Design of a Direct Observation Protocol in the Secondary School Classroom

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Abstract

The teaching-learning processes in the mathematics classroom require continuous improvement; it is essential to analyse what happens inside the classroom [3]. This analysis requires prior observation, which also considers more complex focuses, not only the more instrumental mathematics but also formative and functional mathematics [6]. Therefore, the design of observation protocols is necessary to analyse learning situations that are being carried out in real contexts [18] and from different points of view. In this paper, we describe some ways of classifying observation and the protocols that can be used to carry out such observation. It also proposes a hybrid observation protocol designed specifically for direct observations, as opposed to other models that prioritise video analysis, and systematic and longitudinal observations with a closed level of structuring. It is based on the TEDS-Instruct instrument by Schlesinger et al [16] and the POEMat.ES by Joglar et al [8]. In addition, several qualitative questions are added, which complement the previous ones in terms of quality and implementation levels and other aspects, such as academic performance or curriculum monitoring, which are all aspects that Bostic et al. [2] focus on to categorise the observation. Finally, some limitations are pointed out, such as the length of the protocol or the precaution that the person observing is not part of the observable context, and some future lines are marked out, which are the validation of this instrument and its use to detect strengths and weaknesses of active teachers so that a redesign of the learning situations that are being carried out in real contexts can be made.

Keywords: *Mathematics Education, Secondary Education, observation protocol*

1. Introduction

To design appropriate learning situations that not only include a technical, or instrumental, approach, but also one related to understanding and using mathematics to adapt to the environment, or functional, and one related to favouring the understanding of mathematics, or formative [6], it is necessary to observe first what is being carried out in real contexts [18]. Furthermore, to carry out a good observation, it is necessary to have the support of an observation protocol that is appropriate to what is to be observed [13] [14].

In the last decades, observation protocols, and more specifically, observation protocols in mathematics didactics have increased in complexity [3].

This work aims to design an observation protocol that can be used to see how the teaching and learning process of the subject of mathematics takes place in a Secondary Education classroom. To this end, we consider some of the observation instruments that best meet the needs of our research team, considering current educational legislation.

2. Theoretical Framework

Classroom observation is one of the main procedures for validating theoretical postulates [1]. It is also one of the most solid instruments used to identify and give value to the diversity of nuances, meanings, and intentions with which a pedagogical event manifests itself [4].

An observation process can be through video or direct observation [17]. Another complementary way of classifying observation is according to the relationship to the observed situation: systematic if it is carried with little or no contact with the observed event, or participant if it takes an internal role in the observed pedagogical process [17]. A classification can also be given according to when it occurs, being punctual, if it is carried out at a specific moment, or longitudinal if it is carried out over some time [7]. The level of structuring of the observation instrument can be open descriptive, covering many events and processes, narrative, involving prior planning and structuring, or closed, considering the

sequentially and chaining of events [7]. In the latter, unlike the two previous ones, a protocol is usually used in which a categorisation appears [7].
Observation can be recorded in different ways. In addition to diaries, in which the events are reported exhaustively, there are other observation protocols, such as anecdotal records, in which an event is described, sign systems or feature lists, which consist of a list of the issues of interest, indicating whether they are present or not, or category systems, where it is shown whether certain records occur or not [10].
The different theoretical frameworks on observation in didactics can be classified into several types [5]:

- Generic: they study the quality of aspects of subjects, concerning the general teaching requirements. An example of a protocol of this framework is the Classroom Assessment Scoring System [12].
- Content-specific: these focus on a particular subject and provide subject-specific information. An example of a protocol for this type of framework is the Mathematical Quality of Instruction [9].
- Hybrid: mixes these two types of theoretical frameworks. It has benefits as it is centered on different generic aspects, such as time management or feedback received, how mathematics is taught, using multiple ways of solving problems, or using rigorous mathematical language [5]. Two examples of hybrid framework observation protocols are:
    - TEDS-Instruct, by Schlesinger et al. [16]: this protocol is adapted from a systematic review of the literature in which three major dimensions (classroom management, student support, and cognitive activation) are fixed through the observation of videos for German-speaking countries [15]. It consists of a Likert scale of 1-4, in which different statements are described and must be rated according to the level of agreement, where 4 indicates complete agreement. It distinguishes the categories of classroom management, student support, cognitive activation, quality of the subject, and related quality of teaching.
    - POEMat.ES, by Joglar et al. [8]: this protocol for observing videos of mathematics lessons in Spain is based on a systematic literature review on similar protocols. It is made up of three categories, from which different subcategories and a series of indicators associated with them are highlighted, and ordered with a score between 0 and 3, with 3 being the level of agreement with the subcategory. A distinction is made between the categories of mathematical content, didactics of mathematical content, and classroom management.

