Combining Adaptive and Collaborative Learning: A Case Study

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Abstract. Adaptive Educational Hypermedia Systems (AEHS) have so far largely been adapting to individual learners by modeling their unique characteristics, levels, styles or goals. However, as the emphasis on collaboration and sharing on the Web in general and e-learning in particular grows, the community faces the challenges of adapting to groups as well as to individuals. Typically, many AEHS does not provide many collaborative learning activities in the first place, at least not the levels experienced in Learning Management System (LMS). Therefore a number of research workers have focused on introducing adaptation through an LMS [1, 2]. This paper tries to search for answers for questions proposed by the AEH community. It reports a case study in which adaptation was provided to groups of students on an individual basis along side the collaborative and interactive learning tools where an LMS (Moodle[3]) was used as the login point to this integrated learning environment in WHURLE 2.0 [1]. It suggests that the current knowledge of individualised adaptation and personalisation as presented in this experiment could help in creating group-based adaptation.

Keywords: Adaptive Educational Hypermedia, Learning Management Systems, Moodle, Collaborative learning, Web 2.0, User Modeling, Group Adaptation

1 Introduction

Adaptive learning was introduced when the needs of individual learners were recognised and hence the demand for personalized learning was high. Therefore Adaptive Educational Hypermedia (AEH) [4] became a well established field in e-Learning research attracting people from many disciplines including computer science, education, user modeling, psychology, human-computer interaction and so forth. It provided an adaptive learning experience to students based mainly on their individual needs. However, learning is believed to be a collaborative process as much as an individual journey and hence the isolation of learners could damage the learning experience [5]. On the other hand, LMS have recognized such requirements for communication and collaboration in the online learning context and hence provided the tools to allow for this collaboration to take place. Moreover, as the Web advances and what is known as Web 2.0 increases its influence with concepts and technologies

which promote sharing, collaboration, communication and socilaising, the need for collaborative e-leaning becomes more obvious. Nevertheless, one of the limitations of AEHS has been their limited support to this type of learning. This has encouraged us to propose the delivery of adaptive content and adaptive learning in conjunction with a system which provides tools that enable social learning such as an LMS.

The importance of group-based learning and its link to adaptive learning has recently started to concern the AEH community, resulting in a number of proposals to address this issue. However, it is worth mentioning that various people view group adaptation in different ways. Some see it as applying the adaptation methods and techniques (content, links, interfaces, or all) at a group's level, using parameters that represent the group's characteristics rather than the individuals. who form the group. This is done by providing commonalities that lead to this grouping, for example stereotype groups [6]. Others might view group-adaptation as adaptation that occurs while students, who do not necessarily have any similarities are working together to achieve a certain goal or those who are actively participating in a given activity to complete a specified task..

In [7], the authors present an ontology-based approach for modeling the users and their interactions with the learning system which was built using Web Services' technologies to cater for interoperability. The list of services with their application scenarios operate both at the individual and group level. Another study is presented in [8] which investigates individual-to-group and group-to-individual influences and their possible applications in user modeling and hence adaptation.

A similar work to that presented in this paper in terms of delivering adaptation through the Moodle LMS, presents the adaptation in the context of feedback, is [6]. It looked at the feedback's representation (what should be included?), time (when to provide it?) and distraction to the learning process. Here, the feedback could be tailored according to a specific learns characteristics leading to an individual based adaptation while in the group adaptation is based on the characteristics of a group that this individual has been assigned into according to the value of one or more parameters. The difference between the two types of adaptation is in the way the user modeling and the user identification are organised as well as what parameters are included in the model.

Moreover, [9] which also integrates the adaptive (Jeliot-Adapt) system into Moodle, has examined the individual level personalisation and sees it as the first step towards adapting the program to the group level suggesting many scenarios for adaptation when students are working together. While [10] suggests a semantic learner model based on the FOAF ontology [11], which is a vocabulary for mapping social networks stressing that the automated process of grouping students while preserving the individuals personalisation needs to be supported by an appropriate learning model.

In this paper, we present a case study that combined adaptive learning for individuals within a learning context that provides and promotes collaborative learning. We want to use our experiences from this study to try and answer some questions regarding group adaptation hoping the results we obtained could enrich the knowledge for this emerging area in AEH. The purpose of the experiment reported in this paper was twofold. The first and main purpose was to investigate an architecture that would facilitate the greater usage of AEH by allowing it to be used more freely.

