Dynamic concept maps to support e-learning and evaluation processes

Mappe concettuali dinamiche per supportare i processi di e-learning e di valutazione

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When technologies enter the learning processes, it is always advisable to analyse the changes they trigger carefully. This is because their effects are difficult to predict and generalize. There are several factors related to the times, ways, status, culture, even digital, of the subjects involved and therefore any statement should derive from careful observations and cautious analysis.This article moves along the line of research traced by a laboratory of the University of Salerno, the laboratory RIMEDI@, using for a further academic year, a technology within a learning environment, the e-Lena platform. In fact, this use derives from a first phase of experimentation from which the results have emerged identified possible future developments. After that, a series of corrective measures have been implemented to proceed now with this second experiment, which is either to confirm or refute the results already obtained and to verify the effectiveness of the changes made. The access to the environment is provided in addition to the classroom teaching, so it assumes a form of support and not a substitute form of in presence teaching. We tried to verify if our enriched online learning environment could stimulate remediation processes between digital and analogic artefacts in students and represent a mean to supportautomatic evaluationprocesses. In other words, we would answer the question related about if it favours the development of meaningful learning. The use of this technology was therefore observed and the data collected analysed to be able to synthesize conclusions and outline new objectives in order to move the next steps in research. The results confirm once again that the environment built in e-Lena offers an effective support to students. It takes a significant role both in activating remediation experiences and in automating evaluation processes, so it could encourage the development and the consolidation of learning.

Keywords: Assessment, e-Learning, Dynamic Concept Maps, Automatic test generation

Quando le tecnologie "entrano" nei processi di apprendimento, è opportuno analizzare con attenzione i cambiamenti che attivano. Questo perché gli effetti che producono sono difficili da prevedere e da generalizzare. Sono diversi i fattori che interagiscono (tempi, modi, cultura anche digitale dei soggetti coinvolti) e ogni affermazione dovrebbe derivare da osservazioni accurate e analisi prudenti. Questo articolo si muove lungo una direttrice di ricerca del laboratorio RIMEDI@dell'Università di Salerno nel quale, nell'ultimo triennio, è stato sperimentato ed implementato un ambiente virtuale di apprendimento all'interno della piattaforma e-Lena. L'accesso all'ambiente viene fornito in aggiunta all'insegnamento in aula, quindi assume una forma di supporto e non una forma sostitutiva di insegnamento in presenza. Obiettivo dell'indagine è stato quello di verificare se, e in qual misura, l'ambiente di apprendimento online potesse stimolare negli studenti processi di rimediazione tra artefatti digitali e analogici e rappresentare un mezzo per supportare processi automatici di valutazione. I risultati confermano che l'ambiente costruito in e-Lena offre un supporto efficace agli studenti. Esso assume un ruolo significativo sia nell'attivazione delle esperienze di rimediazione che nell'automazione dei processi di valutazione, in modo da incoraggiare lo sviluppo e il consolidamento degli apprendimenti.

Parole chiave: Valutazione, e-Learning, Mappe concettuali dinamiche, Generazione automatica di test

The authors shared the concept of the work and elaborated the text according to the following breakdown. Antonio Marzano, scientific coordinator of the research, provided the proposition and the general lines of the work, being for this indicated as first name; he also took care of the sections Introduction, 1. Theoretical context and objectives, 4. Data analysis. Sergio Miranda took care of the sections 2. Methodology, 3. The TEST-Maker tool. Both authors elaborated the section 5. Conclusions.

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Introduction

The survey described in this paper has been carried out in the academic year (AY) 2017-18 and represents a further development of a broader experimental plan launched in the AY 2014-15. The objective of the first research was to verify if and how it was possible to experiment with learning evaluation methods supported by automatic test generation processes able to provide diagnostic information on the progress of learning (formative evaluation), to favour self-assessment, offer feedback for improvement in progress of the training paths designed by the teacher. We were starting from a prototype developed by Miranda et al. (2013) which, from a knowledge domain and a semantic modelling based on ontologies (Sutt & Motta, 2004; Naeve et al., 2006), was able to produce test batteries related to all domain topics and to the logical relations between them (Alsubait, Parsia, Sattler, 2012). The tool (*TEST-Maker*) had been experimented in the teaching of "IT and telematic skills" (18 hours, 3 CFU) of the degree course in "Education of playrooms, socio-educational laboratories and recreational services for the childhood"held in the second semester of the AY 2014-15 at the University of Salerno. The battery of tests generated by *TEST-Maker*, delivered to 89 students, had been validated in terms of its overall reliability and the results emerged empirically confirmed the correctness of the conceptual and algorithmic structure at the base of the automatic generation tool (Marzano, Miranda, & Orciuoli, 2017). In the subsequent academic years (2015-16, 2016-17), *TEST-Maker* had been further improved and implemented.

