UNIVERSITY TRAINING FOR FUTURE PRIMARY SCHOOL TEACHERS ON AUTOMATIC FORMATIVE ASSESSMENT

Vittoria Bonanzinga[1], Francesca Casasso[2], Cecilia Fissore[3], Valeria Fradiante[2] and Marina Marchisio[2]

[1]*Dipartimento di Ingegneria dell'Informazione, delle Infrastrutture e dell'Energia Sostenibile, Università Mediterranea di Reggio Calabria, Italy*

[2]*Dipartimento di Biotecnologie Molecolari e Scienze per la Salute, Università di Torino, Via Nizza, 52, 10126 Torino TO, Italy*

[3]*Dipartimento di Lingue e Letterature Straniere e Culture Moderne, Università di Torino, Via Giuseppe Verdi Fronte 41, 10124 Torino TO, Italy*

ABSTRACT

From 2020/2021 the evaluation of students' learning in primary school is no longer expressed through a decimal-based score, but through a descriptive assessment, in a more formative perspective of evaluation. In addition, the widespread use of technological tools in school has changed the teaching/learning process and it has highlighted the need to adopt new teaching methodologies. In this context, it becomes fundamental to train teachers and future teachers on the use of digital resources and innovative teaching methodologies, such as automatic formative assessment. This article presents a training module on automatic formative assessment which involved 153 university students of the Master's Degree course in Primary Education and aims to answer the following research questions: Were students able to design questions with formative assessment and interactive feedback? What were the most adopted strategies? All the forms and the questionnaire completed by students during the training course were analyzed. Even if most of the students had some difficulties in designing the interactive feedback, they really appreciated the development of the training module and the proposed methodologies. They find formative assessment very effective in several aspects.

KEYWORDS

Automatic Formative Assessment, Future Teacher Training, Interactive Feedback, Primary School.

1. INTRODUCTION

In Italy, starting from the 2020/2021 school year, the periodic and final evaluation of students' learning in primary school is expressed, for each discipline, through a descriptive assessment and no longer through a decimal-based score. This change is characterized by a formative perspective of evaluation and by an enhancement of the improvement of learning paths and teaching methodologies. The perspective is that of assessment for learning, which has a formative nature since the information collected is also used to adapt teaching to the concrete educational needs of students and their learning styles, modifying the activities according to what has been observed and starting from what can be valued. This evaluation method allows to represent, in transparency, the articulated cognitive and meta-cognitive, emotional and social processes through which the learning results are manifested. Descriptive assessments refer to the learning objectives that are the subject of evaluation and that are defined in the school curriculum. Each assessment is related to a specific learning level. Formative assessment is a process in which students are active protagonists and have the opportunity to understand what has been or has not been learned and how to learn it. Students can also understand the progress made and the difficulties they have in learning (Beatty & Gerace, 2009). Formative assessment differs from summative or standardized assessment, where the goal is to measure students' learning outcomes generally at the end of a learning path. The best-known example of national standardized assessment in Italy are the INVALSI tests (https://invalsi-areaprove.cineca.it/) in the Mathematics, English, and Italian disciplines (Bolondi et al. 2018, Cascella et al. 2020). The new digital culture and the widespread use of

