



Multimodal Narratives in Research and Teaching Practices

J. Bernardino Lopes (Universidade de Trás-os-Montes e Alto Douro, Portugal), **Maria Clara Viegas**

(Politécnico do Porto, Portugal) and **José Alexandre Pinto** (Politécnico do Porto, Portugal)

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Description

While already validated by the scientific community, multimodal narratives have the potential for a broader application, especially for improved teaching practices from a professional or a theoretical point of view. Applying multimodal narratives within professional development courses creates a focus on the teaching practices rather than the content itself.

Multimodal Narratives in Research and Teaching Practices provides educator and researcher perspectives on the use of multimodal narratives as a tool to reflect and improve teaching practices. Covering such topics as professional development, online learning, and teacher education, this publication is designed for educators, academicians, administrators, and researchers.

Topics Covered

The many academic areas covered in this publication include, but are not limited to:

- Epistemic Practices
- Lesson Planning
- Multimodal Narratives
- Museum Educators
- Nursing Education
- Online Learning
- Professional Development
- Semiotic Registers
- Teacher Education
- Teaching Practice

Multimodal Narratives in Research and Teaching Practices

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COVERAGE

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Section 1

Multimodal Narratives: A Tool and an Open Resource for Practice, Research, and Professional Development

In Section 1, the reader can get a complete idea of what a multimodal narrative (MN) is, how to produce and validate a MN, and its different purposes. This section also serves as a reference part where readers can go to address any doubt regarding specifics aspects of the MN. In the end of Section 1, there are indications on how to proceed to access the MN collection (Chapter 1: Appendix 1). Furthermore, it provides two complete examples of MN in order to better understand its characteristics and potentialities (Chapter 1: Appendix 2).

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The Importance of Making Teaching Practices Public, Shareable, and Usable: The Role of Multimodal Narratives	1
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J. Bernardino Lopes, Universidade de Trás-os-Montes e Alto Douro, Portugal

Maria Clara Viegas, Politécnico do Porto, Portugal

José Alexandre Pinto, Politécnico do Porto, Portugal

It is acknowledged that to improve the value of the learning process and outcomes in areas such as science, technology, engineering and math, the teaching quality needs to be enhanced. Therefore, it is crucial to have access to real teaching practices. The multimodal narrative (MN) tool allows teaching practices to become public, sharable, and usable (open science perspective), preserving their holistic, complex, and ecological nature. This tool has characteristics and a structure that enable an in-depth study of teaching practices, in different contexts, with several purposes (e.g., teacher education, professional development, and research). This chapter presents MNs and the necessary steps involved in collecting multimodal data, structuring the narrative, and validating the document. MNs can be used by teachers and researchers, or other professionals, with multiple specific objectives, globally contributing to improving professional practices.

Section 2

Seeing Teaching Practices in Science and Technology Through Multimodal Narratives

Section 2 is intended to show multimodal narratives (MNs) in action, that is, to use MN excerpts to transport readers into a classroom and understand in first-hand the teaching practices in action. As already explained in Section 1, these MN excerpts are not chosen as exemplary ones, simply as samples upon which the author and the reader may want to reflect upon.

Chapter 2

Understanding the Importance of Students' Assessment and Feedback With Multimodal Narratives 44

Maria Clara Viegas, Politécnico do Porto, Portugal

Eliane de Souza Cruz, Universidade Federal de São Paulo - Diadema, Brazil & Centro de Formação de Educadores da Escola Básica, Brazil

Multimodal narratives give insight of a classroom, teacher mediation, and students' work. In this chapter, the authors use this facility to better understand the importance of assessment and feedback in classroom practice. The analysis of excerpts from two complete multimodal narratives made it possible to highlight the importance of teacher intentions regarding the assessment process, the chosen tasks, and the subsequent feedback. It also provided an inside perspective of what was actually implemented in the classroom and how different teacher mediation leads to different results. These identifications in teaching mediation and students' involvement emerge transversally regarding teaching levels or contexts as objects of reflection, illustration, or simply inspiration. This shows the importance this tool can have in education by addressing parallel and complementary aspects of a classroom, which makes it a powerful tool in teaching.

Chapter 3

Dealing With Unexpected Situations in the Classroom: Evidence From Multimodal Narratives of Teaching Practices 64

Ana Edite Cunha, Escola Secundária S. Pedro de Vila Real, Portugal

Cristina Marques, Universidade de Trás-os-Montes e Alto Douro, Portugal

This chapter examines teachers' practices in dealing with unexpected situations (USs) in the classroom and students' reactions to these practices. This study analyzes the multimodal narratives (MNs) of the classes of five teachers: three from basic education and two from higher education. The results show that the teachers identified USs and most of the time acted in a way to solve the problem by interacting with their students. This interaction took a variety of forms. The students reacted to these teachers' practices in different ways: clarifying their ideas and concepts, establishing links between ideas and/or concepts, answering or taking the initiative autonomously, correctly performing a task or solving a problem, and/or becoming more involved/active in their learning. In cases in which teachers did not act on the US, the students did not understand the task or took a passive attitude toward learning.

Chapter 4

How a Specific Task Was Developed Through Multimodal Narratives 80

Domingos Kimpolo Nzau, Instituto de Educação em Ciência de Uíge (ISCED), Angola

Multimodal narratives (MNs) in the teaching of science and technology seek to report many aspects of a pedagogical nature in a complete and holistic manner. This chapter shows how six teachers of physics, from Angolan elementary education, without adequate pedagogical or academic training to teach physics, specifically the Newtonian concept of force, worked on a task during an intensive teacher training course. The MNs documents the professional development of the teachers in particular showing how they appropriated a tool (a specific didactic model) that was object of the training. The results achieved, with the help of multimodal narratives to register the occurrences in the seminar, once again reveal that MNs are as valuable a pedagogical tool in teachers' teaching practices as in their professional development (PD).

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Using Multimodal Narratives to Study Relationships Between Concepts..... 109

António Barbot, Politécnico do Porto, Portugal

In conceptual teaching and learning, relationships between concepts play a key role. This chapter describes a case where two conceptual fields, water and energy, were treated in order to promote understanding of relationships between them. It deals with the importance of “potential relationships” and describes how multimodal narratives contributed to those elucidations and to these practices in the classroom and their interpretation, as well as to the professional development of teachers. The chapter elucidates concept use, relating concepts, ways of discerning relationships between concepts, loss of relationship opportunities that were created by students, and ways of verifying that certain relationships were achieved.

Chapter 6

Looking at Linear Algebra Teaching Practices Through Multimodal Narratives..... 126

Cecília Costa, Universidade de Trás-os-Montes e Alto Douro, Portugal

Ricardo Gonçalves, Instituto Politécnico do Cávado e do Ave, Portugal

There is a lack of research studies on teaching practices in higher education, which does not contribute to a greater and better reflection on the failure in some disciplines, namely in linear algebra. Multimodal narrative (MN) is a facilitator of research in this field. This chapter describes how the use of MN of linear algebra classes was done and allowed reflection on and modification of the practices. Formative situations are presented: 1) planned and successful, 2) planned and less achieved, 3) unexpected and successful, and 4) unexpected and less achieved. Two transversal aspects to the teaching sequence are also presented: use of technology and geometric approach. This study made it possible to recognize the MN's potential as a tool to “observe” and analyze linear algebra teaching practices in diverse aspects. It also shows that MN analysis allowed linear algebra teachers to promote their professional development regardless of the teacher's experience.

Section 3

Professional Development of Science and Technology Teachers Using Multimodal Narratives

In this section of the book, the use of multimodal narrative (MN) in the practice of Science and Technology teachers is contemplated including a view to their professional development. Throughout the chapters, situations in which action and object centered reflection potentiates professional knowledge and sharing of experiences are presented. Despite these cases being referent to specific themes, since MNs focus on classroom actions and practices, they may prove to be rich in strategies and approaches. They are thus useful in any context, particularly in Science and Technology teaching. The reading of this section can be done from two perspectives: first, from the perspective of teachers interested in performing MN of their classes as a way to better understand their practice to reflect on their work or even to use them for didactic purposes; second, by the reading of MN performed by other teachers (even in different realities) to identify strengths and weaknesses of classroom practices and to better understand the outcome of certain strategies. Regardless of the perspective, it will be possible to use the MN to enrich the practice of teaching.

Chapter 7

Using Multimodal Narratives in Professional Development to Support Collaborative Work:
Improving Teaching Practices to Enhance Learning 148
J. Bernardino Lopes, Universidade de Trás-os-Montes e Alto Douro, Portugal

In this chapter, the authors discuss professional development (PD), self- and hetero-directed based on cases of physics education teachers in secondary and higher education and the role that multimodal narratives have in both processes. They adopt the PD perspective, which assumes that PD should be evaluated by its impact on teaching practices improvement. In this context, the PD aims to improve, incrementally, teaching practices. This process is difficult and complex and involves both teachers themselves and other professionals. Multimodal narratives (MN) are a tool that makes it possible to make teaching practices public and thus open to analysis by the teacher, other professionals, and researchers. The reported PD uses MNs as a tool that supports the teacher's collaborative work with peers and researchers. This collaborative work results in important incremental improvements in teaching practices.

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José Alexandre Pinto, Politécnico do Porto, Portugal

Teacher training processes must incorporate a reflective dimension as a strategy for professional development. The pursuit of a professional identity and the need to give personal meaning to theoretical principles grounds the emergence of young teachers' reflection. In this chapter, multimodal narrative (MN) is presented as a tool to support reflexive approaches in the development of teachers' professional knowledge. The data collected about the perspectives of student teachers and supervisors who experienced the use of MN show the interest of these actors about the tool and about the processes of its use. This chapter presents and discusses constraints identified throughout the pilot study of using a MN in teacher training that the authors developed. It also presents a proposal for the use of MN in the context of initiation of the professional practice that includes an adapted version of the MN tool and a phased process of its use.

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Daniela Pedrosa, Universidade de Trás-os-Montes e Alto Douro, Portugal

Gonçalo Cruz, Universidade de Trás-os-Montes e Alto Douro, Portugal & Universidade Aberta, Portugal

Leonel Morgado, Universidade Aberta, Portugal & LE@D, Portugal

This chapter presents how multimodal narratives were employed as a self-reflection tool within an online professional development program for in-service teacher training at Universidade Aberta, Portugal during two editions of a pedagogic practice course. The chapter includes the aspects that raised issues and those that trainees performed correctly. This is done in three stages: beforehand, upon initial contact with multimodal narratives, and after providing feedback to trainees. The most relevant issues were in aspects directly required to enrich the narrative. Aspects related to multimodal narrative structure and features were completed successfully. It is recommended that future attempts to employ multimodal narratives in this context adapt learning resources and pedagogic support practices by employing formative feedback and continual support during the trainees' process of exploring and exploiting multimodal narratives.

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Improving Visual Representations' Impact in Mathematics Teaching With Multimodal Narratives. 211	
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Paula Montenegro, Universidade de Trás-os-Montes e Alto Douro, Portugal

Cecília Costa, Universidade de Trás-os-Montes e Alto Douro, Portugal

J. Bernardino Lopes, Universidade de Trás-os-Montes e Alto Douro, Portugal

This chapter focuses on the impact that multimodal narratives (MN), elaborated to a first intervention (MN1) and to a succession of interventions (MN2), had in the professional development of a teacher to increase the impact of visual representations in the teaching and learning of mathematical content. The study follows an interpretative paradigm, with design science research and case study investigation methods. The participants are two groups of students (mean age 10.7 years and 11.3 years) and their Mathematics teacher. The data were collected from the students' written records, lesson plans, and teacher's notes. The data collected were organized in a MN. The results show that the MN is a tool that facilitates the process of professional development at the self-reflection level and in combination with researchers. The authors conclude that MN is an efficient and useful tool for professional development that aims to improve teaching practices and student learning.

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Ana Edite Cunha, Escola Secundária S. Pedro de Vila Real, Portugal

This chapter focuses on teachers' professional development, on the task design and on experimental work, as well as on the role of the teachers' mediation in the quality of student learning. The research problem was how the teacher can promote self-directed professional development, namely, improving the quality of teaching practices to influence the quality of students' learning, in their engagement in experimental tasks and epistemic practices. A longitudinal research methodology was followed during 10 years, based on a qualitative case study, from a curricular approach in secondary education. The

analysis of data collection on teaching practices and students' learning over time and the teachers' professional pathways allow to formulate the following conclusions: (1) new traits of teaching practices were identified that promote students' productive engagement; (2) changes to the task design were enough to trigger differences in teachers' mediation, with consequences for students' epistemic practices and their productive engagement.

Section 4

Researching Science and Technology Practices Using Multimodal Narratives

Section 4 of this book reports research on Science and Technology teaching practices based on academic research criteria using as empirical base the multimodal narratives (MNs) in their final public and shareable form, available in a collection of MNs (see Section 1). The set is representative, but not exhaustive, of the several research studies that have already been carried out with MNs.

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Using Multimodal Narratives in Science and Technology Education Research..... 252

José Paulo Cravino, Universidade de Trás-os-Montes e Alto Douro, Portugal & Centro de Investigação em Didática e Tecnologia na Formação de Formadores, Portugal

This chapter begins by presenting how multimodal narratives were developed and how they have evolved in time as a research tool. Their characteristics are explained, as well as their potential for use in research studies. One important aspect discussed in this chapter is the versatility of this tool, which allows for many possible investigative approaches. In particular, it addresses how multimodal narratives can be used to carry out studies in science and technology education research. Several examples are provided of such studies that were developed within a research community which has been working with multimodal narratives for over a decade.

