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Adaptation and Update of a Curricular Didactic Analysis Instrument from STEM Teaching and Learning Units

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Abstract

We begin this project by introducing an instrument designed for textbook analysis which has been brought forth from extensive research in which didactic analysis was used as a research methodology. It has proven itself necessary in the development of the teaching-learning processes of Science, Technology, Engineering and Math (STEM) [1]. Didactic analysis is considered a field of research in Mathematical and Scientific Education which allows for the examination and comprehension of the phenomena of Mathematical and Scientific Education, and their intervention with certain assurances. Despite the indisputable power of this instrument, we are adapting and updating it to include and consider the gender perspective, which was neglected in [1]. With feminism being a crucial element to our line of work, it proved essential to adapt this instrument so that the gender perspective took on the main role which we believe it deserves. Furthermore, the scheme has been simplified and updated to a more technological and easily accessible format. By implementing these modifications, we intend to facilitate the systematization and comparison of the analysis results, which is quite complicated within the current format. These enhancements are being tested by applying them to a sample of textbooks and thus validating them.

Keywords: *Didactic Analysis, STEM, Mathematical and Scientific Education*

1. Introduction

Overall, the main purpose of education is to provide students with the means to develop their physical, personal, social, and moral autonomy [2]. Therefore, Science-Technology-Engineering-Mathematical Education (STEM) in particular must not be limited to the exclusive learning of the use of mathematical and scientific instruments. Instead, it must go much further by helping students comprehend math and sciences so that they can adapt themselves to their environment and thereby organize and transform it. Furthermore, it must prepare the individual to analyze the current options in any given situation and select the best one [3].

It has been three decades since [4], affirmed that certain forms of mathematical and scientific activity favour mainly the development and acquisition of cognitive abilities - hence the formative interest of its teaching. However, the formative values associated with mathematics and science are not simply limited to the cognitive aspect. They are active on a global scale and connected to human standards and values as well as to the emotional field.

Today, progress is being made on this idea, as [5] affirms that Mathematics has a threefold character: Instrumental, Functional and Formative. It is a uniquely interdisciplinary subject as it is related to virtually all fields of study, not simply in its scientific-technological aspect. For instance, it is interwoven within seemingly unrelated disciplines such as the Social Sciences, Music, Sports, Poetry and Politics. Although the formative character or Mathematics is usually forgotten in the teaching-learning processes, it still proves to be just as crucial of a component within the framework of a well-rounded society of the 21st century. For this reason, proposals in this regard are beginning to emerge [6].

Specifically in [7], it is stated that in order for a quality STEM teaching-learning process to take place, one should promote the acquisition of attributes such as being an observant, predictive, critical-reflective person, among others. These attributes will allow for effort to be made regarding the scientific practices of modelling, inquiry and argumentation. Additionally, they will allow for other characteristics to emerge which deal more directly with social and moral skills and abilities such as being a respectful, empathetic or gender-conscious person. This document focuses on the last aspect, as it may be observed from the search for information regarding this matter that the scientific

