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Approaches to Learning of Engineering Graphics Through Learning Objects Multimedia*

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This paper provides details of a study in which Learning Objects (LOs) have been designed and built for the field of Graphic Expression and then introduced into a university degree subject as a teaching aid so that their influence on students' approaches to learning can be studied. The study was carried out with 83 students in the subject "Engineering and Architectural Graphics Applied to Building Design", which forms part of the Degree in Building Engineering. Before starting the course, students show a "Deep Learning" approach but also very close to the "Surface Learning". Results, after using the LOs indicates that the use of LOs in Graphic Expression produces a statistically significant improvement in the Deep Approach adopted by students which is essential for more comprehensive learning. The type and intensity of approach learning was analysed by gender. Although there were no statistical differences, the data shows that women intensify their deep learning.

Keywords: learning objects; approaches to learning; graphic expression; R-SPQ-2F; online higher education

1. Introduction

The changes that have taken place in university education as a result of the implementation of the educational model proposed by the European Higher Education Area (EHEA) have centred on amongst other topics, students' learning processes. Greater weight is placed on student autonomy and deep learning as the means through which to facilitate the correct acquisition of competencies. This requires special attention to be paid to concepts such as *approaches to learning*, or in other words, how students manage their learning based on personal preferences when studying and the context in which learning takes place [1].

The theory behind approaches to learning is becoming increasingly relevant, both as a result of the aforementioned academic context, and also the nature of the content that students must learn when adopting one approach or another. The approach adopted could arguably constitute direct evidence of the quality of the educational process [2].

For this reason, a teacher should establish whether it is possible to improve their students' approaches to learning with the sole aim of achieving a set goal, which is none other than trying to educate their students as well as possible [3]. To do so, the teacher must establishing greater and better possibilities for knowledge acquisition [4] by designing proposals for interventions that contribute towards this task.

This model for innovative learning has led teachers to develop *alternative teaching strategies* that allow for the implementation of new learning process that provide students with the information they need in a more appealing manner [5], and the deployment of new methodologies in university degree programs. These strategies involve designing resources that almost exclusively use new Information and Communication Technologies (ICTs) to facilitate learning [6].

In following this line of action, 'Learning Objects' (LOs) now stand at the forefront when it comes to designing, building and delivering content to students that can be adapted to their needs and facilitate learning and that can also be reused in different learning contexts.

This study contributes to innovation in university education by studying the application of ICT-based Learning Objects designed and built specifically for the field of Graphic Expression, and analysing their influence on students' approaches to learning. The objective of the study is to know if the use of multimedia learning objects and their autonomous use by engineering students produce any change of approach of learning. In the forthcoming sections, the authors: outline the concepts and theories describing LOs and Approaches to Learning; provide details on the nature of their study on LOs in a university degree subject; and provide descriptions

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of the characteristics of the resources that have been designed and developed for this study, the sample groups, and the questionnaire used as a measuring instrument. In the final sections of this paper the results and conclusion are presented.

2. Framework

2.1 Learning objects

Learning Objects (LOs), also referred to as Reusable Learning Objects (RLOs), are digital modular learning resources designed to break information down into bite size pieces (made possible by ICTs wide range of capabilities). LOs are stand-alone structures that contain interactive materials for pedagogic purposes. They can be used and reused by students as many times as they desire and to the point at which learning is performed flexibly and independently [7–9].

David Wiley [10], defines LOs as ''any digital resource that can be used to support learning''. Their raison d'être is to: reduce production and distribution timings and costs; make it possible to exchange and reuse educational resources used in the teaching-learning process. For quality assurance purposes it should be highlighted that they must: be in digital format; for pedagogic purposes; contain interactive content; be indivisible and stand-alone, or in other words, independent of other LOs; and reusable in different educational contexts beyond their intended use [11].

A set of standards and/or specifications have been developed and implemented for the construction of LOs that support the creation of good quality LOs. All LOs must have well-structured educational content and standards for creating metadata [12]. With regards to this structure, it must be clear in order to facilitate the process of sharing, reusing, importing, or exporting them [13]. The SCORM model (Sharable Content Object Reference Model) developed by ADL (Advanced Distributed Learning) is of worthy mention as it is the most widely used model when it comes to LO creation [12]. The most commonly used standard for the creation of metadata is Dublin Core [14], which has widespread acceptance precisely due to its widespread use.

Exe-Learning is one of the most suitable applications for creating learning content [15], as it allows the user to create entire websites and insert interactive content as well as different types of activities and questions for evaluation purposes. It also uses the SCORM model as standard to create LOs containing structured educational content. Exe-Learning allows users to export LOs created in SCORM format so that they can subsequently be imported into a Learning Management System (LMS) for use in virtual classrooms, e.g., Moodle. Additionally, it has adopted Dublin Core for creating metadata [16]. Exe-Learning helps teachers to easily create and publish LOs by allowing them to structure content, insert resources, and export tasks. All of this helps them to create a well-structured final product and set of activities. It is clear that the overall success, in terms of reaching set objectives, depends on the correct planning, sequencing and content of the activities being designed, questions that are more closely related to the teacher's pedagogical training [17].

