Deep Understanding. Control of student understanding in university during distance and face-to-face learning

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Abstract
The health emergency of 2020 has led many university professors to wonder about how to check that the information presented in their lessons generates a correct conceptual representation in their students and, above all, to ask themselves if they have carried out the right training actions capable of triggering what is called deep understanding, that is a set of cognitive processes that produce durable and meaningful learning. This paper describes two experiences conducted in two different Italian universities that have been designed and implemented precisely with these objectives. The achieved results are very encouraging and could represent a starting point to reflect on the methodologies, teaching practices and tools to be used in distance and face-to-face university courses.

Key words: Deep Understanding; Dynamics Concept Maps; Metacognitive Self-Regulation; Learning

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1. Promoting the deep understanding

The pandemic of 2020 has forced the transition to new forms of university teaching. It has led to questions about the control of the correct understanding by the student of the information transmitted in online or face-to-face,

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synchronous or asynchronous didactic interactions. This is not a new problem: at the end of an academic face-to-face lecture, what do we do to check that the information we have presented has generated a correct conceptual representation in each of the students who followed us? It is the problem of the *understanding* (Wiggins & McTighe, 1998, p. 44-62), that is the "mastery" that the student develops in describing the concepts and assertions that are the object of learning, constructing examples, using them to subsume cases, summarize texts, represent them in the form of schemes or maps, explain phenomena, associate them with others, compare them and find similarities and differences. The distinction between a *shallow understanding* and a *deep understanding* is important (Gore *et al.*, 2009). The first one refers to a superficial understanding, deriving from a simple mechanical stimulus-response association, which even a machine would be able to realize. In humans, a shallow understanding can also be a first step towards a good preparation, because it organizes a first conceptual network that the subject can then expand and make more complex. However, if we stop at this level, learning remains – in fact – mechanical. The transition to the deep understanding takes place through training actions that stimulate the student to systematically carry out a plurality of cognitive operations (i.e. active exercise of cognitive processes on specific contents) inherent to learning objects (Trinchero, 2021).

The idea of carrying out this work was born from these considerations. This paper describes two experiences done in two different Italian universities but designed and implemented with the same goal: to stimulate students to develop a series of related cognitive operations to specific contents systematically to favor the development of durable and meaningful learning. These two experiences are in the next sections.

2. An educational experience at the University of Turin, not only in an emergency

Especially in university teaching, several studies show that assessment practices have a strong impact on the quality of learning (Boud & Associates, 2010; Brown, 2014; Andrade & Brookhart, 2019) and assessment methods can significantly influence the university experience of students, their approach to study, the quality of their learning and the results they obtain (Grion, Serbati, Tino, & Nicol, 2017; Price, Carroll, O'Donovan & Rust, 2011). Evaluation can be a powerful agent of involvement and empowerment (Coggi & Pizzorno, 2017; Trinchero, 2020; 2021) as long as it overcomes the limits inherent the traditional evaluation since, often, it is centered on a single summative exam that takes place at end of the university course.

