Testing Understanding by Design

New Zealand Journal of Teachers' Work, Volume 21, Issue 1, 104-119, 2024

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ABSTRACT

Understanding by Design (UbD) is a well-known curricular methodology aiming at leading students to develop a deep understanding of the arguments proposed by teachers. Through a path including stimulating questions, student motivation, deepening of the argument, reflection, design and assessment of authentic performances, the students develop a broad understanding of the learned argument. While there are plenty of articles describing various experiences in classrooms and schools showing the benefits of UbD, rarely has this methodology been the object of experimental or quasi-experimental studies. A study conforming to quasi-experimental criteria has been performed in a Swiss vocational school, where a teacher taught two groups of students using UbD principles, while using with a third group a more usual teaching approach. The curriculum topic was the study of mathematical relations and functions. The results, collected during one school year, showed that the first two groups outperformed the third and that the effect of UbD lasted at least for one school year. Since the teacher remained the same, we can likely attribute the outcome to the use of the methodology.

HELPING STUDENTS IN DEVELOPING UNDERSTANDING

Understanding is one of the fundamental aspects of meaningful learning (Darling-Hammond & Snyder, 2015; Gardner, 2011; Perkins, 1997). A particular field of study is mathematical understanding (Lerman, 2020; Saxe, 2015), that will be the object of the present article. All of us know the experience of failing to fully grasp a concept, and when this happens, we realize that under such conditions, our learning can become fuzzy and superficial. One of the key characteristics of authentic understanding is the attribution of meaning to a specific situation, based on valid inference. Through this process, we connect a certain number of related elements in a structured and meaningful way. Evidence of understanding can occur when the consequences of our inferences apply to a real or realistic context. As Wiggins and McTighe say (2011, p. 6):

> The term understanding is surprisingly tricky, even though it is used widely. It has many different connotations. In fact, you may be aware that Benjamin Bloom and his colleagues (1956) avoided using the term

> in their taxonomy of the cognitive domain because it was seen as imprecise. Yet the term intuitively stands for something important—and different from content mastery, per se. Therefore, at the start, we invite you to stop and reflect. What is understanding? What do we mean when we say we want students to understand the content, not just know it? What is the difference between really "getting it" and just regurgitating back what was taught? If you are like most people, you identified a few clear yet different meanings of the term. Some meanings tend to be about ideas and inferences (e.g., making connections, seeing the big picture, grasping core concepts), and some tend to involve effective use of knowledge and skill (e.g., teach others, say it in your own words, apply learning to a real-world setting, defend your views to an audience). At this point, we merely note that the term is multifaceted, that understanding is something different from mere "knowing," and that the goal of understanding therefore involves instruction and assessment that are more sophisticated than teaching and testing for knowledge and skill alone. If the goal is designing understanding, we will need to plan mindful of these meanings.

It is worth underlining that, even with a teacher who relies on more conventional teaching methods, some students will develop adequate understandings of the topic (see, for instance, the experiences on introducing discovery learning performed by Castronova, 2002). However, others fail to develop analogous mental processes (Minarni et al., 2016). Students at various levels tend to simply reproduce what is taught without clearly grasping the connections between the basic arguments, or they simply give up on learning altogether. This outcome is often due, among other things, to a lack of faith in the meaning, utility, and usability of the contents taught at school. Some students consider such concepts far too abstract and believe that learning could lead to failure in every case. In short, they perceive learning as a waste of energy, and this perception can lead to academic amotivation (Balkis, 2018; Lan & Lanthier, 2003). This kind of situation can have, as a result the development in teachers of the belief that understanding is something achievable only by excellent students. Bruner (1960, p. 33), known for his rather provocative statements, opposes this view and states that “any subject can be taught effectively in some intellectually honest form to any child at any stage of development.”

