Towards the Adaptation of Scientific Course Material powered by Communities of Practice

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Abstract

Several applications support the adaptation of course material. Even though most of these systems allow to specify interaction preferences or even employ user modeling techniques, every system is an island with this respect. In particular, different systems cannot share user models or predict preferences in the absence of prior interactions. We use ideas from the theory of Communities of Practice to consolidate user models and to extend current approaches towards a CoP-sensitive adaptation.

1 Motivation

At the Jacobs University Bremen we offer a lecture on General Computer Science (GenCS) to an international student body. There we are challenged with the students' different mathematical backgrounds. The majority of our students believe that these mathematical discrepancies are very problematic, especially in the beginning of a course. Students reported that they had problems to get acquainted with the professor's notation systems; some had the feeling that the pace of the course was inappropriate, while others did not face any problems.

We believe that the theory of Communities of Practice (cf. Section 2) can help to understand and countervail these discrepancies. Students do not share the same understanding as the lecturer. They actually form various subcommunities that e.g. differ in their preferred notations, basic mathematical assumptions, and mathematical performance. Instead of enforcing students to become acquainted to the lecturer's practice, we want to adapt the lecture taking the social context as well as the emergent nature of educational communities into account.

Several applications[1] support the adaptation of course material providing different perspectives on the lecture material wrt. to the presentation, e.g. in terms of the notation system, the structure, as well as the selection of content (cf. Section 3). Even though most of these systems allow the user (student or lecturer) to specify interaction preferences or even employ user modeling techniques, every system is an island with this respect. In particular, different systems cannot share user models or predict preferences in the absence of prior interactions. We use ideas from the theory of Communities of Practice to consolidate user models across systems as well as to extend current processes towards a CoP-sensitive adaptation.

[1]We focus on systems with semantically enriched artifacts, such as ACTIVEMATH [Act07], CONNEXIONS [CNX08], SWIM [Lan08], or *panta rhei* [pan08c]. However, our approach can be extended to other (non-semantic) systems.

2 Communities or Practice

According to [LW91], CoPs are groups of people who share an interest in a particular domain. By interacting and collaborating around problems, solutions, and insights they develop a shared practice, i.e. a common repertoire of resources consisting of experiences, stories, tools, and ways of addressing recurring problems. The concept is widely used in education to emphasize that learning should involve the engagement in a community of practice "to bring the experience of schooling closer to everyday life" [LW91].

In this paper, we apply the theory of CoPs to the *Science, Technology, Engineering, and Mathematics (STEM)* education. We observed that STEMicians (i.e. students, professors, and teaching assistants) *primarily interact via their artifacts*, including documents in a more traditional understanding such as course materials, homeworks, and books as well as documents in a wider interpretation such as forum postings, ratings, and tags. We assume that *interactions* and *preferences* of STEMicians are *inscribed* into these artifacts and aim at *extracting* and *modeling* their *practice* based on *semantic technologies* (cf. [Koh06]). We further experienced that STEMicians use various tools to accomplish their daily tasks. Consequently, their repertoire of artifacts, including preference settings, is scattered across various systems and so is the repertoire of their CoPs.

We build on the notion of *portfolios*, which integrate a single user's collections of *semantically marked up* artifacts from several systems, in particular, their user data and preference settings. Based on these *single-owned portfolios*, we propose *CoPfolios*, which include *artifact collections and preferences of a CoP* (cf. Section 4).

In this paper, we focus on the *preferences specifications*, which form the user's or CoP's *views* or *lenses* (cf. Section 3). These can be (partially) interpreted by systems to allow *user- and CoP-specific adaptations* wrt. presentation, structure, and selection of artifacts (cf. Section 4). This is especially valuable in scientific education systems, where students should be encourage to address course materials from different perspectives and potentially identify discrepancies with their former education to reduce misunderstandings (cf. Section 6). Moreover, the notion of CoPfolios allows new students to reuse a CoP's preference specification to receive an *initial CoP-specific adaptation* of the course *without prior investments*.

3 State of the Art

In the following we list related work that provides a notion of lenses for the presentation, selection, and structuring of artifacts:

In [KMR08; KMM07] we discuss *notation preferences* and *context* on semantically marked up artifacts. We reified *notation preferences* of scientists into artifacts, that is *notation specifications* [KMR08], which are applied onto the meaning of artifacts (e.g. represented in OpenMath [Ope07] or Content-MathML [W3C03]) to adapt the artifacts' presentation (e.g. in Presentation-MathML [W3C03]).

