SOME ISSUES ON DESIGNING TASKS FOR CAS CLASSROOMS

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When designing CAS tasks we should not look on a CAS as an isolated tool but in connection with other tools. This paper examines how with an appropriate selection of tools can circumvent several shortcomings of CAS tasks. It requires CAS tasks to be adaptable to the needs of their users with respect to procedural and conceptual issues. Finally, it underscores the idea that designing and evaluating CAS tasks should address the whole process of their design, usage and modification.

INTRODUCTION

In her paper Margot Bergen gave us valuable insight into some of the core problems arising when using CAS tasks in mathematical education. In my reaction I try to address the issues Margot raised, but from a slightly different perspective. I use the obstacles Margot observed and the shortcomings mentioned to illustrate some currently available technical possibilities that might enable CAS task designers to circumvent the aforementioned problems.

APPROPRIATE TOOLS

As mentioned in [1], we are in the process of changing the view of mathematical knowledge from a hierarchical structure to a flexible network structure. The construction of tasks should reflect that change. When a CAS-based task is evaluated, it is too often observed within a closed environment, from the perspective of a specific CAS used with the task. Several problems that have been observed in these evaluations could be seen in a completely different light if another tool were used. Margot mentioned in her paper "the task would have better achieved its intended aim … had I explicitly suggested a reasonable window" (p. 3). But is a hint really necessary? Would it perhaps be better to use another tool, and allow students to find the appropriate window on their own?

Task designers all too often exhibit the one-size-fits-all syndrome. Namely they wish to stick with the same tool at any cost. Some amazing tricks can be seen; features are exploited in unusual ways (in, for example, Derive, GeoGebra, or Mathematica) or tricky instructions are provided, everything so as to stay within the same environment, the same program.

It is often argued that students feel more comfortable if they work with the same program all the time. However, when the behavior of modern day students (the so called NetGeneration students) is observed, it is obvious that multitasking is not problematic to them. Different programs are used at the same time; students are switching between windows, gadgets, and tool. Information is collected from multiple sources. Students, while communicating visually, are quick to respond and expect the same from others. They are able to "shift their attention rapidly from one task to another" [2, p. 2.5]. When designing CAS-tasks we should exhibit

the appropriate use of tools. CAS (or a particular CAS) is not always the best choice. Students should be taught how to choose the most suitable tool.

Instead of arguing about the best way to cope with problems that a specific tool introduces into a certain task, we should design the task itself in such a way that students are not merely allowed to but are actively encouraged to use different tools and to mix tools. Research has clearly established that ease of using different representations of various mathematical objects is perhaps one of the most beneficial influences in developing conceptual knowledge in mathematics. There is now a need for research that shows how appropriate use of different tools either promotes or hinders the students' progress.

NOTATION

A lot of technological tools disregard certain notation issues such as: *n* denoting a whole number, *log* being the decimal logarithm. Some programs assume that *x* is always used as the independent variable in functions, and * as the multiplication sign. Mathematics has a complex set of notations that are in common use. The notations used at each stage of schooling are carefully chosen. CAS often introduce new symbols or expose students to symbols they would not normally be exposed to at a certain stage. On the other hand, students often adapt more quickly to different notation than we think they can [3]. Consistent with the above mentioned observation states that students need to be prepared for situations as yet unknown, exposing students to different notation and a different set of symbols is almost essential.

Margot argues, "Being able to distinguish between these different usages of the equal sign requires a type of mathematical awareness different from the mathematical awareness required in paper-and-pencil work" (p. 3). Is this true? Are we not merely trusting that, in a given paper-and-pencil situation, students do know that "=" as used in $f(x) = x + 2$ is a different "=" than that used in $x + 2 = 7 - x$? Is it perhaps not true that the rigidity of CAS tools might prove to be beneficial for the students and help them become more aware of the type of the mathematical object they are dealing with?

Mathematical notation is mostly two dimensional. Entering such notation with a keyboard is often a demanding task, even for an experienced mathematician. What about students? For example, the task in Figure 1, when solved with Derive, is almost meaningless. The student does not even need to know the right structure of the expression. The right result is attained even if the student neglects the parentheses around (-1/2) in the exponent.

Calculate the exact value of the expression $\left(-\frac{2}{3}\right)^{-2} + 0.25^{-\frac{1}{2}}\left(2^{-3} - 1\right)$.

Figure 1. Calculation task from [4]

Perhaps the main problem as regards mathematical notation in CAS setting is a less than adequate user interface most CAS (as well as other tools) possesses. CAS manufacturers have tried different approaches. But these various approaches raise

even more questions about the task design. Whether the interface used influences the students' perception of the task is just one of them. A more practical drawback of using a particular approach to solving problems with mathematical notation issues in this rapidly changing technological world is the fact that all these approaches are usually close form solutions. So they cannot be easily transferred to different CAS.

Hopefully, new breakthroughs in interface technology (e.g., surface computing, handwriting, speech recognition) will provide solutions that will allow us and our students to merge paper and pencil and CAS environments in a straightforward way.

LEVEL OF GUIDANCE

Margot mentioned, "In particular, the construction of appropriate CAS–based signs is often problematic for students and the level of guidance in this regard is a challenge for the teacher" (p. 6). The importance of tasks being prepared in such a way that they can be adapted according to a particular didactical situation should be mentioned yet again. If a task designer overcomes the desire "to stay within the same environment", it is technically possible to design a task in a much more flexible way. The challenge between the two different approaches Margot mentioned (i.e., increasing epistemic value by withholding a hint, providing the hint so students might move forward) can be overcome if certain (and now technically possible) options are exploited.