With this statement, Bruner argues that if teachers teach concepts in a sufficiently accessible manner to every student, considering the development of their mental structures and their state of previous knowledge, along with other conditions such as motivation and attention, the outcome will be a corresponding learning. The understanding of a topic - which is worth emphasizing, can have different degrees of sophistication and complexity (Stamp & Armstrong, 2005) - can be attained and developed by a vast majority of students as long as it aligns with their learning style and is achievable and appropriate to their mental structures and previous knowledge, and in the presence of other conditions such as motivation and attention (Dixon et al., 2014). UbD is an effective teaching methodology for developing understanding among students (Dari, Hidayat & Wulandari, 2024; McTighe & Wiggins, 2014; Ozyurt, Kan & Kiyikci, 2021; Tshering, 2022). Understanding-based forms of knowledge can be of great importance not only for learning but also for the individual (Bada & Olsegun, 2015; Dellsén, 2016). And this is even more true in today's world, where machines are becoming more and more logically evolute (Redecker, 2017, p. 25)

In this context, it is important for the school to see understanding not as something that a student simply possesses or not, but as a mental habit with a greater or lesser sophistication that every student can develop and deeply assimilate.

> The students we graduate from our schools will need to be both more deeply and widely educated than ever before. They will have to be equipped to learn new things quickly and well; to set high standards for themselves and be prepared to work hard to meet those standards; to constantly and easily apply what they are learning to unexpected problems and challenges with creativity, patience and determination; to collaborate closely with others while at the same time acting as an individual with agency and purpose. They must be prepared to act with empathy and understanding, a deeply grounded sense of ethics and, above all, character. (Tucker, 2019, p. 8)

Understanding a topic means having a great idea that can remain for a lifetime, but also contributes to getting an attitude to grasp great ideas in general. This premise is very important for a better appreciation of the study presented in the next pages. As Luckin et al. say (2016, p. 46), "as humans live and work alongside increasingly smart machines, our education systems will need to achieve at levels that none have managed to date."

UNDERSTANDING BY DESIGN

As the name suggests, UbD is a well-known curricular methodology created by Grant Wiggins and Jay McTighe aiming at structuring a learning path where most students will develop a deep understanding of the taught arguments. From an epistemological point of view, UbD shows a clear constructivist orientation (Morris, 2o21; Wilkerson, 2022). Various domains currently use this approach, and it seems to be quite popular in medical instruction (Cline and Rinaldi, 2023; Joyce and Swanberg, 2017; Newell et al., 2023). To be successful, it is paramount for the teacher to carry out their educational design in terms of "backward planning" (Wiggins and McTighe, 2005). However, what is this? Usually, a teacher "covers" the topics stated in the curriculum and, based on the structure of the latter, develops their own teaching path. Then, after teaching each topic, they usually perform some kind of evaluation. Only at the end of this sequence does the teacher find time to consider students' understanding. Regardless of the teacher's goodwill, there is a real risk of understanding coming last, getting lost on the road between planning, teaching and testing. Backward planning, as the term suggests, proceeds in the opposite direction: first, it requires the teacher to define the key concepts, the "great ideas" to be understood. The definition of a suitable assessment process for checking the level of understanding achieved by the students follows this stage (Dean, 2019). This happens through the planning of an "authentic performance", i.e. a concrete situation that the pupils must manage, a task implying the use of understanding for the definition, development and practice of a successful strategy. The assessment of this performance happens most times using rubrics. Unlike more traditional approaches, the educational path will define the lessons and assessments "along the way" only in the last instance. Beyond the importance given to understanding, this way of proceeding has two major advantages: first, the educational activities are immediately "oriented" towards the development of forms of understanding; the required performance in real or realistic environments is not a self-referring end (practice for the sake of practice), but it assumes its full meaning within the planned learning path. The following figure summarizes the entire process:

