A Supporting System for Adaptive Peer Review based on Learners' Profiles

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Abstract. Intelligent tutoring systems cover a wide range of educational processes. There are however scarce attempts to apply those principles for adapting peer review processes according to the student's profile in the educational settings. In this paper, the Adaptive Peer Review methodology is reviewed, paying special attention to the problem of building the student profile. A supporting system based on such Adaptive Peer Review methodology is then introduced, which should facilitate teachers the adoption and deployment of adaptation to the student in peer assessment experiences in real educational settings. Experimental results supporting the ideas presented are briefly discussed.

Keywords: adaptive peer review, peer assessment, adaptation.

1 Introduction

Peer Review amounts to evaluating the work of a colleague and providing feedback about it. This methodology has been widely applied in multiple contexts, ranging from childhood education to academic research.

In the educational context, peer review is being increasingly used with experiences reported for virtually any level and subject. In this context, *peer assessment is defined as an arrangement in which individuals consider the amount, level, value, worth, quality, or success of the products or outcomes of learning of peers of similar status.* [1]

The benefits as well as a detailed topology of peer review in education have been studied in several publications (see [1] for an excellent survey). And there exist abundant references in the literature reporting experimental case studies. Nevertheless, *"how peer assessors and assessees should best be matched ... is discussed surprisingly little in the literature"* [1], an issue that remains true as noted again in [2] and [3].

Nowadays, it is commonly accepted that not all students learn in the same way. Intelligent Tutoring Systems try to take into account this pedagogical premise and to offer a personalized learning path for each student, adapting the contents and activities to the learner characteristics and needs. In this sense, different factors

influence not only how students learn by themselves, but also how they collaborate and learn from their peers. In consequence, student roles and adequateness have been frequently analyzed in collaborative work (see [4] for example). The aim behind these techniques is to adapt the process in order to obtain a more productive experience.

Such studies are outstandingly unusual in the context of peer review, although the framework is indeed similar. The analysis of the influence of student profiles in the peer review process are not usually discussed even though diversification of peer review groups is involved in some experiments, like the one reported in [5].

Only recently a couple of initiatives have been reported that introduce adaptation in the peer assessment process in educational settings. The first attempt (to the authors' knowledge) is the adaptive peer review methodology that we introduced in [3], which identifies the matching of authors and reviewers as the key point for adapting the process according to the students' profiles. Afterward, Giannoukos et al. also propose acting on the author-reviewer matching for introducing adaptation in online peer assessment, in order to improve the peer assessment procedure. [6]

In this paper, adaptive peer assessment is discussed and a supporting tool is then described, which should facilitate teachers the adoption and deployment of adaptation to the student in peer assessment experiences in real educational settings. Some experimental results from the application of the methodology in Computer Science courses are also reported.

2 Adaptive Peer Review

As any other educational process, peer review is suitable to be adapted to student characteristics and needs. And an improvement in the learning outcomes is expected as a consequence of such adaptation, like in any other educational process.

As explained in [7], defining the methodology for adaptive peer review requires analyzing the process and detecting the potential actuation points. Author-reviewer is the only interaction exclusive of peer review processes, among all the different types of interactions involving the students in an educational process (student-teacher, student-content and student-student, according to Moore's model). Thus, adaptive peer review is mainly concerned with the adaptation of author-reviewer interaction, although content adaptation as well as collaborative learning tutoring could also apply.

Adaptive peer review thus copes with defining appropriate author-reviewer matching criteria, based on the students' profiles, that contribute to improving the outcomes of the process. Such matching criteria depend on the objectives pursued with the adaptation.

Focusing on improving the *learning outcomes* as the main goal of the adaptation, a sound pedagogical background is required to support the model. For that purpose (improving the learning outcomes), the student's knowledge can be considered as the key variable to influence the process, according to social constructivism, Vygotsky's zone of proximal development (ZPD) [8] and scaffolded learning theories. Based on these pedagogical premises, several matching criteria have been explored, trying to

form author-reviewer pairs with appropriate knowledge gaps that guarantee learning improvements. Experimental results from a computer science course confirm an improvement in learning when authors and reviewers are matched following this gap-based approach instead of randomly or using other criteria, as explained thoroughly in [9].

3 Student profile

The effectiveness of the adaptation relies on a proper student profile that models the learner adequate and precisely. Building the learner profile means not only specifying the theoretical model that represent the student, i.e. selecting the variables that the adaptation will depend on, but also collecting the actual necessary data.

Different student models could be applied, depending on the objectives and circumstances of the process, as the methodology is generic. Focusing on improving the learning outcomes as the main goal of the adaptation, pedagogical theories lead to consider the student's knowledge as the key variable to influence the process. This decision is supported by educational theories, in particular social constructivism, Vygotsky's zone of proximal development (ZPD) and scaffolded learning theories.