technological tools have changed the teaching/learning process, forcing the school to adopt an innovative teaching model. Technologies also play a fundamental role in the evaluation process and in the implementation of adaptive teaching strategies, supporting both teachers and students. For several years, the Italian Ministry of Education has supported projects for the introduction of innovative methodologies through the use of technologies in the classroom and their integration with traditional resources, such as the PP&S project (www.progettopps.it) for training and continuous support to teachers of all types and disciplines from all over Italy (Fissore et al., 2020a-2020b). In fact, in this new scenario, teachers have a key role, as they can effectively use technologies for educational purposes to make the entire training process more efficient. It therefore becomes essential to train teachers and future teachers on the use of digital resources and innovative and interactive teaching methodologies, in order to integrate them into ordinary teaching. The Delta Research Group of the University of Turin has successfully developed and tested a model for designing automatic formative assessment activities through the use of an Automatic Assessment System –AAS - for STEM (Barana et al., 2020a; Barana, 2021) and other disciplines (Corino et al., 2022; Marello et al., 2019). This article presents a research connected to a training module on automatic formative assessment which involved 153 university students of the Master's Degree course in Primary Education for a total of 8 hours held during the Academic Year 2021-22 at University Mediterranea of Reggio Calabria, in collaboration with University of Turin. The course was delivered in hybrid mode, i.e. a part of the students attended the lessons in presence and a part of the students attended remotely due to the Covid pandemic. The teachers carried out the lessons in presence while the tutors managed the Digital Learning Environment remotely from the University of Turin. In this course, the concepts of formative assessment and automatic formative assessment with immediate and interactive feedback were presented to university students, who will become primary school teachers. After a theoretical introduction and the presentation of several examples of activities with automatic formative assessment, the students were guided in the design of two activities with automatic formative assessment. The first request was the transformation of an INVALSI question (the same one for all) for standardized assessment into a question for formative assessment. The second request was the design of a new question with formative assessment. The design was guided through a form with reflection questions. At the end of the design, the students carried out a peer evaluation activity. The course was held in presence using a Digital Learning Environment integrated with an automatic assessment system. At the beginning and at the end of the course, all students submitted a satisfaction questionnaire. The research question is: Were students able to design questions with formative assessment and interactive feedback? What were the most adopted strategies?

2. STATE OF THE ART

2.1 Formative Assessment and Feedback

The definition of formative assessment that we adopt is that of Black and Wiliam (2009), well known in the literature: “Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded than the decisions they would have taken in the absence of the evidence that was elicited”. Assessments become formative when the information is used to adapt teaching and learning to meet students’ needs. When teachers know how students are progressing and where they are having trouble, they can use such information to make necessary teaching adjustments, such as reteaching, trying alternative didactic approaches, or offering more opportunities for practice (Sadler, 1989). These activities can lead to improved student success (Boston, 2002). Black and Wiliam (2009) conceptualize formative assessment through the following five key strategies: clarifying and sharing learning intentions and criteria for success; engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding; providing feedback that moves learners forward; activating students as learning resources; activating students as the owners of their own learning. The first strategy concerns the sharing of learning objectives. To do so, it is first of all necessary to have a clear understanding of how to formulate the learning objectives. According to the Italian legislation, but which refers to theoretical assumptions well studied in the literature, the learning objectives must contain: a reference to the cognitive process (written through a verb to explain what the student must do) and a reference to the disciplinary content. It is possible to add something about the conditions under which this cognitive process must be implemented. There are six cognitive

processes, written using Bloom's taxonomy revised in 2001 by Anderson and Krathwohl (Anderson & Krathwohl, 2001): remember, understand, apply, analyze, evaluate, create (from the simplest to the most complex). An example of a learning objective of the "understand" cognitive process is: compare two decimal numbers and find the greater number. It is important that evaluation and feedback are coherent with the learning objectives established and shared with the students from the beginning of the teaching activity. Feedback plays an essential role in reducing the discrepancy between current and desired understanding (Hattie & Timperley, 2007; Kluger & DeNisi, 1996). It should indicate what the learning goals are, what progress is being made toward the goal, and what activities need to be undertaken to make better progress. In fact, effective feedback must answer three main questions: “Where am I going?”, “How am I going?”, “Where to next?”. Formative assessment is one of the most important methods for developing students' self-determination, self-efficacy, autonomy, and self-esteem. It can help students increase their motivation to study, acknowledge their strengths and weaknesses, be aware of the level reached, proceed step by step, following the feedback received, which must always be numerous and immediate (Nicol & Macfarlene-Dick, 2006). The development of new technologies, and in particular the use of an AAS, can support the possibility of giving feedback (Bennet, 2002; Nicol & Milligan, 2006). An AAS is often used for summative assessment, because it offers the opportunity to automatically evaluate, collect and analyze students’ responses. However, it can also offer support for a formative assessment, giving immediate and personalized feedback, guiding students in an exercise, and proposing adaptive exercises (Giraudo et al., 2014). Moreover, teachers in the classroom deal with a large number and variety of students. They can have concrete support in offering all students personalized feedback and teaching from educational technology.

