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Knowledge Sharing in the classroom

A social network approach for diagnostic assessment and learning together

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***Abstract*—The basis for individual students' instructional support by teachers is an individual diagnosis of one's learning advances and difficulties. Even though sophisticated diagnostic tools exist, it remains an open question how diagnosis and learning can be merged into a consistent pedagogical method to support both teachers and students with feedback about the learning process. We propose a model for integration of peer assessment functionality for learning into a computer-based Adaptive Diagnostic Learning Environment to solve central problems of classroom diagnostic assessment, adaptive learning and knowledge transfer between peers in a classroom environment. The addressed issues, the approach and our evaluation setup are explained.**

Keywords - Learner-centered Diagnostic Assessment, Technology-enhanced Learning, Knowledge Sharing

I. INTRODUCTION

Effectively supporting secondary school students in the classroom with appropriate learning material is a difficult task for a teacher. Despite the limited time for each student, instruction needs a proper diagnosis of each individual student's competencies and difficulties in order to make adequate didactic decisions for further instructional support.

Currently, tests used to assess students' understanding of certain topics are primarily paper-based [1]. The results are aggregated by the teacher and afterwards feedback is provided to the students. These tests and diagnostic surveys have mainly been developed and accurately proofed from a psychometric point of view [2,3]. This means a very precise and narrow focus on valid measurement, but is incompatible with daily classroom instruction as their evaluation is too work-intensive for teachers and the tests stay isolated from the intended learning processes. Using software tools instead can support teachers in assessing the students' performance faster. Additional support for test adaption helps bridging the gap from diagnosis to instructional support.

II. MOTIVATION – TECHNOLOGY-ENHANCED DIAGNOSIS AND LEARNING

Using software for diagnosis *and* learning still faces some conceptual and technical challenges:

A. *Computer Diagnosis Problem*

Processing and interpreting free text answers, drawings and different solutions of open format questions is still a challenge for computer systems. Advances in text and language processing are made continuously, especially if the context can be narrowed to a specific field. Nonetheless, the matching of semantic meaning in a student's reply to the desired answer remains as a research field. Thus diagnostic software tools widely use multiple-choice, gap text or sorting rather than open format test questions [4]. Unfortunately open format test questions are the most important ones for teachers from a diagnostic point of view as they reveal misconceptions or partial understanding of students [5]. We call this the *Computer Diagnosis Problem*.

B. *Individual Group Assessment Problem*

Diagnosis is usually conducted on an individual level. This prevents students from working collaboratively, sharing knowledge and giving hints. At the same time the benefits of group learning has been reported in many studies [6,7]. More precisely classroom research shows advantages for learning when feedback is given by peers as well rather than by teachers only [6]. Peer tutoring helps students to understand their misconceptions better, if they are explained by other students as they use the same language and share a common background for communication [8]. We call the fact, that for individual diagnosis students need to be assessed individually, but for learning knowledge sharing in the peer group is favored the *Individual Group Assessment Problem*. It is desired to allow the knowledge sharing without risking precise individual students' assessment.

C. Diagnosis *Adaption Problem*

Finally, the main goal of diagnosis is to provide a standardized and comparable result of individuals [9]. A student's motivation for participation (i.e. using the tools provided) increases significantly, if the questions provided fit her individual skills and prevent situations of boredom or anxiety [10,11]. To achieve this, a software tool may adapt to the individual students progress. Still the results of all students need to be comparable.

We propose a system called PEDALE, as a novel approach addressing the above-mentioned problems by combining diagnosis and learning together with social networking principles for peer assessment and knowledge sharing between students. To the best of our knowledge no software with such an approach exists. The system uses a carefully reviewed and empirically validated didactic model of competence development and diagnosis resulting from a 3-year research project [12]. It comprises the competence development of lower secondary class students in the domain of "functions and graphs". Hence, PEDALE aims to be highly valuable for diagnosis (teacher's perspective) and understanding the own learning progress (students' perspective). In this paper, our main focus is on the concept and the evaluation setup.

III. Scenario and Concept

The proposed software PEDALE will be used by teachers during classroom instruction to get a detailed diagnosis about their students' competencies. The students are instructed to use the software within a fixed time period (e.g. 40 minutes, depending on test configuration) to solve the diagnostic tasks, each student at an individual computer.