According to the EHEA, learning must change from being a one-off activity to a lifelong activity that is pursued throughout our professional careers. What this means in reality is that instruments must be in place to facilitate this task; the most adequate tools for this task are Learning Objects, especially those within the field of Engineering and Architectural Graphics as they have an extended lifecycle, which reduces maintenance and update requirements and thus guarantees their reusability [18]. With these considerations in mind, the authors propose creating a series of Learning Objects that serve as teaching aids in the subject 'Graphic Expression' using the application *Exe-Learning*. This application has been chosen for its powerful features, unique characteristics, and its compatibility with both SCORM and Dublin Core.

2.2 Approaches to learning

The construct approaches to learning describes the manner in which students relate to the teaching-learning process. In other words, it explains how students respond to the learning environment. It is understood that these responses are not set in stone, rather they are processes arising from a student's particular perceptions of an academic task, which in turn are dependent on an individual's personality traits and character. As such, students will demonstrate a predilection for a particular approach [19].

The result of learning is conditioned by the type of approach adopted by a student [20]. What this means is that any given learning task is tackled in accordance with the student's intentions or motivation, but in order to resolve issues pertaining to motivation, the student will conceive strategies—termed *approaches to learning.* Thus, an approach to learning is the result of a merger between motivation and strategy [21].

When discussing approaches to learning it should be recognised that there are two key elements at play: the *individual* (their genetics, cognitive abilities, and previous experience) and the *environment* in which behaviour takes place [22]. These interact with one another, and reactions to the surrounding environment and context in which learning is taking place can impact on personal characteristics. In

other words, it should be recognised that whilst individuals may demonstrate a personal preference for a particular approach based on their personality type, it is also true that a certain set of circumstances will stimulate, foster or inhibit when certain any given approach is adopted [23, 24].

To define the study processes used by students, that is to say, to express the intention, the process and the result of learning, the authors Marton & Säljö [25] created the terms *Deep Approach* and *Superficial Approach* (deep and surface learning) to refer to the existence of two qualitatively distinct ways of approaching a task: the first describes learning undertaken for the purpose of understanding and personal development, the second describes learning undertaken to cover institutional demands. The characteristics of these approaches are described by Biggs [19]:

The *Deep Approach* (deep learning), leads to *a transformation of knowledge*. It is based on intrinsic motivation, meaning the student's inner curiosity drives their search for a suitable strategy and motivates them to use it to maximize their understanding of the material being taught. The student seeks to: understand the content as far as possible, relating newly acquired concepts with previous knowledge; become actively involved in each task because of how interesting he or she finds it; focus on understanding and relating the different components of the task to one another, and to other tasks; discuss the task with other students. The student sees learning as something that is enjoyable in itself and the task as a way to attain personal growth. Learning is comprehensive and meaningful in and of itself.

The *Superficial Approach* (surface learning), leads to *the reproduction of information*. It is based on extrinsic motivation; consequently priority is placed on avoiding failure, effort, or having to work too hard. Strategies are used in order to only have to do the least amount of work possible, and information is recalled using memorization techniques. The student sees a task as a demand that must be met and does not see a clear relationship between the different components of the task, or between the components of one task and another. Efforts are centred on memorizing content as a means to pass an exam. The student resents the amount of time needed to complete the task and is only concerned with possible failure. Reproductive/Rote Learning with the sole aim of passing the test or course.

These approaches to learning depend on the motivation and strategies (deep or superficial) possessed by the student. The type of approach to learning adopted will be determined based on whether greater weight is placed on understanding or merely on memorizing [26]. Of the several instruments used to measure approaches to learning, the Revised Two-Factor Study Process Questionnaire (R-SPQ-2F) by Biggs et al. [21], is of noteworthy mention and has been used in this paper. Duff and McKinstry [27] provides an overview of the students' approaches to learning (SAL) literature, including a review of the models, theories, and research instruments. In the pursuit of a more thorough classification system that includes the diverse range of variables that exist, we have seen the emergence of the concept *Approach Intensity*. The intensity of an approach can be classified as *High*, *Medium*, or *Low*. These concepts are used to more accurately describe the differences identified between the *Deep Approach* and the *Superficial Approach* adopted by each student [28].

Some authors have found a relationship between the learning methodology used by the teacher and the engineering students' learning approach [29, 30], even a study has related the deep approach with the academic success in students of mechanical engineering [31]. Numerous studies carried out with engineering students indicate that there is a direct relationship between the learning strategy, the interest, the subject [32] , the learning resources provided [33], and the evaluation [34]. It is notable that the learning approach is related to age [35–37] and to gender [35, 36, 38, 39]. In general, deep learning is shown in older students and women, while the youngest and male a superficial approach is shown.

