{q-p}$. Using the TI-92, however, it renders the solution as follows:

The student must now determine whether both solutions are equivalent either by algebraic manipulation or using equivalence transformations on the TI-92. This type of activity serves to develop and reinforce mathematical communication skills since the student must explain and discuss how one expression is obtained from the other.

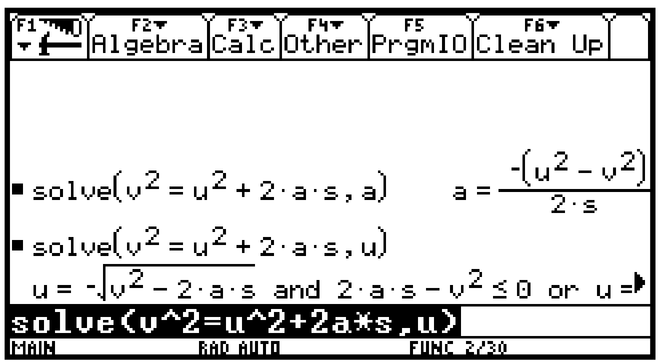
This year in our grade 10 class we will attempt other ways of introducing students to the notions of self-assessment and peer assessment. Working in small groups, two students will design a quiz on a given topic. The others in their group will take the quiz, each student doing it individually. The students will then receive a blank quiz page in which they will record the solutions they have agreed upon as a group after discussing their individual solutions. The students who designed the quiz will mark and grade these collective solutions. The students who received the test will assess the quiz designers on the following points: syllabus coverage of the topic, organization of the quiz, and appropriate level of difficulty in relation to the work done in class. The teacher will oversee the activity, and give feedback to the groups accordingly.

CROSS CURRICULAR ACTIVITIES

After consolidating the topic of manipulation of algebraic formulas used for self-assessment, the student is ready for applications in Physics class (appendix D). The student is given the four classic equations of motion and is asked to describe the equations in his/her own words. They then rearrange the formulas to solve for other variables within the expression. In solving one of the equations of motion, $v^2 = u^2 + 2as$, for a, the student would most probably obtain the following result by hand, $a = \dfrac{v^2 - u^2}{2s}$. Using the TI-92, however, we obtain:



The student must again determine whether the expression obtained by hand is equivalent to the expression rendered by the TI-92 by explaining how one is obtained from the other. A yet more interesting example is to solve the above expression for u. By hand, the student obtains: $u = \sqrt{v^2 - 2as}$. On the TI-92, we get:
and



Again, the student must determine if the solutions are equivalent, and explain. This serves once again to develop and reinforce mathematical communication skills. These exercises are now followed by applications of these formulas as seen in appendix D.

Mathematical modeling assignments using group work can also be set on this topic.

TRADITIONAL ASSESSMENT

We did not forsake traditional assessment in the form of written exams throughout the two years. Indeed our Middle Years Program stipulates 7 written exams throughout the two years (whereby the lowest two grades are dropped), as well as final exams at the end of grades 9 and 10. We were concerned that the use of technology would not adversely affect the ranking of the stronger mathematicians in favor of the strong technicians (recognizing however that ability in one area does not preclude ability in the other). To this end, we first attempted to ascertain that rankings were maintained on tests using GDCs. Determining the Spearman coefficient of rank correlation between two randomly selected tests allowing GDCs only, we saw evidence at the 5% level of significance of correlation between student performances. We then compared the rankings on the two finals exams in which one required the TI-92 and the other a TI-83, and again saw evidence at the 1% level of significance of strong correlation in the performance of the students in both tests (appendix E and appendix F).

CONCLUSIONS

In determining the final grade of the students, conventional tests weighed 25%, final examinations 30%, group work 20%, quizzes15%, and self-assessment 10%. All these weights can be varied to better reflect the ability of a particular class to cope with the alternative assessment forms.

Although the use of group work was initially undertaken as an attempt to more efficiently deal with all the competency differences within the class, its validation as a form of assessment became apparent throughout the course of the year. Assessment in the real world of work is multi-faceted. In our professions we are assessed not only on the command of our particular area, but on our ability to communicate this through a particular medium. Our ability to work with colleagues is important, as well as how we present ourselves personally. Through group work we were able to help students develop their skills in all the above areas. Our model emphasizes not only mathematical competence as evidenced through traditional written examinations, but places importance on the acquisition of other competencies, such as personal, social, and organizational skills. Helmut Heugl's definition of algebraic competence and its assessment in traditional exam situations reinforce the above notions, which support the need to develop a broader definition of student assessment. He expands on the definition of ability, the mere enactment of a procedure, to include competence, the enactment with understanding based on personal decisions and weighed considerations[4]. New ways of learning are indeed challenging traditional ways of assessing, and we question whether traditional exam systems as the sole method of assessing will maintain their validity in the technology age.

