Automated Assessment in Mathematics

Alice Barana[1], Marina Marchisio[2], Sergio Rabellino[3]

[1,2]Dipartimento di Matematica, Università di Torino, Torino, Italy alice.barana@unito.it, marina.marchisio@unito.it

[3]Dipartimento di Informatica, Università di Torino, Torino, Italy sergio.rabellino@unito.it

Abstract—Assessment of learning and assessment for learning are at the core of the research on new teaching strategies involving the use of new technologies recently performed by University of Turin. The practice of automated assessment in Mathematics using the grading system Maple T.A. has been introduced in many undergraduate scientific courses and, after the initial success, it has been diffused in high-schools through several projects aimed to improve Maths teaching and learning. The following paper is intended to describe the effectiveness of automated assessment as a learning tool, the strength of Maple T.A. for grading Mathematics and its integration in a learning content management system, and the results obtained at University and in high-schools.

Keywords — advanced computing environment; automated assessment; e-learning; learning content management system component; Mathematics.

I. INTRODUCTION

In the last 50 years many contributions to educational studies have been addressed to the definition of authentic assessment [15], [13], [4]. According to G. Wiggins, an authentic assessment should be intentionally designed to improve learning, it should be frequently applied giving constant feedbacks to students and teachers. The recent introduction of the new technologies at school [11] and the use of automated assessment systems brought many undiscussed advantages to the assessment practice: in first place they allow to save resources, in terms of time and money, for the correction; moreover, it offer the possibility of testing regularly and offering personalised feedbacks, monitoring the learning process from the beginning to the end. However, it also arises some concerns about the limits of testing, in particular experts wonder whether it is possible to detect student's capacity to use their acquired knowledge and abilities to solve problems, through web-based closed-ended questions, which seems to be more suitable to measurement purposes [14].

In the general setting so far depicted, Mathematics deserves a special regard. In fact, though it is impossible to assess problem-solving competences through multiple-choice questions, the peculiarity of mathematical languages makes it possible to be evaluated by an Advanced Computing Environment (ACE), which is able to recognize the infinite correct forms of formulas, equations, sets and so on [1].

Several Universities, such as the TU of Delft, the University of Chalmers, the University of Waterloo, turned to automated assessment for the scientific disciplines [6]; in the wake of these innovations, University of Turin proposed a new method of authentic automated assessment, which we are going to discuss.

II. THE CHOICE OF MAPLE T.A.

In 2007 the Department of Mathematics of the University of Turin, in collaboration with the Department of Computer Science, started an innovative program, mainly addressed to scientific courses, and in particular to Mathematics ones, which involved the renew of the assessment process and the introduction of an automated testing system. The program was inserted within a wider project aimed to extend the e-learning services and to enrich the curricula through the use of new technologies. In particular, the University adopted the Maplesoft suite [8] of products, including the ACE Maple, the physical modelling and simulation tool MapleSim, MapleNet, which makes Maple contents available on the web and embeddable within a Learning Content Management System [2], and the solution for Testing and Assessment Maple T.A.

Powered by the Maple Engine, Maple T.A. supports all Maple commands, which can be applied to insert graphics, computations and random parameters that vary within a question, as well as to evaluate the correctness of mathematical objects inserted as answers independently from the form. A user-friendly equation editor ensures the graphic format of mathematical formulas. Exploiting the whole power of Maple T.A. [8], the Department of Mathematics of University of Turin has designed an advanced application of automated assessment, intended to perform an authentic evaluation of students' competences. In Maths courses Maple T.A. is used in the entry tests, in the final exams and also to offer weekly assignments for self-training along the whole duration of the course. Students can practice everywhere and every time, receiving an immediate feedback about their level of preparation with precise indication of the didactic material they need to review. Assignments contain open questions, created with the Maple T.A. adaptive question designer: a real problem is proposed, students are let free to reason and have multiple attempts to submit the solution. If they fail, they are guided into a step-by-step path to the solution; then a similar problem, with different numbers and data, is presented, so that they can repeat and learn the procedure to face and solve the problem. The formative value of automatic assessment fulfilled as summarised before had a strategic importance in the

IEEE
computer
society

motivation of students, facilitated in keeping up to date with the program; the effect is clearly evidenced by the students' appreciation of the courses and by the passing rate at the first examination session, which moved from 30% to 70%.

III. AUTOMATED ASSESSMENT INTEGRATED IN A CONTENT LEARNING MANAGEMENT SYSTEM

We worked out for an integration between the Maple Suite and the Moodle LMS, [7], which was the historical choice for an elearning environment in University of Turin since 2004, and actually used by more than 500 university courses and 10000 undergraduate students.

Moodle constructs its world around the concept of courses, listed into categories; every course has a teacher and some students enrolled into it; the Moodle plugin integration to Maple T.A. takes care of mapping a course to a class which is the container for the assessments. A class has a teacher that builds the assignments, grade them and manage all the aspects of the class itself and, obviously, a class has also students that can do these assignments.