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Elisa Saraiva, Escola D. Maria II de Vila Nova de Famalicão, Portugal & Politécnico do Porto, Portugal

This chapter describes an empirical study using multimodal narratives for research into students' development of epistemic practices in the classroom. Multimodal narratives can give access to classroom events, preserving their complex and holistic nature. Through content analysis, they allow a good comprehension of the multimodal nature of teaching and learning practices. The results of this work highlight the importance of multimodal narratives as a research instrument. Their importance is based on the richness of elements they contain that allow the identification, categorization, and characterization of teacher mediation actions that promote, scaffold, and enlarge students' epistemic practice development. This chapter seeks to describe both their multiple potentialities as an instrument and their limitations when researching the development of students' epistemic practices in the physical sciences classroom.

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Carla Aguiar dos Santos, Universidade de Trás-os-Montes e Alto Douro, Portugal & Centro de Investigação em Didática e Tecnologia na Formação de Formadores, Portugal

This chapter aims to identify certain interaction dynamics between pedagogical decisions and students' epistemic practices (EPs) that occur during science and technology lessons conducted by teachers at two different teaching levels. A content analysis was undertaken of multimodal narratives (MNs) of lessons based on two case studies of secondary and higher education teachers. MN excerpts are used to illustrate the interaction dynamics between pedagogical decisions and students' EPs for each teacher. Results show that the secondary education teacher makes more pedagogical decisions than the higher education teacher and that the secondary school students engage in fewer EPs than the higher education students. The results also show that it is possible to use MNs as an instrument to develop research on teachers' pedagogical decisions. Teachers' pedagogical decisions are an important asset for teacher professional development as they have an impact on students' epistemic work in the physical science classroom.

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Ricardo Gonçalves, Instituto Politécnico do Cávado e do Ave, Portugal

Cecília Costa, Universidade de Trás-os-Montes e Alto Douro, Portugal & Centro de Investigação em Didática e Tecnologia na Formação de Formadores, Portugal

This chapter aims to link the known research results on the teaching and learning of linear algebra to research on teaching practices. The same person, as a teacher and as a researcher, plans and implements a teaching sequence, constructs multimodal narratives (MNs) for some classes, and reflects on his own practice, based on the emerging categories from content analysis of the MNs. Regarding the methodology and focusing on the role of MNs in this research, it is worth highlighting the value attributed to MNs because they function as an instrument that embodies the practices of the teacher and aid him in reflecting on his own practice.

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Carolina José Maria, Universidade Metodista de Piracicaba, Brazil

The main objective of this chapter is to extend the discussion of language and the use of semiotic registers in chemistry lessons. Audio and video recordings, students' notebooks, photographs of content, and activities recorded on the blackboard in chemistry lessons for high school students taught in a public school in the interior of the State of São Paulo enabled the construction of multimodal narratives (MNs). The qualitative analysis of the MNs allowed the identification and understanding of the semiotic registers present in eight lessons conducted by a chemistry teacher. The study revealed several semiotic registers present in the lessons, but there is little exploration of the processes of conversion between semiotic registers by the teacher and therefore by the students. The use of different semiotic registers without the necessary understanding of them can result in difficulties in the teaching and learning processes of chemical concepts.

Section 5

Using Multimodal Narratives in Other Contexts

In this section of the book we try to blur boundaries and to point out contexts that are less exploited in the initial moments of multimodal narrative (MN) tool development. Seeking to go beyond familiar circumstances, we are moving forward with the conviction that the characteristics of MN are sufficient grounds to support our confidence that they will be usable and useful in several professional contexts. The two approaches we bring in this section of the book are, first, illustrations of the diversity we foresee for the use of MN. In the following two chapters, we present work done using MN in two very distinct contexts. The first context presents the work done on the Science Museum Educators' Discourse and the second on Nursing Education. It is intended that these examples, in addition to the intrinsic and relevant issues they present, constitute a challenge to the reader to reflect on the MN's potentialities in multiple contexts.

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Susana Afonso, University of Exeter, UK

Ana Sofia Afonso, Universidade do Minho, Portugal

Museum educators play an important role in science communication, as they connect elements of an exhibit with visitors through emotion-driven experiences that are meaningful to them. Language is their main *modus operandi* in face-to-face interactions, but little is known of how they use it to communicate science, in part because little attention has been given to their practices and professional development. Nowadays, museums are changing, and science communication has become more demanding as these institutions exhibit hot themes of science. In this context, it is important that museum educators become aware of how they communicate science with an intended audience and reflect on how their practice can be improved. In this chapter, the authors focus on the way multimodal narratives can be used as a tool to access museum educators' discourse as well as how to promote museum educators' reflection about their practice and their professional development.

Chapter 18

Multimodal Narratives in Nursing Education: Exploring Their Potentialities 356

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Tecnologia na Formação de Formadores, Portugal

Rita M. F. Leal, Universidade de Aveiro, Portugal & Unidade de Cuidados na Comunidade

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Nursing education is driven by emerging challenges of scientific, technological, and professional advances that require the use of strategies that promote students' development of critical thinking for decision making in different contexts. It also requires that teachers constantly reflect on their pedagogical practices and (re)think them using strategies that allow their enhancement. The use of multimodal narratives (MNs) can be an important tool for teachers' professional development, namely to improve their classroom practices. Given the novelty of the use of MNs in nursing education, this chapter presents an analysis concerning the experience of making a MN and how it has been reflected in the authors' pedagogical practices. With this experience, potentialities of continuing to use MNs in nurse education are explored.

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Foreword

Here is the new book of the UTAD's team! A natural question is: how do they do, to be able to publish so many books? Simple: they work. They have worked hard, for almost twenty years, many people together, so now they have a huge amount of accumulated experience, results and knowledge.

This book is an introduction to the method, which, accompanying a strong collective spirit, allowed them to produce these results and knowledge: the multimodal narratives (MNs). This method has been described briefly in scientific articles, and as such, is validated by the scientific community in Science Education. But articles are always too short, and the format of a book is quite necessary to understand the whole richness of this method of collecting and analysing classroom data, to perceive all the opportunities it offers. It is by the way a quality of this book to give to the reader detailed insights of many various MNs.

We must pay attention to both the words in the expression: “multimodal narratives”. In two different dimensions, they manifest the complexity of classroom activity. “Multimodal” because the reality in the classroom mobilises a range of semiotic registers, verbal, gestural, graphical etc., at a given time; if you want to grasp the state of the interaction, you must collect data at these different planes. “Narrative”, because the classroom activity is a story, coherent along time, with a history and an aim, and you cannot understand one moment of the story without knowing what happened before and what happened after.

I have just used the word “complexity”; not in its common meaning: complicated! Following Edgar Morin's theory, by “a complex reality” I mean an entity constructed from intertwined elements, which are linked by relationships of complementarity, competition, and antagonism – with a different mix of each, depending on the case. These relationships between elements allow the complex reality to progress, through the mechanism of recursion, installing constructive loops.

Just as education, research on education is a complex process, with many elements and many loops. Among those elements, students of course, teachers of course – and the book pays a great tribute to the study of interactions between those two kinds of elements. But a long-term characteristics of UTAD's team is to aggregate, without identifying them, the researchers to the social activity of teachers that is, not to put them on a separate (and implicitly higher) level. These characteristics is theoretically grounded on a reflection, developed in Chapter 7, about the nature of professional knowledge, which recognises it from a different nature than scientific knowledge, and which makes it necessary to take into account both perspectives, researchers and teachers. That is why this book is of interest both for researchers and for teachers.

MNs are the tool for making this kind of complexity alive. First, the research practice of UTAD's team is that a teacher, alone in his/her class, can create MNs valid for research. It is the proof of a deep confidence in the professional rigour of the teacher; but is also the affirmation that subjectivity has a

Foreword

scientific value, far from the hard-science perspective trying to rule human sciences. But the subjectivity is carefully controlled – by researchers – through the unified protocol of MNs. The MNs install a well-balanced relationship between research and professional practice.

Second, MNs install the loop. When a teacher, alone in his/her class, elaborates a MN, s/he is not a pure observer; of course, s/he describes what s/he has wanted and done, what the answer of the class was; but this elaboration changes him or her, by the reflection it demands, and the process of collective validation of the MN will deepen the changes as well. Chapter 5 and chapter 7 are eloquent to this regard. After a MN, the teacher will not be the same person, and will not teach in the same way. The product has changed the process. This is a starting point towards long-term professional development. The interested reader can find examples in a former and recent book of the team, *Teaching Science. Contributions of Research for Planning, Practice and Professional Development*.

I do not want to end these notes without emphasizing the great importance of Chapter 12. You fully understand a human or social reality only when you know its history. That is why Chapter 12 recalls the development of MNs' technology. The examples in this chapter in particular give to see the development of a loop at the research level too, due to the use of MNs: when you engage using the MNs with their preformatted framework, you change the nature of the data you collect.

Finally, we must be grateful to the team to have created a website, giving access to a lot of MNs, and giving the possibility to other researchers to enrich this database. This offer is consistent with the adoption of the perspective of the Open Science movement, and also with the choice to address both teachers and researchers.

And that also allows understanding a reason, among others, why they publish a book about the method *after* some books about the results: the method has permitted to obtain some results, through a work that has refined and developed and extended the method, up to a step where other researchers or teachers can appropriate the method, solid enough, and participate in the recursion, enriching the results and the method, in other countries, other specific knowledge domains, other fields of interactive activities, beyond science education.

Enter the loop!

Christian Buty
Université Lyon 2, France
2018, November 2

Foreword

Research on educational practices is receiving a lot of attention currently. Whether for the purpose of a deep reflection on such practices, or simply due to the requirement for teachers to do research as part of their professional performance, studies have truly multiplied. However, the remaining problem is the socialization of them in their entirety. While the Open Science movement has expanded and institutional repositories have progressively become daily resources, authentic records of empirical data still remain mostly hidden. Neither journal articles nor books can include them due to space limitations.

On the other hand, researchers are facing an increasing difficulty entering the field due to several reasons including transportation costs in some cases, but primarily the educational institutions' reluctance to see their routine invaded or affected by academics (trained or in training process), who do not always return to share the results of their studies. Another obstacle is the intrinsic difficulty in collecting field data without altering the natural course of events. Currently methodological discussions in the literature often cover ethical concerns (e.g., how to guarantee total anonymity), and technological issues (how to take advantage of technologies to capture reality), but thus far solutions have not been found.

These reasons, among others, point to the need for a radical shift in empirical research; specifically, to fully utilize the empirical materials collected by teachers and researchers. How could this be done? By developing data collection techniques that capture the complex nature of educational settings, and portray the findings with multimodal elements that transform the narrative into a vivid experience. Diversified types of data, such as audio or audiovisual recordings, teachers' and students' notes, photographs of blackboards, classroom plans, diagrams illustrating the spatial positions and movements of teachers and students, educational resources used in class (posters, slide presentations), students' tests, among others, could possibly more thoroughly capture this complexity. In this way, it might be possible to "transport" the reader to the class.

Through such techniques, we could examine specific phenomena like the teacher's proposals and the students' reactions, or the intended work and the work actually performed by the students, and expand them in turn to the context (for a complete transversal view) and/or to the line story (for a longitudinal perspective), overcoming the reductionism of critical incidents or specific moments in class.

Although this approach seems to be a solution, it is not a simple one. It requires mechanisms capable of guaranteeing the fidelity of the empirical records, and making them complete and standardized so that they can later be used and compared with others. Those mechanisms, in turn, require a guide for achieving a rigorous description which can be openly shared; basically, a protocol to elaborate a Multimodal Narrative (MN). Finally, this tool requires the hard work of creating the necessary database to compile the MNs; validated documents by the academic community in an open source webpage. Thus, MN can be a tool and a collection, a process and a product, and the participants can be MN users and contributors.

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The current book addresses these requirements, framed as the useful formulaic concept of Multimodal Narrative (MN), with ample background information throughout the chapters. Complemented with up-to date references, the book allows readers to build and complete their knowledge on the topic of MN. Overall, the strength of the book is based on two factors: the topic itself -i.e., the importance of MN-, and multiple explanations that show its benefits. Due to the clarity of language, this work is appropriate for a wide audience, including both researchers and educators. The possibilities of MN for research, teaching, and professional development in different contexts are clearly presented and explained. Furthermore, due to the particularities of each kind of MN practice, the book is organized in a first section that addresses them together and then devotes a section to each one.

In this dialectic of the specific profiles and the shared roles between teachers and researchers, existing barriers are removed. On the one hand, teachers act like researchers by collecting their own field material, taking advantage of their complete exposure to natural settings. Likewise, the methodological rigor, usually attributed to researchers, becomes the *modus operandi* of both the teachers and researchers. On the other hand, the researchers have the possibility to engage directly in the analysis of the material constructed by the teachers, suppressing the traditional hierarchies in which the former “own” the data. In this way, the authors fulfill a need for real collaboration between teaching and research, and link the different investigative processes across several contexts, countries and educational levels.

On the part of academics, the scientific research is made accessible to everyone, sharing the results of their work to promote professional development, and thus, contributing to the improvement of educational practices. This objective is imperative in Science, Technology, Engineering and Math, in which there is a need to increase the number of professionals and their skills to deal with a more complex society. In this context, this book is an invitation, a challenge, a proposal, a guide, and a goal.

María Isabel Pozzo

Universidad Nacional de Rosario, Argentina

2018, October 18

Preface

This book is dedicated to all teachers and Science and Technology (S&T) education researchers who want to improve teaching practices from a professional or a theoretical point of view.

It introduces a tool already validated by the scientific community – Multimodal Narratives (MN) – to a vaster audience.