Regarding research on the evaluation of classroom instruction, Bostic et al. [2] make a categorisation divided into two criteria:

- If quality or implementation levels are not addressed: here we find measurable elements, such as waiting time or the number of questions, also included in this criterion is student initiative, such as the impact of cooperative groups, curriculum or technology, and teacher professional development belongs to this criterion.
- Looking at levels of quality and implementation: this criterion includes informal observation, used as anecdotal data, formal observation of the class through a total score, and observation that has several indicators and ranges related to the quality of the class.

3. Observation Protocol

In the research carried out, due to the context in which the study is framed, we need an instrument that is of classroom observation (direct), in which the observer has a relationship with the classroom (systematic) and is also carried out over some time (longitudinal). The level of structuring is closed, so it has a categorisation system. Moreover, it is in a hybrid theoretical framework, as it is based on hybrid protocols.
Its structure is:
An initial part, extracted from the TEDS-Instruct protocol [16], which can be found in Table 1, and for which a Likert scale of 1-4 is available, where 1 is not at all agree with the statement, 2 is slightly agreed, 3 agrees and 4 is strongly agree.

Table 1. *Items used from TEDS-Instruct [16]*

Items	Indicators
Classroom management	
Effective use of class time	Class starts and finishes on time.
	Transitions between the phases of the class occur progressively.
	Class time is used to work on the content of the topic.
Clear rules and routines	Patterns of the organisation are evident.

	Students are part of the organisation of the class.
Organisation/Structure of Learning Processes	The teacher informs the students about the objectives of the class.
	The teacher's explanations are clear.
	Tasks are in an appropriate language.
Productive atmosphere	The level of education is appropriate.
	The students react to the teacher's indications.
	Students and teachers do not interrupt each other.
Class structure	The class follows a common thread.
	The class is divided into clear sections.
	The teacher ends the lesson appropriately.
Student support	
Individual student support	The teacher asks about individual progress/individual difficulties.
	The teacher devotes individual time.
	The teacher gives individual assistance to students.
Heterogeneity	Additional materials for some subgroups
	Specific tasks for different subgroups of learners
	The teacher finally offers differentiation in the classroom (how to vary the cognitive level of the questions)
Self-directed learning	Students correct their results independently of an example solution.
	The teacher encourages students to work independently.
	Students should decide whether they prefer to work in groups or not.
Teacher feedback	Teacher feedback is sophisticated.
	The teacher's feedback is constructive.
	The teacher's feedback is useful for the future.
Teacher's appreciation of his/her students	The teacher is patient.
	The teacher positively enhances students' work.
	The teacher encourages the students to work.
Student feedback	The teacher demands feedback.
	The teacher reacts to student feedback.
	The teacher and students talk about problems in class.
Collaborative learning	The teacher proposes collaborative learning.
	The teacher proposes tasks that require agreement.
	The teacher mediates the interaction processes.
	Students help each other.
Cognitive activation	
Metacognition	At least one sub-process of metacognition takes place.
	The teacher allows time for metacognition processes.
	Students reflect on their learning processes.
Previous knowledge	The teacher asks about students' beliefs on the topic in question.
	Students explain the task in their own words.
	The teacher activates and explores students' previous knowledge.
	The knowledge that is developed in class is based on the students' previous knowledge.
Cognitively challenging teaching methods	Cognitively challenging teaching methods are used.
	The teacher gives enough time to think about the tasks.
	The teaching methods correspond to the content and the class.
Ease of remembering knowledge	The teacher gives enough examples and helps to remember the knowledge.
	The teacher repeats the knowledge sufficiently.
	Relevant steps are discussed with the whole class.
Theme-related quality	
Students' mistakes in mathematics	The teacher uses students' mistakes as an opportunity for learning.
	The teacher analyses the students' mistakes.
	The teacher tolerates students' mistakes.
	Students correct their own mistakes autonomously.
Teaching-related quality	
Teaching practice	The teacher explains the importance of the exercises.
	The exercises contain opportunities for exploration and reflection.
	The exercises differ from each other.

A second part, extracted from POEMat.ES [6], modified the Likert scale of responses, with indicators ranging from 1 to 4 to unify the type of responses. The selected subcategories are complementary to the previous protocol and can be included in the categories of the last protocol. They are listed in Table 2.

