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Research Articles

The cycle of development in educational resources for the experimental teaching of science in primary school: foundations, process, and products

Ciclo de desenvolvimento de recursos educativos para o ensino experimental das ciências para o ensino primário: fundamentos, processo e produtos

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Abstract

The teaching of science at the earliest age is widely recognised as essential for the development of scientific literacy. The concern to make this possible is visible in various educational initiatives aimed at providing suitable educational resources for teaching science during the early years of schooling in Portugal. The purpose of this article is to describe the process of development in science resources designed for the first four years of primary school. These resources were developed according to Educational Design Research, based on iterative cycles. Through a multi-disciplinary team, resources were developed for 120 primary school science activities. A content analysis of data from teacher responses to the questionnaires was used. The results highlight the suitability and originality of resources that support exploration of the practical science activities that were suggested.

Keywords: Educational resources; Science Education; Primary Education; Educational Design Research.

Resumo

O ensino das ciências desde os primeiros anos de idade é amplamente reconhecido como essencial para o desenvolvimento da literacia científica. A preocupação em tornar isto possível é visível em várias iniciativas educativas que têm como objetivo a disponibilização de recursos educativos adequados para o ensino das ciências nos primeiros anos de escolaridade em Portugal. O presente artigo tem como objetivo descrever o processo de desenvolvimento de recursos didáticos de ciências concebidos para os quatro primeiros anos do ensino primário. Estes recursos foram desenvolvidos segundo o Educational Design Research, com base em ciclos iterativos. Através de uma equipa multidisciplinar foram desenvolvidos recursos para 120 atividades de ciências do ensino primário. Recorreu-se à análise de conteúdo dos dados provenientes das respostas dos professores aos inquéritos por questionários. Os resultados apontam para a adequação e originalidade dos recursos que apoiam a exploração das atividades práticas de ciências sugeridas.

Palavras-chave: Recursos educativos; Educação em Ciências; Ensino primário; Educational Design Research.

INTRODUCTION

It is both a goal and a challenge to create conditions in schools that promote science teaching that is capable of stimulating the necessary scientific literacy of students in a world increasingly influenced by the rapid and unavoidable evolution of science and technology (Cachapuz, 2022; Salehjee; Watts, 2020). The advocacy of teaching science from an Inquiry-Based Science Education (IBSE) perspective (Harlen, 2021; Suduc; Bizoi; Gorghiu, 2015) and based on a Science-Technology-Society (STS) orientation (Cachapuz, 2022; Cruz, 2015; Martins, 2006) dates back to the 1990s and remains relevant today (Martins, 2020). It advocates, the teaching of science in

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Study conducted at Universidade de Aveiro (UA), Aveiro, Portugal.

a contextualised, sequential, systematic, regular and meaningful way, which presupposes the active involvement of children in their learning process from the earliest years of schooling.

In Portugal, some studies have shown that practical science activities in primary school take place in an unsystematic, irregular and decontextualised way (Silva; Rodrigues; Vicente, 2023b; Bretes; Correia, 2018). These studies also reveal that the active involvement of children in their learning process is scarce and limited, due to frequent reliance on textbooks, with an excessive focus on memorising knowledge to the detriment of promoting scientific skills, even for activities of an experimental nature. In several studies, primary school teachers identify the following as the main obstacles to the implementation of experimental science teaching: the lack of teaching resources, the lack of a properly equipped place with adequate resources, the lack of time to comply with the curriculum, and their lack of training (Bretes; Correia, 2018; Ramos; Rosa, 2016). A recent study has shown that primary schools in Portugal still lack adequate infrastructure for the development of experimental science activities, for example laboratories and resources/equipment (Rodrigues et al., 2018). However, the presence of a laboratory and its specific resources does not dictate the regular occurrence of experimental activities, but rather facilitates them (Santana; Capecchi; Franzolin, 2018). In terms of environmental studies textbooks, the resource of choice for science activities in this cycle of education, studies highlight the low level of complexity for the practical work proposed in them (Ferreira; Saraiva, 2021).

