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Colloquia: MPTL14

Test and assessment to support cooperative learning of physics with Moodle-style web applications

A. Bresges, S. Hoffmann and M. Kreiten
Institute of Physics Education, University of Cologne - Germany

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Summary. — Learning Management System (LMS) are widely in use in most universities and certain schools. The majority of LMS were not originally developed with the demands of physics teaching in mind. In this paper, general features of LMS like Web based Test & Assessment and Groupwork Organisation are discussed against the backdrop of cooperative learning techniques that are used in physics education. Additionally, we present a customization of the ILIAS Learning Management System, the *Formula Question*, developed to satisfy demands of particularly math and physics teachers.

PACS 01.50.-i – Educational aids.
PACS 01.50.F- – Audio and visual aids.

1. – Problem description

Some patterns of cooperative learning demand to sort participants by skill: Either to mix "experts" with "rookies" to exchange knowledge peer-to-peer based, or to couple peers with similar attitude and skill together to solve a problem groupwise, yet in more or less the own pace. This puts additional stress on teachers, since they are now expected to estimate the topic-related performance of every student when preparing the next lesson's groupwork. An alternative to relying on guts-feeling might be the use of Web-based Test and Assessment.

2. – Proposed solution

2˙1. *The technology.* – We propose to use a Learning Management System (LMS) in an integrated fashion as a cure for the aforementioned problems. The term "integrated" includes the following assumptions:

– The *students* are trained to work with the LMS. Each student has his own personal account, knows how to find materials that were assigned to him, and is used to web-based test and assessment.

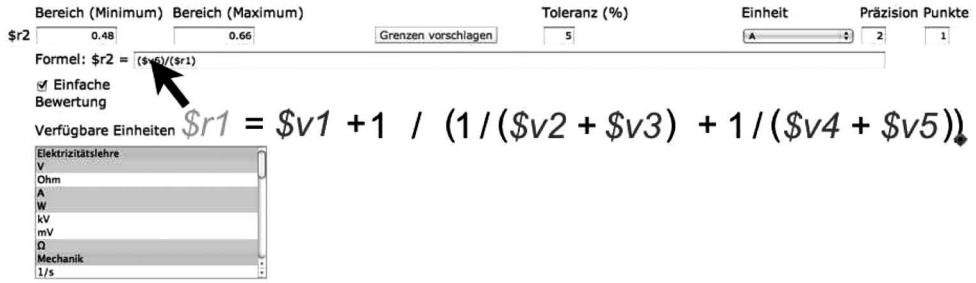

Fig. 1. – The Formula Question in ILIAS was developed in joint venture with the Institute of physics education in Cologne. $v1 . . . $v5 are variables that will be replaced by random numbers whenever a new test is started.

– The *teachers* use the LMS on a regular base, deploy all the necessary materials through the LMS to the students, and keep this resources current.

– The *administration* accepts the work of the students that has been presented via the LMS as genuine, *e.g.* accepts web based test or uploaded materials as homework.

The Learning Management System that was used during this study is ILIAS (`http://www.ilias.de`), but the cooperative learning situations discussed in this paper may be reproduced with any other LMS, *e.g.* with Moodle. A distinctive feature of ILIAS, though, is its *Formula Question* (see figs. 1 and 2):

A teacher can generate an abundance of exercises for a given problem by entering the basic formula, and tagging one or more elements of the formular as random variables. With any new test started, ILIAS assigns random values to these elements and displays an unique excercise to the student. This provides students with more examples to prepare themselves prior to a test. Additionally, it is an essential mechanism to prevent cheating when using web-based testing with numerical answers.