Precisely for this reason, it is necessary to overcome the idea of evaluation intended only as the final moment of a path – substantially isolated from the path itself – and to distinguish three evaluation perspectives (Earl, 2003). The perspective of summative assessment (*assessment of learning*) must be accompanied by that of formative assessment (*assessment for learning*), an ongoing moment aimed at monitoring learning outcomes and proposing course corrections (Nicol & Macfarlane-Dick, 2006), but also – and above all – that of the formative evaluation (*assessment as learning*), that is itself a moment of learning (Trinchero, 2021). In the assessment as learning practices, the student carries out evaluation activities proposed by the teacher which have the aim of both monitoring his acquisitions and assigning him an active, involved and critical role in giving meaning to the information he has experienced, in linking it to his previous knowledge and in achieving the mastery of the knowledge in question. In this perspective, evaluation becomes a regulatory process, activated by metacognition, which leads the student to monitor, personally and systematically, what he is learning through frequent and systematic evaluation tests and to use the results of this monitoring to make adjustments, adaptations and changes, also substantial, in one's understanding. In this way, the evaluation process is welded to the learning/teaching processes (Pereira, Flores, & Niklasson, 2016) and favors active and participatory attitudes on the students. The student himself is empowered to identify strengths and weaknesses of his own preparation and is stimulated to build his autonomy of judgment both in the diagnostic operation on his own knowledge and in defining recovery and growth paths (Munns & Woodward, 2006). In this perspective, assessment is a formidable tool for testing the student and activating both bidirectional teacher-student and student-student feedbacks, that are described by numerous meta-analyzes (Hattie, 2009; Hattie & Timperley, 2007) as key elements to promote effective learning, but also to develop students' self-assessment skills. The term self-assessment refers to a broad spectrum of activities united by the fact that a subject must describe and assign judgments of merit/value to their products and learning processes (Panadero, Brown, & Strijbos, 2016; Panadero & Alonso-Tapia, 2013; Brown & Harris, 2013). Self-assessment can affect study success if it represents an ongoing, systematic and not impromptu operation (Andrade, 2010; 2019; Brown, Andrade, & Chen, 2015; Brown & Harris, 2013; Butler, 2011; Panadero, Jonsson, & Botella, 2017). The goal is to build a self-evaluation habitus that leads the student to reflect in a natural and automatic way on the goodness of his own acquisitions, as they occur, supported by the teacher and by a semi-automatic system that guides him in the right directions, helping him to understand what should be considered good work and what not. In this way, self-assessment can foster the development of critical and reflective thinking, a better understanding of the criteria for evaluating one’s performance

and a better depth of content processing (Logan, 2009), as well as a greater sense of responsibility for one's own learning (Yorke & Longden, 2004).

The experience of the Experimental Pedagogy course for the First Level Degree Course in Educational Sciences, specialization in nursery school and infant communities (included in the study plan in the second year) is going to be described in the following. It has been held in the months from October to December 2020 by one of the authors at the Department of Philosophy and Educational Sciences of the University of Turin (*www.edurete.org/psol*, detailed description in Trinchero, 2021).

In the months from February to May 2020, the course was remodeled for remote asynchronous use, with a view to ensuring both the display of content and the control of in-depth understanding of it, and an initial experimentation was carried out. The students were advised to use the paper text as an insight into what they saw in the video and on the slides. 20 activities were built that the students could carry out remotely and that, in the next editions of the course, will also be used in classroom teaching, in order to support, integrate and – in the case of non-attending students – replace classroom participation. Each activity includes:

a) Watching a video of about 30 minutes in which the teacher carries out a short lesson supported by slides with animations. The animations are very important as they give the right cadence and sequencing to the speech, avoiding to immediately present slides that are too "dense" of text and making the concepts appear as the teacher, visible in the video window on the side, describes them. If the activity is used in person, the video is replaced by the teacher's lecture and the video obviously constitutes a support that the student can use at home, later, to integrate any parts that are not fully understood.
b) The student's reading of the slides presented in the video, available on the platform in pdf format, prior to or at the same time as viewing the video. This allows the student to take notes directly on the slides.
c) The carrying out of a text comprehension test, consisting of closed-ended questions and open-ended questions, specifically aimed at promoting deep understanding. The test is the crucial element of the process: the questions are designed to lead the student to perform a plurality of cognitive operations related not only to recognizing the definitions presented in the video and slides in the questions and answers, but also to reasoning in depth and application on the contents. In particular, the student is asked to:
   1) *Grasp* the essential elements in the text and in the video presentation;
   2) *Identify* specific information within the text and video display;

3) *Select* the information elements useful for formulating elements of an empirical research (hypotheses, factors, operational definitions, samples, data collection plans) and use them in a relevant way;
4) *Describe*, *classify*, *compare* key concepts exposed in the text and in the video;
5) *Produce* inferences starting from the information given;
6) *Produce* personal interpretations of given situations;
7) *Compare* personal experiences with given situations;
8) *Attribute* points of view to certain currents of thought;
9) *Summarize* the main ideas present in the text and in the video exhibition;
10) *Derive* implications from the information present in the text and in the video exhibition.