This tool was developed by a research team as they felt the necessity of being able to capture the holistic nature of a classroom practice. A MN intends to be the class “story”, combining subjective and objective data, producing a written genuine document able to transport the reader to within the class itself. The prior validation of each NM by a research team gives the reader the assurance of its truthfulness.

The reader may immerse in the MN “world” with different levels of commitment and this book will help the understanding of advantages in each one. For instance, the reader can find the necessary indications in order to begin to produce MN on its own. Or the reader may decide to simply read some MNs and reflect upon other teachers’ practice or compare with personal experiences.

On the other hand, the reader may want to use MNs as a research tool in education research. Again, the reader will find different levels in which MN proves useful. From the data collection phase to the study and development of the theoretical framework in any area, by analyzing several MN produced in different contexts. As it will be explained, due to MN main characteristic of focusing on the teaching practice and not on the subjects, this diversity of contexts becomes a major advantage. As a *cherry on the top*, MNs can be found in an open source webpage, in an Open Science perspective, allowing any researcher to access MNs as a reader or as a contributor to enlarge this collection.

In this sense, the book is organized into these different perspectives of usage, following a gradual increase of commitment of the reader with MNs’ usage: as a teacher to acknowledge different practices inside the classroom (Section 2), as a teacher or teacher educator using MNs as a tool to reflect and improve teaching practices (Section 3), as a teacher-researcher or researcher using MNs as a research tool (Section 4).

Following this reader-alignment, in Section 1, the reader can get a complete idea of what a MN represents, how to produce a MN and its different purposes. This section also serves as a reference part, where readers can go to address any doubt regarding structural or methodological aspects of the MN. It also provides indications on how to proceed in the access to the MN collection (<http://multimodal.narratives.utad.pt>) and an index of all MN present as their context and level of education. In the end of Section 1 there are two full examples of complete MN in order to better understand its potentialities. In Section 2, the reader can see particular aspects of teaching practices through MNs, how teachers exploit them and the corresponding developments in class. In Section 3, MN are used and explored in professional development, that is, how teachers may use MNs of their own classes or from other teachers to improve

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their own practice. Finally, in Section 4, some research studies using MNs are presented, allowing better understandings of the complexity of teacher mediation in the classroom. The Section 5 intends to show that MN can also be applied beyond S&T teaching practices or contexts. As long as there is a role of an educator, MN can be useful to better understand and improve that practice.

All through this book the reader can have different viewpoints: educator or researcher. In each one, can opt to read about it or to produce work with MNs. Also, with an open science perspective, using the MN collection, the reader may choose to work upon other teachers' MNs or produce some of his own.

All authors had directly or indirectly contacted with MN and their singular perspectives allowed this book to consolidate MN advantages from different angles. Every chapter in this book went through a process of double blinded review by at least two members of our Scientific Board. These experts from 29 universities and from 12 countries never worked with MN and the great majority never even heard about it before. This was intentional and provided an impartial scrutiny of this work. The thorough analysis produced in each chapter allowed the authors to improve their works and better capture the essence of their contributions. Complementary to this particular analysis, a methodologic and structural scrutiny was produced by the Advisors. Their insights allowed us to successfully improve the readability and flow of the book.

The massive positive opinion about MN capacities, both from the Scientific and Advisory Boards, is already a highly encouraging step towards the success of this book.

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Universidade de Trás-os-Montes e Alto Douro, Portugal

Maria Clara Viegas

Politécnico do Porto, Portugal

José Alexandre Pinto

Politécnico do Porto, Portugal

Acknowledgment

This book represents a combined effort between a large team of teachers and researchers of Science and Technology Education to whom we are profoundly grateful and proud of having work with.

Even though we cannot name them all, we must express our gratitude to all researchers, teachers, students and school staff of all the involved institutions. Each one of them was invaluable in their cooperation and enthusiasm.

In particular, we address a word of thankfulness to each author of the chapters. Their belief in this project from day one, the quality of the presented work and their timely response to all challenges, allowed us to successfully complete this errand.

A special appreciation to our Scientific Board, who certified the quality of each work and gave precious inputs to improve their value and legibility.

An unlimited gratitude to the Advisory Board. We believe that with their help and expertise through the editing process and namely their advices upon the book structure, coherence and flow between the different parts, led to crucial improvements which, in our opinion, helped this book become an important contribution to the scientific community.

At last, we must acknowledge our gratefulness to the research center: *Centro de Investigação em Didática e Tecnologia na Formação de Formadores* – CIDTFF.

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Chapter 1

The Importance of Making Teaching Practices Public, Shareable, and Usable: The Role of Multimodal Narratives

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ABSTRACT

It is acknowledged that to improve the value of the learning process and outcomes in areas such as science, technology, engineering and math, the teaching quality needs to be enhanced. Therefore, it is crucial to have access to real teaching practices. The multimodal narrative (MN) tool allows teaching practices to become public, sharable, and usable (open science perspective), preserving their holistic, complex, and ecological nature. This tool has characteristics and a structure that enable an in-depth study of teaching practices, in different contexts, with several purposes (e.g., teacher education, professional development, and research). This chapter presents MNs and the necessary steps involved in collecting multimodal data, structuring the narrative, and validating the document. MNs can be used by teachers and researchers, or other professionals, with multiple specific objectives, globally contributing to improving professional practices.

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AN OPEN SCIENCE CONTRIBUTION: MAKING TEACHING PRACTICES PUBLIC, SHAREABLE, AND USABLE

In the context of our societies' strong immersion in Science and Technology (S&T) in everyday life, it is fundamental to ensure that the advances in S&T support and promote well-being both for individuals and for society from a holistic perspective. This principle not only involves the challenge of providing people with the capacity to understand and interact in scientific and technological contexts but also encompasses the recognition of the need to shorten the time between the creation of new knowledge and its dissemination and incorporation. This book can contribute to the Open Science movement.

The Open Science movement seeks to make scientific research accessible to everyone, particularly the research community, by taking advantage of the technological communication networks currently available. It is a concept that is widely recognized among researchers (e.g. Altunay et al., 2011; Fecher & Friesike, 2014) and institutions. In this regard, the European Union recognized the value of Open Science in the program Horizon 2020: EU Research and Innovation. It is also acknowledged by the Group of Seven (G7). In a statement (2017, p. 7), the G7 pronounced:

First, the incentives for the openness of the research ecosystem: the evaluation of research careers should better recognise and reward Open Science activities. Secondly, the infrastructures for an optimal use of research data: all researchers should be able to deposit, access and analyse scientific data across disciplines and at the global scale, and research data should adhere to the FAIR principles of being findable, accessible, interoperable, and reusable.

This book shows how Science and Technology (S&T) teaching practices can be public and shareable (the open science perspective), preserving their holistic, complex, and multimodal nature using a tool—Multimodal Narrative (MN)—validated by the academic community (Lopes et al., 2014). This tool has two components: a protocol to elaborate an MN and a validated document. As a document, the MN can be used in education research, in professional development, and in the articulation between S&T teaching practices and S&T education research to improve the quality of both. This tool allows researchers to overcome the difficulty of entering a classroom and obtaining reliable data on teaching practices that can be used and compared by teachers and researchers.

The characteristics and structure of MNs allow for comparability between them (even in different contexts) to achieve purposes related to the improvement of S&T teaching, research, and professional development.

MNs, both as a tool and as a collection, occupy an open science perspective, since (a) professionals can elaborate an MN of their own professional practices, based on data, thus participating in the research process and gradually increasing the MN collection available, and (b) researchers can access and analyze scientific data about S&T teaching practices in several contexts and countries and at different educational levels.

MNs open new possibilities for:

- Research, because they allow the comparison of teaching practices at different levels of education and in different countries and contexts, and even professional profiles, allowing a deeper understanding;

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Chapter 2

Understanding the Importance of Students' Assessment and Feedback With Multimodal Narratives

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ABSTRACT

Multimodal narratives give insight of a classroom, teacher mediation, and students' work. In this chapter, the authors use this facility to better understand the importance of assessment and feedback in classroom practice. The analysis of excerpts from two complete multimodal narratives made it possible to highlight the importance of teacher intentions regarding the assessment process, the chosen tasks, and the subsequent feedback. It also provided an inside perspective of what was actually implemented in the classroom and how different teacher mediation leads to different results. These identifications in teaching mediation and students' involvement emerge transversally regarding teaching levels or contexts as objects of reflection, illustration, or simply inspiration. This shows the importance this tool can have in education by addressing parallel and complementary aspects of a classroom, which makes it a powerful tool in teaching.

INTRODUCTION

The learning assessment has always been part of the teaching process. It is usually used to enhance student learning – called formative assessment or assessment for learning, as well as to judge and certify learning achievements – called summative assessment or assessment of learning (Nicol, 2008; Black & William, 1998; Sadler, 1989). Since the “teaching objective is that students would learn” (Lopes, 2004),

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teachers have increasingly been devoting their attention to the formative role of assessment, which aims to underpin students' learning in their ongoing effort to build knowledge, helped by their teacher's feedback (Dufresne & Gerace, 2004) and their peers' feedback (Cruz, 2012; Nicol, 2008). Simultaneously, teachers are also using learning technologies to aid them in the process (Laurillard, 2002).

According to Sambell (2016), the challenge involves viewing assessment and feedback as dialogic, dynamic and open to negotiation, with an emphasis on process as well as product.

The mediation between teacher and students is a crucial analysis factor that will influence the learning outcomes. The ways teachers organize the curriculum, idealize the tasks and present them to students, guide class discussions or monitor their progress can lead to substantially different results (Cruz, 2012; Lopes, 2004; Viegas, Lopes & Cravino, 2010). Teachers may also have an important role in helping students to understand their achievements toward the learning goals by introducing strategies of learning target identification that they can complete with their peers (Sindelar, 2015).

Inherently, studies using classroom practices are very important to gain understanding of the dynamics of interaction between the teacher and the students and strategies to develop the didactical aspects into practice. The literature presents several studies on teaching, learning, teacher reflections or classroom research (Earley, 2014), but usually as separate studies.

Unfortunately, classroom practices and the link between teachers' actions and students' reactions are not easy to study from the inside. Multimodal narratives (MN) is a tool that can fulfill this request and give the reader insight into a classroom, teacher mediation and students' work (Lopes et al., 2014). This tool, as fully presented in chapter 1, *provides a succinct narrative of the whole class with its storyline filled with contextual information and the detailed description of the actions and the teachers' and students' discourse during the work developed in the classroom*. The great advantage of its usage is that the complex and thorough work of analyzing all the classroom data is validated by the scrutiny of experts; i.e., the MN is a simple text document, easy to read, that will transport the reader inside the classroom. MN makes it possible to visualize how teacher mediation in the classroom can in fact affect student development (Lopes et al., 2014). In addition to the class narratives or even the class video recording, MN allows readers to understand teacher intentions, takes into consideration the class's background and conditions, and shows the way the teacher addresses situations by observing the class's development. Hence, MN may aid in highlighting different aspects of the assessment, such as the design, the chosen tasks and the subsequent feedback. On the other hand, it makes it possible to comprehend not only the teachers' intentions but also the way they are able to implement them in classroom – as well as to infer the results with regard to the classroom environment and students' involvement and comprehension.

The objective of the chapter is the use of MN excerpts to better understand the importance of assessment of and feedback on teaching practices and student development.

BACKGROUND

This section is divided according to the three identified aspects of assessment: the assessment process, assessment tasks and assessment feedback.

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Chapter 3

Dealing With Unexpected Situations in the Classroom: Evidence From Multimodal Narratives of Teaching Practices

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ABSTRACT

This chapter examines teachers' practices in dealing with unexpected situations (USs) in the classroom and students' reactions to these practices. This study analyzes the multimodal narratives (MNs) of the classes of five teachers: three from basic education and two from higher education. The results show that the teachers identified USs and most of the time acted in a way to solve the problem by interacting with their students. This interaction took a variety of forms. The students reacted to these teachers' practices in different ways: clarifying their ideas and concepts, establishing links between ideas and/or concepts, answering or taking the initiative autonomously, correctly performing a task or solving a problem, and/or becoming more involved/active in their learning. In cases in which teachers did not act on the US, the students did not understand the task or took a passive attitude toward learning.

INTRODUCTION

This chapter presents an analysis of the performance of the classes of five teachers, three in basic education (students' ages from 13 to 15 years) and two in higher education, focusing on the decisions of the teachers when facing unexpected situations in the classroom and on the students' reactions to these decisions, in terms of learning.

The authors begin by presenting the reasoning of this study in terms of the classroom real-time decision making of teachers. The relevance of knowing and understanding teachers' decisions is discussed

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to improve their pedagogical practice, especially when decisions are made when facing unexpected situations that occur in the classroom. It is argued that decisions must be taken after critical and systematic reflection on the students' thinking, their execution of tasks, and their learning, as well as the teaching practice. Although there is evidence that teachers and their actions condition the quality of students' learning, the characteristics of teachers' practices that determine improvements in teaching and learning are still unknown. Emphasis is placed on the relevance of teachers' data collection about their teaching and students' learning, so it can be analyzed, reflected on, and interpreted as a way of taking informed decisions, adapted to the reality of each classroom and of each student.

This study intends to identify the characteristics of teachers' decision making in face of unexpected situations in the classroom that contribute to improving students' learning.