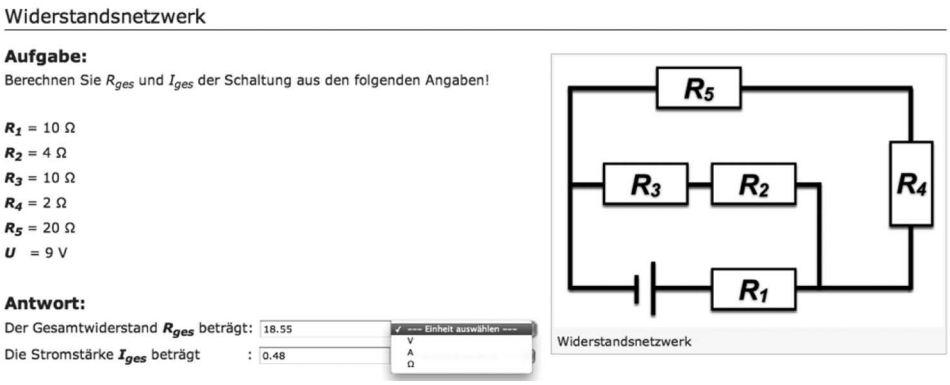

Fig. 2. – The same formula Question as in (fig. 1) as viewed from the student. Due to the random variables ($v1 . . . $v5) in the formula, each student gets a new set of values for the resistors (R1 . . . R5) whenever the test is started. Note the mandatory choice of the appropriate unit in the dropdown field below.

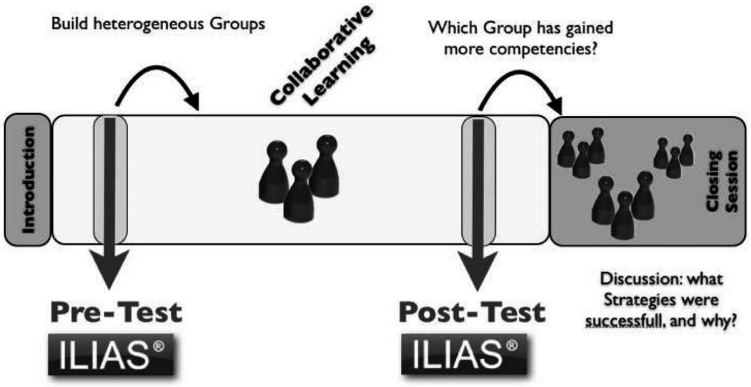

Fig. 3. – Group Ralley with pre/posttest generated and evaluated in the Learning Management System.

A common feature in all Learning Management Systems is the ability to build flexible subgroups of students and assign certain materials to them. We made extensive use of this feature during the preparation of cooperative work. Particulary important was the possibility to deploy tests within the subgroups.

2˙2. *The sample*. – Each of the following examples of supported cooperative learning was tested with a group of science education students at the university of cologne. The group consists of 208 undergraduate students intending to major in biology, chemistry oder physics for teacher service in middle and primary school. The subgroup of students that intended to major in physics consists of 29 students.

3. – Cooperative learning techniques

3˙1. *Group competition rallye*. – Cooperative Learning requires students to manage their group discussions, negotiate strategies for learning and divide their workload effectively. Group-competition or group rallies are described as good excercises to develop the necessary management skills with inexperienced students (Niggli 2000). During a Group Competition Rallye, students are assembled to form homogenous groups were "good", "average" and "weak" students work together. Within ILIAS, it was easy to provide a pretest, sort students by test scores and assemble them to subgroups that have roughly the same average test score (fig. 4).

The basic idea of a Group Competion ralley is to reward entire groups that achieve large gains between pretest and posttest. In our example, the gain was judged using the built-in statistical tools of ILIAS.

For Group Competition Rallies, a closing session is essential where students are supposed to discuss the strategies that lead to the success of those groupes that improved remarkably between pre- and posttest. When using this technique, the more ambitious students should be made aware that they can't score well in the group ranking if less capable students in the group are left behind.

3˙2. *Jigsaw teaching technique/Expert Talks*. – The "Jigsaws teaching technique" (Aronson 1977) is an advanced style of cooperative learning. It is well suited to dis-