The questions proposed are partly closed-ended (with automated correction) and partly open-ended. In the latter case, the feedback is given by comparing the student's answers with the answers of peers and by the teacher, who inserts – with agreed periodicity – comments and suggestions (with different colors) next to the students' answers. All students can immediately see the feedback given to all the others, obviously anonymously, so that they can also learn from any mistakes made by their classmates. If the Activity is used during face-to-face lectures, the comprehension test is carried out in the second part of the lesson and the teacher supports the students in the correct understanding of the questions and automatic feedback given by the computerized system.

As the results are tracked on the server, the test is useful for the student but also for the teacher. He may monitor the student's participation in the course (not only in terms of "how many minutes he is on the platform", but in terms of the cognitive operations he is able to perform correctly on that given topic) and to trace the evolution of performance over the duration of the course (ten weeks). Structured in this way, the Activity is a real formative evaluation activity: the student learns the concepts while carrying out the evaluation test itself, by using all the supports that the teacher has made available to him actively.

From a first survey of 131 students, substantially positive opinions emerge. Tab.1 shows how the students agree with the reported statements.

Tab.1 - Questionnaire results

Question	Answers	No.	%
S1. Carrying out the activities of the online course oriented me in the study of the course materials	*No* and *More NO than YES*	9	7
	More Yes than NO and *Yes*	122	93

S2. Designing the empirical research that I will conduct in the field in the online course activities allowed me to better understand the concepts studied	*No* and *More NO than YES*	9	7
	More Yes than NO and *Yes*	122	93
S3. Carrying out the online course activities gave me tools to improve my ability to reflect on my preparation	*No* and *More NO than YES*	10	8
	More Yes than NO and *Yes*	121	92
S4. Carrying out the activities of the online course allowed me to better understand the concepts studied	*No* and *More NO than YES*	12	9
	More Yes than NO and *Yes*	119	91
S5. Carrying out the activities of the online course allowed me to better apply the concepts studied to carrying out empirical research	*No* and *More NO than YES*	13	10
	More Yes than NO and *Yes*	118	90
S6. Carrying out the activities of the online course allowed me to better understand which things were to be studied and which were not	*No* and *More NO than YES*	13	10
	More Yes than NO and *Yes*	118	90
S7. Carrying out the online course activities allowed me to understand what I understood and what I did not understand about the course topics	*No* and *More NO than YES*	16	12
	More Yes than NO and *Yes*	115	88
S8. Carrying out the activities of the online course made me understand some concepts that I did not understand well in the study	*No* and *More NO than YES*	16	12
	More Yes than NO and *Yes*	115	88
S9. Carrying out the online course activities made me understand how I should study the course topics	*No* and *More NO than YES*	18	14
	More Yes than NO and *Yes*	113	86
S10. Carrying out the activities of the online course gave me tools to apply the concepts studied to work at the nursery or in other educational services	*No* and *More NO than YES*	22	17
	More Yes than NO and *Yes*	109	83
S11. Carrying out the activities of the online course allowed me to interact productively with my classmates	*No* and *More NO than YES*	28	21
	More Yes than NO and *Yes*	103	79
S12. The teacher's feedback in the online course activities allowed me to better understand the concepts studied	*No* and *More NO than YES*	29	22

	More Yes than NO and *Yes*	102	78
S13. Carrying out the activities of the online course taught me a study method that I will also apply to take other exams	*No* and *More NO than YES*	46	35
	More Yes than NO and *Yes*	85	65
S14. Carrying out the activities of the online course led me to become passionate about the subject	*No* and *More NO than YES*	46	35
	More Yes than NO and *Yes*	85	65
S15. If I hadn't had to do the online course activities, it would have taken less time to prepare for the exam	*No* and *More NO than YES*	88	67
	More Yes than NO and *Yes*	43	33