The empirical survey carried out in the AY 2016-17 was designed as a further "segment" of the multi-year experimental plan which we referred to at the beginning of the paragraph and with the aim of responding to a specific question: can aspecifically designed environment stimulate reciprocal remediation processes in students (Bolter & Grusin, 2002) between digital and analogical artefactsand encourage the development of meaningful learning, one in interaction and hybridization with the other one? The survey involved 201 students enrolled in the bachelor of "Science in Primary Education" at the University of Salerno attending the "School and Educational Design" course. The experimental data were collected by elaborating and using four tests for the verification of learning. The network interaction space

for experimentation was the *e-LENA* platform, the Learning Management System of the RIMEDI @ research laboratory. The analogical artefacts we consider are mainly books, papers and any kind of material that is not available on digital devices.

The results that emerged (Marzano, 2017) were positive and confirmed our hypotheses: the virtual environment was an effective support for the students, a device that encouraged the processes of remediation between digital and analogical artefacts, favoured the development and the consolidation of learning.

The references presented up to now constitute the starting point of the research carried out in the academic year 2017-18 and of which we are going to present, after a theoretical and methodological study, some specific processes and aspects.

1. Theoretical context and objectives

This research is part of the use of technologies in teaching, with the aim of verifying the impact in terms of learning. Specifically, we analysed the synergistic use of dynamic concept maps (hereinafter DCM) in an e-learning platform to verify the activation of remediation processes by students attending the AY 2017-18. Methods and techniques of educational research (Master's degree in "Professional educators and experts in continuing education") of the University of Salerno. In particular, we wanted to verify if the DCM could stimulate processes of reflection, the necessary in-depth analysis (also on the book) and thus succeed in bringing a benefit compared to the conventional study alone. The attempt was to understand its formative potentials by proposing a possible interpretation of this process by using the historical-cultural approach of Vygotsky (1974), enriched and "contaminated" by the perspective of reciprocal remediation of Bolter and Grusin (2002) inspired to the theories of McLuhan (1967). "A medium is what remedies" (Bolter & Grusin, 2002); the remediation is the way to "refashion" a media. For instance, photography remediated painting, internet sites remediated newspaper pages. In our study, we consider the remediation processes related to the didactic resources for our courses and the new digital way to keep their knowledge available.

In order to trigger remediation, we assumed that it is essential to have a well-designed learning environment. The interaction space for experimentation was that of the *e-LENA* platform created by customizing the *Moodle* solution and integrating it by means of other components specifically developed in order to respond to the needs associated with the research initiative.

The Vygotsky historical-cultural approach is fundamental to our understanding of the relationships between artefacts and minds. For Vygotsky (1974), the learning and psychic development of the person are determined by biological, instrumental, historical and socio-cultural factors. The cultural context, through its signs and tools, acts as a mediator of the cognitive process of the person. The use of an instrument contributes to the formation of concepts that transcend the instrument itself and therefore allows the emergence of meanings and the construction of new knowledge to interact and solve problems. The artefact can act as a mediator between the individual and the world, triggering transformations in the cognitive characteristics of the individuals themselves (Bonaiuti, 2005). Using an artefact, as a result of intentional and non-involuntary processes (Rossi & Toppano, 2009), transforms the same knowledge for which it was designed (Norman, 1991) and in its design we must therefore consider the task for which it will be used.