2.2 Automatic Formative Assessment and Interactive Feedback

The practice of formative assessment in a Digital Learning Environment integrated with an automatic assessment system allows the automatic processing of students' answers and the provision of feedback. We conceptualize interactive feedback as a step-by-step interactive process guiding the learner in the resolution of a task after one or more autonomous attempts (Barana et al., 2021). Our model requires the use of an automatic assessment system and it is supported by theories on formative assessment and feedback (Barana et al., 2020b). Interactive feedback is a step-by-step interactive solving process which shows a path to the solution after one or more autonomous attempts by the learner. It begins immediately after answering one question, when students are working on an online test. After showing the correctness of the answer, the system proposes a step-by-step resolution that interactively shows a possible process for solving the task. This interactive feedback can be displayed only to the students who failed to answer autonomously to the main question, or even to those who made it correct (Barana et al., 2021). This type of questions also allows the student to try a simpler version of the question, guiding them through the exercise one step at a time, and presenting whatever other approach the instructor thinks is appropriate. Fig. 1 shows an example of an activity with automatic formative assessment and interactive feedback. The first part of the question is taken from an INVALSI question for the second grade of primary school. After reading the text of the problem, students must select their answer from the three proposed options. In the case of the INVALSI question created for standardized assessment, if the students choose the wrong answer, the teacher has no information on the difficulties encountered by the students and the mistakes they made. Consequently, effective and educational feedback cannot be provided. It is different when using interactive feedback, in this case divided into two sub-questions. This step-by-step guided path is proposed in case of wrong answer (as in the example shown). In the first sub-question, the operation to be performed in order to answer the first question is requested. In the second part, students are guided to solve the problem by filling in the blanks by entering the problem data and the result of the operations. In both cases, students have three attempts to answer the question. After choosing their answer they can click on the "verify" button to get immediate feedback on its correctness. In case of correct answer, students go to the next part; in case of wrong answer, they can try to change their answer and repeat the check. The possibility of having more attempts available through a guided and interactive path is very important for students’ self-confidence, and it can help to overcome the errors due to the incorrect insertion of the written answer. The teacher can view the students' answers and all attempts to answer, thus becoming aware of the most frequent errors and any difficulties encountered. Finally, this is an Algorithm-based question. The random values and parameters in the question text, answers, and feedback randomly change at every attempt and for each student. At every attempt, an algorithm generates new data for the number of bags and candies, and updates correct solutions

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accordingly. In this way, students can try to answer the question several times to consolidate the solution process learned and the knowledge acquired. The importance of immediate and interactive feedback is essential for both students and teachers. Through continuous and formative feedback, the student can focus not on the result, but on the progress made, on the mistakes made, and on the actions to be taken in order to improve (Barana et al., 2019). At the same time, teachers can progressively monitor students' learning levels and obtain valuable feedback.

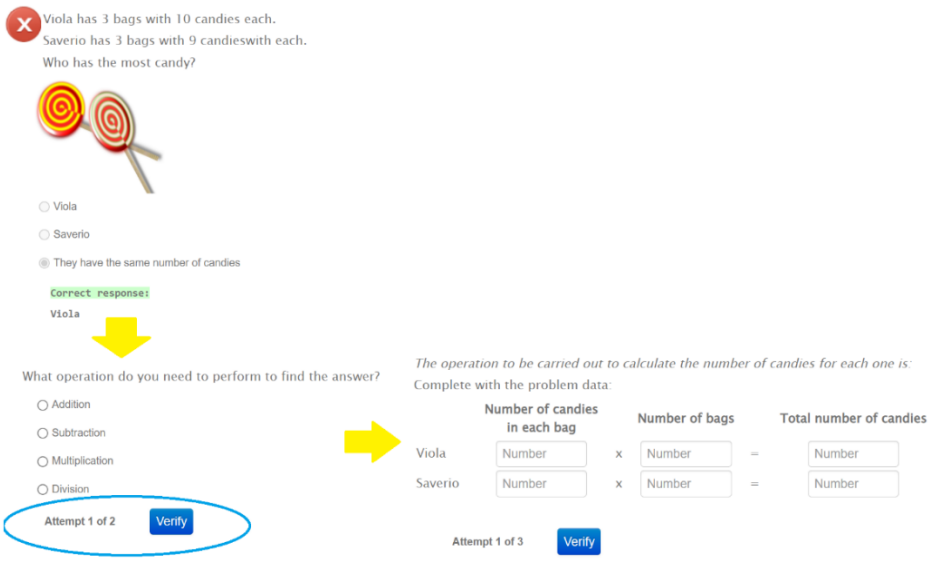

Figure 1. Example of activity with automatic formative assessment

To ensure that teachers implement this type of questions with automatic formative assessment, it is important to train teachers in designing this type of activity and in acquiring formative assessment methodologies.