But lenses are not limited to notations; they also include metadata used for structuring (or ranking) and selecting artifacts. For example, the eLearning system ActiveMath [Act07] includes user models [Mel01] to generate user-specific courses. These *learner models* include concepts, competencies, and layout preferences and are used to *select* and *adapt* appropriate course fragments to compile individualized study material.

The educational knowledge repository ConneXions [CNX08] utilizes the term *lenses* [KBB08; Fle07] to express the approval and authorship of organizations and individuals. Conceptually, lenses are selection of content in the ConneXions repository to help readers find content that is related to a particular topic or focus. Technically, CNX lenses are tags that match multiple articles in the CNX content commons.

Slashdot [sla08] is an online system for sharing technology-related information, so called "nerdy"-news. The system implements an collaborative reviewing approach to assess quality of user-submitted news and comments. The ratings are application of *structural or selective lenses*, since they implement a ranking of the news corpus.

4 Portability via Portfolios and CoPfolios

Portfolios and CoPfolios include several *interrelated* types of artifacts such as *papers* or *discussion items* as well as *profile data*, such as email, name, or address, and *preference settings*, e.g. with respect to general *subscription preference*, *ratings*, or *notation systems*. These types of artifacts are initialized by system-specific data provided by systems such as SWiM, *panta rhei*, ActiveMath, ConneXions, or slashdot. Each system provides an export to and import from these portfolios and CoPfolios, to facilitate the sharing of artifacts across several systems (cf. Figure 1).

4.1 Envisioning the Sharing of User Data

A user creates an online profile in the SWiM system, including personal data as well as discussions, watch items, and notation preferences, which implement his views or lens on the SWiM content. He *authorizes the export* of his user data into his portfolio. SWiM *maps* the user's artifacts into the *portfolio types*: For example, wiki discussions are mapped to general discussion items, while watch items are mapped to subscription preferences. The user then logs into the *panta rhei* system (for the first time) and *authorizes the system to import* his user data from the portfolio. The *panta rhei* system now maps the portfolio types into its system-specific data structures and *applies the user's preferences* on the *panta rhei* content *without further investments* by the user. For example, discussion items are interpreted as forum postings; while the subscription preferences in the user's portfolio are used to initialize the email notification in *panta rhei*. Being a notation aware system, *panta rhei* can even interpret the user's notation preferences and *adapt* its content respectively.

4.2 Envisioning the Sharing of CoP Data

A professor wants to create a CoPfolio for his course. The initial course CoPfolio is a subset of the professor's portfolio, including his slides, recommended readings and preferences. The CoPfolio can be imported in several eLearning environments such as SWiM, *panta rhei*, or ActiveMath, which are able to interpret the professor's settings. All registered students can apply the *course lens* onto the material and receive an initial slide collection, which is selected, structured, and presented according to the professor's lens. During their interaction with the system, the students initialize their own portfolio and create their own lenses. For example, based on the competence tracking in ActiveMath, a student's lens points to all concepts from the course corpus, which the student still needs to focus on.

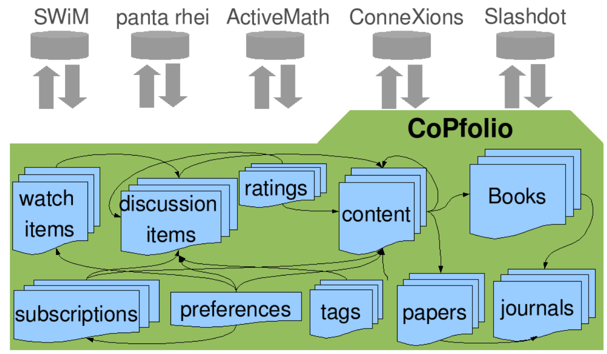

Figure 1: Portability of user and CoP data.

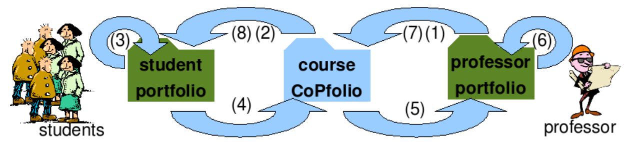

Figure 2: Portability of user and CoP data.