Nepal et al. [40] conclude that learning environment is the key to determining the learning approach that students acquire. The research work of Rahman et al. [33] indicates the ingredients to create the best environment and to provide a deep learning approach in engineering students. Jenkins et al. [41] identify the learning approaches of civil engineering students and propose actions to facilitate the development of "life-long-learner" skills by students. Studies conducted with students from other areas of knowledge provide similar conclusions [42, 43], which we can complement indicating that active learning methodologies promote the students' deep learning [44–46] .

3. Study and methodology

This study was designed to be run in the context of the University of La Laguna, in the subject 'Engineering and Architectural Graphics Applied to Building Design', which forms part of the Degree in Building Engineering. Participants, who volunteered willingly, were students recruited from the academic courses 2014–2015 & 2015–2016, and they were performed in accordance with the ethical standards laid down in the Declaration of Helsinki (Seventh revision, October 2013, Fortaleza, Brazil).

Table 1. Description of Sample (before using LO) by sex and age

Sample	Female	Male	<21	21–25	26–30	>30	Total
Course 14–15	25	26	11	24	14	2	51
Course 15–16	14	18	8	18	5	1	32
Total	39	44	19	42	19	3	83

Table 2. Description of Sample (after using LO) by sex and age

Sample	Female	Male	<21	21–25	26–30	>30	Total
Course 14–15	17	17	5	18	10	1	34
Course 15–16	10	10	6	11	2	1	20
Total	27	27	11	29	12	2	54

All students who took the subject had learning objects available to study. A total of 83 volunteers students completed the questionnaire (2F-SPQ-R) before start the experience. At the end of the semester, 54 students completed the same questionnaire; two of them had not done so before. Tables 1 and 2 contain details of participant demographics.

Before commencing the study, the sample size is checked to ensure is capable of producing statistically viable and consistent results. Calculations are made to establish the number of participants needed to be able to estimate a given parameter with the desired degree of certainty, or to detect differences between study groups [47].

In order to perform this study, a series of 10 Learning Objects have been specifically designed and developed for subjects in the field of Engineering and Architectural Graphics. A screenshot taken of one of these LO as seen in the Virtual Classroom is provided for reference in Fig. 1.

Once the objectives have been established the design and planning phase commences. This begins with an initial outline of the LO's structure and the content that will be dealt with. The content is then organized into sections and subsections so as to establish a hierarchy based on the importance of said content. Once completed, these sections are then placed into a particular chronological order. Next, the scheduling and design of appropriate activities is set—within the limitations of possibility for this type of resource—in order to fulfil the established objectives. At this stage the content for each of the LOs must be carefully selected to ensure that all necessary information is covered for a specific piece of knowledge, whilst also ensuring that there is no overlap with other LOs. Simultaneously, it is important to analyse how to include digital content (made possible thanks to the digital format) whilst always keeping sight of the instructional and pedagogical purpose behind the LO. And finally, in keeping with the defining characteristics of LOs described by Peñalosa and Landa [48],

Fig. 1. Didactic content of Module 1 as Learning Object inserted into the Moodle platform by SCORM.

amongst other authors, it is important to ensure that the content can easily be reused.

In the next phase of the LO design process, images are selected that can serve to illustrate the content in question. These are of vital importance given that the subject matter of each of these revolves around learning questions related to Engineering and Architectural Graphics and their application as a teaching aid for said materials. In order to help users become familiar with how to use the LOs, special emphasis is placed on ensuring that each has a similar structure. As such, all LOs have a home page containing a general presentation that provides a welcome message and informs the user about content. This is followed by a description of the objectives that will be covered during use, and an outline of the content. This outline always begins with the more general content and works down to the more specific content, all of which contains abundant illustrations to assist in their assimilation.

Finally, a series of activities are designed in order to complete each LO, including: gap fill exercises, multiple-choice questions, True/False dichotomous questions, tests, or SCORM questionnaires. Students complete these activities at their own convenience and they can choose to adapt them to their own individual pace of working. The activities can be taken as many times as wanted or needed depending on real-time feedback about the number of correct answers or incorrect answers in each attempt. As this feedback is instantaneously provided by the system, students can identify when they have mastered content and are placed in a position in which they can decide whether to progress onwards or not, which encourages self-directed learning. Once the design process is complete, the LO are then built. The app *Exe-learning* is used as an authoring tool to facilitate this process.

The next stage involves administering the questionnaire that had been selected to measure students' approaches to learning: the Revised Study Process Questionnaire R-SPQ-2F by Biggs et al. [21]. The questionnaire is completed by students at the start of the academic course—in this study, at the beginning of 2014–15 and 2015–16—prior to using the Learning Objects designed for the study. The aim here is to identify their initial approaches to learning when taking subjects within Engineering and Architectural Graphics.