Several experiences have been deployed in diverse courses where peer assessment was applied to completely different artifacts: multimedia programs in a Computer Science course [3] and written reports in a course on Artificial Intelligence [10]. Experimental results gathered from such experiences confirm the influence of the student's level of knowledge about the topic on the learning results. That relation appears between the level of a submission and how much its reviewer learns from it, and also between the level of the feedback and how much the author learns from it.

As noted in [3], significant correlation ($\rho = 0.68$) has been found between the level of a work and how much students learn reviewing it. There is also influence ($\rho = 0.58$) between the quality of the reviews and how much the author (of the work reviewed) learns from them. **Fig. 1** illustrates the former relation.

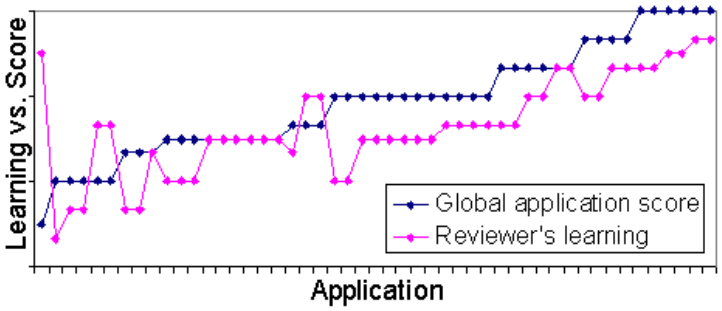

Fig. 1. Learning reported by the reviewers depending on the score of the assessed project.

These results encourage the use of the student's knowledge as an appropriate profile on which the adaptation is based. This however poses the challenge of effectively feeding the model with actual data that represent properly the updated and real state of the student in a given instant. Or their submissions, as the latter are the most up-to-date indicator of his/her state just before the matching process.

Three alternative mechanisms have been explored for building the student profile:

- Initially, predictive modeling was considered, forecasting the learner's level depending on past data (for example, grades from previous examinations and submissions). The main advantage of this approach is that it neither requires additional workload nor interferes with the process. Unfortunately, no significant correlation was found between the forecasted values and the actual level of the submissions[1]. In consequence, the predictive modeling approach had to be discarded due to its lack of reliability.
- Evaluation of the latest submission by the teaching staff provides probably the most accurate and precise data for modeling the student's state. On the drawback, it implies an important burden for the teaching staff and introduces delays in the process. It is a non-scalable solution.
- Self-assessment on the contrary provides a sustainable solution for characterizing the submissions and thus building the students' profiles. The additional work involved is reasonable as it is distributed among all the students. In fact, peer assessment is often used combined with self-assessment. Finally, experimental results confirm that self-assessment results are reliable enough, when compared to teachers' scores (ρ=0.71). [7]

4 A Supporting Tool for Adaptive Peer Review

Supporting programs for peer review in educational environments are reported from 1995. More recent tools such as CPR [11], PG [12, 13], OPAS [14] or OASIS [15] use the web to manage peer interaction. However, to our knowledge, our system was the first one that supports adapting the peer review process according to the learner's profile.

Fig. 2 shows the architecture of the author-reviewer matching system. The system automatically guarantees the validity of any generated *map*[2] is valid, meaning that no student is assigned to review his/her own work, all submissions are assigned the specified number of reviewers, and load balance (all students are assigned a similar

[1] Several factors can explain this negative result that may seem paradoxical. The main reason is probably related to the disparity and deviations in time devoted by the students to the submitted project. Students who did not achieved a satisfactory result in one submission tried to compensate that in future ones with an extra effort. On the contrary, some students with initially good results did not maintain a constant level of work, which turned out in a quality drop in their following submissions. Additional external factors also have an impact (for example, submissions required in other courses).

[2] A map is defined as the set of author-reviewer matches (see [16] for a formal definition).

number of submissions to review). Fuzzy classification is applied to rank the actual pairs according to the criteria, and genetic algorithms are used for exploring efficiently the potential combinations of pairs [16].