As illustrated in Figure 2, portfolios and CoPfolios provide an networked and emergent structure that takes the dynamics of communities into account: The professor's portfolio initialize the course CoPfolio (1). The CoPfolio is used to initialize student portfolios (2), which are modified throughout the students' interaction (3). The course CoPfolio can change based on the students' individual preferences and contribution to the course (4); these changes can provide feeback to the professor to e.g. speed up or slow down the pace of his course (5). Vice versa, changes to the professor's portfolio (6) influence the course (7) and, transitively, the student's portfolios (8).

5 Managing Portfolios and CoPfolios

We propose the community of practice toolkit (`CoPit`) for managing portfolios and CoPfolios. Technically, `CoPit` maintains pointers to artifacts in other system's databases as well as profile and preference data (cf. Figure 4). An *upper system ontology*, potentially based on SIOC [SIO07], supports the mapping between artifact types in portfolios and CoPfolios and system-specific concepts and, thus, facilitates data portability (cf. Figure 3).

The authentication and rights management of `CoPit` is based on [Ope08]. For the representation of notation preferences we refer to our representation format [KMR08]. However, these approaches need to be extended to facilitate the authentication of CoPs as well as the representation of further CoP data and preferences.

6 Case Study

We will carry out two experiments within our General Computer Science lecture based on two web-

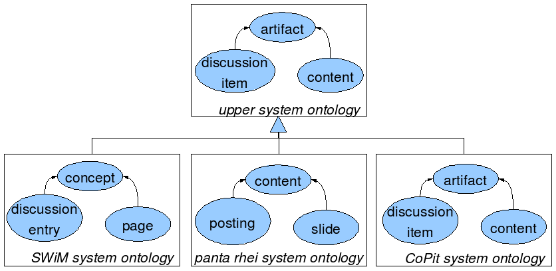

Figure 3: The *upper system ontology* is instantiated by the SWIM, the *panta rhei*, and the `CoPit` system ontology.

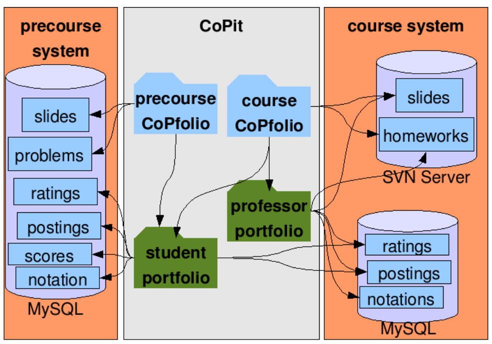

Figure 4: Portability of user and CoP data.

application: An online precourse [pan08b] and a course system [pan08a] (cf. Figure 4). The former prepares new students before arriving on campus. The precourse CoPfolio points to slides and problems, both stored in the system's internal database. Students can interactively solve multiple-choice problems, discuss problems with other students in a forum, and provide feedback by rating the course material. Moreover, they can specify the notation background by manually selecting notations. The students' interactions, e.g. ratings, discussions, scores, and notation preferences can be exported into portfolios.

The course system presents slides and homeworks, both stored in a version control system. The course CoPfolio provides an initial lens based on the professor's settings. Alternatively, students can authorize the import of the formerly created portfolios and apply their own lenses. A course forum and rating facilities enable the discussions and feedback throughout the course, which updates the students' portfolio and course CoPfolios and eventually has an impact on the professor's portfolio. Students can share their portfolios with others and publish them for further computations. Their preferences can then be used to identify subcommunities in the course and to infer the respective (Sub)-CoP lenses. Consequently, students and teachers may access the course from different angles using their own, others, or (Sub)-CoP lenses of the course and identify potential discrepancies and misunderstandings.

7 Conclusion

We emphasized that existing adaptation approaches should be integrated in order to relieve users from the instantiation of the user models and preference settings. Moreover, we illustrated how the theory of Community of Practice can help to facilitate a CoP-specific adaptation of course materials based on the common preferences of CoPs. We proposed portfolios and CoPfolios which consolidate an individuals and a CoP's repertoire and focus on the sharing and portability of preference data, which we conceptually view as *lenses*. Our further work focuses on the implementation and evaluation of our approach. We will develop `CoPit`, which manages portfolios and CoPfolios and facilitates the integration of existing systems. Moreover, a case study on our General Computer Science lecture shall allow us to substantiate our still rather visionary and experimental approach and to evaluate our two course systems.

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