The relevance of the current curriculum and adequate resources for the development of practical science activities has been discussed, in order to promote better learning, awaken children's interest in science and enhance science teaching in schools, including the time dedicated to this area in the curriculum (International Science Council, 2021; Organisation for Economic Co-operation and Development, 2006; Stubberfield; Barton, 2021). It is understood that "[...] despite the efforts made by curricular development teams in several countries, there is still a lack of adequate teaching resources to support STS teaching, which will require greater efforts in pedagogical research [...]" (Cachapuz, 2023, p. 10).

These aspects motivated the development of the Experimental Science Teaching Programme (PEEC) for the first years of school, which will be described in more detail in the following sections. The aim was to provide more explicit curricular guidelines, as well as activities and teaching resources to support its implementation, with the aim of promoting scientific literacy. This article describes the development cycle of a set of scientific activities and teaching resources, from the design phase to its use with children, underlying the PEEC curriculum proposal.

DIGITAL EDUCATIONAL RESOURCES IN PORTUGAL

The integration of digital educational resources (DER) into science teaching is becoming increasingly common (Muhaimin et al., 2020), as, according to some authors, these resources improve the student learning experience (Woo; Kim; Lee, 2020). DERs are seen as "an artifact stored and accessible on a computer, designed for educational purposes, with an identity and autonomy aside from other objects and with appropriate quality standards" (Ramos et al., 2010, p. 45). They are also defined as any "digital entities produced specifically for the purpose of supporting teaching and learning" (Ramos; Teodoro; Ferreira, 2011, p. 13). Other authors (Navaridas-Nalda et al., 2020) include, as DERs, websites, data files, databases, e-books, digital images, videos or digital games, corroborating the idea that they are all digital resources that, whether interactive or not, are presented as audio, visual, or audiovisual. They also refer to it as "[...] a learning resource [...] that can be applied to improve students' skills and content knowledge in a digital environment" (Cavadas et al., 2023, p. 2). In this sense, it is understood that a digital educational resource is any digital resource, or one with a digital component, which also has an explicit didactic purpose that proposes the mobilisation of a set of learning outcomes defined for a given year of schooling.

A DER must: i) have a well-defined underlying objective/purpose; ii) respond to the specific need of the educational system in which it is used; iii) have an autonomous identity in relation to other digital resources; and iv) meet quality criteria (Ramos et al., 2008). From the perspective of other authors (Cardoso et al., 2022) there are five pedagogical-didactic principles that guide the process of developing digital educational resources, namely: i) the creation of meaningful contexts for learning; ii) curriculum integration; iii) the implementation of a constructivist-based instructional design; iv) the promotion of student independence; and v) the promotion of student involvement and motivation in the teaching and learning process. Becta (2007) adds aspects such as accessibility, design, navigability, interoperability, inclusion and quality as some of the fundamental principles for developing DERs.

In Portugal, the lack of mobile devices in primary schools has hindered and inhibited the integration of educational resources in a formal context. Since the 2018/2019 school year, there has been significant investment in equipping schools with computers, with an aim to make teaching with DERs into a reality. While in that academic year there were approximately 6 children per computer, as a result of the SARS COVID-19 pandemic in 2020/2021, there was almost one child per computer (Conselho Nacional de Educação, 2022), and around 96.2% of the computers available in schools had an internet connection. Despite this investment, it is essential to ensure that quality resources are made available in line with current pedagogical purposes and appropriate for the year of schooling for which they are intended (Ramos et al., 2010). Although the lack of resources is one of the main obstacles to adopting digital strategies, the biggest obstacle has been teachers' resistance to change, often due to their lack of training (Ramos; Teodoro; Ferreira, 2011).

EDUCATIONAL RESOURCES IN SCIENCE FROM THE EXPERIMENTAL SCIENCE TEACHING PROGRAMME (PEEC)

The development of the PEEC for primary education is intended to contribute to the promotion of scientific literacy from the earliest years of schooling, offering teachers multiple opportunities for didactic exploration within the various topics on Science. The PEEC is made up of three components: the curriculum, one for activities and assessment and another for learning. These components have been designed based on the IBSE perspective in conjunction with STS guidance.