In a very large majority, students declare that the online course activities oriented them in the study of the course materials (93%), gave tools to improve the ability to reflect on their own preparation (92%), helped them to better understand the concepts (91%), better apply the concepts studied in carrying out an empirical research (90%), better understand the topics to focus on (90%), understand what was understood and what was not (88%), understand concepts that in the were not well understood (88%), understanding how to study course topics (86%), applying the concepts studied to nursery work (83%), interacting productively with classmates (79%), teaching a study method also useful for other exams (65%), being passionate about the subject (65%). The control item (S15) obtained a 33% approval rate, substantially confirming the reliability of the responses to the other items. These results confirm the students' satisfaction and the judgment of effectiveness assigned by themselves to the adopted approach.

3. An educational experience at the University of Salerno

The methodological approach presented in this section is one of the research guidelines initiated by the *Research Laboratory in Media Education and Active Didactics* (Rimedi@) of the University of Salerno and is a further development on the use of *dynamics concept maps* (DCM) in online learning environments as remediators within the teaching-learning process (Marzano & Miranda, 2020). The historical-cultural approach of Vygotsky seems to be particularly effective to understand the relationships between the minds of the engaged learners and the artefacts and to clarify how these artefacts are useful to investigate the potential of the devices and tools used in online learning. For

Vygotsky (1978; 1987; 1999), cultural artifacts and codes play a decisive role: the tools and signs of the cultural context mediate the cognitive process of the person through direct experience on and in the world. Therefore, this is a semiotic process (interpretation and production of signs) that allows the emergence of meanings and the construction of new knowledge and new ways of thinking derived from lived experiences based on the use of signs to solve problems, to accomplish tasks and to communicate. Ultimately, using an artifact transforms the knowledge for which it has been designed. This perspective also includes the notion proposed by Norman (1991; 1993) who defines a cognitive artifact as an artificial device designed to store information, to present it or treat it in order to ensure a representative function and to affect human cognitive activity.

DCMs are cognitive artifacts specifically designed to favour processes of restructuring, conceptual systematization and production. In fact, with the support of multimedia environments, numerous control processes intervene: the mobilization of previous knowledge, the reflection (Azevedo, 2005; Schraw, 2007; Veenman, 2007), the metacognitive regulation. The self-regulation (Winne & Hadwin, 2008) is of fundamental importance since in this process, the students themselves set their own learning objectives, regulate their cognitive processes and give themselves the right motivation in compliance with contextual constraints (Brown, Armbruster & Baker, 1985; Wells, 2013).

The use of DCMs has its theoretical justification in the research carried out by Ausubel (1963, 1968) on *meaningful learning* (ML) and by Novak and Gowin (1984) on the reticular form of knowledge and the possibility of representing it through concept maps. In fact, ML was born and identified in the processing of knowledge (Kalyuga, 2009) when students use strategies aimed at connecting the new acquired information to existing knowledge structures. ML strategies are more effective than any form of rote learning and there is evidence that their success depends on the cognitive processing they raise up (Dunlosky *et al.*, 2013). In this sense, several experimental or quasi-experimental studies have shown how students learn by building, modifying or simply observing diagrams with nodes and edges among them (Nesbit, Olusola, 2006; Karpicke, Blunt, 2011; Schroeder et al., 2018).

From these premises (and due to the persistence of the pandemic emergency), the planning of the teaching activities of the *School Experimentation and Educational Planning* course (8 university credits) for the Degree Course in Primary Education at the University of Salerno was developed. The educational activities, during the academic year 2020/21, were carried out completely online through the synchronous use of the *Microsoft Teams* platform, starting on 29 September 2020 and ending on 2 December 2020 for a total of 48 hours. The methodological and organizational modalities

of the course were presented to the students. In particular, in parallel with the traditional organization of lectures, in-depth studies and discussions, a participation on a voluntary basis in an experimental educational path was proposed. All students were asked to join a private *Facebook* group that was used as a notice board and as a means of communication for the timing of the activities. Every Sunday afternoon, a *Facebook* post communicated the topic to study. The following Wednesday, a written test was held on this (a test consisting of 12 multiple-choice questions). There were 4 weekly administrations and a subsequent summary test on the four topics previously assigned (25 multiple choice questions). These tests, in practice, covered half of the exam program[1]. Each administration was carried out at the beginning of each lesson and lasted about 20 minutes. The administration of a final test at the end of the course was aimed at verifying the topics covered in the virtual classroom relating to the second half of the exam program (40 multiple-choice questions)[2]. Passing all the tests (it was mandatory to complete all of them) was equivalent to passing the written exam in preparation for the oral interview.