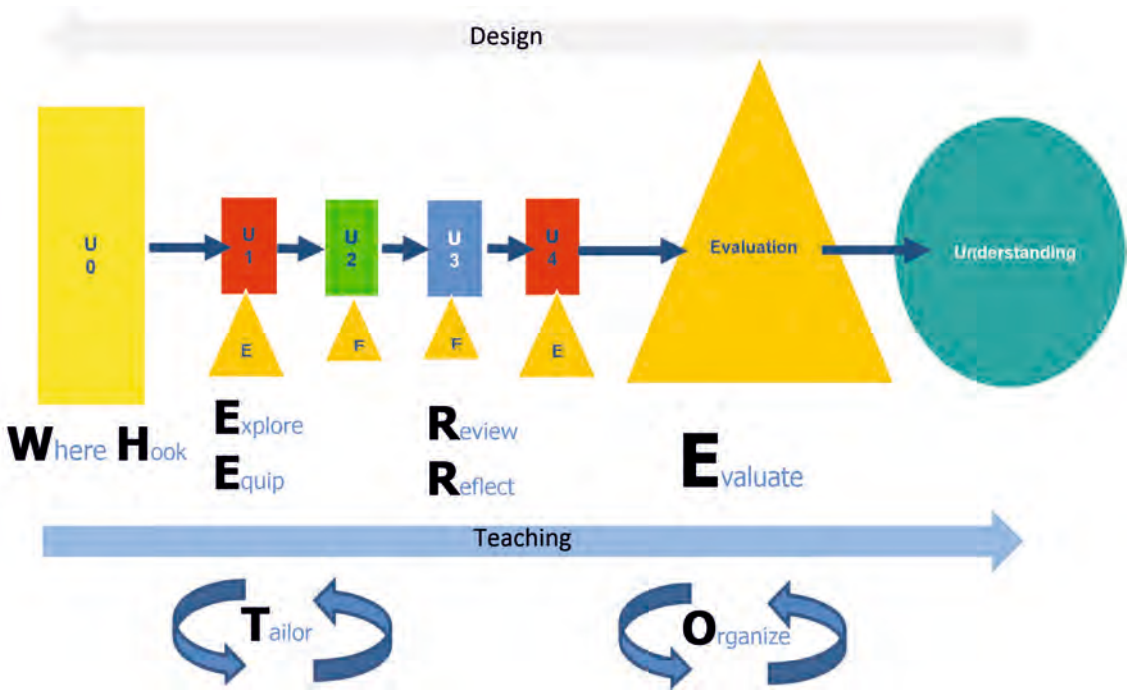


Figure 1: project and performance of learning units using Understanding by Design

The process divides into two distinct paths: planning and performing. In the first, represented in the diagram by the upper arrow, moving from right to left (i.e. with a greater or lesser degree of sophistication "backwards"), the teacher identifies the key aspects that must be understood, defines the authentic performance and expresses fundamental questions on the topic. Following this, the teacher plans the corresponding learning units in detail. Planning does not happen once and only once, definitively, but is a reiterative process with a certain flexibility, which allows the teacher to adapt the foreseen path to the concrete conditions encountered in the classroom during the implementation.

The well-defined order of the sequence of learning units (U) is structured in seven phases, each represented by a letter, part of the acronym WHERETO. The first stage, distinguished by the letter W (Where), has an introductory nature. Its aim is to communicate to the class "where" the teacher would like to guide the students, i.e. the planned educational path. The teacher asks the students to respond to several original and stimulating questions related to the issue, aiming to raise their motivation to deepen the topic. These play the role of authentic "attractors", drawing attention and arousing curiosity in the students: their fundamental role is to foster pupils' interest in the chosen arguments. This stage, represented by the letter H (Hook), has the function of "hooking" the students, and as said before, has a motivational function. However, to give a valid answer to these provocative and stimulating questions, it is necessary to deepen the issues under discussion. For this reason, during the following lessons, the students are usually eager to explore and deepen the topic (E); in the meantime, they have in mind the conclusive, authentic performance that will need to be carried out.