BACKGROUND

The quality of the professional performance of teachers has been a concern among teachers themselves and investigators for a long time (e.g., Bishop, 1976; Datnow & Hubbard, 2016). In addition to the continuous updating of the knowledge to be taught, being a teacher requires constant adaptation to the classroom reality (Cunha, 2015; Santos, Lopes, & Cravino, 2011; Saraiva, Lopes, Cravino, & Santos, 2012). In their pedagogical practice, teachers have to be involved in a very complex process, which includes decision making (Lloyd, 2017). Teachers are often confronted with unexpected situations that occur in the classroom, that is, situations that they did not expect to happen, having to react and make decisions (Aho, Haverinen, Juuso, Laukka, & Sutinen, 2010; Bishop, 1976; Shavelson & Stern, 1981). That is, while teaching, teachers follow their "mental script," a process that is interrupted when unexpected events arise in the classroom. This stopping forces teachers to redirect their focus of attention and react to the new situation (Shavelson & Stern, 1981). According to Bishop (1976), taking decisions is a central activity of the teaching process, because the teacher has to know what to do, and how to do it, in the face of unforeseen situations that occur in the classroom. For example, when students do not understand or do not answer a question, when there are students who want to respond and others who do not, or when students make a mistake, the teacher has to make a decision, given a range of choices (Bishop, 1976). For this researcher, knowing how teachers make their decisions allows an understanding of the objectives and intentions of their teaching and the attitudes and scientific development of the students, making it possible to establish relationships between teaching theories and classroom reality. Borko, Roberts, and Shavelson (2008), after analyzing studies about classroom decision making, concluded that it emerged as a response to students' comments, incorrect responses or performance, lack of understanding, or even unruly behavior. Faced with these situations, teachers react in time, making teaching decisions such as questioning students, selecting students to respond, or giving appropriate examples. Understanding how decisions are made can help to improve the practice of decision making (Patel, Kaufman, & Arocha, 2002) and consequently make teaching more effective (Schoenfeld, 2015). That is, the articulation between thought and action that occurs during decision making facilitates better-quality learning (Lloyd, 2017).

However, it is not yet clear how knowledge about the desired practice is linked to the actual practice (Borko et al., 2008). Lloyd (2017) argued that critical reflection on their teaching practice helps teachers

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Chapter 4

How a Specific Task Was Developed Through Multimodal Narratives

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ABSTRACT

Multimodal narratives (MNs) in the teaching of science and technology seek to report many aspects of a pedagogical nature in a complete and holistic manner. This chapter shows how six teachers of physics, from Angolan elementary education, without adequate pedagogical or academic training to teach physics, specifically the Newtonian concept of force, worked on a task during an intensive teacher training course. The MNs documents the professional development of the teachers in particular showing how they appropriated a tool (a specific didactic model) that was object of the training. The results achieved, with the help of multimodal narratives to register the occurrences in the seminar, once again reveal that MNs are as valuable a pedagogical tool in teachers' teaching practices as in their professional development (PD).

INTRODUCTION

Studies of teachers' PD, focusing on the improvement of teaching practices, have considered a register of activities undertaken in the classroom in educational science as a valuable, powerful, and usable instrument, because it reports the teaching practices in a complete and holistic way in the MN form. According to the scholars who developed them, MNs are able to portray the events occurring in the classroom in great detail (Lopes et al., 2014).

How a Specific Task Was Developed Through Multimodal Narratives

Researching mediation in the classroom requires the didactic action to be captured as a whole; in these terms, an MN is taken as a narrative of the events that occurred in the classroom when a specific task was performed.

The different works developed in the MNs that this work presents show that these tasks are of different natures and even point out that it is imperative to take into account their pedagogical aspects, as the intention is to improve not only the teaching practices of science and technology (S&T) in schools but also other pedagogical aspects, for instance teachers' training.

Central Idea of the Study

In the context of the continuous training of teachers, this chapter aims to show, in relation to a specific task, that MNs can also support the PD processes of physics teachers in Angolan general education, using the conceptual fields of Vergnaud (1987), in particular the Newtonian concept of force, considered as interactions between material systems.

This aspect is pointed out as one of the difficulties that students face in identifying and justifying the forces applied in material systems (Dumas-Carré & Goffard, 1997; Nzau & Costa, 1992; Viennot, 2002) in the teaching and learning process. Diagrams of objects–interactions (Dumas-Carré & Goffard, 1997), which were suggested as a didactic approach by these scholars to resolve this difficulty, were also taken into account in this study, which used MNs as a tool for data collection.

Issues

The study sought to qualify teachers for teaching practice, which many authors, such as Meirink, Meijer, Verloop, and Bergen (2009), Mushyikwa and Lubben (2009), and Starkey et al. (2009), among others, have defended as a way to overcome the weaknesses detected in teachers. It involved a group of six physics teachers in an exercise; each teacher was designated by the first letter of his or her name (M, A, B, C, P, and R), and they belonging to three schools of basic education in Cabinda Province (Angola) without adequate academic training or pedagogical principles to teach physics, namely Tando Zinze, Luvassa, and Barão Puna schools (Nzau, 2010).

The study was based on a specific didactic model of the conceptual field of Newtonian force (Nzau, 2013; Nzau, Lopes, & Costa, 2012; Pinto & Nzau, 2017) in the conceptual field models of Vergnaud (1987).

Study Limitations

Improving the quality of teaching practices, including evidence-based practices for science teaching, while ignoring the nature of professional and epistemological knowledge was questioned by Bradforth et al. (2015), because the conceptual nature and professional knowledge have other components, one of which is the ability to choose the research results that are appropriate for the situation (Winch, Oancea, & Orchard, 2015).

This didactic model was adopted in this program because it is considered to be constructivist, using conceptual teaching (Weil-Barais, 1995) in the conceptual field (Lopes, 2004), which Vygotsky, Leontiev, and Galperin (cited by Fosnot, 1996) advocated as playing an important role in the teaching and

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Chapter 5

Using Multimodal Narratives to Study Relationships Between Concepts

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ABSTRACT

In conceptual teaching and learning, relationships between concepts play a key role. This chapter describes a case where two conceptual fields, water and energy, were treated in order to promote understanding of relationships between them. It deals with the importance of “potential relationships” and describes how multimodal narratives contributed to those elucidations and to these practices in the classroom and their interpretation, as well as to the professional development of teachers. The chapter elucidates concept use, relating concepts, ways of discerning relationships between concepts, loss of relationship opportunities that were created by students, and ways of verifying that certain relationships were achieved.

INTRODUCTION

This chapter deals with part of a classroom study about two specific conceptual fields, water and energy. It focuses on the problematic of the relationship between them, and not on details about the two conceptual fields. The chapter assumes two main objectives: to promote multimodal narratives as an instrument to study relationships between concepts, and to help teachers to clarify topics and relationships to be treated.

The following problem was identified: the need for studies and educational interventions in the classroom environment to promote understanding of relationships between water and energy in teaching. The relationships between water and energy (RWE) are multiple, as evidenced by the Proclamation of the United Nations Decade of Education for Sustainable Development (2002) and the Johannesburg Declaration on Sustainable Development (2002). Mechanical energy is used to produce electricity. The energy of the sun commands the hydrological cycle. Energy is used to produce potable water. From water, hydrogen can be extracted to be used as fuel. Food energy comes from life created with water and energy from the sun, received or stored on the planet. In education, water and energy are studied.

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But relationships are scarce in teaching and research (Barbot, Lopes, & Soares, 2010, 2011; Cerqueira & Barbot, 2010). Water is the origin of life on Earth; it is the dominant element in the constitution of living beings, and it modulates the energy fluxes of the planet, namely, energy transfers (Allan, 2011). Energy is the base factor in the functioning and evolution of the world, of the planet, and of all human beings. The principle of energy conservation is crucial.

In education, when water and energy are studied, they typically are studied separately. Students learn that they are important for the sustainability of the planet and in particular for life, in which the human species is included.

THEORETICAL FRAMEWORK

The study referred to in this chapter (Barbot, 2014) assumes a constructivist view, which has solid and documented theoretical and practical bases, and currently constitutes the core of science education research. The study assumes that learning is always present and always interested, but this study does not focus on the qualities and or quantities of learning and its evaluation. It focuses on physical situations, tasks, models, resources, and physical and virtual models, and it makes suggestions tested in class as to its usability, feasibility, the students' motivation, time required and resources required. All this is intended to explore in class what is the central object of the study: the relations between water and energy, and to build on contributions to teachers, offering possibilities and elucidating the potentialities to treat such relationships. In terms of the teaching-learning dyad, the study focuses on teaching.

Novak and Gowin (1984), referring to Ausubel, report that, in meaningful learning, individuals relate new knowledge with relevant concepts and propositions that they already know. Bruner (1997) points to the importance of the culturally shaped notions by which people organize their conceptions of themselves, of others and of the world in which they live. Buty, Badreddine and Régner (2012) point to the importance of how knowledge relates one thing to other. Therefore, a concept is much more than a word, using a concept is much more than just saying it, and learning meaningfully implies relating.

The study was carried out by a teacher-researcher, as described by Griffiths (1985), who studied his own practice in a natural classroom environment in an example of action research. It also had case study characteristics (Bogdan & Biklen, 1994; Stenhouse, 1988). The study had the following specifications: it involved, in a school year, classes of Initial Teacher Training courses in a school of education; it dealt with the relationship of two specific conceptual fields (water and energy), focusing on the teaching aspect as a specific instance of the teaching practice.

To relate is to understand better. Establishing links, identifying causes and effects, and building rich conceptual networks means knowing significantly more and being better prepared for the profession and for active citizenship (Barbot, 2017a). But a concept is not just a word. A concept, according to several authors, among them Toulmin (1977), has two aspects: representation and use. It is constituted by symbolic representations – natural language – and by other symbolisms, such as equations and other mathematical formalisms, graphical representations, taxonomy and computer programs. Simultaneously, it is also constituted by specifications of its modes of use, application procedures, and scopes and validity contexts.

The main problem was the need for studies and educational interventions in the classroom environment to promote the understanding of relationships between two concepts (here, water and energy) in teaching. In educational research, a problem is a need that exists in some context and that does not allow

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Chapter 6

Looking at Linear Algebra Teaching Practices Through Multimodal Narratives

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ABSTRACT

There is a lack of research studies on teaching practices in higher education, which does not contribute to a greater and better reflection on the failure in some disciplines, namely in linear algebra. Multimodal narrative (MN) is a facilitator of research in this field. This chapter describes how the use of MN of linear algebra classes was done and allowed reflection on and modification of the practices. Formative situations are presented: 1) planned and successful, 2) planned and less achieved, 3) unexpected and successful, and 4) unexpected and less achieved. Two transversal aspects to the teaching sequence are also presented: use of technology and geometric approach. This study made it possible to recognize the MN's potential as a tool to "observe" and analyze linear algebra teaching practices in diverse aspects. It also shows that MN analysis allowed linear algebra teachers to promote their professional development regardless of the teacher's experience.

INTRODUCTION

During the 1960s, introductory linear algebra courses appeared for undergraduates, primarily intended for math and engineering majors (Uhlig, 2003). According to some researchers (Hillel, 2000; Kleiner, 2007; Tucker, 1993), linear algebra is the first full-fledged mathematical theory with which students have contact. It is traditionally taught through an axiomatic approach, which means starting from the axiomatic definition of vector space, followed by deduction of associated concepts and results.

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Vector, vector space, linear transformation, system of linear equations and matrix are the basic concepts of linear algebra. All are abstract concepts (although some have a degree of abstraction greater than others), since they are secondary concepts, that is, concepts resulting from the action of the subject on other concepts, as happens with most mathematical concepts. This characteristic justifies part of the complexity attributed to mathematics and some of the difficulties presented by students. Next, an excerpt of a multimodal narrative (MN) (Multimodal Narrative Excerpt 1) is presented that is illustrative of the concept abstraction level of linear algebra and the students' reaction to it.

Multimodal Narrative Excerpt 1: Teacher R (Subspace of a Vector Space)

Beginning by attending to the axiom on the null vector belonging to the set, soon some of the students' confusions were revealed.

"So what do you say?"

"It has to be all zero," Hélder suggested.

"Or ... who is this, Hélder, right now? This one here, is what?" I asked, pointing to the V in the expression $0v \in V$ [v being a vector of V] that was still written on the board.

"A vector," said Juliana, also entering the discussion.

"It's x , y , z , is not it?" replied Hélder.

"No!" I said in alarm. "This is the generic vector space V ."

Over the decades, linear algebra teachers have found many recurring difficulties expressed by students as well as failure to complete the course. On the one hand, teachers' frustration with students' learning difficulties was recurrent, because for them the reasoning associated with the various concepts were quite obvious (Dorier, 2000; Dorier, Robert, Robinet, & Rogalski, 2000); on the other hand, many students had the "feeling of landing on a new planet and are not able to find their way in this new world" (Dorier, 1998, p. 142). Linear algebra didactic studies identified as conceptual difficulties in linear algebra learning the knowledge of prerequisites (mainly in logic, set theory and analytical geometry) and the use of formalism (students are not prepared for the level of abstraction that is required) (Dorier & Sierpiska, 2001).

The questioning and reflection about the way linear algebra was taught led to curricular reforms in several countries. In the United States, the Linear Algebra Curriculum Study Group (LACSG) played a major role in the change of linear algebra curriculum during the 1990s (Carlson, Johnson, Lay, & Porter, 1993), with influence in other countries. For example, the recommendation to opt for a matrix approach (Carlson et al., 1993), i.e., to explore the concepts from the matrices and based on concrete and practical examples in place of the axiomatic approach, is recognized in Portugal, as evidenced by the programs of linear algebra in various engineering courses.