The curricular component, in brief, consists of a proposed science curriculum for the first four years of primary school organised into four areas: Biological Sciences; Physical Sciences; Earth Sciences; and the Nature of Science. This curriculum proposal defines different subjects with specific statements in terms of knowledge, skills, attitudes and values to be mobilised over the four years of schooling (Silva; Rodrigues, 2023). The curricular proposal can be enabled with resources from PEEC Activities. This component is accompanied by 120 activities, each accompanied by support resources for their implementation in the classroom, distributed in 30 activities per year of schooling, with an average duration of 90 minutes per week. For each one of the activities, teaching resources are available to use with the children, completely free of charge and online on the official website.

The assessment component, in keeping with the other PEEC components, encourages the assessment of children's skills in order for them to improve their learning and much more. In order to monitor learning throughout the sessions, assessment tools have been developed for each of the proposed activities, which are consistent with the curricular proposal. Serious games are also available as a proposed assessment activity for each grade and, alternatively, four assessment tests.

The 120 proposed activities in the PEEC and the teaching resources for preparing and using them with the children are described below. The plans are documents for teachers. Considering that the quality of teaching is intrinsically linked to teacher practice (Teig; Nilsen, 2022), we want to avoid misinterpretations along the lines of the IBSE perspective whereby the role of the teacher is that of a mere observer, an interpretation that could lead to failure in the activity (Aditomo; Klieme, 2020). Some authors point out that the lack of explicit guidelines on how to conduct activities from this perspective can lead to inhibition about implementing more experimental activities (Bernard et al., 2015). In addition, it is important to ensure that teachers recognise the relevance of the proposed activity in terms of the underlying objectives, because the teacher "[...] will be able to promote not only the development of specific skills, but also the development of important transferable skills to other contexts in the daily lives of students" (Bonito; Oliveira; Carneiro, 2023, p. 87). It is in this sense that the PEEC plans, in addition to including general information about the activity (year of schooling for which it is intended, subject, estimated average time), have learning and teaching resources mobilised, as well as contain a brief description on how the session might be conducted. These indications are also included in the Didactic Guides for Science Education and Experimental Teaching, prepared as part of the Experimental Science Teacher Training Programme and in the consequent and more recent *RED_Ciências* project (Rodrigues; Peixinho; Silva, 2023). These plans provide explicit indications of children's involvement in various stages of activity, namely contextualisation, planning, experimentation/ performing the activity, data analysis and formulating the answer to a problem question.

The contextualisation of activities using real or realistic problems aims to provide meaning and sense to the activities as well as the content explored. Several authors argue that contextualised teaching is necessary to arouse children's interest, motivate and involve them in the activity, give meaning to learning and make STS relationships explicit (Ferreira; München, 2020; Kato; Kawasaki, 2011). Contextualisation strategies are not new. For example, Keogh and Naylor's (1999), concept cartoons were innovative for their time and opened the door to other strategies. In this context, videos were developed for each PEEC problem question. Each one of these videos depicts a problematic situation of a scientific and technological nature that involves two characters: Cien and Tista. With these episodes, it is suggested that the children take a stance on the problem and justify their choice. From here they can identify and formulate the problem question, and at the end of the session they can explore the video, recalling the children's predictions and formulating the conclusions and answers to the problem question.

More than 120 infographics have been developed on themes such as health, animals, plants, rocks, the human body, among others. This resource is known as a visual information medium (Locoro et al., 2017), which combines images (illustrations, graphics, photographs...) with text or audio (Tsai; Huang; Chang, 2020). What motivated the development of this type of resource is the fact that they are considered to facilitate the understanding of more complex content in a simpler way, without losing any rigour - and they are generally liked by students (Tsai; Huang; Chang, 2020). Infographics can be of three types: static, interactive and dynamic (i.e., in motion) (Lankow; Ritchie; Crooks, 2012). The development of static and dynamic infographics was prioritised. Static infographics, as the name implies, are posters/images in which the information is immobilised and completely available (Segel; Heer, 2010). All the static infographics presented can be used digitally or in print, and to date, around 110 static infographics are expected to be available and validated at a scientific level. Dynamic infographics are generally videos made up of animation in which information gradually and progressively appears without the user's control (Lankow; Ritchie; Crooks, 2012). In this case, we used this type of infographic because of the large amount of information and the need to include animation, and at the present moment we have created 10 dynamic infographics.