The students participating in the experimental path would have used, for independent and individual study, the recommended study materials (textbook) and the *DCMapp* software for the development of concept maps on the topics communicated with the posts on *Facebook*. The "non-participating" students would have used the book only and could still take the required tests.

DCMapp is a prototype application designed and built as an integration of the *e-Lena* platform, an e-Learning platform based on *Moodle* architecture and specially customized to meet the specific needs of the courses held at the University of Salerno. With *DCMapp* (Fig.1), it is possible to design and build DCMs, define nodes and edges by giving them both graphic and content form. Users may upload multimedia material, manage the dynamic display modes through which concepts related to others can be displayed or hidden according to the needs of those who surf it (for example, *DCMapp* displays one level at a time in a hierarchical map and opens the next ones from time to time according to curiosity, interests or needs of users). In this paper, we will pay our attention only to the description of the path followed by the 113 students who, on a voluntary basis, used *DCMapp*.

[1] The remaining time was dedicated to the discussion of the test and to the deepening of the topics to be verified by means of the DCM developed previously and representing the reference model for the evaluation of the DCMs developed by the students (no reference to these results are reported in this paper).

[2] The verification tests have been delivered in a customized *Moodle* platform and the supervision during the tests was carried out through the *Zoom* platform.

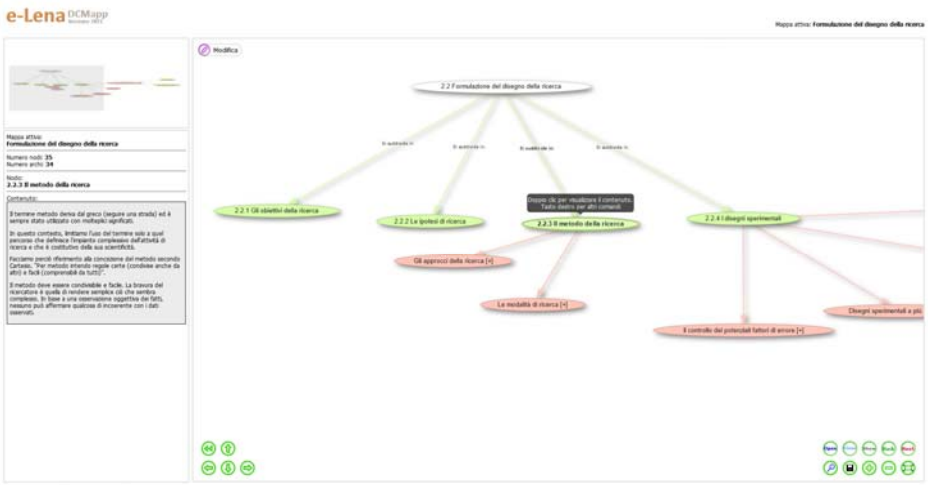

Fig. 1 - DCMapp allows users creating and navigating dynamic concept maps

DCMapp has an integrated tracking system that allows getting data on the use made by the participating students. The data was analyzed to identify the number of created maps, the actions performed in total, the actions performed on each map and the total time of use of *DCMapp* (the minimum number of created maps equal to 2 means that the 113 students have created at least two concept maps each; the maximum number of created maps equal to 9 indicates that some students have developed more than the 4 expected maps). Tab.2 shows a summary of the data relating to the use of this app.

