IMPROVING LEARNING OUTCOMES BY LABELING SLIDES BASED ON THE COMPLEXITY OF THEIR CONTENT

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Abstract

University professors often tend to create slides that blend introductory, intermediate, and advanced contents. Introductory content is necessary to understand the intermediate, and the intermediate is, in turn, necessary to comprehend the advanced. However, typically, it is left to the students to decide which part of the material is basic, intermediate, and advanced. However, many times, the professor does not even consider the possibility of addressing those advanced topics but does not want to remove such material because a few students who are more advanced might benefit from it. Furthermore, the professor loses a lot of class time explaining material that few students are prepared to understand, as they are still grasping the most basic concepts.

In this study, students' academic performance was examined using labels to classify slides in a university course on Object-Oriented Programming. These labels categorized the content of the slides into introductory, intermediate, or advanced levels. To evaluate the impact of the labeled slides, we compared the academic results of the students during the 23-24 course, where the categorized slides were implemented, with the results of the students in the previous academic courses (21-22 and 22-23), in which such classification was not used in the slides. This analysis seeks to understand how the categorization of slides according to their complexity affects student performance, providing a comparative view of learning experiences with and without these labels.

Keywords: material classification, Object-Oriented Programming, knowledge levels, slide labelling.

1 INTRODUCTION

Categorizing the content of a subject plays a critical role in providing students with an organizational structure that simplifies their understanding and approach to topics. By classifying the study materials into specific categories, students can clearly discern distinct subject areas, allowing them to channel their learning efforts more effectively. This organization facilitates not only a thorough understanding of each topic, but also a more efficient management of subject preparation time. By having a clear view of categories and subtopics, students can strategically plan their studies, thus optimizing their academic performance.

In many cases, successive changes in curriculum, driven by new regulations, have resulted in a reduction of time allocated for lectures. On the other hand, despite these time reductions, teachers tend to maintain the content as they consider it indispensable. However, in exams, teachers often pay more attention to basic content that all students must know, as opposed to advanced content, which only a few students manage to grasp.

Teachers use many slides in their classes [1][2]. The format, number, and density of these slides influence their effectiveness as educational aids for students [3][4]. However, as emphasized by J. L. Williams et al. [5], students need to scan the information on the slides to determine what is relevant. Assisting them in increasing the relevance ratios of their notes can enhance their academic skills and lead to more positive outcomes [6].

In line with the first advice for improving presentation Slides of J. Straus et al. [1] proposed the introduction of labels associated with each slide, allowing students to reinforce the importance of what is described in it. Additionally, the results obtained by the students before and after the introduction of these labels in successive courses were compared.

2 METHODOLOGY

The tests in this study were conducted within the framework of the course “Introduction to Object-Oriented Design and Programming” in the Computer Science degree program. This course was taught during the second year of the Computer Science program at the Universidad Rey Juan Carlos. The course lasted for one semester, and its evaluation process included two partial exams, a final exam, and a practical design and programming exercise. The tests carried out to assess the performance of the proposed methodology in this study were conducted over three consecutive academic years: 21-22 and 22-23, where the proposed methodology was not used, and the academic year 23-24, where the proposed methodology was introduced in the classes.

During the first two academic years (21-22 and 22-23), a traditional teaching methodology was employed in the course. However, in the most recent academic year (23-24), an alternative approach involving the labeling of course content was implemented; to evaluate and compare both methodologies, we focused exclusively on the results of the final exams of the course, omitting consideration of the practical part and the two midterm exams. This choice was based on the fact that the final exams covered the theoretical content of both midterm exams, providing a comprehensive view of the knowledge acquired throughout the course.

Evaluation will focus on the overall grade point average for all students in the course, but a more nuanced analysis will categorize students based on their grade levels: 'Below Pass' for grades below 3, 'Pass' for grades exceeding 5, and 'High Pass' for grades surpassing 7. The three-tiered approach allows for a thorough evaluation to identify differences and commonalities in students' performance across various teaching strategies implemented in different academic years.

In academic years 21-22 and 22-23, the first experimental phase called '*tabula rasa*' was implemented. During this phase, a conventional didactic approach was adopted, in which the contents of the slides used in the subjects were not classified. With the exception of some punctual indications provided by the teachers during the explanations, all contents presented in the slides were considered of equal importance, with the same possibility of being evaluated in the exams.