The inclusion of the scientific community and experts in science lessons have been recommended for promoting general skills and contributing to knowledge about the nature of science (Espada, 2007; Fallon; 2013). Videos were created through inspiration of a previous study that used recorded interviews with scientists, addressing questions about themselves and their work (Chen; Cowie, 2014). The "Chatting with..." section is made up of a series of videos with various experts (biologists, researchers, scientists, pregnant women, nurses, doctors, among others). In these videos, the interviewees answer a series of questions on a particular subject in their area of expertise. The aim is to bring the general and scientific community into the school, as recommended, although this does not invalidate the need for children to have direct contact with experts. Whenever possible, it is suggested that other questions that have arisen during the session be raised and that another specialist be invited to answer them in the classroom.

Several analogue games were made available, mostly exploring the theme of living beings. These games are mostly made up of cards and bases and aim to make associations and groupings.

Similar to other studies of this nature in Portugal for primary education (Paixão; Jorge; Martins, 2012; Silva; Tenreiro-Vieira, 2015; Clemente; Vieira; Martins, 2010), proposals for recording were made available to the children. These proposals differ according to the nature of the activity. For activities of a laboratory nature, the record includes those preliminary ones and those during and after the experiment. In the preliminary stage, there are sections for preliminary ideas (drawing, multiple choice...) and planning the activity (sorting). During the activity, there are sections for recording observations/measurements (double-entry tables, drawing). In the post-experimental stage, there are sections for conclusions and/or answering the problem question (open answer, multiple choice...) as in other studies (e.g. Mafra; Lima; Carvalho, 2015). For research or classification activities, these proposed records have a different structure. Generally, children are challenged to answer a quiz before and after the activity. These records can be answered individually, in pairs or in groups of four (maximum recommended).

A learning assessment tool has been developed for each activity which, although it is part of the PEEC assessment component, it is associated with the activity for convenience. These resources are also intended for use by teachers. The recognised difficulty teachers have in evaluating practical science activities (Bonito; Oliveira, 2024) was a determining factor in fostering and encouraging the monitoring of children's learning, through the use of observation recording tools during the activities.

METHODOLOGY

This qualitative study falls within the socio-critical paradigm (Coutinho, 2014) due to its interventionist and transformative nature in terms of science teaching in primary school. Given the nature of the study, its underlying objectives and the process characteristics, the Educational Design Research (EDR) approach was adopted. The methodologies related to Research and Development that emerged at the end of the 20th century and the beginning of the 21st century (Mckenney; Reeves, 2013) emerged in response to the arduous, but highly-sought relationship between theory and practice in research. The existing educational methodologies used in research until then were far removed from the reality of schools and educational policies and often resulted in scientific knowledge that was of little use in solving real-world problems (Reeves, 2006). The EDR and all its variant methodologies have overcome this problem (Design-Based Research Collective, 2003).

With this in mind, the aim of this study strives to contribute to the promotion of science teaching in primary schools in Portugal by providing teaching resources to support the implementation of practical experimental activities. This article presents the cycle of development in PEEC teaching resources, based on the EDR, with the following characteristics:

- Educational innovation: we started out from the problem detected in the Portuguese educational context, in this case, the deficit in the teaching of experimental sciences in primary schools;
- Multi-disciplinary team: a multi-disciplinary team was created by involving senior and junior researchers, class teachers and assistant teachers, children, programmers, designers and other specialists, based on effective collaboration between research participants (Wang; Hannafin, 2005);
- Iterative cycles: it was proposed to develop the resources based on iterative cycles involving the phases of analysis, solution design, implementation and redesign as well as reflection (Mckenney; Reeves, 2013). These iterative cycles make it possible to improve the link between theory and intervention aimed at practice, in the search for iterative solutions that satisfy all those involved.

PHASE I - ANALYSIS AND EXPLORATION

As with any research, the first phase of the EDR consists of identifying and describing the research problem. In this sense, one of the aims of this study was to develop a research-based intervention with proposed solutions to complex problems detected in educational practice

(Plomp, 2013), namely the lack of experimental science teaching in the early years of schooling. This article identifies the intention of developing functional solutions to practical problems within learning environments (Reeves, 2006).

