Call for a Common Web-Repository of Interactive Exercises

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Abstract

Many groups, universities, and individual teachers develop content and/or exercises for eLearning. Since this is a time and cost intensive process, sharing of learning resources is a general goal of the communities serving web-based learning technologies and the semantic Web. Sharing requires the annotation of (instructional) objects with standardized metadata, the machine-readability and/or interoperability of content, as well as repositories and portals for submitting and searching appropriate objects. I want to suggest a joint effort for sharing interactive exercises supported by computer algebra systems. Otherwise, similar exercises will be invented over and over again and used by very restricted user groups ony.

1 Introduction

With the increasing availability and usage of computers many groups, universities, and individual teachers develop exercises for eLearning. Since this is a time and cost intensive process, sharing of learning resources is mandatory. In particular, with growing of the Web and its increasing source of knowledge there is a better chance of sharing resources and this is a general goal of the communities serving web-based learning technologies and the semantic Web.

Collections of exercises exist already, e.g. in http://.

2 An Open Repository of Interactive Exercises

Cognitive and pedagogical studies have shown that learning if more effective when the learner is actively involved rather then being the target of pure knowledge transmission [6]. Cognitive experiments suggest that a learner benefits from feedback to her problem solving activities, not necessarily from showing an expert solution or keeping her along an expert solution. Therefore, more and more learning systems

that aim at being effective for learning will somehow integrate problem solving systems, e.g. CASs, to offer interactivity and problem solving feedback.

Other pedagogical and cognitive reasons for the integration of CASs into learning environments are the support CASs can provide to *explore* a problem interactively and *directly experience* the result of a calculation, to visualize, and to *focus* on a particular subtask or skill in solving a problem rather than paying all the attention to a detailed computation.

2.1 Experiences from the ActiveMath System

The ActiveMath learning environment user-adaptively chooses and presents items for mathematical documents [4]. The dynamically generated documents include a variety of learning items to the student, e.g., motivations, concepts, elaborations, exploratory animations, worked-out examples, exercises with feedback. ActiveMath employs an `XML` knowledge representation, `OMDoc`[3, 5], that is an extension of `OpenMath`[2].

As its name suggests, ActiveMath emphasizes the active role of the student and leaves space for exploratory learning. This feature is greatly supported by the integration of cognitive tools. Currently, ActiveMath integrates the Computer Algebra Systems (CASs) Gap, Maple, and MuPAD and a proof planner. They provide the backbone for interactive problem solving, avoid the necessity of predefining few possible problem solutions, and are used for dynamically producing problem solving feedback to the user's actions. Furthermore, the user's exercise performance is used to update ActiveMath's long term user model.

Our experience with preparing (voluntary) courses in which we used ActiveMath suggests:

- many exercises of different difficulty-level and types are needed to adequately serve students with different levels of expertise and learning style,
- the same holds for exercises from different 'fields' in order to provide a student of psychology, engineering, mathematics, etc. with adequate and motivating questions,
- an evaluation and feedback for the student's actions has to be implemented [1] in order to be effective for learning, and at least templates are needed to help a non-programmer teacher to author those exercises and the feedback
- certain CAS-functionalities have to be disabled depending on the leqarning task that the exercise poses
- different ways of input to a CAS are desirable: in a context, where the student should learn how to handle the CAS itself, CAS-commands and system-specific formula input seem to be adequate but otherwise a pallet-like or schematic

input as well as copy-and-paste input is certainly more appropriate. In particular, a non-proprietary browser-based input editor is desirable

- learning systems and teachers would greatly benefit from an automatic generation of exercises.

The first suggestions are realized in ActiveMath already. Currently, we are working on the last two problems. Having made some technological progress we would like to invite other groups to take advantage of these developments and join a common research and development effort.

2.2 Requirements for a Useful Repository

This experience and the need for a large collection of exercises reusable in different contexts gives rise to propose a joint effort for (1) interactive exercise content and its standardized encoding and (2) for making the CASs (more general, the service systems) truly interoperable such that different systems can work with the same standardized knowledge representation. The second requirement is not new . Rather it was the intention of the European `OpenMath` project which made some progress in this direction. However, many CASs have none or few phrasebooks (for restricted mathematical areas) to serve a translation from `OpenMath` back and forth to their proprietary input.

In order to be able to search effectively for appropriate exercises (3) the content representation has to be annotated (by metadata) and these metadata should conform with the international standards, such as IEEE LTSC and IMS. Then it becomes possible to search for exercises of a particular difficulty or complexity as well as for an exercise motivated by a particular field such as physics or psychology.

To go even further, (4) an encoding of the evaluation of the user's actions during an exercise session or of an ideal solution should be reusable by different learning environments. For this a standardized representation of CAS-commands/functionalities needs to be developed and agreed upon. This amounts to a major extension of the current standards.

One of the immediate questions is, of course, whether it will be feasible and agreeable for everybody to conform to one standard. Is it possible to agree upon one extensible set of metadata for CAS-exercises or one `XML`-encoding. For instance, currently two encodings are in use `OpenMath` and content-`MathML`. As long as they can be 1-1 translated there is no serious problem but otherwise? In this case, we might follow the aproach of Web-portals that can store and search a variety of knowledge representation formats.

2.3 Conclusion

We propose to join forces for a web-based repository or portal of interactive exercises, in particular of those supported by CASs. This should include interchangeable

knowledge representation formats and ontologies, a common representation for problem solving activities and their evaluation, and a standardized characterization of the exercises by metadata.

The Computer Algebra community should join such an effort by

- extending and improving their phrasebooks for `OpenMath` and content-`MathML`
- and by defining a standard for CAS-commands in these `XML`-languages.

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