The DCMs that we tested in this work are cognitive artefacts developed to favour the processes of conceptual systematization through a graphical representation that, according to Novak and Gowin (1989), can favour the emergence of the meanings inherent in the materials to learn and stimulate the reflection on the nature of knowledge and on the relationships between them. Visualizing knowledge through concepts and logical links allows better understanding it, to select the main information compared to the secondary ones and to trigger processes of retrospective analysis and re-elaboration (Rivoltella, 2010). In the field of teaching, when tools for the representation of knowledge are used, two recurring limits concern their static nature and their being limited to broad but generic or specific and restricted domains. These objective difficulties prompted us to design the DCMs as a mediation artefact that allow us navigating the concepts by opening the nodes and discovering from time to time the nodes of existing children and relationships, as well as accessing to the contents associated with them. The DCMs, in our research, have been designed to verify if, and to what extent, they could stimulate reciprocal reconstruction processes between digital and analogical artefacts in both directions (Bolter & Grusin, 2002) and, consequently, favour the hybridization between different mediums (Latour, 1991) for the development of meaningful learning.

These are the basic theoretical references for the research that has been proposed to investigate the role of learning environments in the network, meaning them as devices built with regulatory values. We have made a change, compared to the experimentation carried out in the previous year: the tests were processed by using *TEST-Maker*. The aim of this work is therefore to verify the reliability of the tests automatically generatedby using *TEST-Maker*.

2. Methodology

The students attending the course of "Methodologies and techniques of the educational research" of the Master's Degree in "Professional educators and experts in continuing education"(30 hours, 6 CFU) were involved.

The educational objectives of teaching are to promote the ability to develop and implement research activities, also encouraging the development of practical-applicative skills compared to some techniques and tools that can be used in the different phases of the experimental plan. The teaching program includes, during the assessment of the learning, a mid-term (optional) and a written preliminary and mandatory test to support the interview. The written exam consists of 30 multiple-choice questions divided into two sections (the first 15 items related to the first training segment of the course and the subsequent items, from number 16 to 30, relating to the second segment) and is considered to have been exceeded with at least 8 replies exact for each of the two sections of the test. With the passing of the intermediate exam (whose verification refers to the first training segment) the students, in the subsequent written test (the obligatory one to hold the interview), must answer only the last 15 items of the test.

The educational activities started on October 10th (ending November 30th 2017). In the first two lessons (10th and 12th October), the research project was presented and voluntary participation in the experimentation was proposed.

The second training segment of the course consisted of the study of three chapters taken from one of the two recommended texts for individual study. Participants would be informed during the previous lesson (on Tuesday) the chapter to be studied to take the written test to be held on the following Thursday. The test, consisting of 15 multiple-choice questions, was passed by answering exactly at least 8 questions. The passing of the three tests was equivalent to passing the second section of the written exam. Passing also the optional intermediate test, the students could directly access the oral interview. The experimentation consisted of dividing the participating students into two groups by sampling technique: the students of the first group, the control group (CG), used the book for the preparation for the test; the students of the second group, the experimental group (EG), used the *e-LENA* platform. 59 students participated in the experimentation. From the list, sorted alphabetically, by systematic sampling, the two groups were defined (Table 1).

	CG	EG
Males	3.3(1)	6.9 (2)
Females	96.7 (29)	93.1 (27)
Total	100	100
(N)	30	29

Tab. 1: The composition of the two groups

The trial began on November 7th and the first test was delivered on November 9th. The subsequent tests were carried out on a weekly basis (November 16th and 23rd). The study materials (Table 2) were taken from the book*Methodology of research in education and training* (2002).

Date	Materials
November 9th	The experimental design
November 16th	The evaluation survey
November 23th	Evaluation tools

Tab. 2: The calendar of the experimentation and the study materials

The concept maps were developed according to the Quillian (1968) approach. For each topic, the concepts of a higher order have been identified, from which other less general concepts are expanded hierarchically, which are articulated in further categorization (Marzano & Miranda, 2018). The concepts were placed in a semantic relationship between them (Lalumera, 2009) through the use of predicates (Galliani & Notti, 2014). Three different dynamic maps were constructed, containing respectively 54, 59 and 56 concepts. The maps created were added to the *e-LENA* platform as educational resources. When accessing these resources, the user-student displays only the root node, can click and display all the relationships that start from this node and the related "children" nodes connected to it. On the displayed nodes, you can repeat the opening actions of the relationships and the child nodes or access the contents associated with each of them. The nodes and relationships, in fact, are displayed one level at a time leaving the user free in navigation and allowing him to customize his experience of discovery (Fig. 1).