SOME STUDENT REACTIONS

We asked students to describe their experiences and emotions over the course of the two years that they had ongoing access to the TI-92. The reactions were diverse, but the common denominator seemed to be that, whether they enjoyed using this particular technology or not, it assisted them in improving their skills and enhancing their understanding of the topics under consideration.

The following are direct quotes from student evaluations:

"It (the TI-92) was so cool! I really understood the power of this machine when I was doing mathematical investigations." – Carlos Zednik

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[4] Helmut Heugl, "New Emphasis of Fundamental Algebraic Competence and its Influence in Exam Situation, Exam Questions & Basic Skills in Technology-Supported Mathematics Teaching (Proceedings Portoroz 2000), bk teachware Series "Support in Learning" no. Sl-15, 27-37.

“A very powerful machine! Does the easy but time consuming work in a few seconds so it saves lots of time needed for the important stuff.” – Daniel Staribacher

“It was a great learning tool in this class!” – Alexandra Bychkova

“We had a great deal of material to get through in grade 9. What helped us a lot was the great technology in this class.” – Jinyan Jin

“Using the TI-92 in this course was very challenging since I’m not very good with computers. I often did not understand anything we had to do and I got totally lost. But I did, I must admit, learn a lot from this calculator.” – Julia Hay

“I really don’t like computers, but am glad that we got a chance to use the TI-92s. Once we learned what buttons to push, it didn’t seem so scary, and it became my mathematics trainer!” – Naomi Galinski

“Although the TI-92 was not really a problem for, I am not the technology type so that I didn’t really enjoy using it much. The more I used it though, the more I realized that it wasn’t so bad and it actually helped me in understanding more the topics we did”. – Dimitri Pashlov

FINAL COMMENTS

In order to streamline our initial efforts, the materials and questions we used (see appendices) were taken from standard texts. Over the course of the project, however, as teachers have the opportunity to use the TI-92s throughout the curricula on an experimental basis, materials and resources are being developed accordingly. In addition, essential to integrating the new technology meaningfully is the opportunity for discussion of the pedagogical issues emerging through CAS and for a comprehensive teacher in-service training program. The former is being incorporated into weekly department meetings, and in addition to keeping abreast of new developments through conferences and seminars, in-service training will be ongoing in the form of “teachers teaching teachers”. Furthermore, in addition to continuing to develop new resources, the challenge remains to design meaningful tools to assess the new learning objectives in our changing curricula. The following articles are proving helpful in our discussions and in the design of the assessment instruments.

Herget, Huegl, Kutzler, Lehmann, “Indispensable Manual Calculation Skills in a CAS-Environment”, Exam Questions and Basic Skills in Technology-Supported Mathematics Teaching (Proceedings Portoroz 2000), bk teachware Series “Support in Learning”, 13–26.

Kokol-Voljc, V., “Examination Questions when using CAS for School Mathematics Teaching”, The International Journal of Computer Algebra in Mathematics Education, Vol. 7, No. 1, 63-76.

Kutzler, B., “Two-Tier Exams as a Way to Let the Technology In”, Technology-Supported Mathematics Teaching (Proceedings Portoroz 2000), bk teachware Series “Support in Learning”, 121-125.

REFERENCES

Heugl, Helmut [2000]: New Emphasis of Fundamental Algebraic Competence and its Influence in Exam Situation in Exam Questions and Basic Skills in Technology-Supported Mathematics Teaching (Proceedings Portoroz 2000), bk teachware, Hagenberg, Austria, ISBN 3-901769-33-1.

National Council of Teachers of Mathematics [1989]. Curriculum and Evaluation Standards for School Mathematics.

Torres-Skoumal, M. [1999], Calculators Wars: The Phantom Math Menace in *IB World, the Magazine of the International Baccalaureate Organisation,* ISSN 1560-5795.

BIOGRAPHICAL NOTES

Marlene Torres-Skoumal has been a teacher of Mathematics at the Vienna International School since 1981. Before leaving her native New York for the old world charm of Vienna, she taught Mathematics both in the university and high school levels. She holds degrees in mathematics and educational administration from New York City universities. In addition, she worked at the New York Stock Exchange and Merrill Lynch in brokerage, marketing, and financial markets analysis. Her current interest is introducing CAS technology into the IB curricula.