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A personalized feedback system to support teacher training

Marta De Angelis[a], Sergio Miranda[b1]

[a]*University of Molise, Italy, marta.deangelis@unimol.it, http://orcid.org/0000-0003-3079-3729*
[b]*University of Salerno, Italy, semiranda@unisa.it, http://orcid.org/0000-0002-8554-0123*

Abstract

This paper aims to illustrate an automated system developed to give formative and personalized feedback to teachers in training. It is an expert system (Paviotti, Rossi & Zarka, 2012) that uses concrete examples, cases and scenarios to guide the engaged learners (Leake, 1996). In this regard, this system is able to create questionnaires, deliver them, collect and analyze data, send feedback to the participants to provide information about their beliefs and behaviors about teaching and learning processes. Far from constituting an assessment of teaching practices, the automated feedback demonstrates its usefulness in identifying teachers' mindframes at an early stage, so as to be able to implement more specific and personalized training. This allows its application to be extended to further training areas as well as constituting an effective approach for need analysis and a preparatory action for numerous training activities (guided discussion with experts, observation on practice, modeling, etc.).

Keywords: *teacher education; in-service teacher training; feedback; technology; teaching quality*

Introduction

Teacher training is considered as one of the most important factors capable of increasing the quality of teaching and learning processes (Darling-Hammond, 2000; 2006; OECD, 2005; Korthagen, 2010).

Despite this general consideration about the importance of teacher professional development, not all teachers are equally receptive to training, since often they show difficulties and resistances in changing their professional practices (Jacobs et al, 2018; Eroglu & Donmus, 2021). According to Guskey (1986; 2002), the majority of programs fail because they do not take into account the process by which change in teachers typically occurs.

Teacher professionalism, in fact, does not consist exclusively in the acquisition of knowledge, skills and competences useful for work but also in the possession of specific attitudes and beliefs capable of guiding one's behavior in a profitable way (Korthagen, 2004; Zierer et al, 2018). This means that being involved in a training course will not automatically make a teacher more effective in his action.

This is also evident in the significant difference between teachers *with experience* and teachers *with expertise*. Wanting to explain it with an example, "there are teachers who have been teaching for thirty or forty years who have still not advanced beyond the level of a hobby pedagogue, and there are trainee teachers who show from their first lesson on that they already have what it takes to become a successful teacher" (Zierer, 2017, p. 776). It depends on specific ways of thinking and acting that characterize the second type of teacher.

Hattie and Zierer (2017) define ten specific mindframes that teachers with expertise possess, which are made visible empirically by the effective behaviors that they have during their professional practice and the consequent impact on students' learning. These include evaluating your own impact on students' learning; creating positive relationships; considering the importance of giving and receiving feedback, providing formative evaluation; being an agent of change; working collaboratively with other professionals.

[1] Even though the authors have jointly conceived this paper, Marta De Angelis wrote *Introduction* and section *1. The role of formative feedback in teacher training*, Sergio Miranda wrote sections *2—The management system and the methodological approach* and *3—An exploratory investigation*. Both the authors wrote the abstract and the conclusions.

Professional development programs are based on the assumption that they should increase teachers' knowledge and skills and change their attitudes and beliefs in order to promote student learning (Desimone, 2009). But the possession of these specific attitudes and beliefs is not something automatic after training.

According to Hattie (2012), these mindframes can be a precondition for learning success, and for this reason, they should be developed in the specific training courses for teachers. The acquisition of these mindframes may be promoted during teacher training by focusing the training itself on these aspects. In fact, for both in-service and preservice teachers, "prevention of undesirable teaching behavior through careful and frequent early supervision is much more efficient than later remediation" (Scheeler, Ruhl & McAfee, 2004, p. 405). The automatic feedback system will help us to reveal implicit misconceptions about teaching and learning and encourage a teaching behavior informed by evidence.

1. The role of formative feedback in teacher training

Several studies clearly show that feedback is one of the most incisive ways to improve students' learning (Bransford, Brown, & Cocking, 2000; Hattie & Timperley, 2007; Hattie, 2009; Marzano, Pickering, & Pollock, 2001). The effectiveness of feedback relates to the fact that it must help the learners by providing them useful information to improve their thinking and behavior. Not all feedback, however, is equally effective; there are specific characteristics that make feedback truly incisive and formative. In particular, it must be 1) *goal-referenced*, providing a clear definition of what a person's goals are; 2) *tangible and transparent*, providing clear and concrete results related to the goal; 3) *actionable*, giving information that can be useful in practice; 4) *user-friendly*, understandable by everyone and not too technical, so as to avoid confusion; 5) *timely*, in reference to a task or a performance; 6) *ongoing*, giving the opportunity to reshape the performance during the learning process; 7) *consistent*, stable, accurate and trustworthy (Wiggins, 2012).

Also trainee teachers, like other students, acquire and maintain new behaviors better when they receive systematic education, and have opportunities to practice and receive feedback (Scheeler, Ruhl & McAfee, 2004). In fact, the feedback action can be considered truly effective only when the information communicated to the learner is intended to change his thinking or behavior (Shute, 2008).