community has demonstrated that the historical and current position of women in mathematics and science has been utterly deprived.
We maintain that there are numerous explanations that have led to this: The non-inclusive language and images used, the overall scientific images or perception which have been transmitted to us through culture, and/or the gender stereotypes transmitted through the education system, families, social networks or the media.
In most cases, this causes girls to not have female role models to look up to, and it implies in a very direct way that the number of women pursuing STEM careers is vastly lower than the number of men, [8].
Thus, as an educational research team dedicated to teacher training, we set out to study the importance all of this has in overall teaching performance.
In order to analyze whether a STEM teaching-learning process accurately meets these characteristics, it was proposed to design a new instrument, which would allow precisely this.
As a starting point we focus on the teaching-learning processes suggested by the current textbooks, and for this we start from the analysis instrument proposed in [1] by teachers of the Faculty of Educational Sciences of the University of Malaga, based on Didactic Analysis (DA). DA is a non-empirical methodology of a meta-analytical nature for the study of a problem or a field of research in Mathematical and Scientific Education. It allows examination and understanding of the phenomena of Mathematical and Scientific Education and intervenes on them with certain assurances. In this document, we use it to analyze a didactic unit, a textbook or a portion of a textbook (in its Didactic Curricular Analysis modality) [1].
It is necessary to recognize the leading role that textbooks have played in the entire didactic process, which has made them an object of traditional interest in didactic research [9]. The student body assumes that the textbook is the exclusive work and learning guide, and that it contains all the information that one needs to and must know [10].
After having repeatedly used the textbook-analyzing instrument [1] designed by Gallardo and González based on Didactic Analysis, one can see that it is quite tedious, both due to length and format. Furthermore, it does not take into consideration the aforementioned aspects [8].
The objective of this work is to adapt the instrument presented in [1], based on the Didactic Analysis, so that one may analyze the didactic potential of a given textbook with respect to the gender perspective. In addition to simplifying the scheme, it has been updated to a more-accessible and user-friendly technological format. These changes will permit subsequent systematization and analysis results comparison (both being quite complicated within the current format). Consequently, information may be obtained which will in turn help publishing companies in the designing of their textbooks.

2. Results

Part of the theoretical research work carried out by the group is gathered from [11], with the purpose of defining the categories and dimensions allowing us to adapt the instrument so that it responds to our concerns. After the theoretical study carried out, five main categories have been proposed for the new design of the instrument: “Images of Science”, “Awareness of Female Role Models”, “Non-Sexist Language and Images”, “Gender Perspective Behavior” and “Emotions”. These in turn are individually specified with a series of indicators (22 indicators in total) Table 1.
These five categories and their corresponding dimensions serve as the backbone of the new instrument.

Table 1. *Categories and Indicators*

CATEGORIES	INDICATORS
Images of Science	Importance in Society
	Collaborative Image of Science
	Image of Science Outside of Academics
	Image of Science Beyond the Empirical Field
	Non-Elitist Image of Science
	Stereotypical Image of Science and Technology
	Broad Professional Image of Science
	Image of Science, Technology and Mathematics Connected with Art and Creativity

Awareness of Female Role Models	Visibility of Women Scientists
	Visibility of Women Contributions
	Visibility of the Context in Which Contributions of Women Scientists were Created
Non-Sexist Language and Images	Usage of Alternatives to the Generic Male
	Characteristics of Non-Sexist Discourse
	Characteristics of Non-Sexist Images
Gender Perspective Behavior	Equality
	Women Appreciation
Emotions	Fun/Happiness/Enjoyment/Pleasure
	Expectation/Enthusiasm/Curiosity
	Attraction
	Interest
	Safety/Trust/Gratification
	Calmness/Peace

For each of these indicators, three exclusive levels have been defined, with which each indicator is valued as "Positively" (N3), "Neutrally" (N2) or "Negatively" (N1).
By using the instrument of [1] as a foundation and pairing it with the previously mentioned material, we have successfully developed the new instrument that can be found in http://u.uma.es/Z3/adtxinst/, Limesurvay platform. Figure 1 is the screenshot obtained from one of the parts of the instrument.