During the following stage, students will devote themselves to a review of the performed work (R), based on their reflections; this phase will lead to the definitive structuring of the authentic performance. It is important to remember that teachers perform these formative stages using appropriately different approaches to teaching and learning (lessons, group work, reflections of the entire class, work in pairs, etc.). This aspect is figured through different geometric shapes for every learning unit in figure 1. The small triangles with the letter E show the corresponding evaluation for each learning unit: these evaluations "on the path" can be more or less formal, depending on the activity, ranging from brief questions "on the fly" to checklists, to more elaborate processes of formative assessment. Finally, there will be the conclusive evaluation (E), which is carried out through an authentic performance which is usually evaluated through rubrics, asking students for a self-assessment of their performance and inviting them to compare / negotiate their judgment with the one expressed by the teacher. The letter T (Tailor) shows the personalization (differentiation) of the learning process, including the enhancement of the strengths and the attention to the particular needs of each student, while the letter O (organize) refers itself to the concrete organization of learning experiences oriented towards discovery. These two processes operate continuously, recursively, throughout the entire cycle.

RESEARCH QUESTIONS

When someone observes a class where a teacher uses UbD, or takes part in their first experience of the application of the methodology, they cannot fail to observe how students express a powerful motivation for the performed tasks and take an active part in what is happening. The entire process is well conceived and, as mentioned before, it leads to a genuinely constructivist experience, where the teacher can operate with both flexibility and rigor. The combining of elements from the Deweyan tradition, inserting them organically into authentic and concrete performances, is also noteworthy. However, while these are all detectable through qualitative reports based on subjective experience, they can also be the object of further corroboration through experimental or quasi-experimental procedures. Various constraints make it impossible to secure random samples of students, as required by experimental protocols. However, quasi-experimental studies are feasible using parallel classes in which the teacher can apply different approaches. In the case presented in these pages, a mathematics teacher with three classes of a state institute for commerce (the Centro Professionale Commerciale - CPC in Chiasso, Switzerland) took part in a study on the effectiveness of UbD. This methodology proved effective in other experiences on math teaching (Diviva, 2017; Li & Wen 2023; Pramesti & Dewi, 2023). These were the research questions:

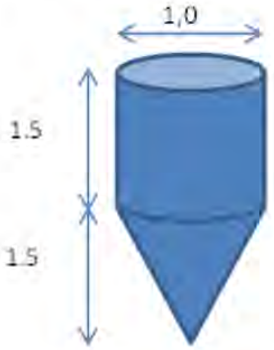
- Does the use of the UbD methodology provide better learning results, compared to a more conventional approach, when teaching a mathematical topic (mathematical relations and functions)?
- Do the answers given by the students to the "understanding-oriented" items (which aim more at the explanation and argumentation of the choices made, rather than their formal correctness) show a positive difference in terms of understanding in the experimental groups?
- Can we say that the students belonging to the experimental groups show a better global understanding of the mathematical ideas of relation and function?
- Do the attained results last?