Although feedback is to be considered as an important learning activity, it is also known that teachers rarely receive it, and when that happens, the information provided is often more focused on evaluating their performance than improving their practice (Jensen et al, 2020). Furthermore, feedback is often not provided immediately but only after the observation of a didactic episode, a task or a performance, not taking into account the positive effects that immediate information can produce (Coulter & Grossen, 1997; Sheeler & Lee, 2012).

The lack of feedback to teachers happens mainly for two reasons: 1) providing continuous information by a supervisor requires a high expenditure of time and human resources; 2) immediate feedback can interrupt an ongoing lesson or training (O'Reilly et al, 1994).

Regarding the second problem, there are numerous attempts, in literature, to use technology in order to provide immediate feedback without having to interrupt the learning process. For example, it is possible to provide useful information, in teacher training, by using e-mail (Hemmeter et al, 2011) or a wireless FM listening system called bug-in-ear (BIE) (Ottley & Hanline, 2014; Scheeler, McKinnon, & Stout, 2012), which gives real-time feedback to teachers without being intrusive. In teacher training, technology has also been used to provide ongoing feedback that combines speed of action with the use of automated or semiautomated systems, in order to assist the action of human trainers. These systems are capable of providing personalized indications to student teachers through automatic analysis of teacher speech or combining feedback and reflection within scenario-based learning activities. In the study of Wang, Miller and Cortina (2013), a speech recognition recorder, called LENA (Language ENvironment Analysis), was used to create an automated teacher feedback system to help teachers monitoring and limiting the time they talk, in order to increase students' active participation in lessons. In Bardach et al (2021), an online scenario-based learning was used to prepare student teachers for the classroom readiness and self-efficacy, providing feedback on authentic learning experiences that teachers can solve in everyday practice.

With the rapid evolution of computer science, *intelligent tutoring system* (ITS) is certainly a research field in which to direct resources and studies, despite most of the experimental research in this field has university students and not teachers as its audience (Mousavinasab et al, 2021). ITS are "[...] computerized learning environments that incorporate computational models from the cognitive sciences, learning sciences, computational linguistics, artificial intelligence, mathematics, and other fields" (Graesser et al, 2012, p.2) "that provides personalized and adaptive tutoring to students based on their needs, profiles and preferences" (Sani & Aris, 2014, p.72). Their use in teacher education could be a valid help in assisting the action of the trainers: those intelligent tutoring systems can observe and analyze learning processes and performance, providing hints or assistance based on specific learning needs (Hwang et al, 2020) and promoting active-participatory methodologies in the learning process (Castro-Schez et al, 2021). In fact, in a review of studies, VanLehn (2011) highlighted that the effectiveness of computer-based tutoring is substantially the same as that of a human tutor: the effect size of intelligent tutoring systems was 0.76, while the effect size of human tutors was 0.79. Another meta-analytic review conducted by Kulik and Fletcher (2017) on 50 controlled evaluations of intelligent computer tutoring systems shows that "ITSs typically raise student performance well beyond the level of conventional classes and even beyond the level achieved by students who receive instruction from other forms of computer tutoring or from human tutors" (p.70). This would confirm both the effectiveness of the artificial tutors in almost all subject domains (Ma et al, 2014).

1.1 Objectives

Starting from these premises, the aim of this paper is to illustrate an automated feedback system[2] able to provide personalized feedback to trainee teachers. This expert system (Paviotti, Rossi & Zarka, 2012), adopted for the *Effective Teaching Questionnaire* in its third version (ETQ3), uses concrete examples, cases and scenarios (Leake, 1996) to reveal implicit teacher mindframes about teaching and learning action.

In order to clarify the functioning of the management system and to show how it can provide personalized feedback, the results of an exploratory survey of its use on a sample of trainee teachers are presented.

2. The management system and the methodological approach

The implemented system is able to manage investigations by means of functionalities that allow building interactive questionnaires, collecting and analyzing answers, delivering, in a totally automatic way, personalized feedback to each participant. Each item of the questionnaires has an incipit describing a situation, according to the theoretical principles of case-based learning (CBL) systems, and a consequent behavior to adopt to face it. CBL relies on both the situated learning theory (Lave & Wenger, 1991) and the situated cognition (Brown, Collins, & Duguid, 1989), which argue learning as not something abstract, but as something happening in a specific context. By following these principles, knowledge and skills are learned in a context that reflects how knowledge is obtained and applied in realistic everyday situations.

The participant, in relation to the situation and the behavior described by an incipit and its item together, may state, as answer, how much he agrees with it on a 5-points scale from 1 (totally disagree) to 5 (totally agree). The system allows also specifying for each item an expected answer on the same scale and a formative feedback that explains why a belief or a behavior could be acceptable or not.

The system allows analysis and visual representations on all the collected data: this functionality is useful to identify in which areas the participants have specific learning needs and, thus, to drive any eventual training activities on the treated concepts. Moreover, all the items may be linked to some more general aspects that could be adopted as dimensions. By means of these dimensions, the system shows overall evaluations and creates overviews on the investigations and the engaged participants. Administrations and analysis may be done in different moments. For instance, they may happen at the beginning of a training course to drive the deepening to the found lacks, or both at the beginning and at the end of some training activities in order to do comparisons and evaluations on their effectiveness and results.