A. Using an Authoring and Player Environment

Beside other application areas, the design of educational software faces the problem that the main experts (e.g. teachers) for the content used in the software are not programmers and vice versa. To decouple the dependencies during development a feasible approach is to provide authoring software for teachers to create content and configure the application behavior independently from programmers who otherwise would need to implement this. A second component is a player that displays the configured test interface and content to the students. In our project we extend an existing Authoring Tool [13] to be usable for the setup of diagnostic tests and the input of test questions fitting the used diagnostic model. The corresponding player [14] is extended accordingly to display the new interface elements and adapt the test course. We decided to build on two components of our own research group, because they are easily extendable and proved their flexibility in several projects [15]. By this approach we benefit from two key advantages: (1) the use of an authoring environment for teachers makes it easy to create class-specific e-learning content and can lead to better learning results [14], (2) the use of a software-based player component provides a comfortable way for data retrieval for retrospect diagnostic purposes. Real-time results, quantitative and qualitative measures can be displayed in a specific teacher's view optimized for supervision, as well as in a student's view comprising his individual quantitative and qualitative measures.

A diagram of the software components with their key functionality and the data flow are displayed in Fig. 1. The work with the software is arranged in three phases: First, the *Assessment Setup* with teachers authoring, creating or selecting the desired test questions and setup the characteristics like duration, amount of peer assessment and the class setup (students). Second, during the *Assessment* students load the configured test via their player software and work through the diagnostic assessment in the classroom (displayed as Student A). In the first phase of the assessment the students solve machine-analyzable tasks. On the base of these tasks a first diagnosis is generated automatically and returned to the students after they went through all the tasks of the first part. The second part of the assessment asks the students to evaluate solved problems regarding the correctness and the solution process. The answers to these solved problems are open test questions and are displayed to peer students (e.g. student B gets a solved problem of student A and vice versa). The solved problems are retrieved from the tool's data repository and the player decides which of the related solved problems matches best to be displayed. A Peer Matching Algorithm will be developed that takes into account students' current skill competence profiles and test performance.

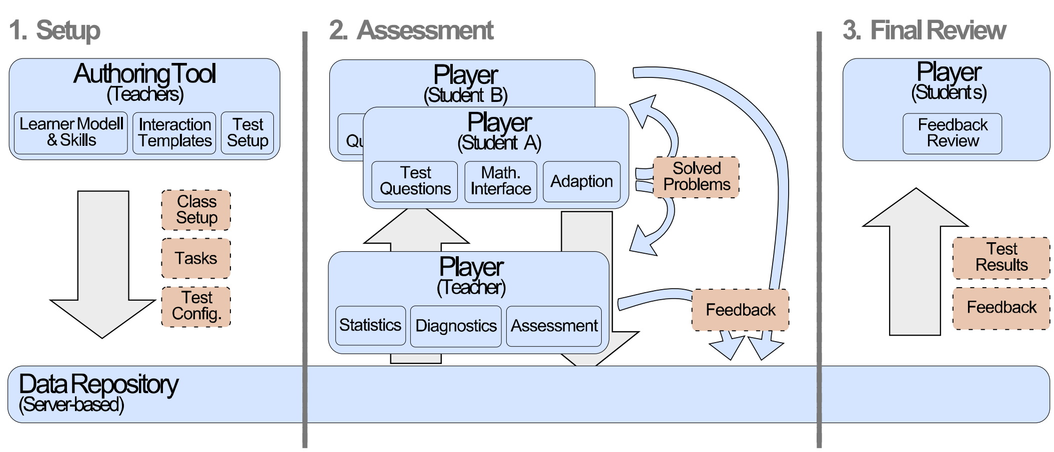

Figure 1. Phases (1-3) of diagnostics and learning with peer assessment

The given peer feedback is then stored for later review. Additionally, a second player version is provided to teachers for monitoring the students' progress and for final review of all solved problems. In a final *Feedback* phase the students are provided with all their assessment results and peer feedback, as well as a feedback from the teacher.