In addition to the emphasis given to the matrix approach, the studies and reflection carried out by the LACSG (Carlson et al., 1993) and by other researchers (e.g., Dorier & Sierpiska, 2001; Harel,

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Chapter 7

Using Multimodal Narratives in Professional Development to Support Collaborative Work: Improving Teaching Practices to Enhance Learning

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ABSTRACT

In this chapter, the authors discuss professional development (PD), self- and hetero-directed based on cases of physics education teachers in secondary and higher education and the role that multimodal narratives have in both processes. They adopt the PD perspective, which assumes that PD should be evaluated by its impact on teaching practices improvement. In this context, the PD aims to improve, incrementally, teaching practices. This process is difficult and complex and involves both teachers themselves and other professionals. Multimodal narratives (MN) are a tool that makes it possible to make teaching practices public and thus open to analysis by the teacher, other professionals, and researchers. The reported PD uses MNs as a tool that supports the teacher's collaborative work with peers and researchers. This collaborative work results in important incremental improvements in teaching practices.

INTRODUCTION

This chapter focuses on professional development (PD) centered on improving the quality of teaching practices with impact on student learning in line with the current definition of PD (Soebari & Aldridge, 2015). The PD of teachers involves multiple dimensions, one of which is the improvement of the quality of teaching practices and students' achievement (Desimone, 2009; Fischer et al., 2018). There may, however, be PD without there being improvement of teaching practices in classroom lessons (Bakkenes, Vermunt & Wubbels, 2010; Vescio, Ross, & Adams, 2008). The most recent conceptualization of PD

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emphasizes that improving teaching practices in classroom lessons with effects on the quality of student learning is an essential component of the definition of PD (Desimone & Garet, 2015; Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009). It is necessary, therefore, that teaching practice in the classroom be central to the PD itself (Vescio, Ross, & Adams, 2008; Wei et al., 2009). As teaching practices are difficult to change (Bakkenes et al., 2010; Lopes & Cunha, 2017; Morris & Hiebert, 2011; Osborne, 2014), it is necessary to consider PD as incremental: a PD that allows successive iterations of the teaching practice and verifying in what conditions a certain aspect of teaching practices works and is effective to students' learning. Thus, the PD, centered on the improvement of teaching practices, must be based on successive cycles of action research, each of them (Lopes & Cunha, 2017) with: (a) design of a proposal for teaching based on intentions, explicit didactics, past experience and research results; (b) implementation of the teaching proposal and data collection; and (c) analysis of data collected to determine the effectiveness of teaching practices and seek new lines of action in teaching practices or refinements of them.

The central idea of this chapter is to show how a tool – Multimodal Narratives (Lopes et al., 2014) – that helps to collect, organize and aggregate data about classroom teaching practices can be used in PD (self- or hetero-directed) centered on teaching practices. The PD is based on collaborative processes of a teacher with peers or with researchers (Avalos, 2011). In these processes, Multimodal Narratives (MN) of lessons allow that: a) teachers collaborate with each other using the MN as a tool to identify objectively what promotes or inhibits students' learning; and b) researchers study the dynamics and processes of teaching and point out new directions. Thus, the main objectives of this chapter are:

Objective One: Conceptualize PD articulating teaching practices and research evidences.

Objective Two: Show how PD centered on teaching practices can incrementally improve the quality of teaching practices and students' learning.

Objective Three: Present the different roles that MN can play in promoting PD focused on teaching practices.

A FRAMEWORK FOR PROFESSIONAL DEVELOPMENT ARTICULATING TEACHING PRACTICES AND RESEARCH EVIDENCES

Teaching practice in classroom lessons is an essential component of a teacher's professional practice in any curricular area. The teaching practice as a professional practice has a tacit dimension that articulates with the explicit dimension in a way that is different according to the theoretical perspective of the authors (Baird, 2004; Cook & Brown, 1999; Nonaka & Takeuchi, 1995; Winch, Oancea, & Orchard, 2015). Understanding the nature of teaching practice is important because only then is it possible to conceive and frame the theoretical and practical problems that its improvement involves.

Cook and Brown (1999) and Nonaka and Takeuchi (1995) conceive professional knowledge as a combination of four areas of professional development. Two are epistemological in nature: (a) explicit individual knowledge (which refers to the conceptual knowledge appropriated by individuals) and (b) tacit individual knowledge (which refers to the know-how an individual reveals only in situations and actions). The remaining two are ontological in nature: (a) explicit knowledge of the group (which refers to shared knowledge among individuals in a group or institution and manifests itself in the shared culture

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Chapter 8

Using Multimodal Narratives in Teacher Education

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ABSTRACT

Teacher training processes must incorporate a reflective dimension as a strategy for professional development. The pursuit of a professional identity and the need to give personal meaning to theoretical principles grounds the emergence of young teachers' reflection. In this chapter, multimodal narrative (MN) is presented as a tool to support reflexive approaches in the development of teachers' professional knowledge. The data collected about the perspectives of student teachers and supervisors who experienced the use of MN show the interest of these actors about the tool and about the processes of its use. This chapter presents and discusses constraints identified throughout the pilot study of using a MN in teacher training that the authors developed. It also presents a proposal for the use of MN in the context of initiation of the professional practice that includes an adapted version of the MN tool and a phased process of its use.

INTRODUCTION

As future education professionals, teachers during their training need to develop a set of skills that enable them to establish a theory-practice dialectic. In this sense, the adoption of a reflexive attitude proves extremely important for their professional future. It is up to the teacher to take a proactive attitude toward the research premise and view it as a training strategy.

This chapter attempts to contribute to ensure an enriching experience for young teachers during their professional practice initiation. The present work try to value the perspective of those who have undergone this challenge but also those who, with more experience, take responsibility to follow them in order to become better professionals. Thus, the focus of this work is on the day-to-day work of teacher trainers and student teachers, particularly in supervising and internship tasks. The importance of the vocational training dimension in teacher education courses is well identified if one considers its preponderance

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in the curricular background for teaching qualification in Portugal. This principle is in harmony with guidelines that emphasize training within the teaching profession (Nóvoa, 2009; Perrenoud, 1998).

The multimodal narrative (MN), as a document, is a written story of a class, with a timeline, and describes all events that take place in the classroom. The MN is focused on actions and languages adopted by the teacher and students during the accomplishment of a task. Its characteristics allow the preservation of the holistic and complex nature of teaching practices.

MN characteristics have aroused the present authors' attention by their potential to incite reflection and to nourish it by the richness and objectivity of the classroom objects and the events that they provide. Next, this chapter presents the authors' work, explaining the context and its actors, which refers to an attempt to value the processes of initial teacher training, in a professional context, incorporating the use of MNs in the training practices.

The authors sought clues, based on the perspective of the student teachers and supervisors, to establish a functional proposal, recognized by the individuals involved and with potential to increase value in the supervising process, throughout a reflective approach.

The pathway was oriented toward the promotion and deepening of reflection, in an attempt to interpret the reality of the classroom. The work was based on collected data, namely, on information, doubts and feelings of the student teachers. The first aim was to provide student teachers with a space for reflection that would challenge them to think about the dynamics of their classes. In this way, the authors intend student teachers to identify what they consider appropriate in view of building their autonomy and professional knowledge. In this sense, the main objectives are defined as: to design a way to operationalize the integration of MN in the process of internship supervision and to evaluate the perspective of student teachers and in-service teachers regarding their interest in the MN in the internship context.

SUPERVISION AND REFLECTIVE TEACHER TRAINING

From the perspective of many authors, teacher training must be structured around reflection as a strategy for valuing pedagogical practice and the development of professional autonomy. This perspective of teachers' education presents itself in an opposite direction to a vision of a prescriptive and external matrix in which teachers fundamentally seek the application and propagation of normative pedagogy perceived as effective (e.g., Alarcão & Roldão, 2010; Sá-Chaves, 2000; Schön, 1987; Zeichner & Liston, 2014).

Assuming the purpose of a reflective teachers' education, it is expected that, in contrast to assuming a role of users of knowledge developed by the academies, teachers can themselves assume a posture of reflective practice by throwing their critical point of view on such knowledge, contextualizing it in their practice (Farrell & Ives, 2015; Wallace, 1991). A significant part of the life experiences of all young teachers is related to their experiences as students. These experiences support their convictions, beliefs, attitudes and values about the meaning of teaching and learning. It is essential to consider such prior and personal knowledge, as it can hinder change and innovation. In this context, it is crucial to support changing teachers' beliefs (Brownlee, Ferguson, & Ryan, 2017). It is in this perspective that Handal and Lauvås (1987) consider that one of the main functions of supervision is to develop the teachers' practical theories, making them sensitive to change.

Theory and practice are two central concepts in teacher education. As Korthagen (2012) warns, it is easy to pull the training process to one of these extremes. On the one hand, adopting a theory-in-practice

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Chapter 9

Multimodal Narratives as a Tool for In-Service Teachers in an Online Professional Development Course

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ABSTRACT

This chapter presents how multimodal narratives were employed as a self-reflection tool within an online professional development program for in-service teacher training at Universidade Aberta, Portugal during two editions of a pedagogic practice course. The chapter includes the aspects that raised issues and those that trainees performed correctly. This is done in three stages: beforehand, upon initial contact with multimodal narratives, and after providing feedback to trainees. The most relevant issues were in aspects directly required to enrich the narrative. Aspects related to multimodal narrative structure and features were completed successfully. It is recommended that future attempts to employ multimodal narratives in this context adapt learning resources and pedagogic support practices by employing formative feedback and continual support during the trainees' process of exploring and exploiting multimodal narratives.

INTRODUCTION

The “Pedagogic Practices Seminar” course took place at Universidade Aberta (UAb), Portugal, in the second semester of the 2015/2016 and 2016/2017 school years, as part of an online training program for the in-service professional development of teachers. This was a formal, non-graduation program.

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The trainees were active non-higher education teachers who aimed to qualify for recruitment group 550 (Computing) of the Portuguese Ministry of Education.

The goal of this course is for students to develop scientific and pedagogic skills for creating and developing pedagogic projects in computing education. They must identify, reflect upon and solve learning issues, combining pedagogic and research components to improve their practices and their professional development. Hence, it is important to provide trainees with knowledge of research techniques that enable them to develop those competences, one of them being multimodal narratives (MNs). MNs are typically documents that describe chronologically, in a self-contained and multimodal way, what a teacher and students do and say in a given context of teaching and learning (Lopes et al., 2014), incorporating multimodal data. They are drawn up in accordance with the guidelines of a protocol defining three stages of implementation: data collection, preparation of the MN and validation. In this way, a MN is a self-contained and concise document that can be analyzed later, avoiding the difficulty of dealing with multiple data sources (*ibid.*). MNs are indeed tools in support of teaching and professional development, since they help teachers understand their decision-making process and the intent of their actions (Lopes et al., 2010). They enable teachers to observe the actual events within their classes (sometimes distinct from their initial perceptions or recollections), and they facilitate the identification of which pedagogic strategies were most effective (*ibid.*). They hold the potential to help improve teachers' professional development (Lopes et al., 2014).

There were several learning activities in the Pedagogic Practices Seminar course. The contact of trainees with MNs took place in the third, fourth and sixth topics of the course, which involved the trainees in reading about their use and then creating several MNs related to episodes in their current professional practice.

The initial contact with the MN technique was in the third topic.

This chapter identifies which aspects raised the most significant issues upon first contact as well as those that were correctly performed by the trainees, over two editions of this course (2015/2016 and 2016/2017). The same analysis was done after providing formative feedback (which was provided only in the 2016/2017 edition).

In both editions of the course, the trainees' initial contact with MNs was challenging, both regarding its initial use and its improvement.

Four categories were analyzed, referring to essential aspects of a MN: Category 1 – *Presents the essential aspects of a MN*; Category 2 – *Presents a well-structured MN*; Category 3 – *Narrating an episode with its essential aspects* and Category 4 – *Enriching the MN*. Most issues occurred in categories 3 and 4, i.e., the aspects that detail and enrich a MN.

In categories 1 (*Presents the essential aspects of a MN*) and 2 (*Presents a well-structured MN*), which are related to MN structure and features, even though several issues emerged, these were infrequent and/or solved after providing feedback (2016/2017 edition only). Therefore, the results suggest that in both editions (2015/2016 and 2016/2017), the students understood the importance of the MN and satisfactorily identified the main features of a MN.

It is also possible to conclude that formative feedback is essential for students to identify, reflect upon and improve their processes for creating a MN. This arises from observing that trainees of the 2016/2017 edition, who had the opportunity to improve their assignments after receiving feedback, managed to overcome and understand their shortcomings in executing a MN.

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Chapter 10

Improving Visual Representations' Impact in Mathematics Teaching With Multimodal Narratives

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ABSTRACT

This chapter focuses on the impact that multimodal narratives (MN), elaborated to a first intervention (MN1) and to a succession of interventions (MN2), had in the professional development of a teacher to increase the impact of visual representations in the teaching and learning of mathematical content. The study follows an interpretative paradigm, with design science research and case study investigation methods. The participants are two groups of students (mean age 10.7 years and 11.3 years) and their Mathematics teacher. The data were collected from the students' written records, lesson plans, and teacher's notes. The data collected were organized in a MN. The results show that the MN is a tool that facilitates the process of professional development at the self-reflection level and in combination with researchers. The authors conclude that MN is an efficient and useful tool for professional development that aims to improve teaching practices and student learning.