Table 2. *Items used from POEMat.ES [6]*

Scale	Indicators
Mathematical content	
Use of representations / Use of multiple representations	
1	No mathematical tasks are developed, or they are, using only the representation register of natural language.
2	Mathematical tasks are performed using a register of representation different from natural language.
3	Mathematical tasks are developed using two registers of representation different from natural language.
4	Mathematical tasks are performed using three or more registers of representation other than natural language.
Conversions of representations / Appropriate mathematical examples	
1	There are no conversions between records referring to the same content.
2	Conversions are made between two registers, other than the natural language register, in one direction only.
3	Conversions are made between two different registers than the natural language register, in both directions.
4	Conversions are made between three or more registers other than the natural language register.
Student relevance of mathematics	
1	There are no connections between the explanation and the reality of the learners.
2	Few connections are made between the explanation and the reality of the learners, but only from the teacher to the learners.
3	Quite a few connections are made between the explanation and the reality of the learners, but only from the teacher to the learners.
4	Many connections are made between the explanation and the reality of the learners, and between learners and teachers.
Definitions / The teacher's mathematical correctness	
1	The teacher does not define any mathematical objects.
2	It merely states the definition or states properties of the object to be defined that fall short of the condition of being necessary and sufficient and uses limiting examples that may violate the consistency and unambiguity of the definition.
3	It states (or describes through examples and counterexamples) properties of the object to be defined that can be understood as necessary and sufficient conditions but stops short of institutionalising the definition.
4	It states (and/or describes through examples and counterexamples) properties of the object to be defined that are understood as necessary and sufficient conditions and thus institutionalises the definition.
Argumentation / Mathematical depth of the class	
1	No argumentation processes are observed.
2	Applies mechanical procedures without mathematical justification, uses trivial or limiting examples to relate different mathematical objects, or uses examples to show a general statement.
3	Uses argumentation processes by explicitly stating how and when they can be executed during most of the lesson.
4	Develops argumentation processes by explicitly stating how, when, and why they can be executed during most of the lesson.
Mathematical flexibility / Mathematical depth of the class	
1	No mathematical task is developed, or they are developed using in each case only an argumentation or resolution strategy.
2	The teacher presents or admits several arguments or resolution strategies for the same mathematical task, without explicitly comparing them.
3	The teacher presents or admits several arguments or resolution strategies for the same mathematical task, explicitly comparing them without reflecting on the characteristics of each one.
4	The teacher presents or admits several arguments or resolution strategies for the same mathematical task, explicitly comparing them and reflecting on the characteristics of each one.
Connections / Mathematical depth of the class	
1	Tasks are approached in isolation, where no connections within or between topics are observed.
2	Tasks are addressed in which connections, within a topic or between topics, are only cited.
3	Tasks with connections within a theme are addressed and substantiated by the teacher.
4	Tasks are approached with connections between subjects, and these are substantiated by the teacher.
Teacher's mathematical errors / Teacher's mathematical correctness	
1	No error was noted.
2	Error in executing a procedure: both standard and non-standard procedures are considered.
3	Error in using a concept: e.g. dealing with a definition or a property.
4	Error when using notation: symbolic-numeric or symbolic-algebraic register.