Therefore, as a basis for identifying the problem, the following studies were conducted by the authors:

1. A comparative study of the current curriculum for primary school science teaching in light of the learning assessed in TIMSS and by comparing science curricula in the United States, Singapore, England and Australia (Silva; Rodrigues; Vicente, 2023a). The results point to the need for more explicit curricular guidelines and equity between knowledge, skills, attitudes, and values. This study led to the development of a science curriculum proposal for primary education (Silva; Rodrigues, 2023).
2. A study on the experimental science teaching practices of Portuguese primary school teachers. To this end, a study was conducted on more than 100 reports from the General Supervisory Board of Education and Science, in the field of experimental science teaching, describing teacher practices (Silva; Rodrigues; Vicente, 2023b). It was noticed that the practical science activities still take place in an unsystematic and irregular way, involve the children very little and are decontextualised.

These preliminary studies served to support the development of a proposal for activities and resources to promote experimental science teaching in primary education that is contextualised, systematic and aims to actively involve children in their learning. In this sense, the research objective was "To develop (design, plan, validate, implement, evaluate) proposals for didactic exploration and respective resources to support implementation of the PEEC curriculum proposal."

PHASE II - DESIGN AND IMPLEMENTATION

The research was conducted in a primary school over two school years, involving 12 classes (250 children) from different years of schooling. After approval from the Ethics Committee, authorisations and data were received from 171 children (a total of 11 classes). A multi-disciplinary collaborative team was set up between class teachers and specialists from various departments (biology, geology, physics and chemistry) to validate didactic and content components, as well as a musician and programmers to design the PEEC resources.

In this development phase, both in the first and second implementation cycles, an iterative dynamic was adopted between the various collaborators in this study. In the first instance, during the design phase, the researcher-creator sketched out the resources needed for activities (e.g. plans, record sheets, cards, boards, posters, videos, assessment recording tools, etc.). For their preparation, websites, books and other teaching resources were researched for inspiration, based on the learning stipulated in the PEEC curriculum. This whole process of design, validation and implementation was supported by formative assessment (Mckenney; Reeves, 2012), enabling it to be constantly redesigned according to feedback from all those involved (Plomp, 2013), as described in Chart 1.

In validation phase 1, different experts in the field were contacted to evaluate some of the resources. The analysis of the resources was collected through meetings and various communication channels, allowing feedback to be obtained for the validation of the illustrations (Figure 1a) and/or the information provided (Figure 1b).

With the feedback provided by the validators, the resources were redesigned where necessary. Next, proceeding onto validation 2. At this stage, the assistant teachers gave their feedback based on their knowledge and teaching experience. With this feedback, the resources were redesigned, and the teachers as well as the assistant teachers were able to proceed with implementation of the activities with the children. The final redesign of the PEEC was made on the basis of a more systematic evaluation, namely on the basis of teacher responses to the questionnaire survey.

Chart 1. Description of the iterative cycle for resource development.

Moment	Description of the moment	Participants
Drawing	Design of teaching resources needed to implement the activities.	PEEC researcher-creator
Validation 1	Validation at the level of scientific knowledge on the subject content, by experts in the field, of some teaching resources.	Specialists
Redesign	Redesign of teaching resources based on feedback from validators.	PEEC researcher-creator
Validation 2	Exploration and analysis of the teaching resources to be implemented (validation at the level of scientific knowledge for teaching content).	Assistant teachers
Redesign	Redesign of teaching resources based on feedback from assistant teachers.	PEEC researcher-creator
Implementation	Implementation of activities with the children.	Full-time and assistant teachers
Assessment	Assessment of the resources used in the session through a questionnaire survey.	Full-time and assistant teachers
Redesign	Final redesign of the teaching resources based on all the feedback received.	PEEC researcher-creator

Source: Prepared by the authors.