This architecture is described briefly in Section 2 and presented in [1, 12]. The advantages of this architecture are shown by it allowing the easy integration of an existing LMS (Moodle) as the delivery service, which in turn allowed the experiment to look at whether effective collaboration could be achieved for a group of students who were at the same time being given individually adapted content. The results of the collaboration component of the experiment are reported here. From this experiment it has been possible to derive some important ideas for further extending the work to encourage greater collaboration and to determine ways in which the content should be adapted for group behavior. The background to the experiment was teaching of software engineering to first year computer science students and to students on MSc courses. Two separate modules were taught in class due to the distinct nature of the groups but a single support website was developed. The method of individual adaptation exploited was stereotyping with the criteria of beginner, intermediate and expert. Initial assessment for this was done through a pre-test. Further detail of the methodology is given in section 3.1. The outcome of the experiment was measured through a post-test and through an online survey, discussed in 3.2, with further evidence derived from the results of a paper based exam as described in 3.3. In particular, specific questions in the exam allowed the lack of effectiveness of the collaboration elements as presented to be established. Evidence gained from the experiment has informed suggestions for further development for group adaptation. This is reported in Section 4.

2 WHURLE 2.0

WHURLE 2.0, which extended the formal WHURLE framework [5], consists of five Web services and an LMS which could be viewed as a delivery service although it is not technically a Web service. These services are the Aggregation Service (AGS), User Modelling Service (UMS), Lesson Plan Service (LPS), Adaptation Filter Service (AFS) and Chunk Management Service (CMS). The Web services were developed with the ability to communicate with each other by adhering to Web service protocols such as SOAP and WSDL. They all share characteristics of independency, interoperability and flexibility. The learning content is saved in conceptually discrete units called chunks which are XML files that contain text or references to other media types [5]. AGS is the coordinator of this learning environment, it handles communications between the LMS and the services that collaboratively work together to provide adaptation as well as managing this collaboration activity itself; communication between the services. A conceptual design of WHURLE 2.0 could be seen below in figure 1, while a snapshot of Moodle LMS which hosts this adaption and provide the end user (student) is found in figure 2.