Didactics of mathematical content	
Use of cognitively challenging materials / Teaching methods	
1	No use of any material is observed.
2	The actions performed with the material are not appropriate for the mathematical content worked on.
3	The actions performed with the material are appropriate for the mathematical content being worked on; however, the students do not use it or limit themselves to following a series of mechanical instructions.
4	The actions carried out with the material are appropriate for the mathematical content being worked on, the teacher exploits its possibilities to work on this content and encourages pupils to work on and reflect on it using this material.
Nature of the tasks proposed / Challenging questions and tasks	
1	No tasks or only closed and accessible tasks (exercises).
2	Set open and accessible tasks (exploratory tasks).
3	It poses closed and non-accessible tasks (problems).
4	It sets open and non-accessible tasks (research tasks).
Contextualisation of mathematical content / Use of multiple representations	
1	Mathematical work is decontextualised throughout the class.
2	It raises situations in which the teacher simply refers to some context in which no mathematical work is proposed.
3	It poses situations in some contexts that require the mobilisation and application of mathematical knowledge that has already been acquired and that must be brought into play to be able to respond to the demands of the situation.
4	It poses situations in some contexts that require the student to construct new mathematical knowledge to be able to respond to the demands of the situation.
Handing over responsibility for the mathematical activity / Self-directed learning	
1	Throughout the entire lesson, the teacher exclusively takes over the classroom work with no questions to the students or with basically rhetorical questions.
2	Throughout the lesson, at some point, it is observed that it is the students who work on mathematical content using an already known strategy, with or without validation by the teacher.
3	Throughout the class, at some point, it is observed that students work intending to construct strategies autonomously with or without validation by the teacher.
4	Throughout the class, at some point, students are seen to debate with each other to establish the validity of a strategy.
Adequacy of the discourse / Teacher's explanation	
1	Not observable because the teacher does not communicate mathematical ideas through oral or written language.
2	He uses a discourse that is not appropriate to the educational level of the students in most of the classes, making it difficult to transmit mathematical ideas.
3	Uses a discourse that is not appropriate to the educational level of the students at some point in the class, without affecting the transmission of mathematical ideas.
4	Use a discourse appropriate to the educational level of the student body throughout the lesson.
Exploiting learner interventions / Self-directed learning	
1	There are no interventions by the students, or they do not include mathematical content.
2	The teacher, for the most part, ignores or merely acknowledges the students' interventions.
3	The teacher takes advantage of student interventions to mobilise mathematical knowledge but does not include students in the reflection.
4	The teacher takes advantage of student interventions to mobilise mathematical knowledge by including students in the reflection and/or promoting debates among them.
Classroom management / Effective use of class time	
1	There is no time devoted to teaching and learning mathematics.
2	There is active time devoted to mathematics, but it is less than 60% of the session.
3	Active time spent on mathematics is between 60% and 90% of the session.
4	Active time spent on mathematics is more than 90 % of the session.
Use of expository resources / Use of multiple representations	
1	The teacher does not use expository resources throughout the lesson.
2	The teacher does not pay attention to the clarity of the expository resources during most of the lesson.
3	Although the teacher takes care to make the resources clear, he/she does not manage to do so in a structured or legible way throughout the lesson.
4	The teacher takes care to ensure that the resources are clear, structured, and legible throughout the lesson.
Use of written material / Cognitively challenging teaching methods	
1	From classroom observation alone, it cannot be said that the teacher is using a textbook or other written material.
2	Classroom observation shows the use of only one written material, which is not known to be the

	textbook or not.
3	Classroom observation shows the use of the textbook as the only written material.
4	Classroom observation shows the use of one or more written materials other than the textbook (which may or may not be used).
Disruptive behaviour management / Disruptive behaviour prevention	
1	Classroom behaviours do not impede the development of the class, so there is no need for teacher intervention.
2	The teacher does not react to student behaviour that impedes the development of the class, or his/her reaction causes the situation to escalate.
3	The teacher reacts to student behaviours that impede the development of the class ineffectively, mitigating the problem, but without managing to finish it.
4	The teacher reacts to student behaviour that prevents the class from developing effectively, in such a way that he/she manages to finish the problem.

A block with qualitative indicators is added where the person observing must add a description of the different items. They are found in Table 3.

Table 3. *Other items used*

Item	Answer
Classroom environment and working groups.	
Academic performance.	
Type of evaluation.	
Access to content.	
Diversity attention.	
Technological and manipulative tools used.	
Reasoning used.	
Methodologies used.	
Working system.	
Relationships between students.	
The mood of the students.	
Attitude of the students.	
Attitude towards problem-solving and mistakes.	
Other interesting insights.	

For the final part, all the Assessment Criteria included in mathematics, for the academic year in which the observation would take place, have been extracted from the Orden del 30 de mayo de 2023 [11].
In the observation protocol, some questions address the quality and implementation of teaching, as distinguished by Bostic et al. [2], and others such as the duration of the mathematics class, the impact of cooperative groups, or the technology used by the students.
This protocol is the result of a literature review on the qualitative technique of classroom observation, following the research of Charalambous and Praetorius [5], focused on the area of mathematics, which, unlike those made through video recordings [8] [16], is intended to be carried out systematically.

4. Conclusion and Further Research

This observation protocol aims to have an instrument that gives us a realistic and complete picture of the classroom situation, allowing us to know the profiles of students and teachers in the classroom, which will facilitate the future design of learning situations. One of the limitations of this protocol is its length, so that in a single observation session it would not be possible to gather all the information that we want to know. It is therefore recommended that more than one observation session be carried out. Another limitation may derive from the role of the person observing using this protocol, since, if he/she is part of the classroom development, the categories may not be detected as accurately. A possible solution to this is for the person using this protocol to remain completely outside the classroom.
In further research, this protocol can be used during different direct observations, as opposed to the widespread protocols in video observation, to detect the strengths and weaknesses of the active teacher and to have the possibility “a posteriori” to redesign the sessions so that the teaching-learning process is much richer.