The Moodle teachers and students are automatically projected in the Maple T.A. class, preserving their respective roles, and the plugin operates to achieve a single-sign-on schema between the two web applications. When a Moodle course is mapped to a Maple class, the teacher can add an assignment to the course together with other materials like pdf documents, blogs, wikis, or forums: it will appear as a normal Moodle activity. Clicking on it, the interface of Maple T.A. will appear, allowing the teacher to build the questions with the advanced tools of the Maple Engine, and grouping them into an assignment. Similarly, when a student clicks on the same link, the Maple T.A. interface will appear and the students will be asked to perform the task.

When the student ends the task, the grading phase can start: the Maple engine will check all the answers, and the result will appear immediately into the Moodle gradebook, together with all the other activities grades that the student has collected in its journey to learning. Later the teacher will view the course gradebook, evaluating the effort of the students, the difficulties encountered by each student and develop a strategy for bridging the learning gap.

IV. CONCLUSION

The University of Turin, in the last years, has made an outstanding effort in order to diffuse this practice of automated assessment to high-schools through several projects in collaboration with external institutions and with the Italian Ministry of Education [7], [10], [12], [16]. The University has extended its e-learning services and made them available to teachers and schools; it started a strong action of training directed to all Italian Maths and Science high-school teachers, who are introduced to the use of Maple TA and supported through weekly web-conference meetings and forum discussions, in order to facilitate the real and effective use of automated assessment in the didactics [3].

The results of the evaluation surveys conducted among the participants to the different projects promoted by the Department prove the efficiency of the good practice of automated assessment: they show clear increases in the final grades of students, but also in their motivation, self-confidence, interest toward and understanding of the subject, appreciation of lessons, participation and diligence; all these values are significatively higher then those obtained by the control groups represented by classes where similar programs and contents have been delivered in a traditional way [5]. This practice of automated assessment recently aroused the interest of other Italian and foreign schools and universities; in particular the University of Turin is involved in an European project called S.M.A.R.T. (Science and Mathematics Advanced Research in good Teaching) aimed to study and exchange good practices of using technology in scientific education.

REFERENCES

[1] Artigue M., Learning Mathematics in a CAS Environment: The Genesis of a Reflection about Instrumentation and the Dialectics between Technical and Conceptual Work. International Journal of Computers for Mathematical Learning, 7(3), 2002, 245–274.

[2] Baldoni M., Baroglio C., Coriasco S., Marchisio M., Rabellino S. (a cura di). E-learning con Moodle in Italia: una sfida tra passato, presente e futuro, Seneca Edizioni, Torino, 2011.

[3] Barana A., Demartini C., Marchisio M., Pardini C., Produzione e condivisione di risorse didattiche nell'ambito del Progetto Problem Posing and Solving, Bricks, 2014, AICA, Milano, 29-48.

[4] Comoglio M., La valutazione autentica. Orientamenti Pedagogici, 49 (1), 2002, 93-112.

[5] Giraudo M.T., Marchisio M., Pardini C., Tutoring con le nuove tecnologie per ridurre l'insuccesso scolastico e favorire l'apprendimento della matematica nella scuola secondaria, Atti Didamatica Informatica per la didattica, AICA-Università di Napoli, 2014, 834-843.

[6] Keijzer-de Ruijter M.A., Assessment Practices at TU Delft, C.G. Huizer, Drs. G.M. Ouwehand, Dr. Ing. A.H.W. van der Zanden (Ed.) 2011.

[7] Marchisio M., Melgiovanni R., Rabellino S., La piattaforma Moodle al servizio del recupero scolastico nel Progetto "Scuola dei Compiti" della Città di Torino, L. Tommaso Leo (Ed.) – Atti del MoodleMoot Italia 2013, 81-88.

[8] Maple, http://www.maplesoft.com

[9] Moodle, www.moodle.org

[10] Palumbo C., Zich R., Matematica ed Informatica: costruire le basi di una nuova didattica, Bricks, Anno 2, n. 4, 2012, 10-19.

[11] Prensky M., Digital Natives, Digital Immigrants, From On the Horizon, MCB University Press, Vol. 9 No. 5, 2001.

[12] Ricchiardi P., Torre E., Progetti di tutoring per contrastare l'insuccesso scolastico e favorire la motivazione ad apprendere nella scuola secondaria, L'integrazione scolastica e sociale, 13, 3, 2014, 285-306.

[13] Scriven, M., The methodology of evaluation. In R.W. Tyler, R.M. Gagnè, M. Scriven (eds.), Perspectives of curriculum evaluation (pp. 39-83). Chicago, IL: Rand McNally, 1967, 39-83.

[14] Wiggins G.P., Assessing student performance. Exploring the purposes and limits of testing, Jossey-Bass Publishers, San Francisco, 1993.

[15] Wiggins G.P., A true test: toward more authentic and equitable assessment, The Phi Delta Kappan May 1989 vol. 70 n.9, 703-7013.

[16] Zich R., Pardini C., Marchisio M., Moodle&Maple: una struttura integrata al servizio del Progetto MIUR su Problem Posing and Solving, (2012). G. Fiorentino (Ed.) – Atti del MoodleMoot Italia 2012, 10-12.