

Metadata for ACTIVEMATH

J.Büdenbender, G.Goguadze, P.Libbrecht, E.Melis, C.Ullrich

November 4, 2003

Abstract

An important feature of the ACTIVEMATH learning environment is its user-adaptivity which is based on an internal user model and a rule-based course generator. To provide this adaptivity, every item's representation must contain carefully chosen metadata. In this paper, we specify the metadata we use.

Why Metadata?

As we use an XML language (OMDoc) to encode content for the ACTIVEMATH system, metadata can be encoded in two different ways. In this paper the term "metadata" refers to both of them.

- **Metadata elements** are XML elements defined in the OMDoc DTD or in the ACTIVEMATH DTD. The OMDoc metadata element occur inside the <metadata> element, the ACTIVEMATH metadata elements occur inside the <extradata> element which is a child of <metadata>.
- Some of the OMDoc elements we use have **attributes** that contain information about them.

A combination of both is often used, as metadata elements can have attributes for a more detailed description of their meaning. Our practice is to use attributes for metadata elements in the cases where we want to define a restricted set of values, and metadata elements without attribute when the values are arbitrary. Attributes for OMDoc items which are not metadata elements are only used to express very profound aspects such as **type** and **for**. This practice allows the automated validation of restricted metadata values as the values of attributes can be checked against the ones specified in the DTD. This use of attributes does not follow the recommended practice of IMS [?] to use only metadata elements and to provide the value in the elements body. However, an export or import to or from the IMS standard can be done by a program which takes care of this.

In the context of ACTIVEMATH, the essential functions of metadata are

- to supply parts of the information the presentation planner needs to automatically chose the most suitable material in the current learning situation. In addition to this, the presentation planner draws information from the user model.
- to supply parts of the information that is needed to update the user model after the user has worked on the material. In addition to this, information from the session manager is used.
- to describe general characteristics of an element.

Metadata in OMDoc

Metadata Elements

The metadata scheme of OMDoc is compliant to the Dublin Core [?] metadata scheme includes the following metadata elements **contributor**, **creator**, **translator**, **subject**, **title**, **description**, **publisher**, **date**, **type**, **format**, **identifier**, **source**, **language**, **relation**, **coverage**, and **rights**.

In the current version of ACTIVEMATH, we make use of the following OMDoc metadata elements:

- **title** is needed to be indicated on an ACTIVEMATHpage as the title of an item. This element can contain any text. It is not required but recommended for any kind of element.

- **rights** is needed to provide copyright information. This element may contain any text. It is not required but recommended for any kind of element.

Authors may use the other **OMDoc** metadata elements to further annotate their materials in a human readable way.

These metadata elements only cover one of the functions mentioned above: they describe general aspects of the element that contains them. To further describe the elements and their mutual dependencies, we use additional metadata elements defined in a separate **ACTIVEMATH-DTD**.

OMDoc Attributes

OMDoc makes also use of attributes for some of its elements. The **OMDoc** attributes which we use in **ACTIVEMATH** are:

- **for** The **for**-attribute is used to annotate definitions, assertions, proofs, and elaborations. It contains the identifier of the symbol or concept that is treated (proved, explained, ...) in the element. For example, in the case of a definition, it points to the id of the symbol to be defined, whereas for a proof, it points to the id of the assertion to be proved.
- **type** The **type**-attribute gives further information about the type of a definition, an assertion, etc. The possible values of **type** depend on which kind of element is to be annotated:
 - The **type** of a definition can be **simple**, **inductive**, **implicit**, **recursive**, or **obj**.
 - The **type** of an assertion can be **theorem**, **lemma**, **corollary**, **conjecture**, **false-conjecture**, **obligation**, **postulate**, **formula**, **assumption**, or **proposition**.
 - The **type** of a text can be **abstract**, **introduction**, **conclusion**, **thesis**, **antithesis**, **elaboration**, **motivation**, **evidence**, **note**, or **annotate**.
 - The **type** of an example can be **for** or **against**.