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REFERENCES

[1] Arnau Gras, J. “Métodos de investigación en las ciencias humanas”. Barcelona: Omega. (1978).
[2] Bostic, J., Lesseig, K., Sherman, M., & Boston, M. “Classroom observation protocols: Choose your tool”. Research report presented at the National Council of Teachers of Mathematics Research Conference, San Antonio, TX. (2017).
[3] Bostic, J., Lesseig, K., Sherman, M. et al. “Classroom observation and mathematics education research”. Journal of Mathematics Teacher Education 24. (2021). Pp. 5–31. https://doi.org/10.1007/s10857-019-09445-0
[4] Buendía Eisman, L. “Análisis de la investigación educativa”. Universidad de Granada. (1993).
[5] Charalambous, C. Y., & Praetorius, A. K. “Studying mathematics instruction through different lenses: setting the ground for understanding instructional quality more comprehensively”. ZDM - Mathematics Education, 50(3). (2018). Pp. 355–366. https://doi.org/10.1007/S11858-018-0914-8
[6] González Marí, J. L. “Claves para una educación matemática humanista”. Uno: Revista de didáctica de las matemáticas, (88). (2020). Pp. 49-59.
[7] Gutiérrez, J. “Elementos para el análisis de la investigación observacional”. In L. Buendía Eisman (Ed.). “Análisis de la investigación educativa”. University of Granada. (1993). Pp. 35-47.
[8] Joglar, N., Ferrando, I., Abánades, M. A., Arteaga, B. P., Barrera, V., Belmonte, J. M., Crespo, R., Fernández, I. A., Fraile, A., Hernández, E., Liñán, M. M., Macías, J., Muñoz-Catalán, M. C., Pla-Castells, M., Ramírez, M., Segura, C., Tolmos, P., & Star, J. “POEMat.ES: Pauta de observación de la enseñanza de matemáticas en educación secundaria en España”. Avances de Investigación En Educación Matemática, 20(20). (2021). Pp. 89–103. https://doi.org/10.35763/AIEM20.4004
[9] Learning Mathematics for Teaching Project. “Measuring the mathematical quality of instruction”. Journal of Mathematics Teacher Education, 14(1). (2011). Pp. 25–47. https://doi.org/10.1007/s10857-010-9140-1
[10] Matas-Terron, A. “Introducción a la investigación en Ciencias de la Educación”. Bubok Publishing S. L. (2011).
[11] Orden de 30 de mayo de 2023, por la que se desarrolla el currículo correspondiente a la etapa de Educación Secundaria Obligatoria en la Comunidad Autónoma de Andalucía, se regulan determinados aspectos de la atención a la diversidad y a las diferencias individuales, se establece la ordenación de la evaluación del proceso de aprendizaje del alumnado y se determina el proceso de tránsito entre las diferentes etapas educativas. Boletín Oficial de la Junta de Andalucía, 104, de 2 de junio de 2023. Pp. 9727/1-9727/289.
[12] Pianta, R., & Hamre, B. K. “Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity”. Educational Researcher, 38(2). (2009). Pp. 109–119. https://doi.org/10.3102/0013189X09332374
[13] Santagata, R., Zannoni, C., & Stigler, J. “The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience”. Journal of Mathematics Teacher Education, 10(2). (2007). Pp. 123–140. https://doi.org/10.1007/s10857-007-9029-9
[14] Star, J. R., & Strickland, S. K. “Learning to observe: Using video to improve preservice mathematics teachers’ ability to notice”. Journal of Mathematics Teacher Education, 11(2). (2008). Pp. 107–125. https://doi.org/10.1007/s10857-007-9063-7
[15] Schlesinger, L. & Jentsch, A. “Theoretical and methodological challenges in measuring instructional quality in mathematics education using classroom observations”. ZMD – Mathematics Education, 48(1-2). (2016). Pp. 29-40. https://doi.org/10.1007/S11858-016-0765-0/TABLES/2
[16] Schlesinger, L., Jentsch, A., Kaiser, G., König, J., & Blömeke, S. “Subject-specific characteristics of instructional quality in mathematics education”. ZDM - Mathematics Education, 50(3). (2018). Pp. 475–490. https://doi.org/10.1007/S11858-018-0917-5/TABLES/5
[17] Tójar Hurtado, J. C. “Planificar la investigación educativa: una propuesta integrada”. 2001. Fundec.

[18] Zhou, J., Bao, J. & He, R. “Characteristics of Good Mathematics Teaching in China: Findings from Classroom Observations”. International Journal of Science and Mathematics Education 21. (2023). Pp. 1177-1196. https://doi.org/10.1007/s10763-022-10291-5