The potential of this system lies in the characteristic of being generic enough to be instantiated and adopted in various contexts. The questionnaires it creates and delivers are in *Google Form* so they are accessible from a wide range of devices connected to the Internet and equipped with a common web browser (computers, tablets or smartphones). The engine of the system has been developed as *Google script* procedures that allow to customize the questionnaires, to modify all the texts that will be in it, and to collect and analyze the answers of the participants. These procedures are activated by simple clicks on the interface buttons in a *Google Sheets* file.

The personalized feedback is sent directly via e-mail, and it may include an overview on the specified dimensions in terms of the percentage on how much the participant is in line with the expected behaviors in relation to each dimension and more details on all the items, in terms of comparisons between the expected response and that provided.

This system has been instantiated and experimented for the *Effective Teaching Questionnaire* in its third version (ETQ3). ETQ3 presents 38 questions on four dimensions of teacher professionalism: *design/planning*, *cognitive*, *evaluative* and *management*. Each dimension represents a kind of cluster of abilities aggregating situations or events that teachers may find in their career and should be able to face by adopting the right behavior. These situations and the consequent actions to do or the behaviors to adopt are the items in the questionnaire (Fig. 1).

Incipit	***In your professional experience, an effective teacher believes that ...***
Item	... it is very important to present the real problem to the pupil as a whole and let him discovering the resolution for himself.
Dimension	DESIGN / PLANNING Dimension
Reference response (from 1 to 5)	1-2
Feedback	This statement can be shared in very limited situations and in front of already experienced students. The majority of pupils fail if the problem is not simplified and graded appropriately to the level of their skills.

Incipit	***In your professional experience, an effective teacher believes that ...***
Item	... We should try to add as many stimuli as possible to presentations of a new topic.
Dimension	COGNITIVE Dimension
Reference response (from 1 to 5)	1
Feedback	Stimulus overload is one of the most frequent causes of learning difficulties, especially by inexperienced pupils. The mind is able to acquire only a few elements at a time and when there is a lot of information it disperses, unable to select the most important ones. It is advisable to deepen the Cognitive Load Theory, a fundamental reference for all teachers.

Incipit	***The subject (the solar system) has already been addressed. To verify the quality of the learning obtained by pupils, teachers propose various solutions:***
Item	A visit to an observatory or a planetarium located near the school including an interview with an expert.
Dimension	EVALUATION Dimension
Reference response (from 1 to 5)	1
Feedback	There is confusion between the verification tool and the learning activity. Museum visits or interviews with experts could be good forms of enrichment, but they are certainly not good solutions to evaluate the achievement of the learning goals by the class.

Incipit	***The teacher enters the classroom, there are some rubbish on the ground. The air is breathable but a little heavy ...***
Item	... the teacher instructs the pupils near the objects on the ground to throw the papers in the trash and take the textbook. Meanwhile, he goes to the window and opens it.
Dimension	MANAGEMENT Dimension
Reference response (from 1 to 5)	4-5
Feedback	The teacher's behaviour offers a positive model of attention to the environment without stigmatizing the pupils.

Fig.1. Some examples of items adopted in ETQ and created in the developed management system.

[2] The system was conceived by Antonio Marzano and built by Sergio Miranda (See Calvani, Marzano & Miranda, 2021).

The *Effective Teaching Questionnaire* (ETQ) was designed by Antonio Calvani (2014) and saw a first systematic application on preservice and in service teachers in 2019 (Menichetti, Pellegrini & Gola, 2019). Its aim is allowing a comparison between teachers and experts to bring out all the components possessed by teachers that can be decisive factors for effective teaching.

The theoretical basis of the questionnaire refers to the evidence provided by the works of Hattie (2012) and Hattie and Zierer (2017), which are related to the previously described midframes and integrated with other acquisitions emerging from evidence-based research. These other components have been identified in the context of research on *Instructional Design* models by Gagné & Briggs (1974), Merrill (2002) and Rosenshine (2012) relating to the design of educational interventions and their phases. These models converge on aspects such as the definition and explanation of objectives, the use of guided and independent practice and the regular review of learning. All these aspects have been grouped under the *design/planning* dimension. The research on the difference between mnemonic learning and meaningful learning (Ausubel, 1978) and the *Cognitive Load Theory* (CLT) on cognitive load and intrinsic, extraneous and relevant learning (Sweller, 1988) were then examined. These aspects have been merged into the *cognitive* dimension. The theories on the effectiveness of formative evaluation and feedback (Hattie & Timperley, 2007; Hattie, 2012; Australian Society for Evidence Based Teaching, 2017) were analyzed. These aspects were identified in the *evaluation* dimension. Finally, the theories on behaviors and attitudes to establish an effective relationship with the class (Gordon, 1991) have been taken up with the researches on classroom management reported in the systematic review by Simonsen et al. (2008). This made it possible to identify the *management* dimension.