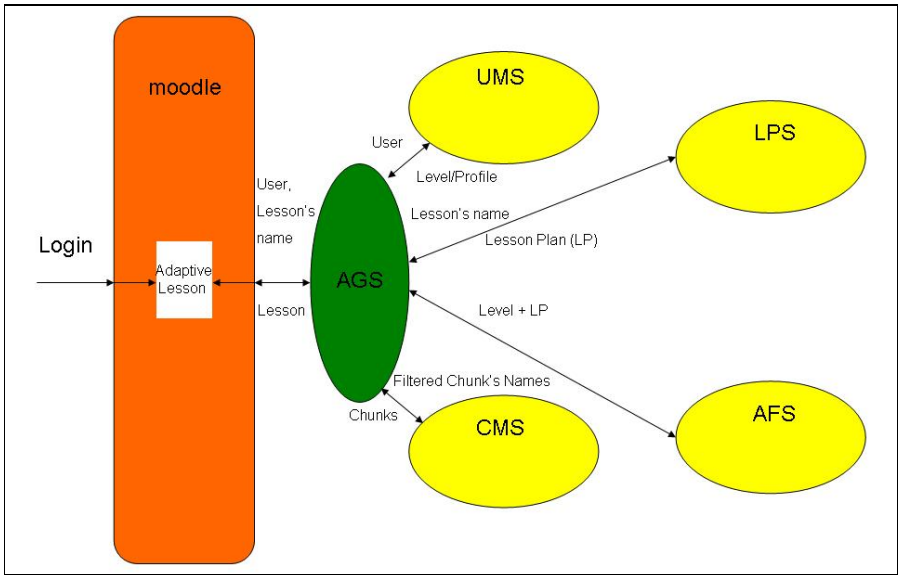

Fig. 1. WHURLE2.0 Conceptual Design

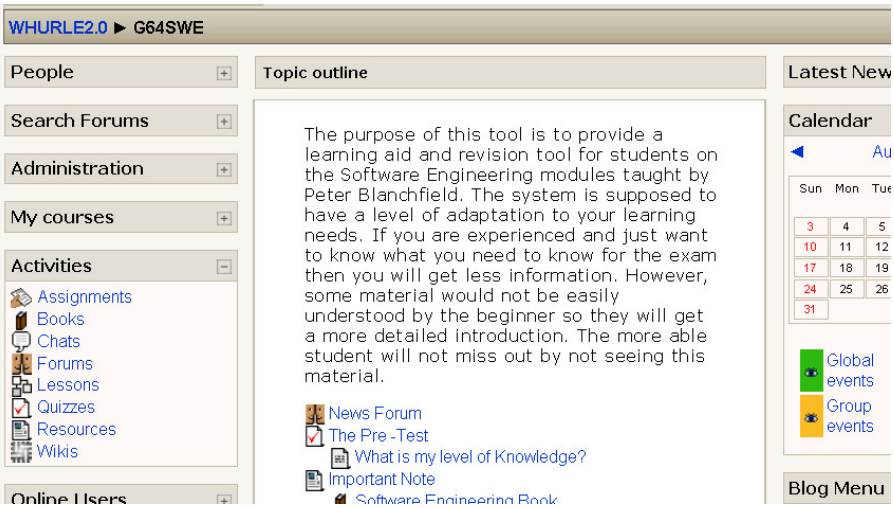

Fig. 2. WHURLE 2.0 Learning Environment: Moodle as the delivery system that provides both adaptive learning content and social tools

3 A Case Study: Software Engineering Module

3.1 Methodology and Description

The WHURLE2.0 learning environment has been tested for its adaptation and social, collaborative interactive functionalities with students at the University of Nottingham. These were a total of 140 students who belonged to two unique groups: the first year Computer Science students studying an introductory software engineering module, and Masters' students on specialist and non specialist courses, who take a separate software engineering module. This latter group has people from different first degree backgrounds, different languages and a different level of knowledge in computer science making them 'real-world' examples of the need of adaptation and how it could be applied.

The system was given to the students as a revision guide five weeks before the exam as an optional tool. After introducing them to the systems, they were asked to register in their own time. The students had access to other resources such as lecture notes or slides and books on the module's reading lists.

The goal of this case study was to find answers for the following questions: how did the system perform in real world settings? What is the students' reaction to the adaptation and the way the content was presented and delivered? Did they make use of the social and collaborative learning tools? If so, did these tools play any role in aiding their learning process?

The students first registered individually through the built-in registration form of Moodle, which then sent them an e-mail with a link to activate their accounts as each individual logged on for the first time. When they initially logged into Moodle, they were given a Pre-Test (using Moodle's Quiz activity tool), that could only be taken once. The Pre-Test was composed of 7 single choices questions, answers were compared against a scale of 1-9 marks, where scoring 1-3 makes you a Beginner, 4-6 an Intermediate and 7-9 an Advanced type of learner.

After students submitted their answers, they got feedback regarding each question. Next, they returned to the course's main page and clicked on a *Resource* link, which when clicked for the first time triggered the Web service client. This client registered students with the external User Modelling Service and assigned a level of knowledge in this topic according to their quiz's marks. Students immediately got feedback stating their score for the test and the corresponding level that they had been assigned.

In Moodle, the course was organized into 11 sections with defined topics; the first 8 topics or sections taught a specific concept of software engineering such as: Requirement Analysis, Design, Uses Cases, Testing and so forth. Each topic used a number of the LMS, Moodle's, built-in tools to aid the learning process where appropriate, such as Forums, Wiki's, Lessons, Resources, Chat, Quiz, Book and others. The *Lesson* tool or activity has been used to provide the personalised learning content in Moodle. When the students clicked on a Lesson, it activated a Web service client to prepare the adaptive content. The end result of this adaptation process (as performed by the external services) was returned to the calling client in Moodle which in turn pushed them into the Lesson's activity database. An example of an adaptive lesson is presented in figure 3.