Subsequently, the LOs designed and built especially for the study are put into use. To do so, they are exported from the design application *Exe-Learning* in SCORM format, and imported into the virtual classroom hosted on the e-learning platform of the University of La Laguna (Moodle). In doing so, students are given access to the newly created resources for their use and learning, and these serve as teaching aids for the teachers' explanations. Once the subject has been delivered for the aforementioned courses, the students are once again asked to complete the R-SPQ-2F Questionnaire by Biggs et al. [21], in order to establish the influence of the LOs on students' approaches to learning when studying Engineering and Architectural Graphic subjects.

4. Results

For the statistical treatment of the results that were gathered, first each variable was identified and then assigned a code or simplified name. These variables are listed with an accompanying description in Table 3. The variable descriptions also include the terms *before* and *after* that correspond to the moment in time in which the questionnaire was administered and measurements taken.

Using the coding system of the R-SPQ-2F Questionnaire, the *Type and Intensity* of the approach to learning (TIA) is listed in Table 3 for the aforementioned variables in the following order: *Deep–High; Deep–Medium; Deep–Low; Superficial–Low; Superficial–Medium; Superficial–High*. The best value for an approach to learning is *Deep–High*, whilst the worst value is *Superficial High.*

To determine students' approaches to learning (based on their responses to the questionnaire), the authors follow the procedure indicated in the questionnaire itself, thus obtaining values for each scale and subscale, as displayed in Table 4.

The student's type of approach (deep or superficial) is determined by the highest value obtained for the type of approach (*Deep Approach* –DA– or *Superficial Approach* –SA–).

The value for *Focus Intensity* of the approach is obtained following the criteria established by Recio Saucedo & Cabero Almenara [28]. The *Focus Intensity* is calculated based on the difference between the values on the scales for *Deep Approach* and *Superficial Approach*, as displayed in Table 5.

An analysis of the frequencies is displayed in Table 6. It's possible to observe that the majority of students have a *Deep Approach* to learning, and according to Schmeck [49], these students are not

Table 3. Identification of variables in R-SPQ-2F Questionnaire for Approaches to Learning

Variable	Approach to Learning Factors
DA_B	DEEP APPROACH BEFORE
DA_A	DEEP APPROACH AFTER
SA B	SUPERFICIAL APPROACH BEFORE
SA_A	SUPERFICIAL APPROACH AFTER
TIA_B	TYPE AND INTENSITY OF APPROACH BEFORE
TIA_A	TYPE AND INTENSITY OF APPROACH AFTER

Table 4. Obtaining scores for Scales and Subscales. R-SPQ-2F

Summary of R-SPQ-2F instrument items, according to scale and subscale		
Scales	Deep Approach (DA)	1 + 2 + 5 + 6 + 9 + 10 + 13 + 14 + 17 + 18
	Superficial Approach (SA)	3 + 4 + 7 + 8 + 11 + 12 + 15 + 16 + 19 + 20
Subscales	Profound Motivation (D_Mot)	1 + 5 + 9 + 13 + 17
	Profound Strategy (D_Str)	2 + 6 + 10 + 14 +18
	Superficial Motivation (S_Mot)	3 + 7 + 11 + 15 + 19
	Superficial Strategy (S_Str)	4 + 8 + 12 + 16 + 20

Source: Prepared by authors (based on [22]).

Table 5. Ranking of Focus Intensity

Value Difference	Focus Intensity
1–13	Low
14–26	Medium
27–40	High

Source: Prepared by authors (based on [27]).

Table 6. Frequency of Student Approaches to Learning Being Studied (before using LOs)

R-SPQ-2F Results TYPE OF APPROACH TO LEARNING	Frequency	%
Deep Approach	61	73.49
Superficial Approach	22	26.51
Total	83	100

Table 7. Frequency of Student Approaches to Learning Being Studied, based on Intensity (before using LOs)

R-SPQ-2F Results TYPE OF APPROACH TO LEARNING (TIA)	Frequency	%
Deep Approach–High	2	2.41
Deep Approach–Medium	17	20.48
Deep Approach–Low	42	50.60
Superficial Approach–Low	18	21.69
Superficial Approach–Medium	4	4.82
Superficial Approach–High	0	0.00
Total	83	100

only interested in the academic task itself and enjoy carrying it out, but they also looking for the inherent meaning behind the task; they place personal significance on it and relate it to their own experiences and their real world, and integrate parts or aspects of the task to a greater whole. Students with a *Superficial Approach* to learning are less. These are students who, according to the aforementioned authors, see the task as a demand that must be met, or as an imposition that needs addressing in order to complete a particular objective. Likewise, these students perceive elements of a task as unrelated to one another, or equally, unrelated to other tasks. They show concern for the amount of time it takes to perform a task, avoid making a connection between the task and their personal experiences. They also tend to rely on memorization techniques in order to reproduce the superficial aspects of the task.