In the 23-24 academic year, the second experimental phase, '*labeled*', was implemented. Although the same didactic content was addressed and the same slides were used as in the previous course, each slide corresponding to a specific subject was labeled with a pictogram indicating its level of knowledge in relation to the course syllabus (see Figure 1). Three levels were considered for classifying the content:

1 *Basic Knowledge*: Essential for passing the course, this level comprises fundamental content without which it cannot be claimed that the student has acquired the necessary knowledge. Slides with this type of content are labeled with a pictogram in Figure 1a.

2 *Advanced Knowledge*: These concepts are considered advanced in subject matter. While it is not necessary to pass the course, they may be of interest to more dedicated students and will be further explored in subjects of future courses in the degree program. Slides with this type of content are labelled with a pictogram in Figure 1b.

3 *Intermediate Knowledge*: This level includes concepts that, although not basic, are necessary to surpass the course. Despite not being fundamental, they are crucial for evaluating the capabilities attained by students and ensuring that they have assimilated the course, reaching an acceptable level of understanding of the subject matter. Slides with this type of content do not require pictograms to indicate their level.

In addition to the use of these pictograms distinguishing between basic knowledge, which is crucial for passing the course, intermediate knowledge, and advanced knowledge that might be of interest to students, it was communicated to the students during the course that basic and intermediate knowledge would be assessed in the exams. Meanwhile, advanced knowledge, although presented, would not be evaluated, but could serve as potential subjects for individual research.

During the slide presentation classes, the professor explained the slides labeled as basic and those labeled as intermediate, but hardly stopped to explain those labeled as advanced.

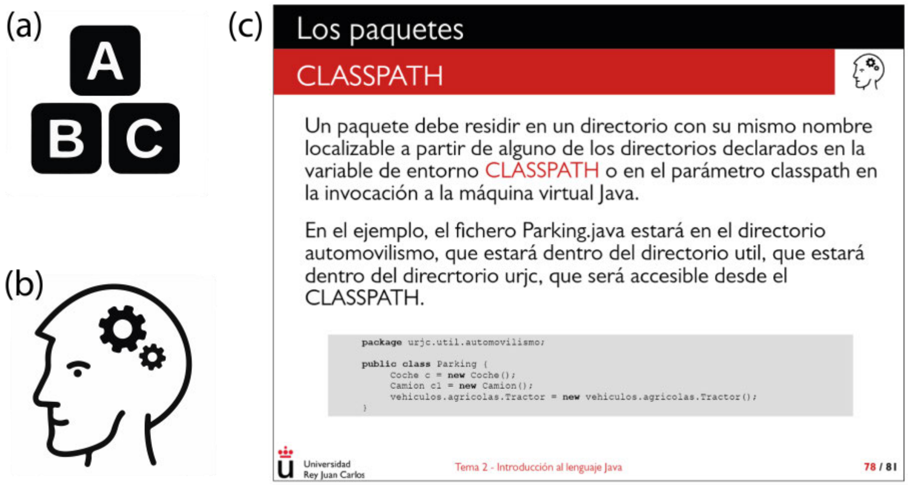

Figure 1. Pictograms indicating the level of content:
a) Basic and essential knowledge.
b) Advanced knowledge subject to research by students.
c) Example of slide with advanced material label.

3 RESULTS

To assess the outcomes of the proposed methodology, data from the initial six weeks of an “Introduction to Object-Oriented Design and Programming” course in the second year of a Computer Science degree were utilized. Each week comprised two classes, each lasting two hours, covering three key topics: an introduction to object-oriented programming and design with Unified Modeling Language (UML), a presentation on the Java programming language, and an exploration of inheritance capabilities in Java, along with other class relationships.

This section provides a detailed explanation of how the teaching materials used in classes have been labeled. In addition, the construction of the exams was discussed, considering the level of the questions in terms of advanced, basic, and intermediate knowledge. Finally, a comparative analysis of the results obtained by the students was conducted, in contrast to the results of previous years when the material was not labeled. This allowed us to examine and compare the results before and after implementation of the proposed methodology.