EVALUATING THE EFFECTS OF UNDERSTANDING BY DESIGN: METHODS AND RESULTS

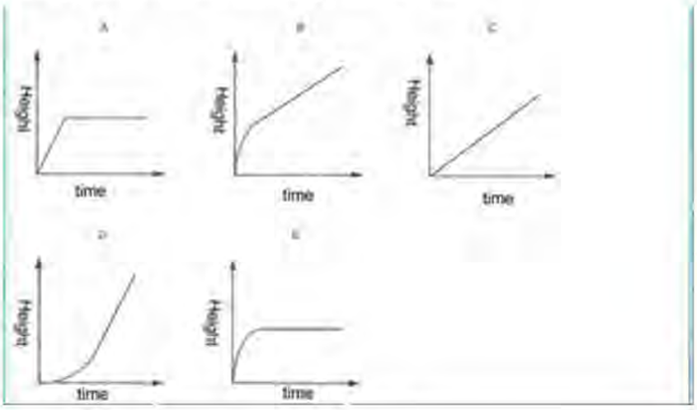
From a theoretical point of view, UbD is based on the principles of learning and cognition research conducted by Bransford and his colleagues, where understanding is a key factor for successful learning (Bransford, Brown & Cocking, 2000, cited in McTighe & Seif, 2003; McTighe & Willis, 2019). It finds support in studies on the use of authentic pedagogy in schools and its benefits (e.g. Newmann, 1996). Although the theoretical basis of this methodology is solid and recognized, there are only a few empirical studies corroborating its benefits through quasi-experiments (Dari, Hidayat & Wulandari, 2024; Ozyurt, Kan & Kiyikci, 2021; Tshering, 2022; Yurtseven & Altun, 2017). This led to the decision to investigate the effects of UbD in a Swiss vocational school. A School Improvement Advisor / researcher (Ostinelli, 2019), who introduced this methodology to the school, asked a math teacher[1] to teach two classes using UbD, while maintaining a more conventional teaching approach with a third class. The chosen curricular topic was "Mathematical relations and functions". The students completed an entry test, which was repeated at the end of the cycle. This was based on some items taken from the PISA 2012 survey, duly adapted, and aimed at verifying the basic understanding of the mathematical concepts defined above. Five months after the second administration, I administered the test for a third time to check the persistence of the outcomes. In Figure 2, the reader can find an example of the items used:

[1] I am very grateful to Gianluca Sigismondi for participating in this research, and for teaching and working very effectively.

There is a water tank whose dimensions are shown in the drawing. At the beginning it is empty, then it is filled with water at the speed of one litre per second.



Which of the following graphs shows the variation of the height of water surface over time, taking into account the shape of the tank?



Explain and justify your choice with your words

Figure 2: Example of the item used (Item 3)

The three classes taking part in the experience summed 15, 18 and 16 pupils (Exp1, Exp2 and Trad). The first two classes followed a math course on relations and functions based on UbD, while in the third class, the same teacher taught the topic in his habitual way, without using UbD. The assessment scales were of two types: the first, aiming at measuring the more "knowledge-oriented" items, had only two answers (correct or incorrect). The teacher evaluated the students using a right/wrong criterion. The remaining items, more "understanding-oriented" in their nature, required explanations and justification for the answers. They required therefore, the use of a scale made up of four levels. Here, the reader can find the assessment criteria and the scale relative to the example in Figure 2.

The choice of the right answer (B) has to be based on the understanding of the concepts of linear and curvilinear representation and inclination and its relation to the shape of the reservoir. While the lower part is an inverted cone, the upper part is a cylinder. As a result, the level increases more rapidly at the beginning of the filling, since the jet is constant and the volume to fill is smaller. As the level rises, the speed of the increment decreases. For the conical part, a curve with a more inclined slope at the beginning must represent this increase.

For the cylindrical part, instead, the increase of the height assumes a constant rhythm, since the fillings of the volumes for each second are equivalent. As a result, a straight line must represent this trend. In order to assess the answer, I used the following rubric: 1) Sound and valid argument; 2) Argumentation fairly valid, but partial; 3) Limited but acceptable argument; 3) Inadequate or absent argument.

I analysed the resulting data with SPSS, using T-tests and analysis of variance (ANOVA). I performed a first analysis of variance on the entry test. There were no statistically significant differences between the classes, evidence that at the beginning of the experience, each group possessed a similar level of understanding and knowledge of the proposed topic. After the teaching sequence, I administered the test for a second time. On this occasion, I analysed again the data with ANOVA. Six items out of the twelve were statistically significant, with *p* values ranging from .002 to .03. For further details of the analysis, the reader can consult Table 1 in the appendix.