B. *Adaptive Diagnosis*

As a sound diagnosis of the students' current state of knowledge is required for effective and individual learning, we use the diagnostic instrument developed in the 3-year project HEUREKO [3]. Within the project a competence model for the mathematical domain "functions and graphs" for lower secondary level students was developed. Focus of the model is the heuristic use and change between the fundamental mathematical representations (numerical, graphic, symbolic, verbal) what can be considered as a significant competence of mathematical problem-solving and modelling [16]. Theoretical didactic models of ability that have proven successful at a national as well as an international level were operationalized and empirically assessed in order to provide an empirically grounded instrument for diagnostics and promotion that can be applied to school practice. The Rasch analyses proved a four-dimensional model to be the best predictor. Furthermore, the separability of these dimensions could be shown. Latent class analyses indicate that seven typical competence profiles can be identified empirically across the model dimensions [16]. The resulting competency model here provides the basis for a diagnostic instrument for mathematical competencies in the domain "functions and graphs", while at the same time offering approaches to promotion. The underlying model maps four dimensions of competencies on three levels of mastery. The first two levels comprise tasks that require a predefined input like multiple choice, decisions and numerical solutions, plotting points, intercepts or intersections. The highest level comprises open format replies like describing and reasoning.

We are transfering the paper-based tests about the understanding of mathematical functional dependencies into a software-represenation and provide an user-interface that allows students to choose between and produce verbal expressions, to draw and modify graphs, to develop and modify algebraic terms and to note and complete numerical representations.

About ¾ of the questions can be assessed automatically by the software as the solutions and results are definite. Variants of correct and incorrect students' solutions are taken from the results of the HEUREKO-Research Project. The questions that ask for open text input and the corresponding given answers (Solved Problems) are assessed by the teacher and peers while the student continues solving the next tasks. PEDALE uses the results to update the internal didactic learner model and select further questions accordingly. This adaptive diagnosis is possible without risking the comparability of the results due to the didactic model behind. The test questions are all categorized into several dimensions mapping exactly the tested competencies. Consequently the use of the appropriate didactic model avoids the *Diagnosis Adaption Problem* stated above. From the adaptive diagnosis approach we convey the first hypothesis for evaluation:

H1: Enhancing diagnosis with adaption lowers the number of needed test questions to achieve the same accuracy as tests without adaption (paper-and-pencil tests).

C. *Peer Assessment*

The test itself will be organized into several parts, each containing questions for specific dimensions of the model. With the completion of one part of the underlying diagnostic model a student (Student B) is asked to review so called solved problems of this domain. These are questions that display the approach and/or solution of another student (Student A) and that ask student B to

- decide whether or not the approach is correct, partly correct or not correct and to rate it on a given scale (1=completely right, 3 = about 50 percent correct, 5 = all wrong),
- give qualitative feedback on where he identifies mistakes,
- give hints how to solve the task differently or correctly and
- finally to correct the graphs (if applicable).

The peer assessment helps solving the *Computer Diagnosis Problem*. It enables us to provide open test questions with PEDALE and still get a reasonable assessment result. The learners' assessment of peer solutions is of great value for the learning process as it prompts the students to reflect a given solution and set it in relation to their own approach and knowledge. In doing so students are encountered with (a) real solutions and (b) approaches and mistakes of students with same social and learning background [17].

H2: Assessing solutions of other students enhances learning: Students gain a better awareness of their own knowledge about the assessed domain.

For peer assessment the effects of social networks have to be taken into account. Conflictive forces influence the student's motivation to invest time and energy in providing a good or average feedback to peers. Research in Social Network Analysis shows complex interdependencies between individuals in a social network. Studies show for settings in which people feel themselves as part of a common organizational team (like a school or class) a strong motivation to help each other with constructive and qualitative feedback [18]. However, in a classroom environment a competitive situation can exist. The influence on the peer feedback in this scenario remains an open research question. We investigate with one setup for evaluation, whether students provide more appropriate feedback to students from a different class (with a different teacher) or to close friends, where the emotional connection is valued higher than the potential disadvantage of helping a competitor. It is expected that students in general have the desire to see and comment other students' solutions as research for computer-supported collaborative learning environments indicates [19]. The proposed peer assessment setup is expected to support group learning aspects with knowledge sharing through feedback and to prevent the

Individual Group Assessment Problem, because the students still carry out the test parts independently from each other.