Specific Metadata in ACTIVEMATH

Metadata for all kind of elements

- As opposed to particular pieces of a book, objects in a knowledge base can be exchanged individually against a newer version. Therefore we introduce a **version** element which contains information about the version (number, date, ...) of the item. It is currently meant to be provided and read by human editors or authors only and can contain any text. A further specification will in the near future respect demands arising from the use of **ACTIVEMATH** in different projects.
- **difficulty** describes the author's view on the level of difficulty of the element. It has a **level** attribute with the possible values *easy*, *fair* and *hard*.
- **abstractness** describes author's view on the level of abstractness of the element. It has a **level** attribute with the possible values *concrete*, *neutral* and *abstract*.
- **learningcontext** In future, we will sometimes work with knowledge bases that contain material from different sources. For this case, we need a possibility to specify for which learning context the material was intended originally. Otherwise, the metadata element **difficulty** has no sense. On the other hand, it is possible to better estimate the difficulty of an element for a given user from the information in **difficulty**, **learningcontext** and the user's learner model. **learningcontext** is also important for editors who want to build a course out of available learning material from different sources.
learningcontext has a **use** attribute, the possible values are the ones defined in the metadata standards from IMS or IEEE [?]: *primary-education*, *secondary-Education*, *higher-education*, *university-first-cycle*, *university-second-cycle*, *university-postgrade*, *technical-school-first-cycle*, *technical-school-second-cycle*, *professional-formation*, *continuous-formation*.
- **field** describes the field to which the content of the element belongs. It enables the system to provide appropriate elements for students from other fields than mathematics. **field**

has a **use** attribute with the possible values *mathematics, statistics, engineering, psychology, biology, chemistry, physics, computer-science, economy, historical, other*.

- **verbosity** is an attribute of CMP (Commented Mathematical Property). As every kind of element can contain a CMP as a child, we mention this attribute in this section. It describes the verbosity of any CMP in order to be able to generate more or less detailed documents for different purposes. The values of **verbosity** are numbers that range from 1 (minimum verbosity) to 5 (maximum verbosity).
- We provide a group of metadata elements which point to an item or a symbol to which the given item is related. It is always used if there are more relations to specify than the one that is expressed by the **for** attribute as described above. These elements are:
 - **depends-on** contains the required previous knowledge. It is needed to generate the instructional graph before applying any pedagogical rules.
 - **counterexample-for** is applied if the given item may serve as counterexample for the specified item.
 - **definition-for** is applied if the given item may serve as a definition for the specified symbol.
 - **elaboration-for** is applied if the given item may serve as an elaboration for the specified item.
 - **example-for** is applied if the given item may serve as an example for the specified item.
 - **motivation-for** is applied if the given item may serve as a motivation for the specified item.
 - **proof-for** is applied if the given item may serve as a proof for the specified item.
 - **similar-to** is applied if the given item can be used to replace the specified item.

Bibliographic references are another kind of relation, but we realize them exclusively via the **ref** element. So there is no metadata element for this purpose.

A group of metadata elements which allow to specify a teachers view on the item (including typical errors, predefined feedback ...) is planned but not specified yet.

Additional metadata for exercises

An adaptive learning environment should be able to deliver appropriate exercises for different users and learning situations. Furthermore, the impact of success or failure on the user model should depend on the characteristics of the exercise. Therefore we use additional metadata to describe the pedagogical aspects of an exercise.

- The **ped-level** element is used to differentiate between the different pedagogical levels that exercises may aim to. It has a **use** attribute with the possible values
 - **knowledge** Here we test if a certain knowledge is available, i.e. if certain facts can be reproduced by the learner.
 - **comprehension** These exercises are obviously related to the concept specified in the **for**-attribute.
 - **application** The learner has to solve a problem where the relevance of the concept in the **for**-attribute is not obvious.
 - **transfer** The learner has to solve a problem in which the specified concept occurs in a *new* context.
- The **ped-type** element specifies the pedagogical type of the exercise. It has a **use** attribute with the possible values
 - **control** By solving these exercises, the user can control his knowledge (comprehension, ...) himself. The user's answer is not evaluated by the system.
 - **calculate** The learner has to solve the exercise by calculating the result.
 - **give-example** To solve this exercise, an example that fulfills the given conditions has to be given.
 - **prove** The learner has to prove a given assertion.
 - **hypothesize** The learner should find and formulate a hypothesis.

- **model** These exercises require mathematical modeling.
- **explore** Here, the learner will explore a mathematical concept and eventually verbalize what he found out.
- The **system** element specifies the external system or the didactic method that is used to present an exercise. It has a **use** attribute with the possible values: **maple**, **mupad**, **gap**, **omega**, **mc**, **fillin**.

References

- [1] <http://dc.org/>
- [2] *Learning object metadata from the IEEE committee* <http://www.edna.edu.au/edna/aboutedna/metadata/analysis/LOM.htm>
- [3] *IMS Learning Resource Meta-data Information Model* <http://www.imsproject.org/metadata/>
- [4] *IMS Question & Test Interoperability: ASI Information Model Specification* <http://www.imsproject.org/question/>