INTRODUCTION

This chapter refers to the intermediate phase of a research study with the general objective of exploring ways to increase the impact of the use of visual representation as an epistemic tool in teaching and learning different mathematical contents of basic education. In the initial phase of the study, specific-

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ties of the use of visual representations in teaching were identified that were not evident either to the teacher (first author) or to the students; this led to the need for a professional development phase to better understand the identified specificities and explore ways to improve the impact of the use of visual representations (Montenegro, Costa, & Lopes, 2018). During this stage of professional development, the teacher used a multimodal narrative (MN1) (already done in the first phase of the research study) to start her professional development process; she further elaborated and analyzed a multimodal narrative (MN2) to record her reflections and organize the data she collected about her attempts to enhance the impact of the use of visual representation as an epistemic tool in classroom activities and what she considered relevant for this purpose.

The objective of this chapter is to evaluate the importance of multimodal narratives in the teacher's self-reflection and to develop her knowledge about the use of visual representations in teaching and learning, exploring ways to increase the impact of their use in the classroom.

The constant adaptation of mathematics curricula, together with the changes in competencies evidenced by students resulting from curricular changes, bring teachers to a continuous need for professional development.

According to Ponte (1994), the need for growth and various acquisitions is recognized in professional development, and the role of the fundamental subject is attributed to the teacher himself. Thus, the teacher is in constant development and it is up to him/her to decide when, how, and what s/he wants to study, or to get involved in a given project. However, the training provided is not always adequate to the needs of certain teachers' professional development. This was the case for the teacher of our study, which is why she opted to become involved in a well-structured professional development based on research on her own practices, developed in collaboration with two researchers in a PhD scope.

Through her experience as both a teacher and as a learner, the teacher was convinced that visual representations played an important role in teaching and learning. She received positive feedback from students when using visual representations in teaching, but she did not understand the reasons why students were reluctant to use them.

That is why we look for an answer to the following problem: what actions should the teacher take to improve her teaching practice using visual representations? In more detail, we seek to know how to use a visual representation to represent a mathematical concept, how to do a demonstration using a visual representation, how to explain something through a visual representation, or how to use a visual representation to get to other types of more abstract representation—for example, algebraic. In this chapter, we focus on identifying the role of MNs and how they were used in the professional development process of the teacher to enhance teaching practice using visual representations.

THEORETICAL BACKGROUND

Although tolerated, the use of visual representations in mathematics teaching and learning is not accepted by teachers and students with the same status as other more widely used representations (e.g., arithmetic and algebraic) (Montenegro, Costa, & Lopes, 2018). Hence, a phase of professional development is needed to explore ways of using visual representations in teaching. A professional development model focused on the improvement of teaching practices in line with the most recent conceptualization (Soebari & Aldridge, 2015) is adopted, based on the articulation with research on teachers' own teaching practices (Fischer et al., 2018; Lopes & Cunha, 2017).

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Chapter 11

Assessing Teaching Practices Development With Multimodal Narratives

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ABSTRACT

This chapter focuses on teachers' professional development, on the task design and on experimental work, as well as on the role of the teachers' mediation in the quality of student learning. The research problem was how the teacher can promote self-directed professional development, namely, improving the quality of teaching practices to influence the quality of students' learning, in their engagement in experimental tasks and epistemic practices. A longitudinal research methodology was followed during 10 years, based on a qualitative case study, from a curricular approach in secondary education. The analysis of data collection on teaching practices and students' learning over time and the teachers' professional pathways allow to formulate the following conclusions: (1) new traits of teaching practices were identified that promote students' productive engagement; (2) changes to the task design were enough to trigger differences in teachers' mediation, with consequences for students' epistemic practices and their productive engagement.

INTRODUCTION

The essence of this work was devoted to the professional development of a teacher, focused on improving the quality of his teaching practices (planning and teaching practice), in particular considering the conception of experimental tasks and effective mediation in the classroom.

In this way, a curriculum (tasks) of physics and chemistry for secondary education was designed, implemented and evaluated, based on the execution of experimental work in the physics component, taught in the 10th and 11th years of schooling, based on teacher mediation, to promote students' productive engagement in tasks and students' quality epistemic practices.

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During the execution of this work, reflections were made on the performance of the professor and subsequent changes were made, when necessary. In particular, the study of the role in learning of tasks in experimental teaching – namely, its characteristics, classroom management, and student appropriation, as well as its use as an instrumental tool – was undertaken to develop knowledge, skills and attitudes, as well as to promote epistemic practices in students.

In teaching, by epistemic practice is understood the work that the student does to accomplish a task with a view to the construction of scientific knowledge, having as reference the activity of scientists. To engage in an epistemic practice, the student has to mobilize prior knowledge and has to build scientific knowledge. Epistemic practices should be induced and improved by the teacher, even those that, in some cases, may occur “spontaneously.”

The question of research that is considered to help solve the research problem is presented below: What aspects of teaching practices (in task design and effective mediation) have changed over time? The main objectives of this research are:

- To study the influence of increasing the quality of teaching practices on student engagement and on epistemic practices.
- To characterize the influence of the use of multimodal narratives (MNs) on professional development with an impact on teaching practices.

BACKGROUND

Being a teacher requires that one constantly adapt to the reality of the moment and continuously update the knowledge to be taught.

After acquiring competences inherent to the activity of teaching, teachers’ professional development and the process of improvement are done continuously, always keeping in mind the goal of achieving excellence. In order to develop professionally, teachers must be careful to update themselves by staying informed about the most appropriate methodologies, as well as all that appear recently.

It was necessary to reflect on methods or strategies that aim to increase teacher-student and student-student interaction (Berland, et al., 2016) and increase the taste for learning science in general and physics in particular. This practical problem was assumed as a research problem and was based on the professional development of a teacher focused on improving the quality of his teaching practices (planning and teaching practice) to improve student learning. It was necessary to realize that curricular modifications had to be carried out, to design pertinent tasks that aimed at the development of learning objectives and to design the way in which they would be implemented. From year to year, more modifications were introduced, taking into account not only the literature but also the reflections on the practice carried out until then. The detailed analysis of the practice developed within the classroom is a method well known and used over time for the professional development of teachers. In order to analyze in detail how this lesson has been developed in various possible ways, teachers should record their class (audio or video). The classroom space is a place where teachers and students (who are human) express emotions in interpersonal relationships of the most varied possible sensations, making teaching and learning unique in each class. A simple audio or video recording, and its simple transcription, is not enough to allow description and study of the relationships established within the classroom between teachers and

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Chapter 12

Using Multimodal Narratives in Science and Technology Education Research

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ABSTRACT

This chapter begins by presenting how multimodal narratives were developed and how they have evolved in time as a research tool. Their characteristics are explained, as well as their potential for use in research studies. One important aspect discussed in this chapter is the versatility of this tool, which allows for many possible investigative approaches. In particular, it addresses how multimodal narratives can be used to carry out studies in science and technology education research. Several examples are provided of such studies that were developed within a research community which has been working with multimodal narratives for over a decade.

INTRODUCTION

This chapter starts by introducing the need for a new research tool and how a research group went about developing it in the context of a research project. Over time, this tool became known as multimodal narratives. Their characteristics are described, how they are produced, and how they are validated, as well as some of the difficulties in this process. Since one of the main characteristics of multimodal narratives is their versatility, how they may be used in different research approaches is discussed. To support this claim, and to provide a better insight into how multimodal narratives have been used, several examples are presented and discussed to highlight the contribution of this research tool. The goal of this chapter is to inform the reader what a multimodal narrative is, how it is produced and validated, and how it may be used to study various research problems. It is hoped that this chapter may inspire others to use this tool in their own research studies.

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BACKGROUND

This section describes the development and evolution of multimodal narratives as research tools.

Multimodal narratives (MNs) were developed within a research group based at the University of Trás-os-Montes and Alto Douro in Vila Real, Portugal, dedicated at the time to a research project on the teaching of physical sciences in the classroom. This project was about the teacher mediation of student learning in physical sciences lessons (project ‘Guiding principles and tools for fostering teacher mediation in physical sciences’ classes’, funded by Fundação para a Ciência e Tecnologia under grant number PTDC/CED/66699/2006). One of the goals of the project was to contribute to improve both teachers’ mediation and the quality of students’ learning. Relevant empirical data were therefore necessary, in particular empirical evidence from the classroom. This approach focused on the classroom posed a particular problem in collecting, organizing, and processing data on classroom-based teaching. The intention was to collect data about teaching and learning taking place in the classroom that were reliable and useful for research, but with minimum disruption to the actors in the classroom, and preserving the holistic character of the classroom in all its complexity.

The obvious solution—and widely described in numerous studies and research methods handbooks—is to video or audio record lessons. Then the recordings should be transcribed for analysis. It should be noted that at the time some computer programs were already available to assist in qualitative data analysis, and in particular in the content analysis of texts. For example, NVivo 7 was at that time a recent evolution of the NUD*IST software (Numerical Unstructured Data Indexing Searching and Theorizing). There were also other software programs, such as ATLAS.ti, MAXQDA, and QDA MINER. Later, a web-based software was created by Portuguese researchers from the University of Aveiro (webQDA). All these programs allowed the analysis of content based on text files, although it was already possible to work directly on audio or video files with some of them.

However, the main problem that the research group faced was the need to capture the lesson in its integrity and not just the dialogues between teacher and students, which would be easy to capture with audio recordings. The video recording makes it possible to better capture the lesson globally, using multiple camcorders, but this strategy poses some problems: it is quite intrusive and there are many obstacles to recording images in the classroom due to the need for multiple authorizations and privacy issues. Schools and students’ parents are very sensitive to these problems. On the other hand, to capture the lesson in a more holistic way, it is usually necessary to use multiple cameras in order to capture both global views and the level of groups or individuals, whether in terms of sound or of image.

Excluding the possibility of collecting data through video recordings, the remaining option was therefore to use only audio recordings. However, these record only the most audible interactions in the classroom—typically the teacher’s speech and the interactions between the teacher and his or her students. Of course, it is possible to use several audio recorders strategically placed around the classroom to maximize the capture of what is said, but it is complex to synchronize all interactions and it increases intrusion, potentially compromising the spontaneity of the interactions.

On the other hand, though audio recordings capture (if conditions are appropriate) what is said in the classroom, they do not capture what is written or drawn, the gestures, the expressions, and everything else that occurs in a classroom that is not spoken speech. And a lot of what happens in the classroom is not spoken speech, as the examples just cited show.

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Chapter 13

Researching Epistemic Practices Development With Multimodal Narratives

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ABSTRACT

This chapter describes an empirical study using multimodal narratives for research into students' development of epistemic practices in the classroom. Multimodal narratives can give access to classroom events, preserving their complex and holistic nature. Through content analysis, they allow a good comprehension of the multimodal nature of teaching and learning practices. The results of this work highlight the importance of multimodal narratives as a research instrument. Their importance is based on the richness of elements they contain that allow the identification, categorization, and characterization of teacher mediation actions that promote, scaffold, and enlarge students' epistemic practice development. This chapter seeks to describe both their multiple potentialities as an instrument and their limitations when researching the development of students' epistemic practices in the physical sciences classroom.

INTRODUCTION

This chapter describes an empirical study using multimodal narratives (MNs) as an instrument for research about teachers' mediation actions that influence the development of students' epistemic practices in the classroom. The study intends to identify and characterize teacher mediation actions that promote, sustain, and enlarge students' epistemic work. The use of MN as a research instrument allows the achievement of a good level of understanding about teacher mediation actions that can promote and scaffold students' work in the classroom when engaged in social practices that lead to knowledge construction in the classroom. This study intends to highlight the role played by MN as a research instrument, elaborating its multiple potentialities and limitations when used for the identification and characterization of teacher mediation actions that can promote and enlarge the development of students' epistemic practices in the classroom.

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Researching students' epistemic practices as they occur in the classroom remains an important issue: it is important to know more about the cognitive, discursive, and social activities in which students are engaged to develop their understanding of scientific knowledge and to produce, communicate, and evaluate knowledge (Kelly, 2008; Sandoval, 2005). For research in this field of knowledge, and for teachers' professional development, it is very important to know more about teachers' mediation actions that influence the quality and variety of students' epistemic practices in the classroom. The teacher's mediating role is crucial in promoting and sustaining a learning environment that enables the acquisition of rich and diverse conceptual and epistemological knowledge: teachers need to develop professional knowledge about their actions and about their impact on students' epistemic work in the classroom. That is why the main focus of this research is the identification of teachers' mediation actions that influence the quality and variety of students' epistemic practices. This research work intends to investigate teachers' mediation actions and the occurrence of students' epistemic practices, but without interfering with the natural environment of the classroom. The research question focuses on the identification of teacher mediation actions and their influence, and the occurrence and development of students' epistemic practices in the classroom. For that, MN was adopted as the research instrument. The richness of the different elements that MN contains allows the identification of "different modes, modalities, means, languages, resources and spatial and temporal organization adopted by teachers in the classroom" (Lopes et al., 2010, p. 16) and students' engagement in investigative activities in the classroom (Sandoval & Millwood, 2005).

RELEVANCE OF EPISTEMIC PRACTICES FOR STUDENTS' LEARNING

Students' engagement in epistemic practices, as claimed by some authors (Berland et al., 2016; Duschl & Grandy, 2013; Jiménez-Aleixandre & Crujeiras, 2017; Krist, 2016; Osborne, 2014), is crucial for the development of a deeper understanding about the nature of scientific knowledge and the process of its construction. It is essential that learning about scientific concepts should not be separated from learning about the practices used in the production of scientific knowledge (Duschl & Grandy, 2013). According to the authors listed, there must be a change from an education focused on just what you know (e.g., facts and skills) to an education focused on how we know what we know.