The contrasts confirmed the expectation that the difference resulted from the comparison between the results obtained by the two experimental groups (Exp1 and Exp2)–which showed a stronger mean growth–and the control group, whose mean values remained similar (Trad). The differences found between Exp1/ Exp2 and Trad were statistically significant, with p-values ranging from .006 to .014. There were no statistically significant differences between Exp1 and Exp2. Therefore, both groups Exp1 and Exp2 performed significantly better in these six items than the group Trad. (For further detail, the reader can consult the data in Table 2 in the appendix). I corrected the outcome where necessary because of the existence of statistically non-homogeneous variances. This may be the consequence of the reduced number of participants in each sample, which sometimes results in significant values on the Levene test (except for items 2.4, 4.2 and 4.3).

Even for the remaining items, where the difference was not statistically significant, the Exp1 and Exp2 groups achieved better results than the Trad group. It is important to note that, for the items that required the students to justify their answers through argumentation, the difference between the assessment level 1 (inadequate or absent) and level 2 (limited but acceptable argument) is important in school terms as it shows whether or not the result is to be considered acceptable. The value of this interval, even if nominally equal to the others (i.e. those between level 2 and 3, or between 3 and 4), is actually different. In future surveys, I plan to conduct statistical analysis using more appropriate methodologies that can consider the non-homogeneity of the intervals on the used scale. These methodologies will assign different weights to the performances of the students. Future surveys will be conducted on broader databases from other classes and teachers. However, the evidence highlighted in the present study retains its validity: the results were always better in the experimental classes, where the improvement in terms of pupils passing from the status of inadequate or absent to a limited but acceptable was evidently superior, when compared with the control group. These results are shown in Table 3 of the appendix. One argument supporting the use of UbD in classrooms is that enduring understanding underpins knowledge, fostering deeper forms of learning:

> To be a worthy understanding, the proposition must be enduring. We propose two different connotations for the term:
>
> - The understanding has endured over time and across cultures because it has proven so important and useful.
> - The understanding should endure in the mind of the student because it will help the student make sense of the content and it will enable transfer of the key ideas. Thus, it should be learned in such a way that it does not fly away from memory once the unit is over or the test is completed. (Wiggins & McTighe, 2005, p. 136)

To prove this hypothesis, I administered the questionnaire to Exp1/Exp2 groups for a third time, five months after the second test. During this time lapse, did the students keep or forget the key ideas grasped? A period of five months should help in reducing the bias caused by the use of a test-retest procedure. I compared these results with the previous data using a T-test. This information is available in the appendix. Sometimes, the results were not statistically significant, signalling a maintenance of the results. Where the output was statistically significant, however, the difference between the third and the second measurements of the performance of the two Exp groups demonstrates an improvement of the previous results, signalling a further development of understanding.

CONCLUSIONS

From the data analysed here, relative to six significant items from a total of 12, it emerges that the use of UbD had a positive impact on the understanding of the ideas of mathematical relation and function in two groups of Swiss students. This quasi-experimental study, involving classes with similar profiles, has helped in showing that this methodology can be effective in improving the teaching/learning process of the mathematical topic of relations and functions. The present study adds further evidence to the usefulness of UbD in teaching and learning, as results from other analogous studies show (cf. Dari, Hidayat & Wulandari, 2024; Diviva, 2017; Li & Wen 2023; Pramesti & Dewi, 2023; Ozyurt, Kan & Kiyikci, 2021; Tshering, 2022).

The first research question was: ‘Does the use of the Understanding by Design methodology provide better learning results, when compared with a more conventional approach, while teaching a mathematical topic (mathematical relations and functions)?’ Regarding the case studied here, it is possible to give a positive answer. In fact, both experimental classes achieved better results if compared with the control group in all the items, and their results were statistically significant in six cases out of a possible 12.

The second research question asked if ‘the answers given by the students to the understanding-oriented items (which aim more at the explanation and motivation of the choices made, rather than their formal correctness) show a positive difference in terms of understanding for the students of the experimental groups?’ The answers to the following 'comprehension-oriented' items show a much better performance for both experimental classes, statistically significant for items 1.5, 2.4, 4.2 and 4.3. This can be taken as evidence of a better understanding of the subjects learned.