With regards to the *Focus Intensity*, Table 7 shows that for the *Deep Approach* there is a trend towards *Low* intensity (50.60%), followed by *Medium* intensity (20.48%), and there are very few cases of *High* intensity (2.41%). In the case of the *Superficial Approach*, the majority of students show *Low* intensity (21.69%), the remainder show *Medium* intensity (4.82%). No student shows *High* intensity.

It is important to remember that the ideal value for students would be *Deep Approach–High*, as this would imply that: there is a high dispositional affect towards study and the quest for understanding; satisfaction is gained from the learning process itself; new concepts are related to prior knowledge; tasks are engaged in because of how interesting they are perceived to be and for personal growth. All in all, the principal strategy used in this approach is one in which understanding is sought and the student does not merely rely on memorizing techniques.

On the opposite end of the scale is the value *Superficial Approach–High*, which implies that the general stance with regards to learning is one that focuses on the external recognition factors that it can generate, such as getting good grades or winning awards. The view taken of learning is that one should obtain enough knowledge to avoid failure, learning just enough without making too much effort. To do so, a student will employ strategies that allow them to do the bear minimum needed to reach an objective, and will use memorizing techniques instead to trying to understand fully.

The analysis of the descriptive data for students' answers to the R-SPQ-2F Questionnaire suggest a predisposition towards learning in the first academic term. The values obtained for the *Deep Approach* (DA) and *Superficial Approach* (SA) scales, reveal a predisposition towards DA.

Figure 2 shows the descriptive statistics for the scales and subscales analysed using the R-SPQ-2F Questionnaire that was administered *before* the use of LOs. It shows that the predominating approach to learning is the *Deep Approach* with an average

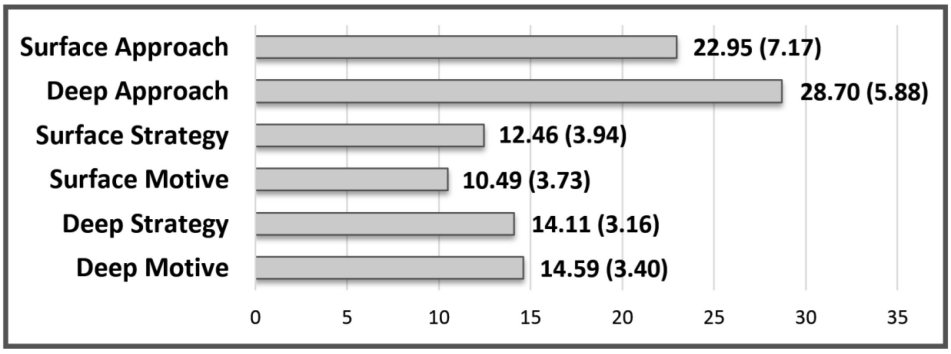

Fig. 2. Scales of approaches to learning results (before using LOs). Average and Std. Dev.

Table 8. Descriptive Statistics. R-SPQ-2F Sample Test—*before* and *after* experience

	N	Average	Standard Dev.	Min.–Max.
DA_B	83	28.70	5.880	18–44
DA_A	54	30.46	5.901	13–45
SA_B	83	22.95	7.174	13–47
SA_A	54	23.39	7.342	10–42

value of 28.70, compared against an average value of 22.95 for the *Superficial Approach*. In terms of subscales, the highest values are seen in the *Deep Approach* with scores of 14.59 for Deep Motivation (D_*Mot*) and 14.11 for Deep Strategy (D_*Str*), values of 10.49 for Superficial Motivation (S_*Mot*) and 12.46 for Superficial Strategy (S_*Str*) in the *Superficial Approach*. In the case of the *Deep Approach*, it can be observed that the values for D_*Mot* are greater than those for D_*Str*, while in the case of the *Superficial Approach*, S_*Str* is greater than S_*Mot*.

It is important to remember that these results are the product of an analysis of student responses to a self-report questionnaire about their perceptions of themselves, and that these represent the perceptions of a sample of students participating in what is a pilot study. This initial look at the use of LOs and *approaches to learning* offers up certain interesting points that invite further reflection on the characteristics and traits of our students, and the motives and strategies that emerge when learning. Likewise, the study also obliges us to reflect on the need to analyse and rethink the teaching process.

Regarding the influence of LOs use on approaches to learning in Engineering and Architectural Graphics, the data from the R-SPQ-2F Questionnaire has been analysed to study whether there is any change to an approach as a consequence of using LOs to study this subject. As such, the aim is to:

1. Analyse whether a change has occurred in the type of approach to learning used by students *before* and *after* using LOs.
2. Identify whether the use of LOs in Engineering and Architectural Graphics influences the *Type and Intensity* of the approach to learning.

We begin by analysing whether the *Deep Approach Before* and *After*, and the *Superficial Approach Before* and *After* are significant, in other words, whether there is a change in approaches. Next, data for each variable (*DA* and *SA*) is checked to see whether it is normal before and after (see Table 8). As the sample contains more than 50 sets of data, the Kolmogorov-Smirnov test is used (Table 9).