Teaching and learning science requires significant and productive student engagement (Engle & Conant, 2002; Mortimer et al., 2014) in social practices for the construction of knowledge, including the elaboration of theories and models, the construction of arguments, and the use of different forms of communication and representations of concepts or phenomena (Duschl & Grandy, 2013). Such epistemic practices emerge from the investigative activities carried out by students in the classroom (Sandoval & Millwood, 2005) and have as a reference the work done by scientists in the context of producing scientific knowledge. The epistemic practices must emerge from students' attempts to solve a problem or task, "mobilizing prior knowledge and using procedures like description, representation, prediction and so on" (Lopes, Branco, & Jiménez-Aleixandre, 2011, p.2).

Thus, epistemic practices may be defined as the social activities of the production, communication, and evaluation of scientific knowledge (Kelly, 2008; Kelly & Duschl, 2002; Kelly, McDonald, & Wickman, 2012; Sandoval, 2005) that give students the opportunity to develop positive attitudes about science and ways of doing science. Students' engagement in scientific practices in the classroom gives them more authority and makes them more competent in the application of scientific knowledge in the real context (Lopes et al., 2011).

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Chapter 14

Researching Science and Technology Teachers' Decisions Through Multimodal Narratives

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ABSTRACT

This chapter aims to identify certain interaction dynamics between pedagogical decisions and students' epistemic practices (EPs) that occur during science and technology lessons conducted by teachers at two different teaching levels. A content analysis was undertaken of multimodal narratives (MNs) of lessons based on two case studies of secondary and higher education teachers. MN excerpts are used to illustrate the interaction dynamics between pedagogical decisions and students' EPs for each teacher. Results show that the secondary education teacher makes more pedagogical decisions than the higher education teacher and that the secondary school students engage in fewer EPs than the higher education students. The results also show that it is possible to use MNs as an instrument to develop research on teachers' pedagogical decisions. Teachers' pedagogical decisions are an important asset for teacher professional development as they have an impact on students' epistemic work in the physical science classroom.

INTRODUCTION

Decisions are present in almost everything that humans do, either in their personal or professional lives (Edwards & Fasolo, 2001). Teachers are no exception and as noted by Shavelson (1973), any act of teaching is a decision, so it is easily inferred that the teacher makes many decisions throughout the entire teaching process (Shavelson & Stern, 1981). Teachers' decisions include three distinct phases, which take place at different moments in the teaching process (e.g., Shavelson & Stern, 1981). They can occur in the lesson planning phase, during the interaction in the classroom, or after it has happened (i.e., after the lesson) (e.g., Shavelson & Stern, 1981). In this study, we focus only on the teachers' decisions that take place inside the classroom, which for simplification we call "pedagogical decisions."

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Students' epistemic practices (EPs) are important in developing competences (Lopes, Branco, & Jiménez-Aleixandre, 2011), and for promoting the construction of scientific knowledge (e.g., Berland et al., 2016; Driver, Asoko, Leach, Scott, & Mortimer, 1994) in the science and technology classroom; this can effectively be used in a huge variety of contexts or situations (Kirschner, van Vilsteren, Hummel, & Wigman, 1997).

The study of pedagogical decisions and students' EPs requires data analysis related to the practice of teaching, which generates a large amount of data, making its analysis very time consuming. Grouping all the data collected in the classroom and turning them into a single analytical instrument is possible through the use of multimodal narratives (MNs), (Lopes et al., 2014), facilitating research. Similarly, one may exploit MNs as a tool preserving the holistic nature of teaching and the natural environment of the classroom (Lopes et al., 2014). The great added value of MNs, which we wish to highlight in the context of this work, is that they have the same structure, they are focused on the development of the proposed tasks in the classroom, they are narrated from the perspective of the teacher, and they enable comparison of multiple case studies (Lopes et al., 2014). Even if they are elaborated by different teachers or researchers, as they have the same structure, they are comparable and verifiable (Lopes et al., 2014), facilitating the adoption of methodological approaches such as content analysis. In this particular case, we intend to investigate the ways in which the use of MNs allows access to information regarding all the actions and decisions of each of the teachers and the students' EPs at the different teaching levels in the context of the classroom.

Teachers' pedagogical decisions are an important asset for teacher professional development since they have an impact on students' epistemic work in the physical science classroom. We studied lessons that took place in identical teaching contexts with privileged inquiry methodologies, and in which experimental work took place. The interpretative analysis (Cohen, Manion, & Morrison, 2011) of this research was undertaken through the MNs related to the lessons taught by two teachers in the area of physical sciences. The study of the interactions between teacher's pedagogical decisions and the students' EPs at different teaching levels can help to understand the mutual influence of these interactions.

Thus, the objective of this study was to identify the interaction between pedagogical decisions adopted by teachers and the students' EPs in two different teaching contexts. We present excerpts from the MNs that highlight these pedagogical decisions and the students' EPs.

BACKGROUND

According to Kennedy (2006), during the planning phase, the teacher imagines how the class will be conducted and how all associated actions will occur. However, no matter the extent to which a teacher plans the lesson, there are always decisions that have to be taken in the classroom to address challenging situations that arise (Aho, Haverinen, Juuso, Laukka, & Sutinen, 2010), regardless of the teaching level. However, given the specificities of each teaching level, there may be a set of decisions more characteristic of one level than others (Santos, Lopes, & Cravino 2011).

Pedagogical decisions are not always interpreted by teachers as a decision, but as their way of acting in the classroom. Sometimes the teacher takes decisions without being aware of the act, but even when taken spontaneously, such action is characterized as a result of a decision (Shavelson, 1973). This can be explained by the fact that teachers during their work act "without thinking about it" (Roth, Masciotra, & Boyd, 1999, p. 771). It may also happen because the act of deciding is inherent to every human and

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Chapter 15

Researching One's Own Practice: Reflections on the Teaching of Linear Algebra Using Multimodal Narratives

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ABSTRACT

This chapter aims to link the known research results on the teaching and learning of linear algebra to research on teaching practices. The same person, as a teacher and as a researcher, plans and implements a teaching sequence, constructs multimodal narratives (MNs) for some classes, and reflects on his own practice, based on the emerging categories from content analysis of the MNs. Regarding the methodology and focusing on the role of MNs in this research, it is worth highlighting the value attributed to MNs because they function as an instrument that embodies the practices of the teacher and aid him in reflecting on his own practice.

INTRODUCTION

This chapter's theme is in the field of higher mathematics education, in particular linear algebra teaching, and the reported research is based mainly (1) on comprehensive knowledge of the literature regarding teaching and learning of linear algebra, but also (2) on the study of teaching practices of undergraduate mathematics teachers.

In the 20th century, linear algebra became a branch of mathematics and began to be taught mainly in university and colleges. At the end of the century, the learning difficulties observed in the students, the frustration of the teachers, the technological advances, and the needs of client disciplines led to interest

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in improving the undergraduate linear algebra curriculum in several countries (Carlson, Johnson, Lay, & Porter, 1993; Dorier, 1998; Dubinsky, 1997; Tucker, 1993). The work that became better known was that conducted in the United States by the *Linear Algebra Curriculum Study Group* (LACSG) (Carlson et al., 1993). Over the last three decades, the earlier lack of studies in the field (Dubinsky, 1997) has been remedied with an extensive body of research on the teaching and learning of linear algebra, first concerning student learning and later, in the search for answers to these difficulties, with the development of new teaching strategies.

Another matter is the recurrent reference to a small number of investigations for describing and analyzing the teaching practices of undergraduate mathematics teachers (Hannah, Stewart, & Thomas, 2013; Schoenfeld, Thomas, & Barton, 2016; Speer, Smith, & Horvath, 2010). Teachers constantly investigate their own practice, reflecting on their activity. However, when they reflect uncritically on their teaching practices (or without the rigor of scientific or academic investigations), it only results in “tacit” knowledge (Cochran-Smith & Lytle, 1993) or “craft” knowledge (Artigue, 2001). This is why there is a lack of research aimed at knowing, understanding, and improving “what teachers do and think daily, in class and out, as they perform their teaching work” (Speer et al., 2010, p. 99). In this regard, the research problem we considered was how to link teaching practices to the orientations of the international movement on the teaching and learning of linear algebra. In the search for contributions to an answer, we developed an investigation focusing on the teaching practices of the teacher himself (first author).

In our opinion, the Multimodal Narrative (MN) approach is the best way of making known the work done by the teacher (and by the students). The MN is a relatively recent instrument, but has already been validated in the scientific community (Lopes et al., 2010, 2014). MNs have been used mostly to investigate physical science teaching practices, some in higher education (e.g., Lopes, Cravino, Branco, Saraiva, & Silva, 2008; Pinto et al., 2014; Santos, Lopes, & Cravino, 2011). Our research is the first to use MNs in mathematics in higher education.

Chapter 1 of this book presents MNs in detail, and in the “MN: Value, Construction, and Validation” subsection we will show how we used them in our investigation, now in the context of linear algebra. With specific reference to possible ways of teaching the concept of linear combination, and considering the suggestions in the literature (“Theoretical Background”), we will seek in the “Results” and “Conclusion” sections to uncover the emerging opportunities and difficulties faced by a linear algebra teacher. This is based on the teacher’s own reflection on his practice and the content analysis of the MNs constructed for some classes.

THEORETICAL BACKGROUND

This research builds on extensive knowledge of the research results on the teaching and learning of linear algebra published over the last three decades.

Concerning learning difficulties related to linear algebra in general, Dorier and Sierpinska (2001) organized them, in a review of literature, according to conceptual difficulties (related to the nature of linear algebra) and cognitive difficulties (related to the kind of thinking required for the understanding of linear algebra). On specific learning difficulties, and pointing to the particular concept of linear combination students look at linear algebra as a catalogue of abstract concepts, commonly defined in generic terms (Harel, 1997), and “submerged under an avalanche of new words, new symbols, new definitions, and new theorems” (Dorier, Robert, Robinet, & Rogalski, 2000, p. 95). For these researchers, the

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Chapter 16

Researching Language and Semiotic Registers in Chemistry Lessons Using Multimodal Narratives

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ABSTRACT

The main objective of this chapter is to extend the discussion of language and the use of semiotic registers in chemistry lessons. Audio and video recordings, students' notebooks, photographs of content, and activities recorded on the blackboard in chemistry lessons for high school students taught in a public school in the interior of the State of São Paulo enabled the construction of multimodal narratives (MNs). The qualitative analysis of the MNs allowed the identification and understanding of the semiotic registers present in eight lessons conducted by a chemistry teacher. The study revealed several semiotic registers present in the lessons, but there is little exploration of the processes of conversion between semiotic registers by the teacher and therefore by the students. The use of different semiotic registers without the necessary understanding of them can result in difficulties in the teaching and learning processes of chemical concepts.

INTRODUCTION

Since the earliest times, scholars have sought explanations for natural phenomena that are part of everyday life. However, explaining something that is not directly perceptible through the senses is an extremely complex task. In the case of atoms and molecules, which have a real structure that is not perceptible by the senses, this is a great challenge for chemistry, and consequently the teaching of this science. One of the major issues is how to enable students to perceive the relationship between microscopic and macroscopic levels, that is, how to ensure they understand microscopically the phenomena of their daily lives.

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One of the main objectives of the teaching of chemistry is that the student appropriates the diversity of representations that belong to this area, that is, it is necessary that the student appropriates the specific language of this field of knowledge characterized by a diversity of semiotic registers. The relevance of the study of the semiotic registers is due to the fact that the development of the sciences is linked to semiotic systems that are increasingly specific and independent of the natural language. To overcome this challenge, the discussion of the appropriation of the specific language of chemistry is fundamental. According to Roque and Silva (2008), the chemist understands the world through models, graphs, figures, and equations, namely idealized and simplified representations of the real world (semiotic registers). It is thus understood that for students to understand natural phenomena, they must learn the specific language of chemistry. Understanding this language can facilitate the study of this science, since for the teaching and learning of chemical concepts it not necessary to have a concrete macroscopic model; indeed, through symbols, students can imagine the substances and their behavior.

Comprehension of chemistry is subject to the understanding and meaning of symbolic representations. Thus, it becomes necessary to study semiotics - the study of any and all language. According to Peirce (2005), the processes of signification include written symbols, gestures, and written or spoken words, and these can occur whenever something has meaning for an individual. Lemke (1998, p. 6) states that “the natural language of science is a synergistic integration of words, diagrams, pictures, graphs, maps, equations, tables, charts and other forms of visual and mathematical expressions.” Therefore, it is understandable that chemistry lessons must be permeated by diverse semiotic representation registers that will help the student to develop the ability to “read” the world.

Thus, in a general way, this study aims to understand how the use of semiotic registers in chemistry lessons are employed considering one case study, without aiming at generalizations, in order to broaden the discussion of the language and the reflection on how the use of these registers can contribute to understanding of the chemical concepts.

BACKGROUND

Based on semiotic science, recent research on science education, mainly with a cognitive orientation (Zompero & Laburú, 2010), has provided important advances in understanding aspects related to representations, including mental, internal, and external (semiotics), involving the learning of concepts (Duval, 2003). For this author, the mental representations comprise a set of images and conceptions that an individual can have concerning an object; the internal aspects are those characterized by the automatic execution of information, and the external, or semiotics, are productions constituted by the use of signs belonging to a system of representation, used as a means of externalizing the mental representations for communication purposes.

According to Duval (1993) semiotic registers can be understood as any form of enabling the symbolic representation of the construction of cognitive thinking. In the case of sciences, we can highlight mathematical formulae, Cartesian graphs, and algebraic writing, among other semiotic representations present in teaching. Understanding of scientific concepts requires the engagement of several systems of representations called registers, such as verbal language, and graphical and numerical representations, etc. Each register can contribute in a specific way to a wider understanding of the context and therefore to the organization of the student’s mental representations. This means that, when learning chemistry, the student must also learn the specific language.