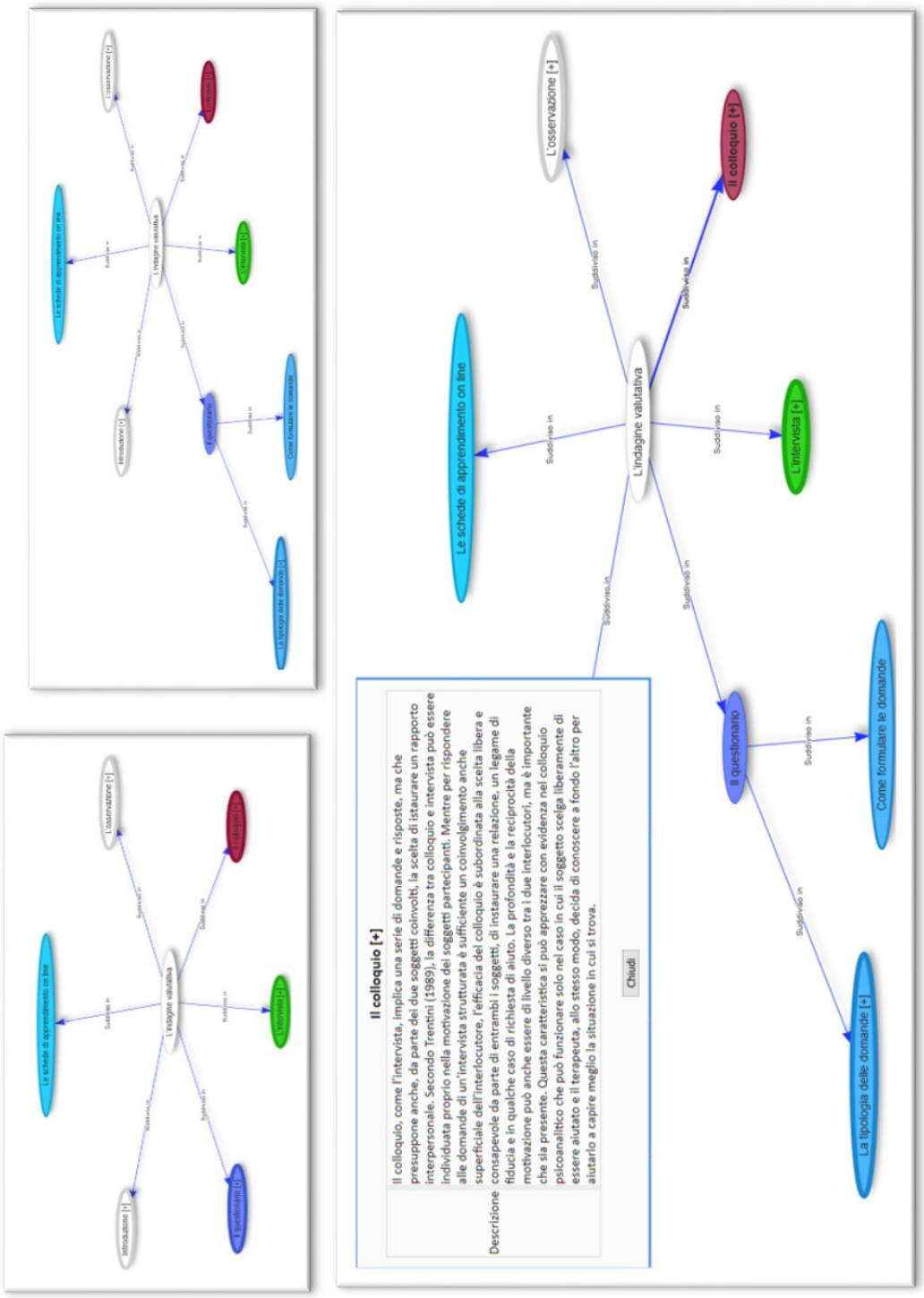

Fig. 1: The dynamic concept map

3. The *TEST-Maker*tool

The automatic generation of tests is based on the design of a concept map as a useful tool for the purposes of a common and shared organization of a specific knowledge domain. The schemes used refer to the semantic web paradigm whose architecture aims to enrich data and information with metadata and semantic maps to facilitate understanding and processing. Considering the definition of Gruber (1993), according to which a semantic map is the specification of a conceptualization (through an appropriate definition/description of the concepts and relationships that may exist for an object or a set of objects), we canaffirm that they facilitate the interpretability of content and constitute a basis of "learning objects" organized through the terminological consent for their indexing and designed with the aim of being reused and shared. The use of maps makes it possible to identify explicitly determined relationships by defining knowledge structures and inference rules.

Having said that, we considered a concept map as a shared knowledge structure negotiated and formalized by the scientific community through semantic description languages (Studer et al., 1998). The ontological structure reflects the shared conceptual core and aims to integrate the formal dimension of a knowledge domain with the relational one of the daily activities of the different communities of practices and learning. In essence, they are configured as support environments for the representation of knowledge: they organize the key concepts of a specific knowledge domain, define and interconnect them dynamically between them through semantic relations (Marzano & Notti, 2015). Conceptual networks thus formalized want to qualify as instruments mediators of the complexity of a field of knowledge.

In the case under examination, the concepts used for the definition of the three maps refer to the topics and themes reported in Table 2. Exploiting the procedures of Euzenat and Shvaiko (2013) according to which an ontological representation with any number of relationships can be brought back to one in which the types of relationships present are only relations of order or decomposition, it was chosen to draw the concept map (also known as the subject ontology in Miranda et al., 2016) with only three types of relations (*Subdivided into*, *Prerequisite of*, *Suggested Order*) in order to simplify the representation of the domain of knowledge taken into consideration and therefore to reduce the algorithmic complexity during the generation.

Starting from these ontologies, our tool is able to generate the questions for the verification testsautomatically. In order to articulate its composition, some "distractors" are also created using concepts and descriptions external to the treated domain as well as non-existent relationships.