3.1 The slides

The duration of each course analyzed was 12 weeks, with two classes of 2 hours each, totaling 24 teaching hours. The teaching material used in these classes consisted of three blocks of slides that addressed the afore mentioned topics: introduction to programming and object-oriented design, programming with Java, and relationships between classes. These slides were developed six years ago, and their contents remained unchanged during the testing of this study. The only modification introduced in the slides, exclusively during course 23-24, was the addition of pictograms indicating the level of content, either basic or advanced. Slides with intermediate levels of content did not require any labeling (see Figure 1).

Excluding structural slides, such as covers and indexes, a total set of 148 slides were labeled. Among them, 51% (76 slides) were labeled as Basic Knowledge, 45% (66 slides) as Intermediate Knowledge, and the remaining 4% (6 slides) as Advanced Knowledge (Figure 2a). It is relevant to note that most of the slides address basic and intermediate knowledge, with advanced knowledge slides being in a smaller proportion.

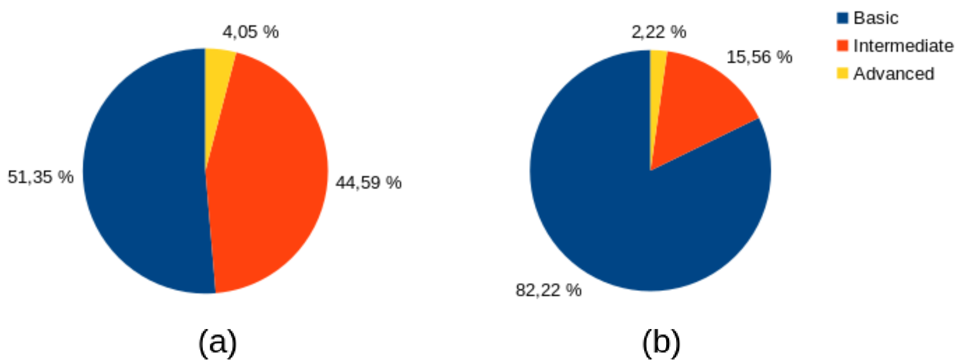

Figure 2.
(a) Percentage of slides labeled at each level and
(b) percentage of questions corresponding to each level in the question bank.

3.2 The multiple-choice test

As previously mentioned, the complete evaluation of the course comprises two multiple-choice midterm exams, each with 10 questions, a final design exam, and programming practice. In this analysis, we focus on the results of the first midterm, which consists of 10 multiple-choice questions selected from a question bank, with a total of 46 questions. This question bank was created six years ago, along with the slides used as teaching material for the subject and has not undergone any modifications during these courses. The consistency of the question bank has been maintained over the last five years, spanning the data collection period.

The questions in the bank assessed knowledge categorized as basic, intermediate, or advanced on the slides. Upon examining the question bank in detail and relating it to the slides that made their answers possible, it was found that 37 questions corresponded to *Basic Knowledge* slides, seven *to Intermediate Knowledge* slides, and one could not be related to any slide, so it was labeled as *Advanced Knowledge* (see Figure 2b).

It is crucial to highlight that most questions in the bank were linked to basic slides. This finding is significant considering that the questions were created years before labeling the slides and that the labels were assigned without reference to the question bank.

3.3 Test results

The results obtained in the different tests are presented in detail in Table 1 and illustrated in Figure 3. This table shows the number of students for each of the courses analyzed, the average grade obtained in the final exam and the percentage of students in each of the established categories: 'below pass' less than 3, 'pass' more than 5 and 'high pass' more than 7.

As shown in Table 1, the number of participants remained similar over the three consecutive years, with a constant attendance of 85-87 second-year computer science students. In addition, there was a progressive increase, from 5.08 to 6.09, in the average grade obtained in the final exam of the subject throughout the course.

In general, 60% of students answered the questions correctly. More specifically, 61% of the students answered correctly to questions classified as easy, while 59% obtained correct answers to intermediate-level questions.

Figure 3 presents a more detailed comparison of the test results for grades 21-22, 22-23 and 23-24. After the implementation of content labeling, there is a slight increase in the percentage of passes and a one-point increase in the average grade in course 23-24 compared to 22-23, and one point above course 21-22.