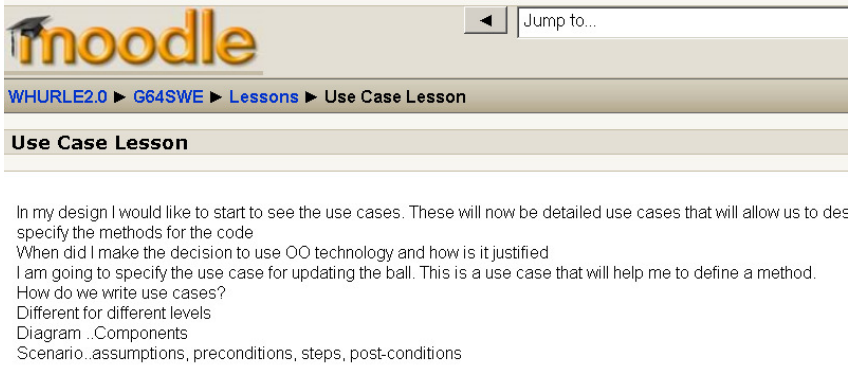

Fig. 3. An adaptive lesson about Use Cases as it appears in Moodle for an **Advanced** learner (Use Case Lesson)

As the adaptive content was adapted and prepared in real time and since the Lesson activity could fail to show any content at all for reasons such as students not registering to the User Modelling Service (UMS) properly or any other unforeseen reason, a risk-control procedure was taken using Moodle's *Book* activity. In this book, a default (Beginner) view of the learning content was made available to the users as a reference that was always available to view. In addition, it served another purpose, since the advanced user got less information than the beginner, having a full version available to him/her could address possible complaints about not having the full picture or missing on some vital information. Moreover, it allowed an advanced user to compare the two versions and decide which one was more suitable for his/her learning needs, which provided useful feedback for this system (figure 4).

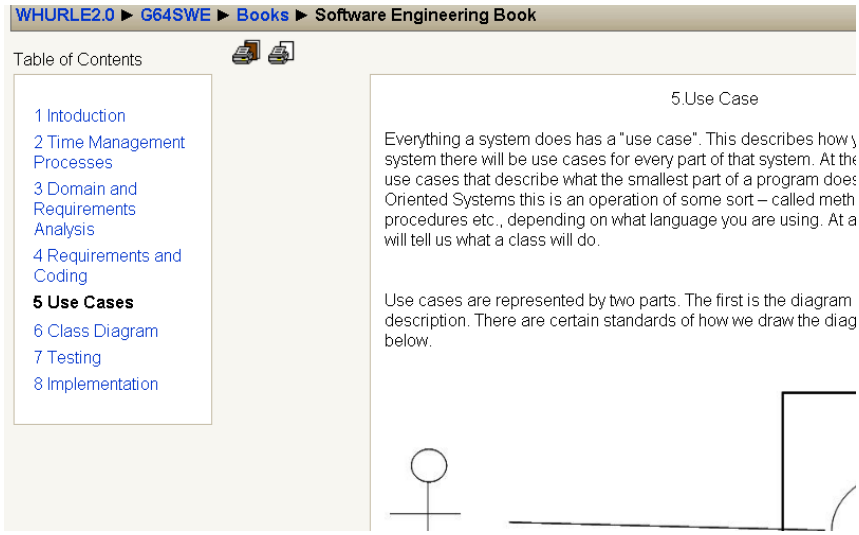

Fig. 4. Moodle's Book activity: the default **Beginner** view (Use Case Lesson)

The Post-Test was used for updating the user's model by comparing the new scores against the same predefined scale which would determine if the student's level needed to be upgraded, down graded or remain the same.

Logs and statistical data provided by Moodle as well as the Pre and Post tests, in addition to a user satisfaction online questionnaire were used for collecting data, both quantitative and qualitative, in order to answer the research questions.

3.2 Data Analysis and Results

The number of students who registered officially (using their e-mails) to Moodle's end of the system was a total of 88 students out 140, while the rest seemed to have logged on as guests several times. Both an oral presentation and an online instruction document, which was made available through the learning environment, were used to introduce the student to the WHURLE 2.0 learning environment. However, a few number of students, who had not attended the lecture or checked the available documentation had problems in viewing the Lesson's activity content. This was due to the fact that adapted content was only viewable for students who had already been registered to the UMS backend. Students were clearly notified that not taking the Pre-Test Quiz and not clicking on the Resource link to check their level would result in such problems. Nevertheless, having a dedicated Forum titled "Report System Problems" helped those students to report those issues and get advice on how to solve them.