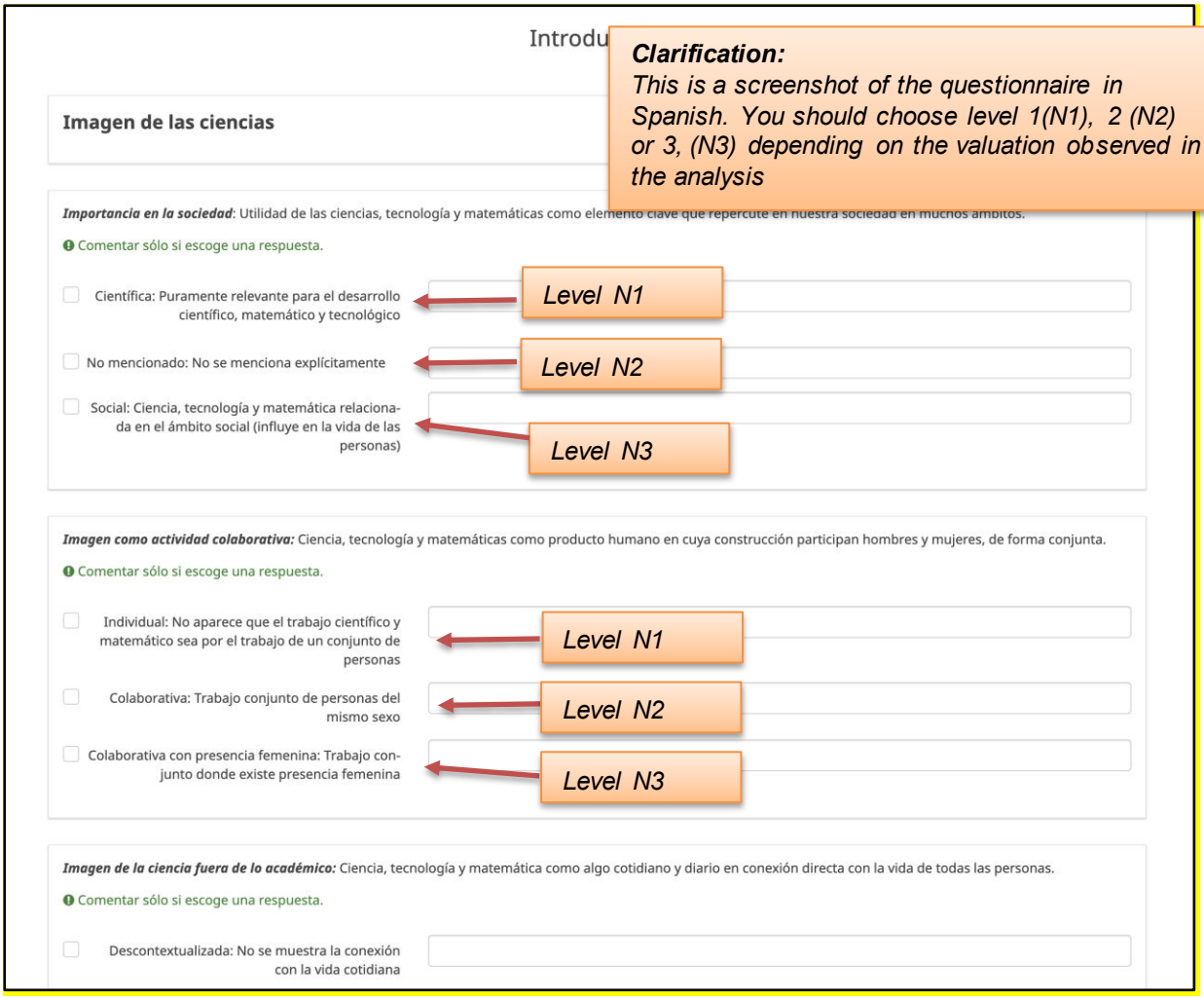

***Figure 1**: Screenshot of a section of the instrument, with some clarifying notes overwritten*

This new instrument has been tested in two high school textbooks, (Science and Mathematics respectively), and is currently being validated by a committee of nine experts.

3. Conclusion

The instrument that has been constructed through the adaptation and updating of [1] will allow for a new perspective in textbook analysis in which gender equality takes on the leading role which it necessarily deserves. Didactic Analysis, in its modality of Curricular Didactic Analysis, has served to examine and understand some of the phenomena of Mathematical and Scientific Education. Moreover, great progress is made in those studies which state that Mathematics has a threefold character (Instrumental, Formative and Functional).

Thus, it may be observed in a more direct way if textbooks truly promote the acquisition of certain attributes needed from citizens of the 21st century - specifically those related to social and moral skills and abilities. This is achieved through the appropriate usage of language and image, promoting the transmission of a more up to date image of science, where female role models can be seen, and allowing emotions and behaviors which favor equality between men and women.

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