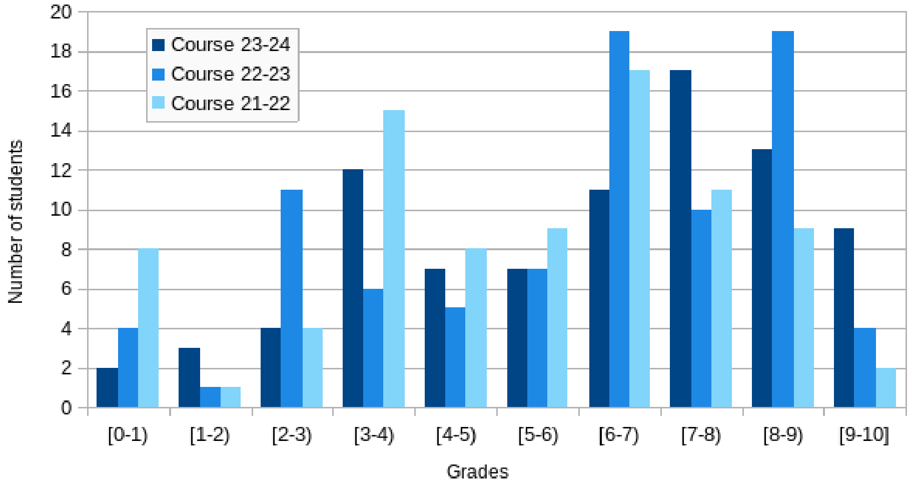

Figure 3. Grades obtained in test exams before and after the introduction of the labels in the slides.

Table 1. Test exam resumes obtained before and after the introduction of the labels.

Course	***2021-22 (No labels)***	***2022-23 (no labels)***	***2023-24 (labels)***
Total students	85	87	85
Average rating	5,08	5,81	**6,09**
Less than 3	15,48%	18,60%	**10,59%**
More than 5	57,14%	**68,60%**	67,06%
More than 7	26,19%	38,37%	**45,88%**

3.3.1 Discussion

Throughout the study, a notable reduction was observed in the percentage of students receiving grades 'below pass' in the 0-3 range. The number decreased from 18.60% of students with grades below 3 in the previous academic year to 10.59% in the 23-24 academic course. This substantial decline indicates a positive influence of the implemented methodology in enhancing academic performance, particularly in lower grades.

The proportion of students who managed to pass the course remained constant throughout the study period. This result indicates that despite the changes introduced, the methodology did not negatively influence students' overall ability to pass the subject.

A significant increase in the number of students who achieved remarkable and outstanding grades was observed, going from 38.37% of students with a grade higher than 7 to 45.88%. This phenomenon suggests that the intervention had a positive impact on student performance, which was reflected in the higher grades.

As detailed in Table 1, the percentage of passes in course 23-24 with labeled content exceeds the pass rate of course 21-22, although it does not reach that of course 22-23, both with 'tabula rasa' content However, a more detailed observation in Figure 3 reveals that among the students who passed, there was an increase in grades. This result suggests a possible improvement in the mastery of content and competencies, even among those who have already passed.

Despite not achieving a passing grade, it was observed that students who did not pass the course obtained higher grades than those in previous studies. This finding may reveal a higher overall level of difficulty for the subject.

The distribution of grades in the 22-23 academic year showed a shape closer to a normal distribution. This change in the distribution could indicate greater homogeneity in student performance and a reduction in extreme biases in grades.

4 CONCLUSIONS

In this work, we have proposed labeling the relevance of the content of various slides by means of an indicative pictogram on each slide, classifying them into three levels: *'Basic Knowledge'*, '*Intermediate Knowledge'* and *'Advanced Knowledge'*.

The approach of labeling teaching material versus the classic 'tabula rasa' approach provides a more reassuring and focused approach for students who may need more support in certain aspects of the subject matter. In addition, it creates a stimulus for interested students to investigate and delve deeper into advanced concepts, thus fostering a spirit of inquiry and self-discovery.

The results obtained by the students in a multiple-choice test seem to indicate that the slide labeling methodology enabled them to answer the questions better than when the slides were not labeled. Considering that most of the questions corresponded to content explained in slides labeled as basic, it is important to note that this methodology did not result in a decrease in performance on questions related to slides labeled as intermediate level.

Moreover, the process of labeling the slides was very instructive for the teachers because it allowed them to think about the level of the slides. In addition, analysis of the relationship between the test exam questions and the slides explaining those questions allowed the teachers to reason about the appropriateness of the exam.

On the other hand, we expect that labeling content as '*Advanced Knowledge*' plays a motivating and guiding role in the educational process.

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