The Pre-Test and Post-test were compared in order to measure students' performance in this course. Out of the 88 students that registered to the system, 61 completed and submitted the Pre-Test but this number dropped to 25 for the Post-test. Although the rest of the students had a look at both tests since - the system showed that 136 students (including those logged as guest students) had made a 140 attempts at the Pre-Test while 51 students made 64 attempts for the Post-Test. However, some students viewed the test but did not complete it or submit it, while those who did, where less than 40.

In the Pre-Test, there were all three levels of students, with the majority being advanced, not unusual if taking into consideration that they were preparing for their exam. This is reflected even more in the Post-Test, which was enabled for students shortly before the exam, giving them a chance to use the system for at least 4 weeks. In this later test, there were no beginners (again from those logging with their registered accounts), fewer intermediates than the Pre-Test and the majority being advanced.

Moodle's *Activity report*, showed that almost all aspects of the learning environment, both in terms of adaptation and social learning have been explored and used at least once.

It is worth mentioning here that when it comes to social activities such as Forums, Chats or Wikis, there were two kinds of usage: viewing which has been high in all activities (and the Forum scoring the best in its category) and participating by doing (posting a question, adding a comment or sharing a link). Fewer students, compared

to those who have viewed the forums, participated actively by posting and contributing. The following table presents the order of the activity in terms of usage:

Activities ordered by their usage
Book
Quiz
Lesson
Forum
Chat
Wiki
Blog

Table 1 The learning environment's activities ordered by their usage

As mentioned earlier students where presented with an online questionnaire to get their direct feedbacks regarding the system's adaptation, social aspects and the overall experiences with the implemented version of WHURLE 2.0. The questionnaire was composed of ten questions, nine which were single or multiple choice questions producing qualitative data results as well as open question options to justify the choices that produced qualitative data.

The goal of this case study was to find answers for a number of questions, the first being how did the system perform in the real world setting? The answer is the system not only worked but it did handle this large number of students very well, the adaptation was achieved and framework's components worked collaboratively and smoothly with each other. Moreover, there wasn't a delay time in presenting results compared to the old monolithic WHURLE. Students did not report any noticeable delay in starting their lessons. And the integration was transparent to the users since the learning content was presented using Moodle's standard tools. Moodle, as most LMS, was easy to use and did not require any training either for the tutor nor for students to learn how use it, which is not the case for a number of traditional original AEHS, a point that would appear to justify the choice of using an LMS as a delivery system.

The other question was to detect the students' benefits from and reaction to the framework in general and the adaptation in particular and the way it was presented and delivered. Moodle activity reports showed that the system has been heavily used in the period of 5 weeks, and the Post-Test when compared with the Pre-Test showed an increase in student's overall ability and knowledge about the subject. Moreover, according to the results gathered from the questionnaire, the majority of students, that is 70% of them, found the system useful or useful to some extent in aiding their learning and preparation for the exam. As for the adaptation, although only 30% liked the adaptation while 40 % liked it but preferred a unified view and 20% found it not useful, a result that could have been affected by other factors apart from the actual adaptation. Those factors include the facts that the students were preparing for the exam and wanted to see the full picture as well as for everybody to receive the same content, time limitation, the actual content design and the course's structure. For

example some complained about the lessons being too long, too simple or have some mistakes.

The final issue in this section, is one which deals with the social and collaborative aspects of WHURLE 2.0. Did the students make use of the social and collaborative learning tools? If so, did they play in role in aiding their learning process? The results suggest the two things: firstly, students admit they use a number of social networks and collaborative or communication tools quite often in their daily life and some use them for educational purposes. Secondly, those students agreed to the importance and usefulness of such tools and yet did not use them to a large extent. The reasons given here include: short period of time, exam preparation and not having enough people at one time to communicate with.

3.3 Exam Responses

Further evidence on the use or lack of use of the collaborative tools was provided by the exam. The two groups (undergraduate and the Masters students) were given separate written exams which investigated some similar but distinct material. Students had been asked to give input to discussion boards (Forums) in two areas that were used in the evaluation in both the exams. The Masters students had also had seminar discussions in which they were able to share their ideas in these areas. These seminars were not provided to the undergraduates, who only had access to discussion via the Moodle interface as part of WHURLE 2.0 integrated system. MSc students freely entered the discussion and as a result evidence of this discussion showed up in their exam responses. The undergraduates did not take part in the discussion and the responses showed that the students had not thought about these areas before trying to answer the exam questions. Other factors including the difference of maturity of the two groups will have affected these responses. Clearly this aspect of the collaboration requirement needs to be addressed. It is felt that this would be a good place for group based adaptation with the more mature (MSc) group being given the chance for the discussion board and the less experienced group being given more directed teaching.