CAS tasks are all too frequently designed in a way that closely mimics the learning path used in a paper-and-pencil environment. I strongly believe this is not necessary. For example, tasks could be designed in such a way that a link to different task or aid (perhaps a video clip) would be available to students who are unable to progress without a particular hint or that when they were struggling with inappropriate windows of graphs. Hyperlinks, an appropriate user interface with dynamically open content, are one technically easy means that can be used in task preparation.

When I was thinking about Margot's example, a question that simply cannot be avoided occurred to me: did she perhaps want many of the students to achieve too much at one time by having the task goal be "to help students understand the notion of an interval on which the Maclaurin polynomial approximated the original function by a certain amount (e.g. 0.1 units) and how to find this interval" (p. 2)? Should a task be designed in such a way as to provide appropriate fallback? For example, a first task could only deal with the appropriate plotting. If a student was unable to find appropriate windows, he could use a "suggest window" link, something another student would not need to. In this way the epistemic value of the task would be improved.

Namely, instead of speculating the precise ratio of both the procedural and the conceptual approach that would make the task suitable for all students, the fact that

this ratio is different for different students and each particular set of circumstances should be considered. Therefore, tasks should be designed in such a way that this ratio can easily be adapted to the needs of the user, be it a teacher or a student.

THE ROLE OF A TEACHER AND REUSING RESOURCES

When we are working with e-teaching materials, we too often find that the authors of such materials, meant for the use of teachers in the teaching process, do not use the opportunities offered by new technologies. All too often the materials are a monolithic block (or at least their main part is), constructed in the way an ordinary book or workbook would be. This demands that the teacher takes them as a whole, precisely in the order they were written in. Is that really necessary? Do all teachers need the same form of resources, do they want to use them in the same order, and do they want all of their students to see the same examples, do the same exercises? Why not use the possibilities that new technologies offer and at the very least give teachers the chance to adapt the materials to their own and their students' needs.

In the design of tasks the role of the teacher is too frequently neglected. The author of the task usually focuses solely on the students. The process of using the task is AUTHOR → TASK ← → STUDENT. The author develops a task and publishes it. A student accesses the task and tries to solve it. He interacts solely with the task. Thus the author is required to incorporate all of the necessary guidance and feedback into the design of the task itself.

But the majority of tasks are used in a different manner. Students are not usually exposed directly to the task, as there is a teacher present in most cases. The teacher serves as a mediator between the task and the student. He chooses an appropriate task. If necessary, he adapts it or provides additional guidance. So the process is really AUTHOR → TASK ←→ TEACHER ←→ STUDENT. The relation TASK ←→ TEACHER, where the teacher adapts the task, is of extreme importance in the teaching process.

Although CAS can be used to create high quality learning resources, such resources are difficult to find at various portals [5]. Several studies (e.g. [6]) also show that teachers use just few of the resources made available. A somewhat surprising fact in itself is that math teachers were especially slow to adopt such materials. Also, there seems to be a decline in the usage of available materials for several reasons. The possibility of task modification is one of the properties teaching materials most often lack and math teachers demand. If teachers have at least the possibility of modifying the teaching material provided, they have a much more positive attitude towards using the particular material. And the teachers' attitude towards the task used is perhaps the most important part of the usage of ICT in the teaching process. Math teachers, especially those teaching in upper primary and secondary schools, do not like using close form solutions or solutions where the complete didactical situation, in which the task is being used, relies on a particular aspect of CAS; they want to be in control of the whole process [6].

Also, as is the case in Margot's example, the task designer often pays special attention to a particular CAS or a particular didactical situation. As Margot observed, both factors can be of extreme importance and the nature of a task can be drastically changed if the CAS used is different than the one the task designer presupposed. When designing and evaluating a particular task, we should envision the whole process of its design/ usage/modification (see the model illustrated in Figure 2).

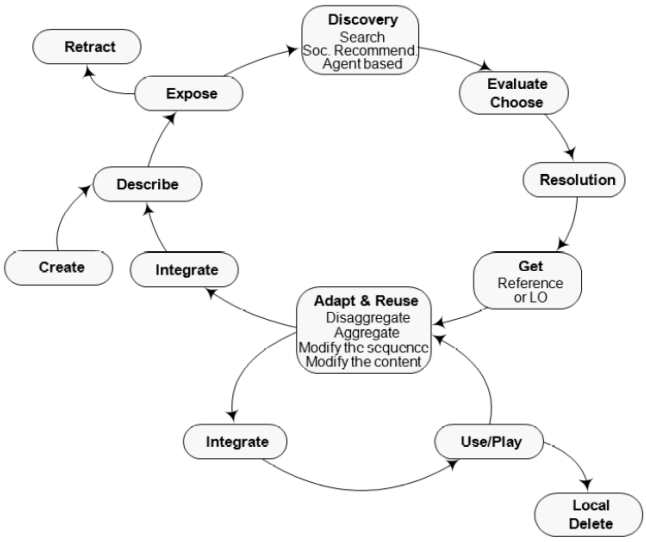

Figure 2. Design/usage/modification process ([7], slide 18)

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