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Chapter 17

Accessing Science Museum Educators' Discourse Through Multimodal Narratives

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ABSTRACT

Museum educators play an important role in science communication, as they connect elements of an exhibit with visitors through emotion-driven experiences that are meaningful to them. Language is their main modus operandi in face-to-face interactions, but little is known of how they use it to communicate science, in part because little attention has been given to their practices and professional development. Nowadays, museums are changing, and science communication has become more demanding as these institutions exhibit hot themes of science. In this context, it is important that museum educators become aware of how they communicate science with an intended audience and reflect on how their practice can be improved. In this chapter, the authors focus on the way multimodal narratives can be used as a tool to access museum educators' discourse as well as how to promote museum educators' reflection about their practice and their professional development.

INTRODUCTION

Science museums, initially created to preserve and study collections of objects of scientific interest, have expanded their mission to include an educational purpose that can contribute to supporting the process of adults' lifelong learning. This has led to the reinvention of the museum space so that exhibitions can be framed around hot scientific themes that are pressing society (e.g. global warming, sustainable development), or around processes of science (e.g. modeling or contemporary scientific research), that attend to the visitors' needs, interests and motivations (e.g. Dillon et al., 2016), in contrast with tradi-

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tional exhibitions that provide friendly interpretations of the message and do not encourage visitors to go beyond what they already know. Exhibitions on hot themes cover complex scientific ideas, requiring visitors to think critically about science (Rennie, 2014). As a result, science museums face the challenge of how to represent science in a version that encourages engagement and that is meaningful to an intended audience (Tlili, Cribb, & Gewirtz, 2006). One way to move forward is to present key ideas in a clear and simple story (Rennie, 2013), told mainly through objects and interactive exhibits explicitly linked together. However, because resources do not talk for themselves, front-line museum educators (museum educators, henceforth) may aid visitors to go beyond what they already know, and to create emotional links with what is being presented (Rennie, 2014). Hence, they can impact on visitors' learning experiences in multiple ways, including inspiration and creativity, attitudes and values, aesthetic appreciation, knowledge and understanding in science, among others, as has been accounted in a diversity of frameworks (see for example the six strands of science learning in Bell, Lewenstein, Shouse, and Feder (2009), or the Generic Learning Outcomes in Hooper-Greenhill (2007)).

Communicating science in museums is a challenging and complex task for museum educators, who are asked to support visitors' learning in diverse types of activities, ranging from guided visits to unstructured interactions in the exhibition area. They act between unseen or hidden science of the curatorial department and the visitors (Anderson, Cosson, & McIntosh, 2015). What they say is, to some extent, shaped by the institutions' missions and rules (Clark, 1996), but their discourse is not prescriptive. Indeed, they need to adjust the content of the message and the form of the language used to engage in successful science dialogues with an intended audience, i.e. dialogues where any participant can ask questions, give, and evaluate an answer (Gilbert, 2013). The emergent dialogues are unplanned and unfold as a museum educator and an audience coordinate their individual actions to negotiate meaning (i.e. a joint activity), which is influenced by visitors' feelings, beliefs, desires, and the role they assume in the conversation (Clark, 1996). There are some good practices that museum educators need to have in mind to enhance the coordination between what they mean and what their addressees understand them to mean (e.g. Laszlo, 2006; Stocklmayer & Rennie, 2017). In particular, museum educators need to take time to know the audience (Stocklmayer & Rennie, 2017); to carefully select the content (e.g. key ideas to convey and their level of precision, complexity, and abstraction (Yeo & Gilbert, 2014)); and to adjust the form of language, both at a macrolevel (e.g. the structure of the discourse itself) and at a microlevel (e.g. lexicon, use of analogies), to an intended audience. As a result, dialogues on hot science themes may have different levels of complexity and formality depending on the audience: from those that focus on an awareness of scientific issues, to those in which participants reflect on the impact of science on their lives. However, little is known on how museum educators use language to communicate science in museums, in part because little attention has been given to their professional development (Patrick, 2017). The majority of known studies focus on museum educator-student interactions during guided school visits. While some studies suggest that museum educators tend to transfer their knowledge to students, to use scientific terminology without clarification, and to neglect students' needs (Cox-Peterson, Marsh, Kisiel, & Melber, 2003; Tal & Morag, 2007), other studies show that museum educators are receptive to students' needs, employ and adjust the depth and content of the message by using a diversity of strategies (Tran, 2007). Additionally, Pattison and Dierking (2012, 2013), in studies with families in a science museum, pointed out that museum educators employed several strategies (e.g. checking in, guiding, modeling, encouraging) to facilitate family learning. These studies provide few insights on how museum educators use language in science communication, as in most of them data were collected by observing and/or interviewing museum educators about their pedagogical approaches. Additionally,

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Chapter 18

Multimodal Narratives in Nursing Education: Exploring Their Potentialities

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ABSTRACT

Nursing education is driven by emerging challenges of scientific, technological, and professional advances that require the use of strategies that promote students' development of critical thinking for decision making in different contexts. It also requires that teachers constantly reflect on their pedagogical practices and (re)think them using strategies that allow their enhancement. The use of multimodal narratives (MNs) can be an important tool for teachers' professional development, namely to improve their classroom practices. Given the novelty of the use of MNs in nursing education, this chapter presents an analysis concerning the experience of making a MN and how it has been reflected in the authors' pedagogical practices. With this experience, potentialities of continuing to use MNs in nurse education are explored.

INTRODUCTION

The use of multimodal narratives (MNs) as an instrument to improve teachers' practices has been intensively researched, since 2008, by a Portuguese team under the coordination of J. B. Lopes (Lopes et al., 2012, 2014). Since 2017, there has been a web page available (<http://multimodal.narratives.utad.pt>) with information for researchers and teachers about all the work that has been developed so far by the

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team. From this work, there is strong evidence that MNs play an important role in teachers' professional development. However, this research has been mainly conducted in the field of science education in elementary and secondary schools, although its scope has been expanded, more recently, to other areas, like mathematics, information & communication technologies and to higher education (HE). The idea of studying the potentialities of the use of MNs in nursing education in HE was the main reason for conducting the analysis to be described in this chapter.

The chapter starts with an overview on the complexity of nursing education in HE, namely at a postgraduate level, due to the challenges faced by the nursing profession nowadays. This section also explores the professional requirements that nursing educators should have, particularly which professional competences are concerned, and the instruments that have been used to develop them. Then, and given the characteristics of a MN, a comparative analysis is made between the potentialities of the use of narratives and MNs which leads to the relevance of the use of MNs in nursing education. Furthermore, a description and analysis of the use of a MN in nursing education is conducted, specifically in a postgraduate class, and the implications for the professional development of the teacher are explored. The last section includes the main conclusions of this analysis concerning its potentialities, the limitations of this study, and recommendations for future work.

BACKGROUND

Nursing education integrated into higher education (HE), as it is in Portugal, has undergone deep changes, not only to follow the scientific–technological evolution of the area, but also the paradigm's changes in nursing care and the pedagogical-didactics approaches recommended for HE. Today it is expected that a nurse, in the context of clinical practice, is a professional who supports his/her practices with scientific evidence for a contextualized decision-making in order to care for the person, family, groups and community throughout the life cycle, and to follow them up in their transitions and in the management of their health projects (Costa, 2011; International Family Nursing Association/IFNA, 2017; Rua, 2011).

Regarding the health-care contexts, where nursing practices most often occur, and where decision-making based on a set of specific competencies can be observed, these are highly demanding and unpredictable, not only from the point of view of the health/ illness conditions of the users, but also from their involvement in their health projects. This requires nurses' competencies in different dimensions, which are developed from initial education, but which must be extended throughout life, particularly when leading to a specialist level in a specific nursing area (IFNA, 2015; Popil, 2011). Given these assumptions, the training of these professionals, at the specialization level (always in the context of HE), requires a constant movement to improve the pedagogical practices of their teachers based on strategies that promote the development of new and deeper competences, such as critical thinking, considering that they are postgraduate students and, most of them, have been working for some years.

Taking on board the literature about teaching practices in the context of nursing education at the second cycle (postgraduation), where this study took place, it is evident that there is a constant need to improve them through more active strategies and critical-thinking activities, among other competencies.

For years in HE, students have been educated through what is identified today as traditional lectures (expository teaching). Active-learning strategies have been progressively widespread and researched, and they "...contrasted to the traditional lecture where students passively receive information from the instructor" (Prince, 2004, p. 223). A definition of active learning may be "...any instructional method

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Conclusion

This book, *Multimodal Narratives in Research and Teaching Practices*, focuses on Science and Technology Education, a relevant issue in the present society. It contributes to the field presenting an innovative way to capture the reality of what happens in the classroom and to make it public: the tool Multimodal Narratives (MN). This tool is explained from its origin, to its construction and illustration of how it can be used from several perspectives and purposes. The potential readers are primarily teachers, teacher trainers/students and researchers. This book shows how this tool can contribute to teachers' professional development and to educational research. It also approaches other contexts of usage (nursery and museums) as examples of other applications.

In brief, an MN is a descriptive and multimodal account that aggregates several types of data of professional practices in a real work context, which can be public and shareable. MN is characterized by their self-containment, reliability and representing public descriptions of professional practices in the real work context. MN tool is distinguished from others with similar purposes by: (a) having a verifiable chronological line, (b) being based on collected data of various types and the possibility to validate its accuracy, (c) incorporating descriptively the teachers' perspective, necessarily subjective, (d) being enriched by multimodal elements; (e) have a clear structure and similar characteristics; (f) present itself in a public register, easily consulted and open to different communities. These unique characteristics of MN allow them to be used by teachers, researchers and other professionals with different interests, visions and purposes taking advantage of the collection of validated MNs, in its present state, accessible on <http://multimodal.narratives.utad.pt/> or even extend the collection.

All these characteristics are fully explained and described in the first chapter, which also shows the importance of the teaching practices become public and shareable and presents a tool –the MN– to do that. This chapter inscribes the work with MNs in a general trend of an Open Science perspective, gives the book a direction towards a strong coherence, and a fully assumed citizenship. In particular, explains in detail how MNs can be developed and validated and articulates the rationale of MN, its characteristics, the development process, its use in teacher training, professional development and research.

The book presents multifaceted contributions from several authors who over time have joined the team of researchers and teachers who developed the MN tool. Their seek to provide answers to questions that gradually emerged from the tool development process itself allowed to detail different views and lines of research and its acceptance in the professional and academic communities. Each perspective of the MN usage allowed the adjustment of this book for different target reading audiences closely aligned with each part of the book. By showing evidences of the MN's relevance and ways of usage through reports of cases, a useful mixture of theory and practice is made. In all chapters the respective authors had in mind the development of the teaching quality of Science & Technology and the students' learning quality.

Conclusion

The research developed and the collaborative work showed in this book involved teachers and researchers from Portugal, Brazil and Angola (with 11 Higher Education Institutions, 9 Basic and Secondary Schools directly involved). This allowed to verify that MNs are a rich and multifaceted tool that can:

1. Provide an integrative vision of a S&T teacher in action. In Section 2, chapters 2 to 6, showed how Teaching Practices in S&T can be seen through the MN, namely while exploiting specific issues of teacher mediation in different practices.
2. Be used by teachers in the context of their professional development or even in initial training. In Section 3, chapters 7 to 11, showed how the usage of MNs can aid improve the professional development of S&T teachers, articulating with research of teaching practices.
3. Be object of research. Since their foci are not in the “teaching subjects” but in the “teaching practices”, MN from different contexts can be used to compare different practices and serve wider research purposes related to the improvement of S&T teaching or other professional practices. In Section 4, chapters 12 to 16, illustrates some of these possibilities.

In addition to the S&T teaching professionals and researchers’ interest, NMs may also have a potential interest in professional development in other professional sectors that are based on interaction with people such as doctors, nurses, caregivers, etc. In Section 5, chapters 17 and 18 explored some possibilities in this direction, in particular, science communication in museums and nursing education.

The most values of this book are presenting, explaining, using and exploring the possibilities of use (researching, teaching and professional development) of a tool – MN – that may:

1. Enhance the possibilities of researching S&T teaching practices by other teams, using the currently MN collection available in a portal articulated with the book. It is possible to do large-scale research studies (using the MN diversity of the collection available) or in depth (using few MNs). This possibility is based on the structure and characteristics common to different NMs secured by a protocol for their elaboration. In addition, MN can be explored using different theoretical approaches and analysis techniques. Finally, the same MN can be used for different research purposes.
2. Expand the MN collection with other MNs from different professionals and contexts. Given their public character, MNs can be taken as a reference to improve the teaching practices of S&T. The MN reports and shows what happened, as it happened. There are unsuccessful situations and others with different degrees of success. The lessons to be taken from one or more MNs will be personal, perhaps even depending on the experience of each one. The same can no longer be said of research studies due to their aim of contributing to a better and systematic understanding of specific aspects of teacher mediation.
3. Disseminate the MNs’ potential to larger audiences which can include not only academics, but also teachers and other professionals who daily contact with other people in their practice. MNs allow access to the point of view of the teacher. Since MNs reconcile objective data and subjective descriptions, and accepting them both, as fundamental, it is possible to focus on main points for professional practice or professional development. It is well known how important the implicit and subjective aspects are for the repertory of professional skills.

In light of the above, we are convinced that this book, while presenting the MNs and the different scenarios in which it can be used, can constitute the basis for many future and fruitful research lines as well as the empirical basis support for teachers in the development of their educational practices!

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