Each dimension has a set of items. For each item there are, as reference, the expected answer in terms of agreement level and the notes explaining why the described behavior or action could be acceptable or not on the basis of the experiences of engaged experts in the evidence-based education (Calvani, 2014; Calvani, Marzano & Miranda, 2021). Thus, the adopted approach is quantitative. The engaged teachers who fill in ETQ have to point out how much they agree with each represented item. All the answers are compared with the reference ones in order to measure the distance between what the teachers think about the treated dimensions (and specific related items) and what the experts suggest to do.

By analyzing the answers given to ETQ3, the implemented management system builds the personalized feedback for each participant and sends it by email in a totally automatic way. First, it provides an overview with respect to the four dimensions and then it offers a detailed focus on the various points, by placing the accent on those for which the answers are far from the reference ones. In fact, the notes are used as formative feedback that justifies the expected response and that can be used to give explanations to those who do not find themselves in line with it. Thus, it helps to highlight the *mindframes* possessed by the participants and which can constitute decisive factors for effective teaching. For example, when a situation occurs, a possible attitude to take is told and the participant is asked to indicate whether or not he agrees with what is described. It can be very useful for a need analysis to initiate insights and learning activities.

ETQ3 created as *Google Form* by the developed management system is shown in Fig.2. The *Google Sheets* interface of the management system instantiated for ETQ3 is shown in Fig.3.