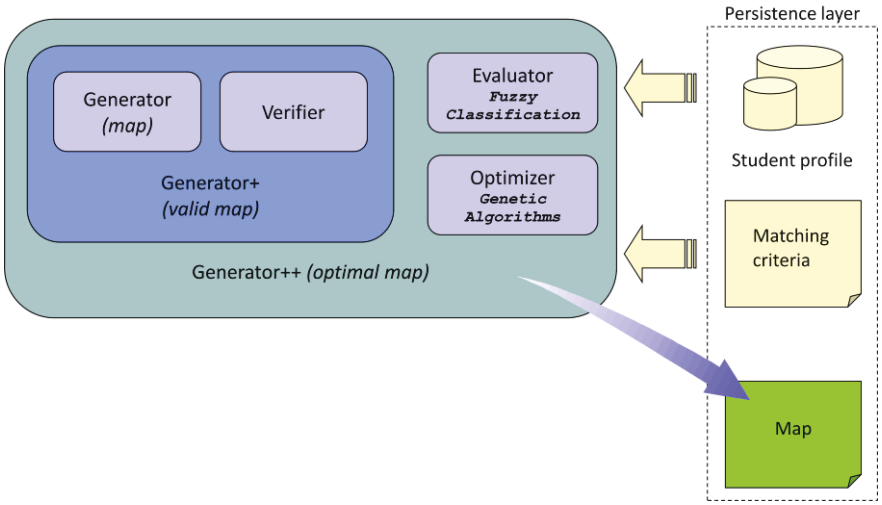

Fig. 2. Architecture of the author-reviewer matching system

A unique characteristic of this system is that it allows management of both individual and collaborative assignments. I.e. the matching process can be applied both when each submission has a unique author as well as for processes where assignments are done in teams and each submission has several authors. It also manages matching multiple reviewers to each submission. Another advantage of the system is that it provides an intuitive model for specifying the matching criteria. The instructor does not need to elaborate complex rules but just define a set of typical, representative cases (prototypes) and score each of them depending on the interest of getting author-reviewer pairs similar to that one.

Experimental evaluation with data from real students proves that the system effectively matches students according to the specified criteria while observing validity constraints. **Fig. 3** shows the distribution of author-reviewer pairs for an example map generated with the system. In this case, criteria for matching authors and reviewers promoted pairs where authors and reviewers had complementary profiles; pairs joining authors and reviewers both with low proficiency levels where severely undesirable while pairs with both components having proficient levels were considered neutral.

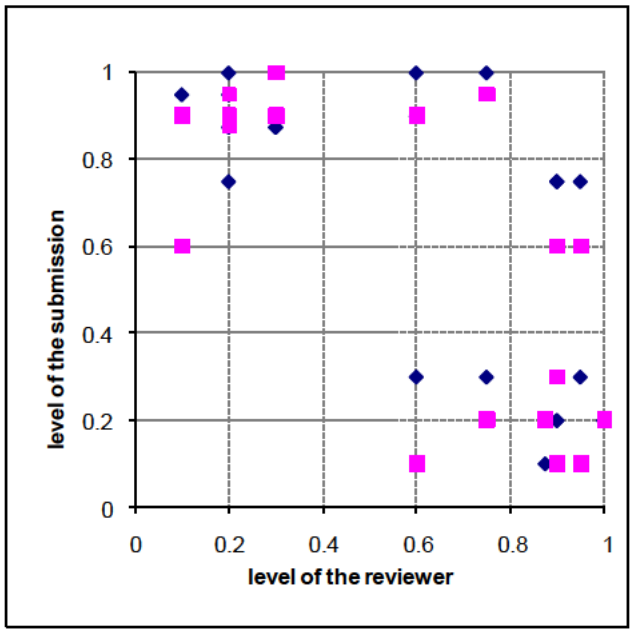

Fig. 3. Example of distribution of author-reviewer matches.

Since [16] where a prototype implementation for the matching algorithm was first described, the functionality of the system has been validated in several experiences applying different matching criteria and continuously improved. The most recent version provides a graphical user interface (in Spanish) that improves the usability of the tool facilitating its use by non-technical users [17].

The system also implements the functionality for editing a given map, so that the teacher can manually modify particular author-reviewer pairs if needed (**Fig. 4**). A tree-based structure displays the list of submissions with all the related data, including characteristics of the submission itself (title, authors and their profiles) as well as the corresponding reviewers with their profile information. In the bottom part of the window, displayable lists allow to visualize and change the reviewers matched to the submission. Profile data is provided for each reviewer, so that the instructor can take that information into account when introducing any modifications.

Additionally, the application allows visualizing the results and provides statistical information about the distribution of scores and profiles, which is expected to be useful for revising the matching criteria. For example, the dispersion of the set of submissions is visualized in the screenshot shown in **Fig. 5**; the displayable list at the bottom allows specifying the variable which the analysis is based on, in this case the scores (*"Notas"*). Statistical information about authors' profiles, mean values and variance can also be visualized.