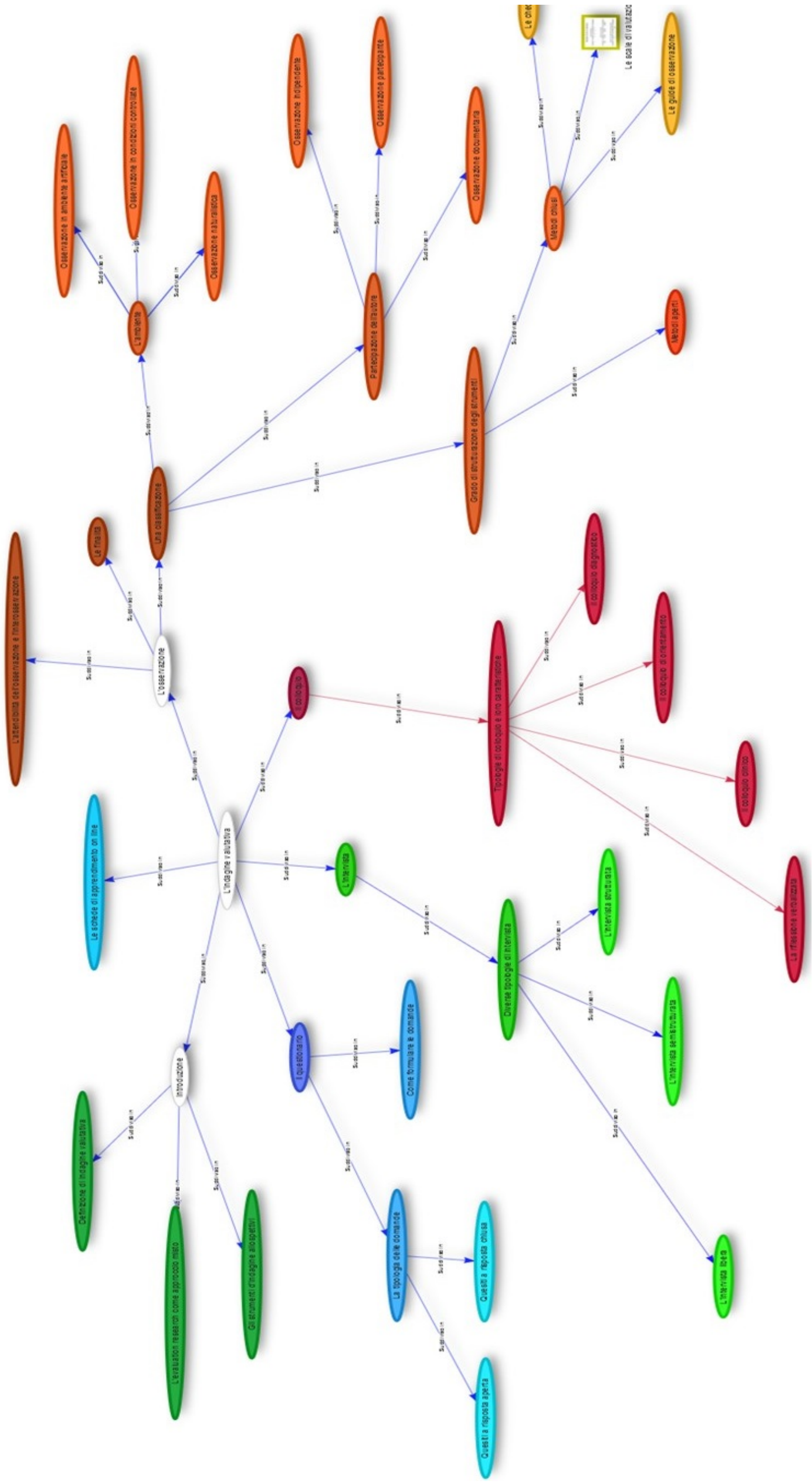

Fig. 2: The concepts and the relations of the map "L'indagine valutativa"

The types of questions generated (in our case we have used only the multiple choice questions) can only be textual or with images in the body of the application itself. The text is created with simple rules of composition using the name of the concept, the description, the outgoing relationships and the names of the concepts connected by these relationships. The images are created either by taking parts of the ontology or by adopting different criteria of representation (ensembles, analogies, puzzles).

The logic of creating the questions is mainly linked to the navigation of the relationships of the knowledge map. The level of complexity of the questions can vary according to the depth of the relationships that goes from