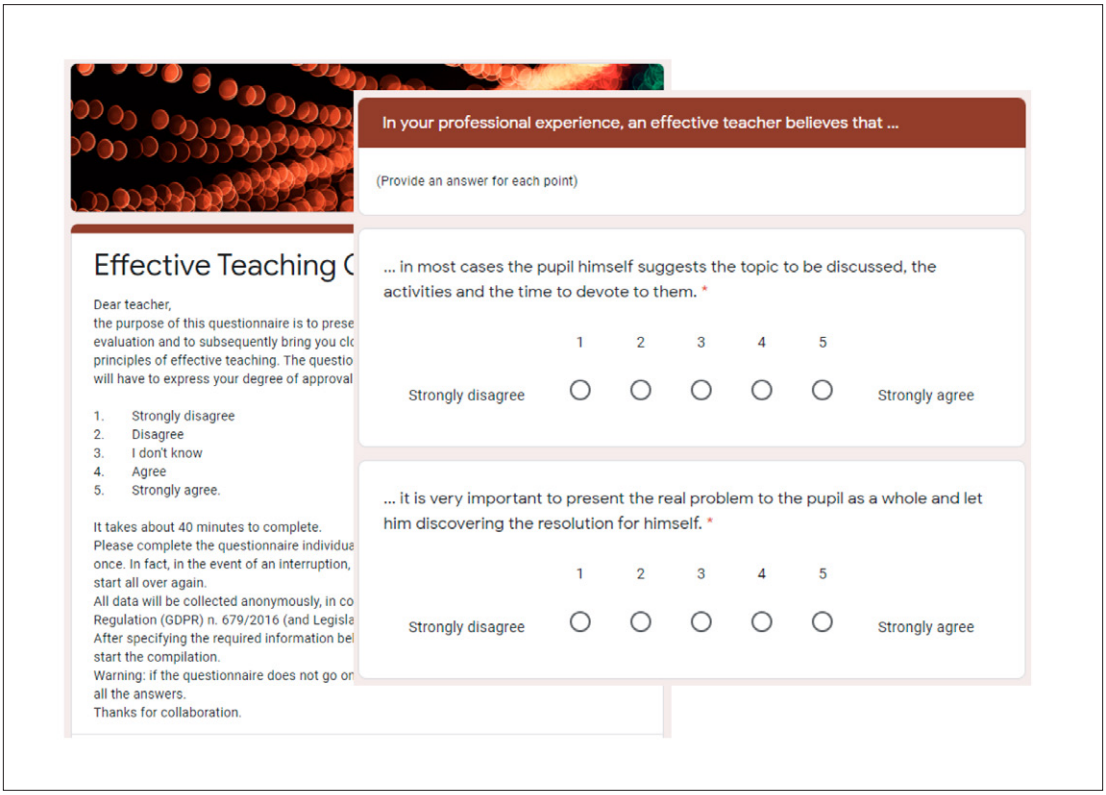


Fig.2. ETQ3 created in *Google Form* by using the developed management system

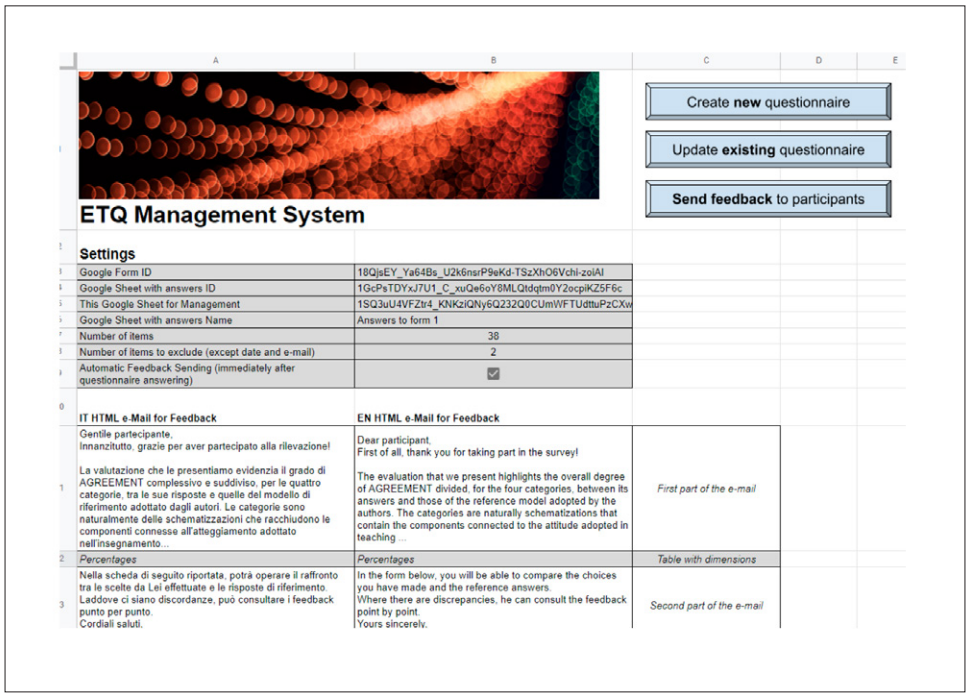
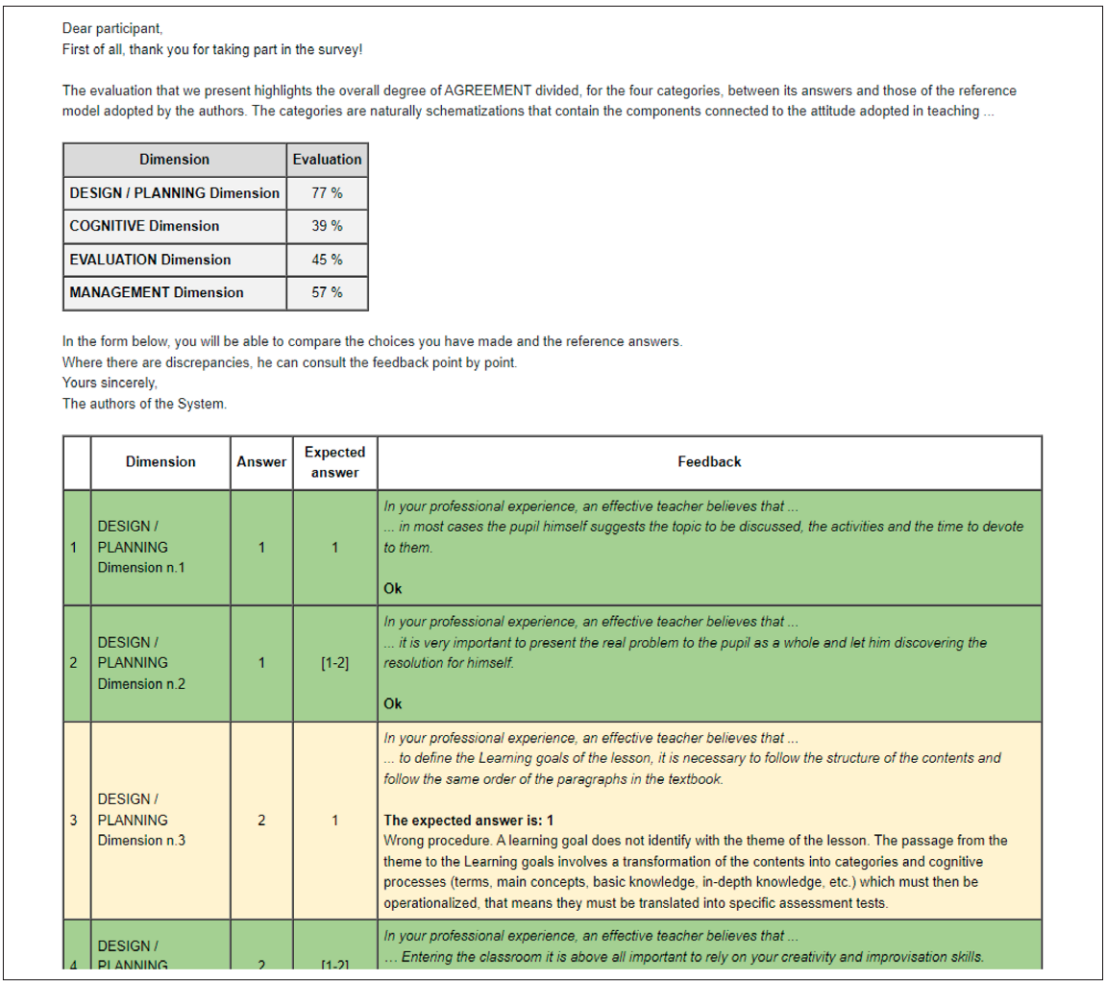


Fig.3. One of the graphical user interfaces of the developed management system.