3. METHODOLOGIES

The purpose of the training module is to introduce future primary school teachers to the concepts of formative assessment and automatic formative assessment and to adopt these methodologies in the teaching of Mathematics. Through the acquisition of educational-didactic tools and strategies before taking up service, they will be able to disseminate good practices of educational action in schools. The training module involved a total of 153 university students (future primary school teachers). The duration was 8 hours for each group of students. In the 4-hour meetings a Digital Learning Environment was used. The didactic methodologies adopted were frontal explanations with discussions, learning by doing, and peer evaluation. The training module was organized as follows: a first part of theoretical explanation with discussions; a second part of planning activities with automatic formative evaluation by filling in a form; a third part of peer evaluation in which students evaluated the activity planned by one of their classmates by answering questions. In the design module, the first request was the transformation of an INVALSI question (the same one for all) for standardized assessment into a question for formative assessment. The question asked to observe a line in which two numbers were marked and to find the number placed halfway between the two (choosing between three options). Students had to design a possible interactive feedback to guide students in answering the question in case of an error. They were then asked how the question was adapted for the formative assessment and what they thought was the goal of the question. The second request was the design of a new question with formative assessment. The question had to be a contextualized problem to be solved through a guided procedure. The students had to pay particular attention to the choice of context, which must be close to the experience of the primary school students. Then they had to design the various parts of the question indicating the sub-questions texts, the correct answers, and the number of attempts to answer. Again, they had to indicate the objective of

the question. The peer evaluation activity was guided through the following questions: "Did you find it difficult to understand the question requests? If so, which ones?"; "Was the contextualization you chose effective?"; "What difficulties do you think students may encounter in interpreting the requests of the question and in answering the question?"; "Is the question pertinent to the stated objective?". Students completed an initial questionnaire at the beginning of the workshop and a final questionnaire at the end. In the initial questionnaire, students were asked if they were using automatic assessment as students and what benefits they think it provides. Then they were asked, on a scale from 1 (not at all) to 5 (very much), to what extent they considered the use of automatic formative assessment to be effective for various aspects, such as: understanding and reviewing knowledge; developing problem solving skills; raising awareness of one's knowledge and skills; increasing interest in the subject; understanding one's mistakes; and adapting teaching activities. In the final questionnaire, the latter question was asked again and the satisfaction about the proposed activities and methodologies was discussed. To answer the research question, the activities planned by the students and the students' responses to the initial and final questionnaires were analyzed. The questions designed by the students in both parts of the form were analyzed and classified into three different categories: effective interactive feedback, not fully effective interactive feedback, ineffective interactive feedback. The analysis also reported the reasons for the classification made. The strategies adopted for formative assessment, the learning objectives indicated by the students and the context chosen for the activity they invented were also analyzed.

4. RESULTS

4.1 Design of the Activity with Automatic Formative Assessment

Following the analysis of the 153 design forms, three types of interactive feedback emerged:

- not very effective feedback: the sub-questions do not guide the students in the solution process;
- quite effective feedback: the sub-questions guide students in finding the solution, but they do not allow students to think about the solution procedure;
- very effective feedback: the sub-questions guide students gradually, stimulating them to think about their mistakes, about the possible solutions and about the meaning of the final result.