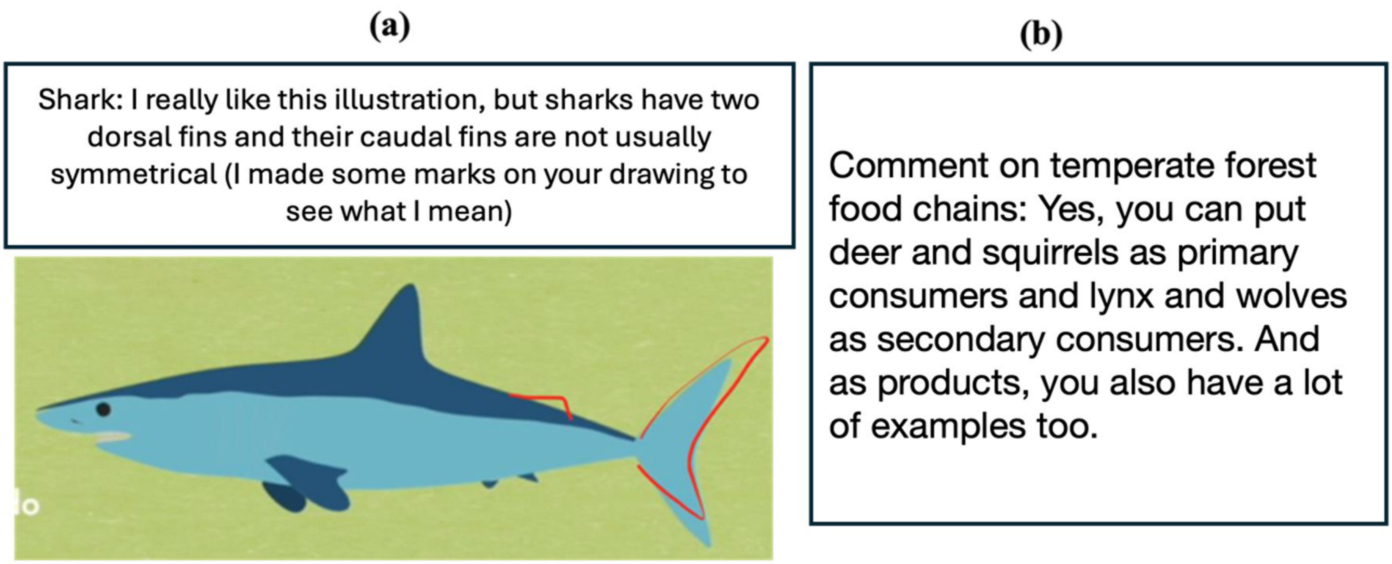

Figure 1. Feedback from a biologist, (a) on the illustration of a shark, (b) on food chains. Source: Prepared by the authors (2024).

The activities were explored, in most cases, on a weekly basis, in 90-minute sessions and in the context of the school laboratory with the 12 classes. The selection of PEEC activities was the result of a consensus between the researchers responsible for creating the programme and the lead teachers from each class, taking into account the activity proposals available and the pedagogical intentions. The sessions implemented began with the viewing of contextualisation videos, which allowed the children to gather their previous ideas and formulate the problem question. Then, using various strategies (sorting, drawing, filling in), the children, with the teacher's support, planned the activity, decided on the steps and tasks to make the plan operational and selected the resources needed to carry it out. The activity was then performed, always ensuring that sufficient resources were available so that all the children could be actively involved in the experience. In this way, it was possible to promote various investigative skills, such as measuring, observing, collecting and recording data, researching, selecting and organising information. In this sense, it was advisable, on average, to conduct the activity in groups of three to four children. They were encouraged to interpret the data and formulate an answer to the problem question and conclusions, ending the activity with reflection, evaluation and communication of the results.

Over the two school years, a total of 168 sessions were implemented, corresponding to 61 different problem questions. In Year 1, 17 questions were implemented, in Year 2 and 3, 15 questions and in Year 4, 14 questions. 30 PEEC activities were developed for each year. As far as activities in the 1st Year are concerned, 30 activities were designed and 23 were implemented, which corresponds to around 77% of the activities for this school year, 13 of which were implemented with six different classes and the remaining 10 were implemented with three classes. For Year 2, 30 activities were also designed and 20 were implemented, corresponding to around 67% of the total activities designed, 12 of them with three classes and the remaining eight activities with six classes. In the case of Year 3, 30 activities were designed and 25 were implemented, around 83% of the total number of activities, 13 of which were implemented with six classes, and eight activities with three classes. Although the remaining activities (around 25%) were not implemented, most of them were validated by experts in the field.