All collected data are processed by using the *Google Script* procedures that prepare and send personalized feedback directly via e-mail based on the answers provided. The system indicates, in a first part, the percentage on how much the participant is in line with the expected behaviors in relation to each dimension and then, in a second part, the item-by-item comparison between the expected response and that provided, integrated by the specific feedback (Fig.4).



Dear participant,
First of all, thank you for taking part in the survey!

The evaluation that we present highlights the overall degree of AGREEMENT divided, for the four categories, between its answers and those of the reference model adopted by the authors. The categories are naturally schematizations that contain the components connected to the attitude adopted in teaching ...

Dimension	Evaluation
DESIGN / PLANNING Dimension	77 %
COGNITIVE Dimension	39 %
EVALUATION Dimension	45 %
MANAGEMENT Dimension	57 %

In the form below, you will be able to compare the choices you have made and the reference answers.
Where there are discrepancies, he can consult the feedback point by point.
Yours sincerely,
The authors of the System.

	Dimension	Answer	Expected answer	Feedback
1	DESIGN / PLANNING Dimension n.1	1	1	*In your professional experience, an effective teacher believes that ...* *... in most cases the pupil himself suggests the topic to be discussed, the activities and the time to devote to them.* **Ok**
2	DESIGN / PLANNING Dimension n.2	1	[1-2]	*In your professional experience, an effective teacher believes that ...* *... it is very important to present the real problem to the pupil as a whole and let him discovering the resolution for himself.* **Ok**
3	DESIGN / PLANNING Dimension n.3	2	1	*In your professional experience, an effective teacher believes that ...* *... to define the Learning goals of the lesson, it is necessary to follow the structure of the contents and follow the same order of the paragraphs in the textbook.* **The expected answer is: 1** Wrong procedure. A learning goal does not identify with the theme of the lesson. The passage from the theme to the Learning goals involves a transformation of the contents into categories and cognitive processes (terms, main concepts, basic knowledge, in-depth knowledge, etc.) which must then be operationalized, that means they must be translated into specific assessment tests.
4	DESIGN / PLANNING	2	[1-2]	*In your professional experience, an effective teacher believes that ...* *... Entering the classroom it is above all important to rely on your creativity and improvisation skills.*

Fig.4. The customized feedback.

The custom feedback identifies the dimensions where the participants may have some lacks and the specific items where they are not in line with the expected answers. For these items, the feedback allows each user finding critical issues and underlining his/her own actual training needs that may lead to any kind of insights and learning deepening.

This system, on the other hand, allows experts and instructional designers having a complete detail on their students. They may see the overview related to the dimensions, by accessing the dashboard of the system which, in the range of time when the participant filled out the questionnaire, is shown as the percentages of each participant and the mean values on all the considered samples (Fig. 5).

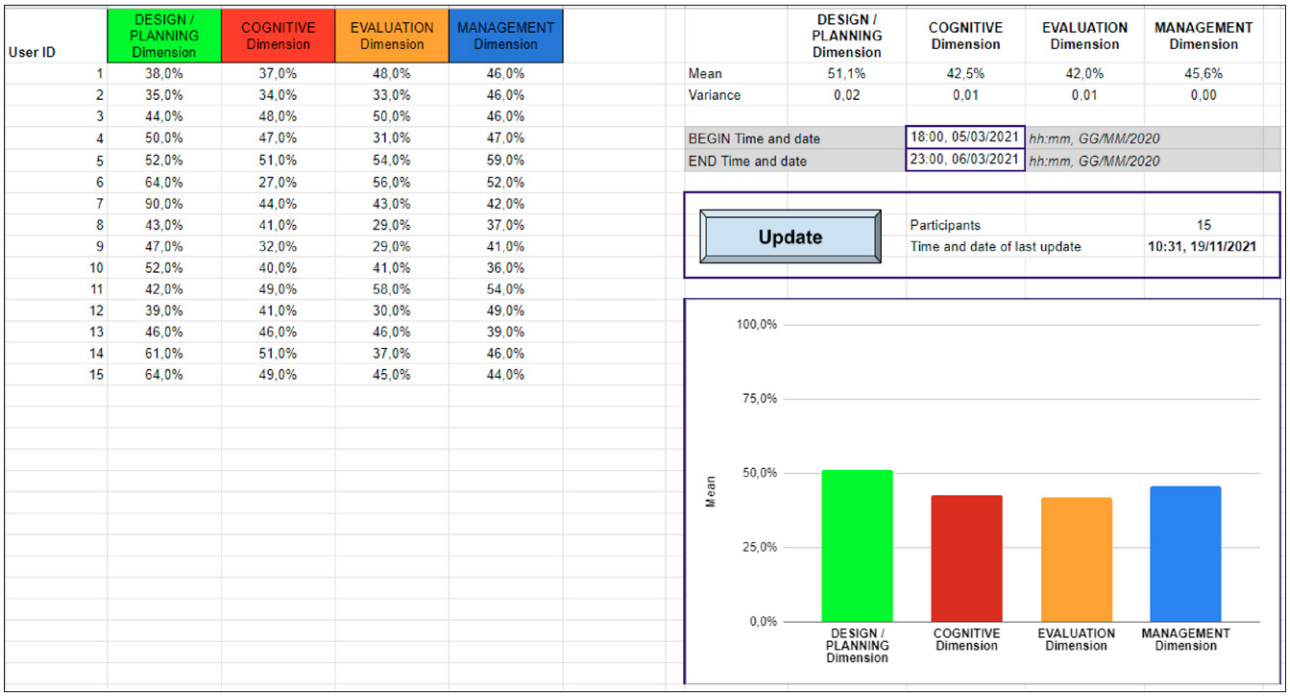


Fig.5. The dashboard of the developed management system on the dimensions of ETQ3.