Regarding the first request of the form: 54% of the students designed a not very effective feedback, 41% a quite effective feedback, and 5% a very effective feedback. We want now analyze the cases in which students have project a not very affective feedback. 77% of the not very effective feedback has sub-questions in which the student is asked what operations are needed to reach the solution (For example: "What operation is needed to arrive at the solution?"). In this case, there are two main issues. The first one is that it leaves no room for different solution strategies (not all students solve the problem in the same way or in the teacher's way). The second problem is that this type of feedback does not guide the student in the solution process and whoever made the first question wrong does not have the information to reflect on the mistakes made. The remaining 33% of the not very effective feedback consisted of sub-questions not related to each other, which did not allow to build a logical reasoning. The interactive feedback that has been classified as "quite effective" allows the student to get to the solution, but it does not make them reflect adequately on the solution process. An example of this category is given by the two sub-questions "If we add the value 2 to the value 10, what number do we get?" and then "If we divide the number 12 by 2, what number do we get?". Following the interactive feedback, the students do a calculation exercise but do not think about the operations to be carried out and with which data of the problem to carry them out. In questions with very effective interactive feedback, the sub-questions gradually guide students towards the solution by making them reflect on the solution strategies. An example of this category are the following sub-questions: "What are the numbers between 2 and 10?" and "Represent numbers on a straight line and indicate the number that is in the middle". When students reflected on how they adapted the question for formative assessment, most (73%) declared a strategy that was inconsistent with the one implemented. This result may reflect the students' difficulty in understanding the request and the difficulty in transforming a standardized evaluation question into a formative evaluation question. Regarding the second designed activity, invented by the students, 49% of the interactive feedback was not very effective, 36% of the interactive feedback was quite effective and 15% of the interactive feedback was very effective. By analyzing all the different types of feedback designed by students, even in the second form, 53% of the not very effective feedback focuses exclusively on the operations necessary to reach the solution. The remaining students have

designed some interesting sub-questions which, however, do not make the question formative. 61% of the students who designed a quite effective interactive feedback created sub-questions with the aim of solving the problem mechanically, asking them to complete the operation and the solution formula, rather than dwell on the meaning of the problem, on the most important data, on the construction of the solution process and on the meaning of the result obtained. In these cases, the students manage to reach the solution, but they are not aware of the procedure used. 18% of future teachers have devised sub-questions that ask to argue the chosen strategy to solve the problem, but in this way students who cannot answer the question correctly are not guided in the resolution. 21% of not very effective feedback has sub-questions that are too articulated and complex and which could therefore be unclear and confusing. The future teachers who designed a very effective feedback did not just lead the students towards the correct result, but asked the students to think about their mistakes, the solution procedure followed and the meaning of the result obtained. The goal of interactive feedback is to show the student a possible solution process and induce him to think about his mistakes, rather than simply obtaining a correct result. A very positive aspect was the choice of context. 89% of future teachers were able to find a real context and very close to the students in such a way as to stimulate their interest and involvement. Among the most used contexts are: candy distribution, games, stickers, birthday parties, Christmas decorations and dessert recipes. Here is an example of a captivating context: “Alessandro wants to go to a toy store to buy Christmas presents. Alessandro finds a train for € 16, a helicopter for € 18, a doll for € 12 and a Lego for € 6. Alessandro's mother gave him a maximum of € 39. What can Alessandro buy without exceeding the money limit imposed by his mother?". The students also reflected on the objective of the problem, and in most cases the objectives indicated do not correspond to the real purpose of the problem. This highlights the need to deepen the definition of learning objectives, also referring to what is contained in the National Guidelines. This is both in terms of the disciplinary contents to be addressed and in terms of the goals that the students must reach, in order to design adequate activities and make the correct learning objectives explicit. From the analysis of the deliveries of the two papers, it clearly emerges that, in designing the questions for the formative assessment, only few have managed to create very effective interactive feedback. The reasons for this difficulty may derive from the fact that, being the first time they have found themselves designing interactive feedback, most of the students took inspiration from the examples shown to apply formative assessment strategies without taking into account that the feedback of such examples cannot always be generalized to other problems, with the result that the feedback they design is not entirely effective. For example, many students have focused on the operations to be done (adding and dividing by the formula of the midpoint, or difference) by binding the student to a solution strategy imposed by them. The results revealed the need to increase the references to National Guidelines, in particular regarding the declaration of the learning objectives to be achieved with a specific activity and the target they address, in particular paying attention to the words used, to clarity of the text and the reference context of the problem.