In all cases it is above p-value 0.05, as such, the data gathered in the sample follows Normal Distribution. Tests are run to identify whether there is significant difference in the behaviour of the type of approach (*DA* and *SA*) *before* and *after*. Data for the variable *Deep Approach Before* (DA_B)/*Deep Approach After* (DA_A) is compared with the aim of

Table 9. Kolmogorov-Smirnov test on one sample. Approaches to Learning

		DA_B	DA_A	SA_B	SA_A
N		83	54	83	54
Normal Parameters (a,b)	Average	28.70	30.46	22.95	23.39
	Standard Dev.	5.880	5.901	7.174	7.342
Max. difference	Absolute	0.087	0.095	0.113	0.115
	Positive	0.087	0.093	0.113	0.115
	Negative	–0.051	–0.095	–0.083	–0.063
Kolmogorov-Smirnov Z test		0.794	0.699	1.032	0.845
Asymptotic Sig. (2-sided)		**0.554**	**0.713**	**0.238**	**0.473**

a Contrast difference is Normal. b Calculated using data.

Table 10. Statistics of related samples. Test R-SPQ-2F

		Average	N	Standard Dev.	Standard Error of the Average
Pair 1	**DA_B**	28.83	52	5.316	0.737
	DA_A	30.46	52	5.995	0.831
Pair 2	**SA_B**	23.08	52	7.538	1.045
	SA_A	23.23	52	7.385	1.024

Table 11. Correlation of related samples

		N	Correlation	Sig.
Pair 1	**DA_B / DA_A**	52	0.514	0.000
Pair 2	**SA_B / SA_A**	52	0.611	0.000

identifying if there is significant difference in the values. In other words, the aim is to identify if there is an improvement in the Deep Approach (if it has deepened); the same comparison is performed for the variable *Superficial Approach Before* (SA_B) and *Superficial Approach After* (SA_A) in order to identify whether there has been any improvement in the values so as to become less superficial. The values from a paired sample are used, meaning the data available for *before* and *after*.

To compare whether the average values are significantly different or not, the following hypotheses are used:

- **Null hypothesis**: H_0—both averages are the same; in other words, the difference between the averages in both cases is zero: $m_d = 0$, or $m_{before} = m_{after}$.
- **Alternative hypothesis:** H_1—the two averages are not the same; in other words, the difference between the two averages is not zero: $m_d <> 0$, or $m_{before} <> m_{after}$.

Table 10 shows the descriptive statistics of the paired sample of 52 participants with data available before and after the experience. A correlation analysis (Table 11) indicates that there is a correlation between the sample data before and after, therefore a student t-test is performed to check if the averages before and after are significantly different (Table 12).

The Alternative Hypothesis (H_1) is accepted for the *Deep Approach*. The results indicate that there is significant difference in the *Deep Approach* of students, in other words, there is a significant improvement in the *Deep Approach*; if we look at the average, we see it increase from 28.83 to 30.46, and according to the test on related samples, this positive difference is statistically significant. No significant difference is registered for the *Superficial Approach*.

In the frequency table it is possible to observe that in addition, the number of students with a *Deep Approach* following the use of LOs has increased, and the number of students with a *Superficial Approach* has decreased. In other words, some students who previously used a *Superficial Approach* to learning have changed to using a *Deep Approach* when learning, which was made possible by LO use (Table 13).

From the 52 students who responded *before* and *after* the use of LOs, we see that 3 individuals changed their approach from superficial to deep (12 vs 9). From a quantitative point of view, those already classed as using a *Deep Approach* intensified this approach, as the significant value is less than 0.05. However those classed as using a *Superficial Approach* from a statistical point of view continue to remain so.

Next, the *Type and Intensity* (TIA) of the approach pertaining to the use of LOs in the subject is analysed. The values recorded for the *Type and Intensity of Approach Before* (TIA_B) and *Type and Intensity of Approach After* (TIA_A) are qualitative (Table 14 and Table 15); for this reason, the Wilkinson rank-sum test is used for the parametric test of two paired samples (Table. What is observed is that the majority of students are ranked *Deep Approach–Low* and *Deep Approach–Medium*. Statistical analysis is performed using paired data (52), and values on a scale of 1 to 6 are assigned. One (1) is the worse value on the Type and Intensity scale and six (6) is the best: (6) Deep Approach–High, (5) Deep Approach–Medium, (4) Deep Approach–Low, (3) Superficial Approach–Low, (2) Superficial Approach–Medium, (1) Superficial Approach–High.