Experts and instructional designers may also see a detailed report on all the items of the questionnaire. The system shows the percentage of the nearness of the answers of the participants to the expected answers on each item (Fig.6). It allows them identifying the real lacks of the engaged users and it may correctly address any consequent teaching actions with the aim of filling in those gaps.



Fig.6. The dashboard of the developed management system on the items of ETQ3.

3. An exploratory investigation

This investigation is in line with the studies described by Calvani, Marzano and Miranda (2021) that, by means of the same ETQ3 questionnaire, identified in both preservice teachers and in-service teachers the same *mindframes* and the

same lacks in terms of knowledge, abilities and attitudes that usually lead their behavior in facing didactic situations that happens in the classroom during their teaching experiences. In particular, these results are also close to those detailed by Menichetti, Pellegrini and Gola (2019) and found by using some previous versions of ETQ.

Thus, during the research described in this paper, new data regarding the attitudes of the school teachers with respect to the situations identified in the cited four dimensions have been collected. In doing this, 333 schools teachers that have been subscribed to professional training activities have been engaged. They are from 5 comprehensive schools distributed in 3 different regions: Calabria, Emilia Romagna and Campania in the school year 2020-2021. Most of them are employed in primary schools (154 teachers). The others are divided between lower secondary school (111 teachers) and kindergarten (68 teachers). The sample is detailed in Table 1. To these participants, ETQ3 has been delivered and the results have been gathered.

Table 1. The distribution of the engaged teachers by school order.

	Kindergarten	Primary School	Lower Secondary School	Total
IC1—Calabria	19	35	43	97
IC2—Emilia Romagna	23	49	32	104
IC3—Emilia Romagna	0	37	2	39
IC4—Campania	24	10	17	51
IC5—Calabria	2	23	17	42
Total	68	154	111	333

The analysis of the answers has been conducted in general on the four identified dimensions and in detail on the individual items. It allowed observing how much the declared behaviors differ from the expected ones. Fig. 7 shows the results emerged from the administration of ETQ3 to all the involved teachers in this investigation. The reference value of 100% in each dimension means that all the answers in that dimension are equal to those pointed out by experts and stored as expected answers.

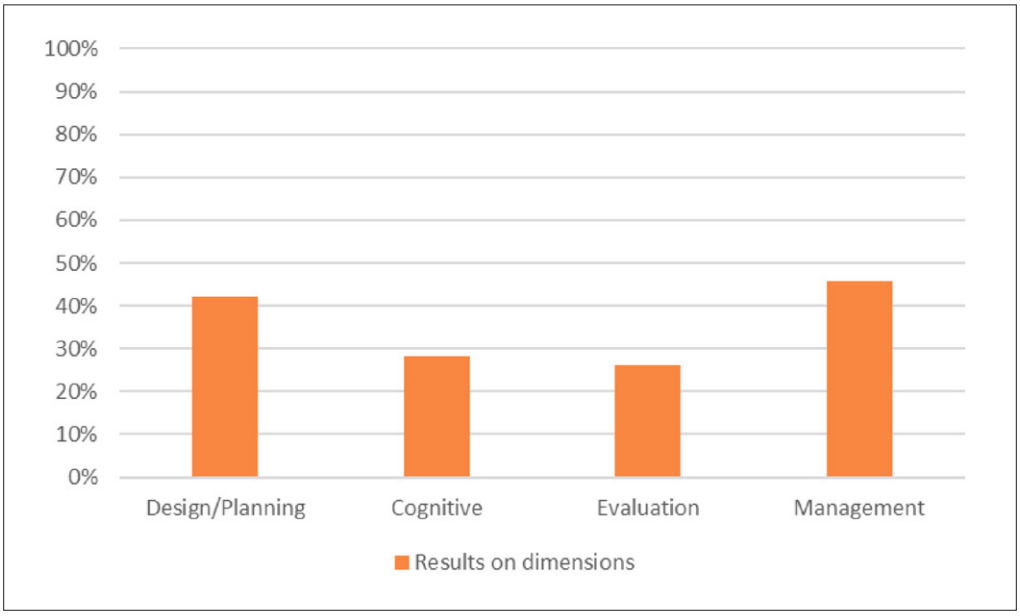


Fig.7. Similarity between declared and expected behaviors on this investigation that adopted ETQ3.

The bars represented in Fig.7 highlight the lacks on these chosen dimensions of the engaged teachers. In particular, knowledge and beliefs on the design/planning and management are just a little bit over 40% and evaluation and cognitive aspects are under 30%. It means that they are far enough from the expected answers expressed by the experts and it highlights real gaps on the participants. This analysis has been done also on the items of the questionnaire. Fig. 8 shows the percentages on each item.