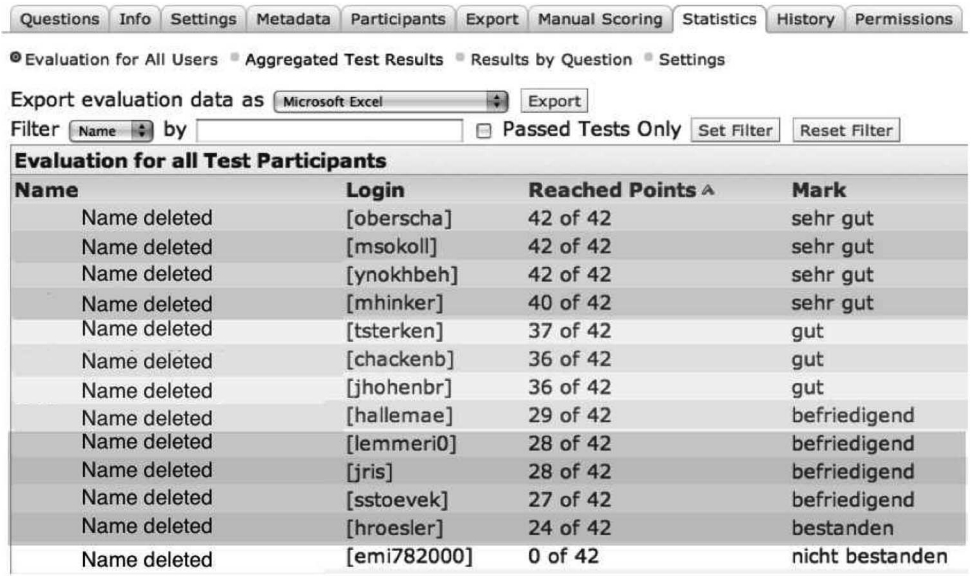

Fig. 4. – Using the outcome of the pretest in ILIAS, the teacher can easily sort his students to homogeneus or heterogeneous groups.

tribute large amounts of information into a group in a well-structured fashion.

Jigsaws starts with an introduction were the general problem is brought to the students. The students are then grouped into "expert groups", which are supplied with distinctive learning materials. In our example, this was accomplished by assigning the 208 Students to 14 groups that each consist of 4 expert groups and providing 4 types of materials to the (totally 56) subgroups.

Within jigsaw lessons, the solution to a common problem can usually only be found when the experts form "jigsaw groups" and exchange their information. In a further step, the pieces of information must be evaluated towards a possible solution of the problem. In our sample lessons, the discussion was moderated by "mentoring" students; additionally, a post-test was set up within ILIAS to asses the ability of the students to derive similar solutions independently, and transfer their knowledge towards different contexts.

3˙3. *Learning by teaching.* – "Learning by Teaching" LByTe is a cooperative learning style that was developed particularly for teacher education (Bresges 2008). Of 208 students in the sample group, 29 intend to major in physics, while the remaining 179 attend the physics lecture as minor subject. Nevertheless, all have to master a weekly online Test & Assessment, where a 50% score is required in at least 80% of all tests. The 29 physics students are required to take an additional course. This course was not only used to extend the theoretical background of the students, but to provide them with methods and media to teach their fellow students the necessary skills to pass their weekly assessment. A Mentoring-Team, consisting of educational research assistants and senior students, supervised the group sessions. They helped out when additional explanations appeared necessary and gave the physics teaching students feedback after each lesson.

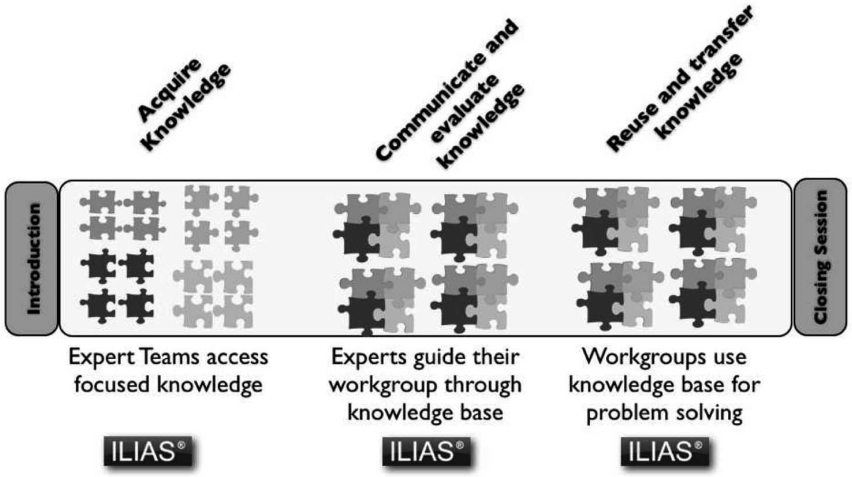

Fig. 5. – Typical "Jigsaw" teaching. A Learning Management System like ILIAS or Moodle may be effectively used in any step of the workflow.