4 Discussions

Our case study aimed to present the students with a combined learning experience that provides adaptive learning for individuals and collaborative learning for groups of students. In terms of the collaborative and social learning we tried to resemble the class-room environment where students were activity socialising and participating with each other in the learning process. However, the results of the case study did not meet our expectations. The majority of students did not make use of the tools made available to them such as the Forums, Wikis, Chat rooms or Blogs. They did not create this rich environment that allows them to benefit from each others knowledge and experiences. Despite the reasons given by them in section 3.2, the question of why was this true? Remains open and is yet to be investigated further. In addition, another question here adds to the former one: how could we use our knowledge from

individual adaptation and user modeling to help us in applying adaptation techniques to bridge this gap and enhance the students' collaboration?

In a learning environment such as Moodle, there is a lot of information about individuals and groups that is scattered all over the database. Although a user model does not exist on its own, the available data could be used as a base for creating a rich and detailed user model. In WHURLE 2.0, since the user modeling occurs externally in the UMS where the user profiles are also stored, it could be used by the LMS as well as any other adaptive or non-adaptive system. A distributed user modeling service helps the end-users, provided they have access to it (which is not yet the case in our current implementation) stay in control of their profiles and to therefore have this flexibility of using different LMS that provide different courses. In our case, the UMS was used by two different LMS: Moodle and ATutor [13].

This information in the database tables has been collected from the user's interaction with the different solo or social activities presented to them within this environment. Locating this information and transferring it to the UMS does not present a real challenge compared to the semantic side of it when it comes to making use of this information both for individual and group adaptation. The semantics of the data needs to be tackled in greater details. For example, what does it mean (in terms of user's knowledge-level) if a specific learner is engaged in more than one chat room or if he/she is participating in a workshop or in forum discussion? Could it be an indication of interest and progression? Or is it rather a sign of him/her facing a lot of problems and difficulties in understanding the course's materials? Those are important questions that are yet to be answered.

The same concept could be applied at a group level, people who participate in the same activity; does this mean that they are at the same level? But what if one student was actually asking a question while the other is providing possible answers, this points that the second one have more knowledge or has spent more time revising. Does it reflect sharing the same interest? Again, not necessarily, it could be one student posting a negative comment regarding the topic being discussed. Nevertheless, a first step could be taken by monitoring students who participate in say more than one activity or more than once in the same activity, and then could initially be placed in the same group. Hence, their user profiles could be compared and when one of them engages in a new activity, this activity is recommended to the other. One idea strongly influenced by the exam response is that group adaptation should be provided on the basis of maturity, while maintaining individual adaptation on the basis of the stereotype.

5 Conclusions

This paper has presented a case study that provided both adaptive and collaborative learning. The results obtained showed that the systems' integrated architecture satisfied the intended requirements allowing for interoperability and usability of content as well as delivering adaptation through an open source LMS such as Moodle. In addition, the majority of students who participated in the study found this combined environment useful or useful to some extent. Moreover, the collaborative and social aspects of the system were examined by different methods. This revealed a

poor usage of the collaborating and Web 2.0 tools. Many reasons could have caused these unexpected results when compared with what takes place in the actual classroom. The paper has given suggestions in how to address this problem using adaptation techniques, which would result in providing group adaptation.
However, group adaptation should not be aimed to replace individual adaptation, since students remain unique and group adaption could be looked at as another dimension for aiding students needs. This was also concluded by another study [6], which suggested that a purely individual or a purely group-based feedback adaptation both have short comes and therefore an approach that combines both type of adaptation is likely to be more adequate in providing a more useful feedback.

Our implemented approach does not yet adapt to social aspects of the LMS nor does it adapt to groups and how they communicate with each other. Our work takes the first step towards achieving such goals: it brings adaptation to the environment where those activities take place. Therefore, we were able to monitor individual adaptation while observing collaborative (not yet adaptive) learning.

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