DATA COLLECTION AND ANALYSIS PROCEDURES

The preferred data collection technique in this study was through questionnaire research. Teachers were asked to express their opinion on the degree of suitability, using a Likert scale (1 - not at all appropriate and 5 - completely appropriate) in relation to each activity used with the children, its resources and its purpose. In total, there were 57 responses to the questionnaire in the first implementation cycle and an additional 62 in the second implementation cycle. In order to analyse data from the open-ended questions, the analysis tool, "Assessment of PEEC resources" was developed, as shown in Chart 2.

Table 1 lists the total number of pieces of evidence per dimension of analysis and type of question from data collected out of the questionnaires.

Chart 2. Analysis tool: Assessment of PEEC resources.

Dimension	Parameter	Examples of evidence	
		Positive aspects	**Aspects for improvement**
Activity	Learning	"Suitability in relation to expected learning"	-
	School level	"The activity was completely appropriate for the age level"	"A little easy for them"
	Coherence	"A positive aspect from this activity was the consistency with previous sessions"	"A previous activity is needed, introduction of the topic..."
	Structure	"Well-structured activity"	-
	Relevance	"The topic was appropriate, because children generally think that a scientist only works inside a laboratory"	-
	Feasible	"Easily put into practice"	-
Planning	Organisation	"Well-organised and structured"	-
	Detail	"Describes the activity well"	"Put the possible discussion about the contextualisation video in the planning"
	Understanding	"Easy to read and understand"	-
	Preference	"I like the new document better, the division (before during and after) is easy to understand"	-
	Aesthetics	"Aesthetically pleasing"	-
	Size	"Simple, short"	-

Source: Prepared by the authors.

Chart 2. Continued....

Dimension	Parameter	Examples of evidence	
		Positive aspects	**Aspects for improvement**
Contextualisation video	Use	"Suitable video for the start of the activity, stimulating interesting predictions from the students"	"It could be introduced in another way, without the need for information from the video"
	Status	"Suitable in relation to the topic to be handled and the situation portrayed"	
	Aesthetics	"Very appealing, which arouses more curiosity!"	-
	Duration	"Short video"	-
	Pleasant	"The children's reaction to the video is always one of great expectation on their part, because they always want to find out about the topic"	"It wasn't used to grab the students' attention"
	Language	"Suitability of the language/dialogue used by the characters"	-
	Technical	"The video was clear, well structured"	"The sound should be improved"
	Simplicity	"Simple"	"simple for Year 4"
	Innovation	"the video was an innovation"	-
	School level	"It is suitable for Year 1"	"not very challenging for this age group"
	Suitability	"Just as suitable as the other videos"	-
Teaching kit	School level	"Suitable for the age level of the children"	"The kits, in my opinion, were not the most appropriate for the age level"
	Construction	"The acquisition of material and construction was simple"	"It can be difficult to implement due to lack of resources in schools"
	Costs	"Low cost, any school can arrange the activity"	"Activity with some associated cost due to colour printing and laminating of resources"
	Originality	"Original resources"	-
	Suitability	"Completely appropriate"	"Didactic resources, complicated to manage the session at the cies [sic] for the bases, and they could not print everything, so it could have worked better. There are many bases and animals for each group to have"
	Quality	"Very appealing video, totally appropriate speech and very understandable language"	"Poster - place the night and day images to help understand the poster - it can be tricky at the beginning of the year because of reading; illustrate what you're exploring"
Record sheets	School level	"The method used was the group record sheet, which has worked very well for this age level"	"Slightly unsuitable for the age group"
	Aesthetics	"The aesthetics used were the same as the previous ones, excellent, which gives the theme a common thread"	-
	Registration	"They completed the sheet well, they had no difficulty filling it in"	"The students (from all classes) had difficulty filling in the tables (with two entries)"
	Size	-	"I think the record sheet is a bit long in the way it's being provided"
	Understanding	"the children can fill it in independently"	"more guidance to make it easier to fill in"
	Preference	"Much better than last year"	-
	Adequate	"Very suitable, because they draw the picture as a group and then have an individual record"	-
	Children's enjoyment	"The children like it"	-
	Final	"There was no record sheet -> I agree there is no need for a record sheet"	"No, but there could be a system for recording the points"

Source: Prepared by the authors.