4. – Results and discussion

4˙1. *LMS supported Group Competition Rallies.* – While Niggli (2000) describes Group Rallies as a good exercise to make students used to cooperative learning that are otherwise unfamiliar with it, our experience with group rallies in higher education and especially teacher education was ambiguious. An obvious problem was that a certain number of the teacher education students was already familiar with the mechanism of group rallies, since cooperative learning styles are a common lecture topic in educational studies. This partly explains that, despite all efforts to secretly protect the output of the pretest from the eyes of the students, the group members regularly questioned each other how they've scored in the pretest to find out which group member has the "leading" role in the heterogeneous group, and who was the weak "loser". This made the students with lower scores unhappy and had negative short-time effects on their learning motivation. Results may vary in middle school when most students are inexperienced with cooperative learning styles.

4˙2. *LMS supported Jigsaw Technique.* – Our experience with LMS supported Jigsaw technique or "expert talks" where cardinally positive. Even inexperienced students picked up the basic principle fast. More, the students that served in the role as "teachers" had no difficulties to prepare the groupwork, assign students to groups in the LMS and the classroom, provide the assorted materials for the expert teams and asses the output of their groups with aide of the LMS. The whole process was easy to supervise by the research assistants, despite the fact that 208 students in 14 subgroups populated the LMS during our test runs.

4˙3. *Learning by teaching.* – "Learning by Teaching" is an example of successful use of both LMS and cooperative learning in teacher education. The success rate of the 179 students which minor in physics was 98% in the final exam, compared to 48% with lectures covering the same topic in 2005. The students that major in physics declared in a questionnaire that with LByTe, the connection between theory and practical use in teacher education appears to be "outstandingly clear" (80%) or "very clear" (20%).

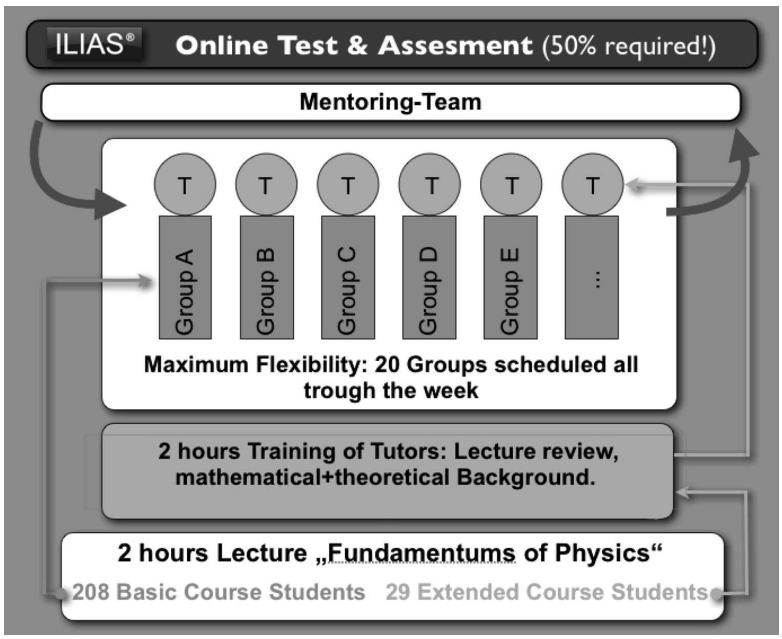

Fig. 6. – Structure of "Learning by Teaching" LbyT.

4˙4. *General*. – Web-based Test and Assessment was well accepted by the students. The students view the computer as a "fair judge" and accept the test scores in a calm fashion, especially when there was ample opportunity to practice the test questions before. Judgments that are made by peers in a group situation are often prone to criticism. Even in this study, students were occasionally suspected by peers to give pejorative judgement to improve their own standing. This never was the case with judgements that were grounded in the scores of web-based tests. With the feature "formula question" added, ILIAS can be used as a tool for both teacher and students to assess skills prior to any lesson. Students welcome the occasion to refresh their skills prior to an demanding task like an exam, or prior to lab work.

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