the simplest direct link (level 1) to more complex semantic subsumed relations or links outlined by a chain of relations of the same type (level *2, 3 , 4,… n*, based on the length of the chain).

Once the ontology has been defined, it is possible to "activate" the test generation tool which analyses all the direct and semantically derived relationships and, based on a series of parameters and options, creates the questions to construct the verification tests (Fig. 3).

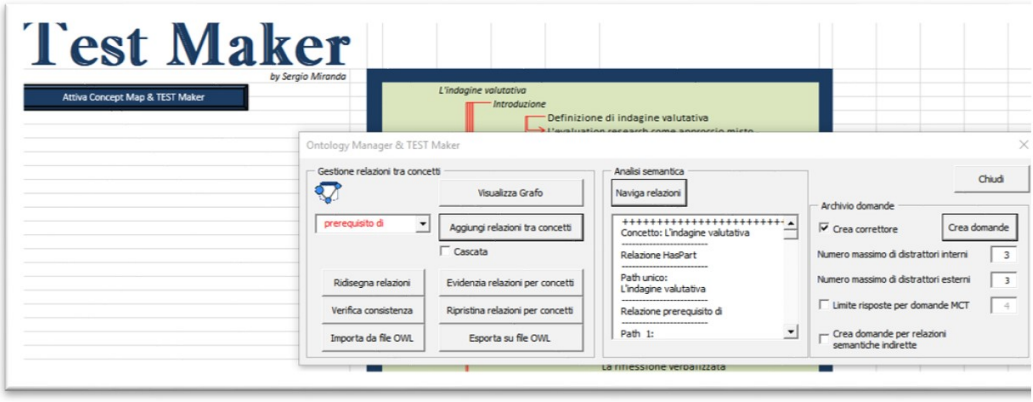

Fig. 3: The Automatic Test Generation Tool

The creation phase is automatic and, based on the choices made, the tool creates a single battery of questions or various random combinations to be used for verification tests to be printed or distributed through, for example, an e-learning platform. An example is shown below (Fig. 4).