H3: Due to competitiveness in class, students give better feedback to peers from different classes (no competition) and close friends as to class companions.

H4: Students are more motivated to use the tool when they have the possibility to reflect other students' solutions and give feedback.

D. Provision of Feedback

When the assessment time is over students are provided with a direct feedback. The tool returns an evaluation of the machine-analyzable questions as well as the feedback given by peers and the teacher. As Social Network Analyses indicate, the level of trust plays a major role for giving advise and critics [20,21]. The transferability of effects of trust and closeness for classroom settings remains to be explored. As students share a more similar cultural background, language and interests with their peers as they do with the teacher, it is expected that feedback of other students is valued as a positive additional learning source. As the overall feedback is displayed after the test, it does not raise the *Individual Group Assessment Problem*.

H5: Students value peer feedback positive for learning

IV. Evaluation Approach

The validity and reliability of the diagnostic questions is shown in [3]. Based on the diagnostic instrument we evaluate the technical feasibility and the validation of the electronic instrument at the beginning of the school year 2011/12 in three 9th grade classes. The assessed competencies are expected to be available for the students but need to be revived and checked by the teacher in order to get a status quo and plan the next instructional unit. The evaluation of the computer-supported diagnostic instrument will last three weeks with a 1.5 hour diagnostic test each week in three school classes in parallel. The teachers and schools attending the study were already committed to the HEUREKO project. The tests for the classes will consist of the following setups, each in one class:

- Setup α: A paper-based test, consisting of the re-arranged HEUREKO test questions as a reference group
- Setup β: A PEDALE-based test (same questions as paper-based) with no feedback function as an indicator of changes due to software implementation of the test
- Setup γ: A PEDALE-based test with feedback to and from anonymous peers (no displaying of names) as an indicator of the influence by feedback functionality
- Setup δ: A PEDALE-based test with feedback to and from peers of same school class and parallel school classes with displayed names as an indicator of the influence by social ties between students and anticipated competition.

V. Related Work and Future Work

E-Learning environments that can serve diagnostic purposes are in the scope of different research interests. Intelligent Tutoring Systems try to keep track of the student's input and are predefined in a very elaborate way [4]. They are proved to be useful to provide feedback in time of the problem solutions. In addition didactic research proved the advantages of methods like learning by teaching, collaborative learning and the benefits of social exchange for motivation [6].

The impact of peer assessment has been studied earlier [8], highlighting the positive effects like raising interest for challenging tasks and fostering prosocial behavior. Beside a general interest of students in examining peer work [19] better knowledge acquisition has been shown for computer-supported collaborative work as well [22]. From the field of computer science the Social Network Analysis has carried out extensive research to investigate the phenomenon of knowledge sharing over weak ties between users not closely related [21,23,24]. Strangers are strong providers of help and knowledge without a directly expected reward [18].

Software Adaption to the progress of individual learners is especially investigated in the field of Serious Games for Learning [25,26] as this field combines the challenges of dynamic reactions to user behavior in the game as well as the learned skills. Therefore software maintains a player model to adapt to characteristics of decision behavior in games and updates the probabilities of learned skills in a learner model. These models' states parameterize specific issues like next scenes, challenges and information displayed to users.

Due to the former research it is expected to find evidence for H1, H2 and H4 to support the core concept of the stated approach of combining diagnosis with peer assessment for learning. Competitiveness in school class has certainly to be taken into account as a factor for peer assessment. However because the field test described above cannot affect any marks of students and covers the mathematical content of the previous school year, students might not consider competitiveness during the peer assessment, which will result in no significant proof for H3. If there is evidence supporting H3, considering this aspect in further projects seems to be reasonable. Last, if beside H4 indications for H5 can be found, we will further intensify our integration of Social Networking components.

Technical issues for future work include the creation of a web-based solution that can be used by students not only in the classroom, but also accompanying homework to assess peers' solutions, receive feedback and develop knowledge together in a *Social Adapting Diagnostic and Learning Environment*.

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