Tab. 2 - Statistics on the use of DCMapp

	Min	Max	Average
Number of maps created	2	9	4,7
Number of actions done	117	5471	1136
Number of actions done for each map	27	782	240
Total time in hh:mm:ss	00:51:38	73:42:44	12:40:57

At the end of the teaching activities, students filled in an online questionnaire on the study methods and the effectiveness of the use of concept maps (13 questions to be answered on a 4-level Likert scale). Of the 113 participating students, 110 completed the final questionnaire. Table 3 shows the overall data of the detected frequencies. In order to make students' opinions more evident, we aggregated the percentages of the extreme and contiguous

modes of the dependent variables considered (*No* and *More NO than YES*; *More Yes than NO* and *Yes*).

Tab.3 - Questionnaire results

Question	Answers	No.	%
A1. Building dynamic maps improves learning.	*No* and *More NO than YES*	18	16
	More Yes than NO and *Yes*	92	84
A2. Building dynamic maps takes a long time.	*No* and *More NO than YES*	23	21
	More Yes than NO and *Yes*	87	79
A3. The study of the book is facilitated after the construction of the dynamic maps.	*No* and *More NO than YES*	24	22
	More Yes than NO and *Yes*	86	78
A4. Studying with dynamic maps increases study times.	*No* and *More NO than YES*	34	31
	More Yes than NO and *Yes*	76	69
A5. The construction of dynamic maps allows you to identify the salient points of the topic to be studied.	*No* and *More NO than YES*	4	4
	More Yes than NO and *Yes*	106	96
A6. Dynamic maps allow you to effectively organize study times.	*No* and *More NO than YES*	53	48
	More Yes than NO and *Yes*	57	52
A7. The study with dynamic maps stimulated you to deepen the topics with the book.	*No* and *More NO than YES*	36	33
	More Yes than NO and *Yes*	74	67
A8. Building dynamic maps is simple.	*No* and *More NO than YES*	41	37
	More Yes than NO and *Yes*	69	63
A9. The construction of dynamic maps allowed you to better organize the study carried out with the book.	*No* and *More NO than YES*	27	25
	More Yes than NO and *Yes*	83	75
A10. The construction of dynamic maps facilitates the organization of contents.	*No* and *More NO than YES*	13	12

	More Yes than NO and *Yes*	97	88
A11. Dynamic maps allow you to efficiently organize study times.	*No* and *More NO than YES*	55	50
	More Yes than NO and *Yes*	55	50
A12. Studying from the book improves learning when combined with the construction of dynamic maps.	*No* and *More NO than YES*	21	19
	More Yes than NO and *Yes*	89	81
A13. I worked out the map with "pen and paper" before building it on the web.	*No* and *More NO than YES*	66	60
	More Yes than NO and *Yes*	44	40

The students believe that the construction of DCMs facilitated the organization of study contents (A10), facilitated the study of the book (A3), stimulated its in-depth study (A7) and allowed to identify the relevant points of the topic to study (A5). On the other hand, the construction of maps, albeit simple (A8), takes a lot of time (A2) and increases study times (A4, A6, A11). Finally, the students believe that the construction of DCMs improves learning (A1, A12). These data are encouraging and an average positive evaluation emerges.

4. Some concluding reflections

The pandemic has raised problems, but it has also led to new opportunities. First, it led to reflect on past practices and exposed several pre-existing criticalities. Among these, there is the problem of monitoring students' understanding of what the teacher has said, stimulating the experimentation of well-known strategies but that are, often, under-used. The experiences described in this paper have made us understand that there is no way to go back. The tools designed for the pandemic must be put into operation for the future, to help all those students who cannot fully benefit from the possibilities related to the face-to-face interaction and to improve the interaction itself.

The positive opinions of the students are important. They seem to recognize the role of the tools proposed in stimulating the self-assessment of the understanding of the concepts of the course, in guiding the efforts in the study, in applying these concepts in practice.

A famous aphorism attributed to Albert Einstein defines the crisis "the greatest blessing for people and nations, because the crisis brings progress". It is not automatic that this is the case, but it can be. It depends on us.

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