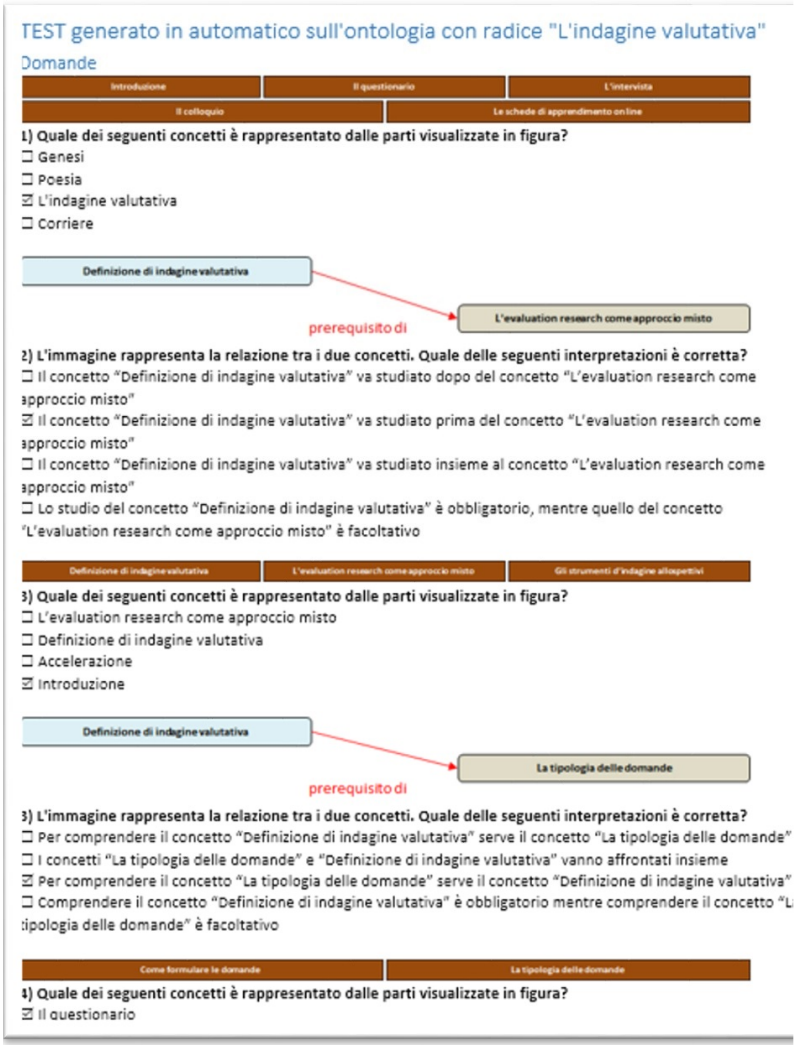

Fig. 4: Examples of tests generated automatically

4. Data analysis

The first test (15 items generated by *TEST-Maker*) was given on November 9th to the 59 students participating in the trial. In order to be able to grasp the significance of the collected data, we first proceeded to perform a first series of statistical elaborations (Table 3): the calculation of the central tendency indices (*arithmetic mean*,,*modal value*, Mo and *median*, Me), of the standard deviation and of the Cronbach coefficient.

		Mo	Me		
CG	7.21	8	7	1.97	0.79
EG	7.45	7	7	2.11	

Tab. 3: The statistics of the first test

Overall, the test was neither too easy nor too difficult. The value of the standard deviation indicates a fair level of homogeneity of the scores and a distribution of responses almost symmetrically concentrated around the value of the mean as regards the trend of the scores in the two groups. The value of Cronbach's indicates a fair internal homogeneity of the test. We present the indices emerged from the processing of data related to the administration of the second test (Table 4).

		Mo	Me		
CG	7.86	8	7	1.67	0.74
EG	7.72	8	7	1.75	

Tab. 4: The statistics of the second test

Also in this case, the test was neither too easy nor too difficult. The value of the standard deviation indicates a good level of homogeneity of the scores and the value of the Cronbach shows a discrete internal homogeneity of the test. The statistics on the data of the third test are in the Table 5.