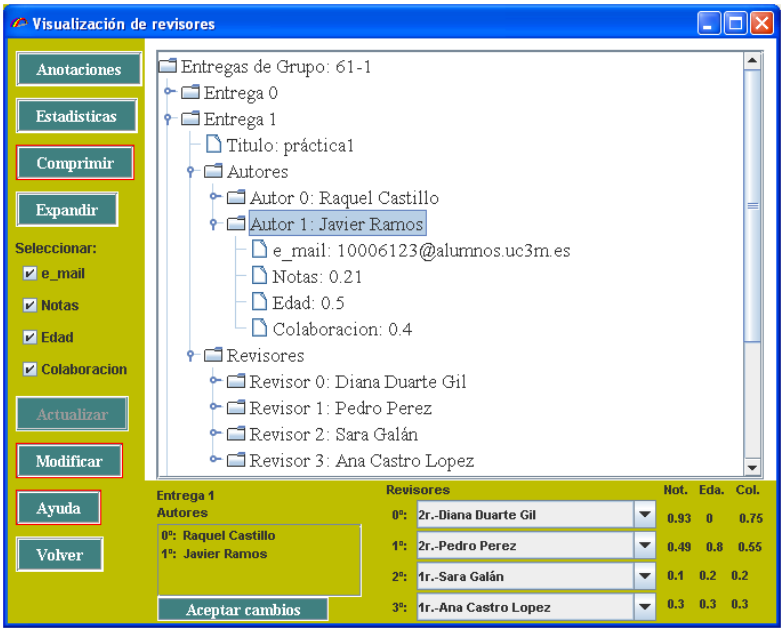

Fig. 4. Map edition (modifying author-reviewer matches)

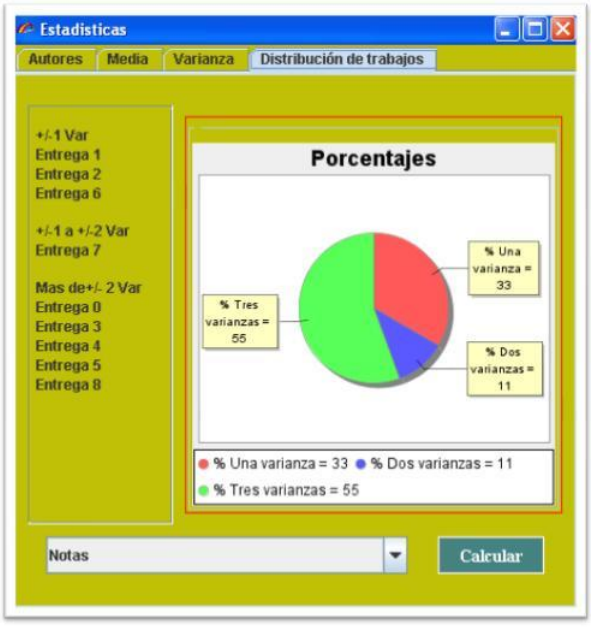

Fig. 5. Results visualization (statistical information)

5 Conclusions

Synergies between intelligent tutoring systems and peer review processes have started to be explored only recently. In this paper, it is discussed how the peer assessment process can be adapted and personalized depending on the learner's characteristics. A generic methodology for adaptive peer assessment is reviewed, which focuses on selecting the most appropriate reviewers for each author to introduce adaptation in the process.

Adaptation to the learner is expected to empower and improve the benefits of the peer review process, and to lessen its potential problems. Although any other improvement objectives may be pursued, in the educational context the underlying reason behind adaptation will usually be optimizing the learning outcomes. In consequence, appropriate pedagogical criteria have been defined and tested in several experiences.

Evidently, the success of the process adaptation relies on the quality of the learner profile which it is based on. Problems related to building the student profile are thus discussed, together with possible solving strategies. Experimental results supporting the advantages and drawbacks of the discussed strategies are also presented.

Finally, a supporting system is presented that implements an algorithm for matching authors and reviewers depending on their profiles and the matching criteria configured by the instructor.

Several experiences have been deployed in different courses applying adaptive peer review with the help of the described supporting system (see [9] for a detailed description). Promising experimental results have been obtained, showing an improvement in the students' learning outcomes (in particular, the students' knowledge on the topic) as expected, in comparison to not using peer review at all and also in comparison to using peer review but matching authors and reviewers randomly.

Future work includes several lines of action. From a technical point of view, other algorithms could be explored for the matching process. On the other hand, natural language processing technologies offer a wide range of tools for characterizing the students' submissions when consisting on open texts. From the pedagogical perspective, it would be interesting to apply the methodology to new scenarios, and analyze the convenience of the matching criteria depending on the settings. Finally, additional experiences should be deployed in order to refine the methodology, corroborate its pedagogical soundness and confirm statistical significance of the results.

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