4.2 Students’ Observations on the Training Module

Only 35% of the students knew and used automatic assessment tools (google forms and web applications like Kahoot) before the training module. This shows that formative assessment, and even more the automatic formative assessment, is unfortunately an educational practice still little used by teachers in service. According to the students, some of the aspects that are favoured by automatic assessment are: interest, involvement, attention, verification of the level of learning, self-assessment, correction of homework (speed and comfort), analysis of results and monitoring of learning, immediate feedback, objectivity and impartiality of evaluation, enhancement of teachers 'and pupils' digital skills. Table 1 shows the students' considerations on the effectiveness of automatic formative assessment in teaching in various aspects indicated. For each aspect, students had to choose a score from 1 (not at all) to 5 (very much). The table shows the mean scores and standard deviation before and after the training module. According to the students, automatic formative assessment was very effective in various aspects even before the training module. After the training module all scores increased and the standard deviation decreased. In particular, according to the students, automatic formative assessment is especially effective for remedial actions, to make students autonomous in solving problems, to increase students' autonomy and increase their awareness, and to facilitate study autonomy. The course, in addition to inviting students to design and implement a question for the formative evaluation with interactive feedback, was an important moment of reflection and meta-reflection on this teaching methodology.

Table 1. Students' considerations on the effectiveness of automatic formative assessment in teaching

	Mean before	Dev.St. before	Mean after	Dev.St. after
Review your knowledge	3,99	0,93	4,28	0,75
Improve understanding of content	4,13	0,87	4,42	0,72
Develop problem solving strategies	4,16	0,90	4,43	0,71
Develop autonomy in solving problems	4,25	0,86	4,46	0,62
Develop argumentative skills	3,83	1,00	4,15	0,82
Facilitate recovery actions	4,19	0,91	4,33	0,74
Valuing excellent students	3,79	1,10	4,00	0,99
Raise awareness of one's knowledge and skills	4,35	0,78	4,47	0,72
Facilitate autonomy in the study	4,27	0,86	4,38	0,78
Promote metacognitive reflection	4,11	0,93	4,28	0,78
Increase motivation for the matter	4,16	0,89	4,29	0,80
Allow the inclusion of students with SEN-SLD	4,08	0,99	4,15	0,96
Understanding your mistakes	4,44	0,88	4,54	0,62
Personalize educational activities	4,16	0,95	4,42	0,70

Students positively assessed the congruence of the training contents and the clarity of the proposed material (both with an average score of 3.6 out of 4). Table 2 shows the students' scores on different aspects of the training module and the proposed methodologies. The results are very positive. Students find the proposed methodologies clear and interesting, and they think they can support innovative and interdisciplinary teaching. The proposed methodologies help "collaborative learning", student learning and their development of skills. They intend to use the methodologies proposed in the classroom in the near future and to deepen the proposed methodologies.

Table 2. Students' considerations on different aspects of the training module and the proposed methodologies

	Mean	Dev.St.
The proposed methodologies are interesting	4,53	0,67
The proposed methodologies are clear	4,31	0,78
The proposed methodologies support innovative teaching	4,55	0,62
The proposed methodologies support interdisciplinary teaching	4,27	0,80
The proposed methodologies support "collaborative learning"	4,47	0,70
The proposed methodologies help students' learning	4,49	0,71
The proposed methodologies help students develop skills	4,50	0,70
I intend to use the methodologies proposed in the classroom	4,50	0,64
I intend to deepen the proposed methodologies	4,49	0,65

5. CONCLUSIONS

In this paper we have presented a training module on automatic formative assessment which involved 153 university students of the Master's Degree course in Primary Education (future primary school teachers). In this course, the concepts of formative assessment and automatic formative assessment with immediate and interactive feedback were presented. Students designed effective, not fully effective and ineffective interactive feedback. Most of the students had some difficulties in designing the interactive feedback, but those struggles are understandable, since it was their first time dealing with the topic. Most of the students had never used an automatic assessment system before, and this did not facilitate them in the design of the questions and related answers. The results revealed the need to increase the references to the National Guidelines (MIUR, 2012), in particular regarding the declaration of the learning objectives to be achieved with a specific activity, also paying attention to the words used, the clarity of the text and the context of the problem. Students really appreciated the development of the training module and the proposed methodologies. They find formative assessment very effective in several aspects. This type of training can also be very useful for teachers already in service. We believe it is important to train teachers of all levels on an important topic such as automatic formative assessment and on the strategies to be implemented to carry it out. For primary school teachers (in service or

pre-service), this training is particularly effective according to recent regulations. This type of training can be deepened by training students on the use of the automatic evaluation system and having them implement the planned questions. A further possible fallout can be the creation of a database of activities with automatic formative evaluation that can be shared among future teachers and with primary school teachers.

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