> Q1.3 Explain and justify your choice, including at least two good reasons
> Q1.5 Explain and justify your answer, if necessary with drawings or examples
> Q2.2 Explain and justify your choice in your own words
> Q2.4 Explain and justify your answer, if necessary with drawings or examples
> Q3.2 Every day, even if the amount of drug in the body decreases, a percentage remains approximately equal to that of the previous day. Which of the following percentages represents this value?
> Q3.3 Explain and justify your choice, with your own words, including values and calculations
> Q4.2 Explain and justify your choice, with your own words
> Q4.3 If the value of ‘a’ changes, what happens to the chart line?

The third research question asked ‘Can we say that the students belonging to the experimental groups show a better global understanding of the mathematical ideas of relation and function?’ From the previous data analysis, I can say, also considering the results coming from Tables 1-3 in the Appendix, that students belonging to the experimental groups gained a better global understanding of the mathematical concepts of relation and function. Finally, the fourth question asked if the achieved results were kept. The third administration of the test showed that the experimental groups had not only kept their learning but also, sometimes (Q1.4, 1.5 and 2.4), had improved their performance.

This study also has some limitations. First, its quasi-experimental nature, because of the practical impossibility of working with random samples in schools, affects the possibility of generalizing the conclusions to other similar situations. The small number of pupils in each group limits the significance of the statistical results. However, considering these restrictions - and considering the exploratory nature of this study - the evidence of the benefits generated by the use of UbD in the investigated situation is evident. The repetition of this experience with a greater number of teachers and classes, involving more disciplines, could prove useful. In fact, it could give more support to the hypothesis, that the use of UbD methodology is effective in supporting teachers and students in the acquisition and development of deeper and more valid understandings of curricular subjects, when compared with more conventional ways of teaching.

From this study, it also appears that the collaboration between a School Improvement Advisor/researcher and a teacher can give some interesting results, through the combination of their respective competencies:

- The teacher has received feedback on the effectiveness of different approaches to teaching, and since the benefits of UbD have been confirmed, they can teach all their classes using this methodology.
- This study contributes to the confirmation of the validity of UbD;

- All the pupils enjoyed the participation in the experience, and even the students in the control group showed improvements in their learning, even if less characterized by deep understanding.

Considering all its characteristics, this process can be described as an experience that involves research and reflection, contributing to the improvement of teaching based on evidence. As a direct consequence of using the UbD methodology in the situation under investigation, a greater number of students not only developed an authentic understanding of the basic principles of the curricular argument "mathematical relations and functions", but also increased their attitude towards understanding and deepening in their relationship with reality. This experience has the potential to be replicated and adapted to different contexts and disciplines. UbD is particularly suitable for teacher professional development, and it can be recommended for teachers and schools aiming to actively foster an effective attitude towards understanding.

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APPENDIX

Table 1: ANOVA, items with statistically significant results

Item	df	F	Sig.
Q1.4	47	3.8	.03
Q1.5	47	3.8	.03
Q2.4	47	4.8	.01
Q4.1	47	7.1	.002
Q4.2	47	3.9	.03
Q4.3	47	3.0	.03

These items show a statistically significant difference between the three groups (Exp1, Exp2 and Trad)

Table 2: Planned contrasts between classes

Item	Contrast	Value	Std error	t	Degrees of freedom	Significance
Q1.4	1	-.34	.15	2.36	20	**.029**
	2	-.02	.12	.19	29	.853
Q1.5	1	-.64	.22	2.90	45	**.006**
	2	-.22	.25	.89	45	.377
Q2.4	1	-.98	.38	2.59	45	**.013**
	2	-.18	.21	.84	45	.405
Q4.1	1	-.37	.13	2.78	15	**.014**
	2	.056	.056	1.00	17	.331
Q4.2	1	-.73	.26	2.77	45	**.008**
	2	. 00	.30	.00	45	1.000
Q4.3	1	-.76	.28	2.73	45	**.009**
	2	.078	.31	.25	45	.805

I predicted that the two experimental groups (Exp1 and Exp2) would perform better than the control group (Trad). The planned contrasts confirm this hypothesis: contrast 1, between Exp1 and Exp2 against Trad show a significant value, while contrast 2 (setting Exp1 against Exp2) doesn't. The groups submitted to the treatment show better results than the control group, and there is a huge probability for this difference not being casual.