Before starting the experience, the 2F-SPQ-R

Table 12. Student t-test of related samples

		Related differences					t	gl	Asym Sig. (2-sided)
		Average	Standard Dev.	Standard Error of Average	95% Confidence Interval for difference				
					Upper	Lower			
Pair 1	**DA_B - DA_A**	–1.635	5.605	0.777	–3.195	–0.074	–2.103	51	**0.040**
Pair 2	**SA_B - SA_A**	–0.154	6.581	0.913	–1.986	1.678	–0.169	51	0.867

Table 13. Students by type of approach *before* and *after*

Deep before	Deep after	Superficial before	Superficial after
n = 40	n = 43	n = 12	n = 9

Table 14. Frequency table. Type and Intensity of Approach Before (TIA_B)

		Frequency	%
Valid	**Sup. Medium (2)**	3	3.5
	Sup. Low (3)	9	10.6
	Prof. Low (4)	28	32.9
	Prof. Medium (5)	12	14.1
	Total	52	61.2
Lost	**System**	33	38.8
Total		85	100.0

Table 15. Frequency table. Type and Intensity of Approach After (TIA_A)

		Frequency	%
Valid	**Sup. Medium (2)**	1	1.2
	Sup. Low (3)	8	9.4
	Prof. Low (4)	27	31.8
	Prof. Medium (5)	16	18.8
	Total	52	61.2
Lost	**System**	33	38.8
Total		85	100.0

Table 16. Descriptive Statistics. Type and Intensity of Approach before and after using LOs

	N	Average	Standard Dev.	Min.–Max.
TIA_B	83	3.94	0.846	2–6
TIA_A	54	4.11	0.718	2–5

questionnaire was administrated to a total of 83 students. At the end of the course, a total of 54 volunteers students completed the same questionnaire. We carry out a comparison study using the paired data of 52 individuals who performed the questionnaire before and after. The results of the Wilcoxon test for Type and Intensity of Approach before and after indicate a p-value greater than 0.05 (p-value = 0.072), as such, there is no significant difference in the *Type and Intensity* of the approach.

Table 17. Descriptive Statistics. Gender & Type of Approach before and after using LOs (paired data)

	GENDER	Average	Standard Dev.	N
DA_B	Male	29.42	6.300	26
	Female	28.23	4.150	26
	Total	28.83	5.316	52
DA_A	Male	29.65	6.362	26
	Female	31.27	5.611	26
	Total	30.46	5.995	52
SA_B	Male	25.96	8.793	26
	Female	20.19	4.613	26
	Total	23.08	7.538	52
SA_A	Male	25.38	7.637	26
	Female	21.08	6.578	26
	Total	23.23	7.385	52

The impact of LO use on the types of approaches to learning as studied from the perspective of gender is detailed in Table 19. A multivariate analysis of variance (MANOVA) is performed to study the relationship between the types of approach followed *before* and *after* using LO, and the variable gender. In doing so, it is possible to identify whether significant difference exists between men and women with regards to *Types of Approach Before* and *Types of Approach After* LO use in the area of Graphic Expression (Table 18). A review of the paired data mentioned previously is performed and students for which there is both *before* and *after* data are selected (52 individuals, 26 male and 26 female), then the same calculations are run to those mentioned in the previous section.

Having done so, and upon reviewing only the paired data (52 individuals) of the sample, results reveals that there is no significant difference in *Deep Approach* for men or women, neither *before* nor *after* LO use. However, there is significant difference for *Superficial Approach*, both *before* and *after* LO use (Table 19). When looking at average values, women display a less of a superficial approach than men (Table 17). As such, there is a difference in *Superficial Approach* for the variable of gender.

Table 18. Multivariate Contrast(b). Gender & Type of Approach before and after using LOs (paired data)

Effect		Value	F	Gl of Hypothesis	Gl of error	Significance
Intersection	**Pillai trace**	0.984	743.220(a)	4.000	47.000	0.000
	Wilks Lambda	0.016	743.220(a)	4.000	47.000	0.000
	Hotelling trace	63.253	743.220(a)	4.000	47.000	0.000
	Roy's largest root	63.253	743.220(a)	4.000	47.000	0.000
GENDER	**Pillai trace**	0.202	2.968(a)	4.000	47.000	0.029
	Wilks Lambda	0.798	2.968(a)	4.000	47.000	0.029
	Hotelling trace	0.253	2.968(a)	4.000	47.000	0.029
	Roy's largest root	0.253	2.968(a)	4.000	47.000	0.029

a Exact statistic. b Design: Intersection + GENDER.