		Mo	Me		
CG	8.05	9	8	1.44	0.83
EG	8.21	8	8	1.52	

Tab. 5: The statistics of the third test

The value of the standard deviation indicates a good level of homogeneity of scores and a distribution of responses almost symmetrically concentrated around the value of the mean. The value of Cronbach's indicates a good correlation and internal homogeneity of the items of which the survey instrument is composed. Overall, the data show a substantial homogeneity about the performance of the students of the two samples.

With the analysis of the questions, some characteristics of the ques-

tions generated by *TEST-Maker* were verified. In particular, the focus was on checking the ability of the tests to adequately select the students according to their level of preparation. In this sense, one of the methods that can be used to ascertain the reliability of the questions used to verify the knowledge held by the students, is the *item analysis* or analysis of the answers, which allows obtaining information about the reliability of a test on the whole and on the functioning of the single items (Notti, 2003). This procedure is carried out to ascertain the degree of difficulty of individual questions and their ability to discriminate in relation to the overall outcome. It is therefore possible to check whether, and to what extent, there are questions that are too trivial or too difficult, ambiguous or ill-structured questions, if each item is discriminating, i.e. able to quantitatively differentiate students based on the different knowledge possessed.

The Table 6 shows the values assumed by the indices of difficulty (*D*) and of discriminativity (*d*) related to the entire battery of applications used, highlighting the criticalities in bold.

	D	d
1	0,5	0,6
2	0,6	0,7
3	0,7	0,6
4	**0,3**	**0,3**
5	0,6	0,7
6	0,7	0,7
7	0,6	0,4
8	0,6	0,5
9	0,7	0,8
10	0,6	0,5
11	0,6	0,7
12	**0,4**	**0,3**
13	0,6	0,7
14	0,5	0,6
15	0,6	0,5
16	0,7	0,6
17	**0,3**	**0,4**
18	0,6	0,7
19	0,7	0,6
20	0,6	0,7
21	0,5	0,7
22	0,5	0,6
23	0,6	0,5
24	0,5	0,6
25	0,6	0,7

26	0,7	0,6
27	0,5	0,7
28	**0,8**	**0,4**
29	0,6	0,6
30	0,5	0,7
31	0,8	0,7
32	0,7	0,6
33	0,5	0,4
34	0,6	0,5
35	0,7	0,6
36	0,6	0,7
37	0,5	0,7
38	0,5	0,6
38	0,5	0,6
40	**0,4**	**0,5**
41	0,7	0,6
42	0,7	0,6
43	0,6	0,5
44	0,6	0,6
45	0,5	0,6

Tab. 6: The values of the indices D and d

There are five questions that present critical values in the indexes (4, 12, 17, 28 and 40). However, the test is on average reliable and of fair quality. Ultimately, considering what emerged from the data processing, the tools built for the verification of the learning can be considered valid and reliable. This data seems to confirm empirically the correctness of the conceptual and algorithmic structure that is at the base of the automatic test generation tool named *TEST-Maker*.

5. Conclusions

The research was a continuation of the survey already carried out in 2016. Although starting from the same objectives and using the same methodology, a modification concerning the elaboration of the tests was introduced using a tool called *TEST-Maker*. In this sense, the objective was to verify the reliability of the tests processed through the use of this semi-automatic generation software with the aim of providing an effective, valid and reliable support tool. While considering that any measure is essentially an approximation (De Luca & Lucisano, 2011), the analysis of the results relative to the quality of the single items and of the overall test is decidedly encouraging and can be, in

perspective, the premise for the development of an application to support the processes of self-evaluation also useful for in progress re/planning the training paths.

The results that emerged must be taken into account in order to launch further and more in-depth investigations. In fact, the latest version of *TEST-Maker* can and must be further improved. For this reason, the authors have planned some actions to be launched during the next AY2019-20 in order to make it even more reliable and effective. Moreover, in parallel, the system will be experimentally integrated as a self-assessment tool in *e-LENA*, the e-learning platform of the *RIME-DIA*, the researchlaboratory in Media Education and Active Didactics of the Department of Human Sciences, Philosophy and Education of the University of Salerno.

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