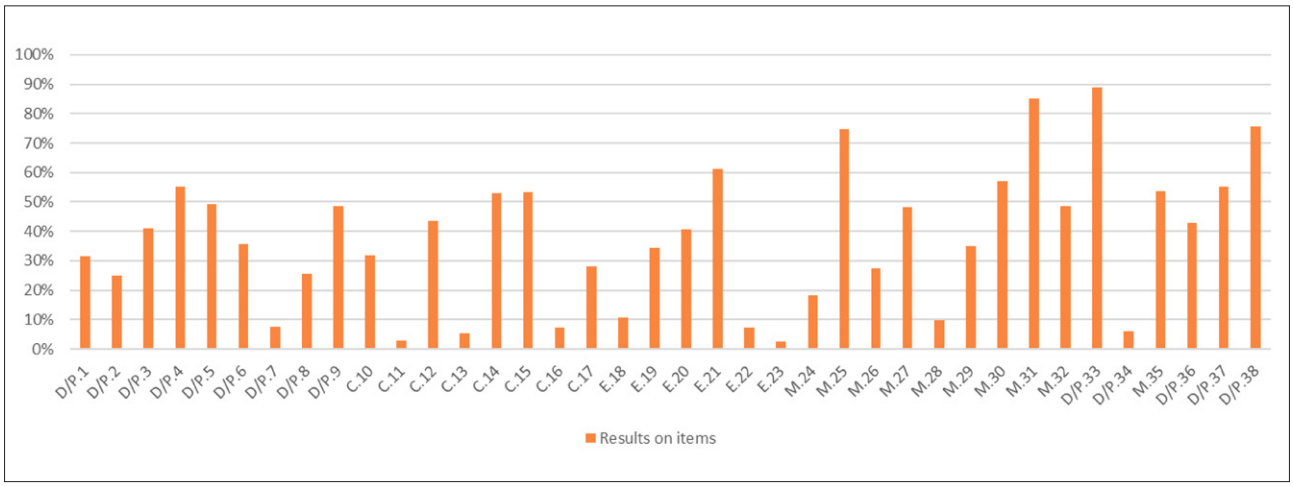


Fig.8. A comparison of the results on each item on this investigation that adopted ETQ3.

The items are related to the four dimensions: *design/planning* (D/P), *cognitive* (C), *evaluation* (E) and *management* (M). It should be noted that teachers do not know that increasing information and multimedia do not mean improving learning (items on the *cognitive* dimension: C.11 and C.16). This implies that they have little knowledge on the cognitive load theory and the consequent need to avoid overload. They have an incorrect approach to evaluation (items on the *evaluation* dimension: E.22 and E.23) since they ignore the importance of giving feedback immediately and they identify learning activities as means of verifying learning outcomes. Misconceptions are also confirmed on the goodness of consoling and renouncing attitudes (item on the *management* dimension: M.28) that are ineffective *mindframes* (Hattie, 2009). They trust in teamwork for hyperactive subjects (item on the *design/planning* dimension: D/P.34). Finally, teachers do not consider it important to have a precise idea of the lesson before entering the classroom (item on the *design/planning* dimension: D/P.7). It is interesting that these points of maximum dissonance confirm what has already emerged from the previous application of ETQ3 (Calvani, Marzano & Miranda, 2021) on the four identified dimensions and on the specific items on different participants. In other words, in the attitudes and knowledge of teachers, there could be constant features that evidence the lack of some fundamental notions and particular cognitive traits.

Mindframes relating to the nature of learning and teaching but also lack of information constitute a complex world of teachers that affects their decision-making process and that distinguishes their level of expertise. Also, this investigation with different items on the same problems highlights in the participants a set of naive beliefs on teaching due to misinformation and recurrent stereotypes in line with models and "myths" (Calvani & Trinchero, 2019) that would need cultural interventions, reviews and comparisons with the progress of research in order to adopt a more critical attitude of one's own teaching.

Conclusions

The use of the automated feedback system has, in this specific exploratory investigation, brought to light that teachers' beliefs on effective teaching are concentrated on specific dimensions. This reinforces the starting idea that teachers acquire mindframes within which they structure their attitudes in teaching and they hardly abandon them over time. Providing personalized and targeted feedback to bring out misconceptions and ineffective mindframes on teaching and learning can therefore be a valid help in training courses dedicated to teachers. This action, far from constituting an assessment of teachers' teaching practices, demonstrates its usefulness in identifying teachers' mindframes at an early stage so as to be able to implement a more specific and personalized training. This allows its application to be extended to further training areas as well as constitute a preparatory action for numerous training activities (guided discussion with experts, observation on practice, modeling, etc.).

The exploratory survey presented here will have to be supplemented by further interventions that could be developed in the future. These include an analysis of the usability of the system by teachers and the evaluation of the effects that the tool can have on the training provided. It is also possible to hypothesize its use as a pre- and postevaluation tool of training interventions, or in training courses for future teachers.

Acknowledgments

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