Table 3: Improvement in learning for pupils passing from inadequate to at least acceptable answers (initial level, final level and net improvement)

Item	Trad			Exp1			Exp2		
	init	fin	Δ	init	fin	Δ	init	fin	Δ
Q1.3	11	4	**7**	11	3	**8**	15	3	**12**
Q1.5	15	9	**6**	13	3	**10**	15	2	**13**
Q2.2	10	6	**4**	12	6	**6**	14	5	**9**
Q2.4	14	8	**6**	14	2	**12**	16	2	**13**
Q3.3	11	6	**5**	14	3	**11**	13	4	**9**
Q4.2	14	7	**7**	14	0	**14**	12	1	**11**
Q4.3	15	7	**8**	15	1	**14**	18	2	**16**

In order to have a more complete view on the data, Table 3 shows the improvement, from entrance to final test, in terms of the number of pupils passing from inadequate / absent answers to at least acceptable answers. The data show the results were always better for the experimental classes, which sometimes show very relevant progresses (2.4, 4.2, 4.3). For example, if we look at the data for point 4.3, we find that in the Trad class, seven pupils out of fifteen follow in giving inadequate answers, while only one over fifteen and two over eighteen show a similar profile in the Exp1 and Exp2 groups. In conclusion, these results confirm the statement that UbD can lead to effective improvements in the understanding of school curricular arguments.

Table 4: Comparison of means at the test five months after the second administration. Class Exp 1

Item	Mean 2	Mean 3	t	Sig.
Q1.4	2.1	2.8	3.2	.006
Q1.5	2.1	2.7	2.2	.045
Q2.4	2.0	2.9	3.0	.009
Q4.1	1.0	0.9	1.0	.336
Q4.2	2.7	3.0	1.2	.263
Q4.3	2.6	3.1	1.6	.139

Table 5: Comparison of means at the test five months after the second administration. Class Exp 2

Item	Mean 2	Mean 3	t	Sig.
Q1.4	2.4	2.9	2.5	.024
Q1.5	2.2	1.8	1.9	.083
Q2.4	2.1	1.9	0.8	.455
Q4.1	0.9	1.0	1.0	.332
Q4.2	2.8	2.8	0.0	1.00
Q4.3	2.6	2.9	0.7	.509

As seen in Tables 4 and 5, the results attained by the pupils lasted during the five months. The group Exp 1 showed for the first three items a significant result, showing an improvement, while in the remaining ones the difference wasn't statistically significant. On the whole, the average improved. For the group Exp 2, the results did also show a permanence of the effect of UbD, even if its performance was less brilliant than the one of the other class. In fact, only the item Q1.4 showed a statistically significant improvement, while the remaining ones didn't show a similar trend. The means of item Q1.5 and Q2.4 showed a slight (but not statistically significant) decrease.

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After obtaining a degree in Philosophy at the State University of Milan and a PhD in Pedagogy at the Alma Mater Studiorum in Bologna, Giorgio Ostinelli worked as contracted professor at the University of Bologna and at the Catholic University in Milan and as State Teaching Expert for the State of Ticino (Switzerland) for several years. Currently, he continues to collaborate with Ticino as School Improvement Advisor-researcher, and lectures at UniTreEdu of Milan. He has led and participated in several national and international projects and published several books and articles. His teaching experience ranges from primary school to university. At present, he acts as editor for the book *Innovation in Teacher Professional Learning in Europe (Routledge).*