Table 19. Test of inter-subject effects. Gender & Type of Approach before and after using LOs (paired data)

Source	Dependent variable	Sum of squares type III	gl	Mean square	F	Significance
GENDER	**DA_B**	18.481	1	18.481	0.649	0.424
	DA_A	33.923	1	33.923	0.943	0.336
	SA_B	432.692	1	432.692	8.777	0.005
	SA_A	241.231	1	241.231	4.749	0.034

5. Discussion

It has been possible to determine the initial type and intensity of the approaches to learning used by students taking subjects in Engineering and Architectural Graphics, and also study the influence of LO use on these. Students of ''Engineering and Architectural Graphics Applied to Building Design'', which forms part of the Degree in Building Engineering at the University of La Laguna, before experience to use LOs designed to study Engineering and Architectural Graphics subjects, adopt a deep approach to learning, seeking to understand the subject's content to their utmost whilst using strategies that go beyond merely interacting with information superficially: efforts are made to relate content to their experiences and prior knowledge in order to grant it greater significance and use, they become more engaged in tasks (which are perceived as interesting), thus they are able to enjoy the sense of personal growth that each learning opportunity provides. Moreover predominantly fall under the category *Deep Approach–Low* in terms of the type and intensity of approach adopted. This means that they are students whose curiosity comes from their desire to learn, and this causes them to seek out and use strategies in order to understand the material being taught. However, this low intensity indicates that they resort to strategies similar to those observed in the superficial approach, although be it to a much lesser extent, and consequently make less of an effort in tasks and resort to using memorization and reproduction techniques to complement learning so as to guarantee success. This predominant type of intensity is trailed at a considerable distance by *Superficial Approach–Low* and *Deep Approach–Medium*, which signifies in the case of *Superficial Approach–Low* the adoption of strategies based on memorization and rote learning as a means to avoid failure and working too hard, although with the presence, to a lesser extent but with little difference, of motivational features and strategies from a deep approach that seeks understanding above reward for passing. In the case of *Deep Approach–Medium*, it implies there is a clear leaning towards the use of strategies based on a desire to learn in a manner that leads to a thorough understanding of the material being studied. However, the desire to ''pass'' is otherwise still present, although to a lesser extent, but it does not interfere with the search for deep understanding vs. simple memorization. The aforementioned thus places the Type and Intensity of approaches to learning demonstrated by these students in the medium to high range, a range is not to be sniffed at, however there is still room for improvement. Also, a significant difference in the gender variable has been observed for *Superficial Approach*. Women and men present statistically significant difference: women demonstrate a higher rate of *Superficial Approach–Low* than men (showing less superficial motivation and strategies). This means women use a deeper approach to learning than men, which proves positive in terms of achieving better quality and more comprehensive learning than that based on memorization techniques.

Once the students had the experience to study using LOs, some changes were observed regarding the approaches of learning. In particular, the use of LO in Engineering and Architectural Graphics significantly improves students' approaches to learning. This is characterized by a quest to understand content to the fullest. Learning is seen as something that produces satisfaction. New concepts are related to prior knowledge. Students engage in tasks as they are seen as interesting and a means through which to attain personal growth. Ultimately, this strategy is based on understanding and not on memorization techniques. Otherwise the use of LOs in Engineering and Architectural Graphics produces an improvement in the type and intensity of learning approaches, although it falls short of being significant. An increase in the intensity of the approach is perceived, which translates into higher value placed on understanding what is being studied than on memorizing what is being studied. However, this increase falls short of being significant for the sample size in question. Moreover following the use of LO in Engineering and Architectural Graphics, significant statistic difference in approaches to learning based on gender is identified. Women and men present statistically significant difference: women demonstrate a higher rate of *Superficial Approach–Low* than men (showing less superficial

motivation and strategies). This means women use a deeper approach to learning than men, which proves positive in terms of achieving more comprehensive learning than that based on memorization techniques, and thus better quality learning.

6. Conclusions

Everything discussed throughout the previous section is positive and can be directly attributed to the introduction and use of the LOs proposed in this study which were designed and built as teaching aids within Engineering and Architectural Graphics. This is a fact that can be appreciated by comparing the results obtained following LO use against data obtained from students' prior any pedagogic intervention. The overall objective has been achieved and it shows that the use of multimedia learning objects and their autonomous use by engineering students produce a change of approach of learning. However, caution is advised when looking at the results and conclusions of this study, as the authors' initial aim was to merely build a pilot study that would reveal a suitable approach for a larger scale experiment. In particular, one great limitation relates to the scarce number of students undertaking Engineering and Architectural Graphics courses offered as part of university degrees. Nevertheless, there is no doubt that the results have delivered positive findings. The fact that this study has provided good results can, and should, serve as an invitation to further exploit the use of these types of pedagogical methodologies and initiatives as a means through which to comfortably handle the new teaching styles that are currently being imposed. It is also worth noting that this study has proven an incredibly positive experience and is highly recommended for university teaching. This study, in focusing attention on the design and implementation of LOs in the field of Graphic Expression, and on the analysis of their impact to secure deep learning, that in turn acts as a more convenient way to get and develop competencies in subjects within the field of Graphic Expression, has demonstrated its contribution towards innovation. Based on the results presented, there is hope that this study will serve as inspiration to the academic community to continue building on the findings and strengthen the desired relationship between teaching and research. In terms of future courses of action, there exists the possibility of taking the experiences of first-year Engineering and Architectural Graphic students and expanding on them to include all Engineering degree students in order to analyse the variances that arise from larger and more heterogeneous sample sizes.

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