Chart 2. Continued....

Dimension	Parameter	Examples of evidence	
		Positive aspects	**Aspects for improvement**
Assessment recording tool	Filling	"easy to fill in"	"Sometimes there are too many lessons, which makes it difficult to fill in"
	Transport	"easy to move around"	-
	Reading	"good reading and interpretation after the session"	-
	Adequate	"Suitable assessment tool"	-
	Structure	"it was well designed"	"adding columns for all the children"
Session developed	Children's emotions	"The children love the activity, they had fun"	-
	Learning	"It allowed the students to learn well"	"the children didn't learn as they should have"
	Duration	"It was done in the allotted time"	"I wouldn't recommend doing it in just one session".
	Involvement	"Activity with involvement"	"The issue of little involvement among the children"
	Strategy	"The activity was designed as a match".	"They haven't mastered research work"
	Completion	"The activity works very well"	-

Source: Prepared by the authors.

Table 1. Number of pieces of evidence by dimension and type of question.

Dimension	Type of question	Number of pieces of evidence
Activity	Closed-response question	119
	Open-response question	177
Planning	Closed-response question	59
	Open-response question	120
Contextualisation video	Closed-response question	119
	Open-response question	221
Teaching kit	Closed-response question	119
	Open-response question	213
Record sheets	Closed-response question	108
	Open-response question	149
Assessment recording tool	Closed-response question	119
	Open-response question	177
Session developed	Open-response question	252
TOTAL		1952

Source: Prepared by the authors.

DATA ANALYSIS AND DISCUSSION OF RESULTS

The answers to the questionnaires made it possible to evaluate the implemented PEEC activities through the teachers' position on positive and/or negative aspects, suggestions for improvement and/or change, problems detected in the dimensions "activity", "planning", "contextualisation video", "record sheet", "teaching kit", "evaluation recording tool" and "session developed".

Table 2 shows the percentage data relating to the teachers' assessment of the six analytical dimensions of PEEC activities implemented by the five levels of suitability. In general, most of the teacher evaluations for the dimensions are those with total suitability (level 5), with an emphasis on the dimensions of planning (94.92%), assessment recording tools (86.55%) and teaching kit (73.95%). The averages show values higher than 4.5 out of 5 in all dimensions.

These results show that the activities proposed and the resources developed are suitable from the perspective of the collaborating teachers who have used and explored them with their children. We also conducted a content analysis of teacher comments in the answers to the open questions in the questionnaire, which are presented below for each one of the analytical dimensions.

Table 2. Percentage level of suitability by dimension for the activities implemented.

Dimension	Level of suitability					Average
	Not at all appropriate (1)	Not very appropriate (2)	Appropriate (3)	Very appropriate (4)	Completely appropriate (5)	
Activity (n=119)	0.00%	1.68%	2.52%	23.53%	72.27%	4.66
Planning (n=59)	0.00%	0.00%	0.00%	5.08%	94.92%	4.95
Contextualisation video (n=119)	0.00%	0.00%	3.36%	26.05%	70.59%	4.67
Record sheets (n=108)	0.93%	2.78%	6.48%	23.15%	66.67%	4.52
Teaching kit (n=119)	0.84%	0.00%	5.88%	19.33%	73.95%	4.66
Recording tool (n=119)	0.00%	0.00%	0.00%	13.45%	86.55%	4.87

Source: Prepared by the authors.

ANALYTICAL DIMENSION "ACTIVITY"

In regard to teacher assessment of the activities (Table 3), it was possible to ascertain that the most frequently mentioned positive aspects are the suitability of the activity for the level of schooling it is aimed at, the coherence of the activity in relation to what has previously been explored and the feasibility of the activity taking into account the resources, time and learning objectives. As aspects for improvement, with little expression (9.04%), the teachers mentioned that some of the activities were not appropriate for the level of schooling and pointed out the lack of coherence with the previous activity, aspects that have been corrected. In general, it can be seen that the proposed activities are appropriate to the learning objectives, relevant, feasible and coherent.

Table 3. Percentage level of suitability for the "Activity" dimension.

Dimension	Parameter	Frequency of assessment		Total frequency
		Positive	To be improved	
Activity	School level	66	9	75
	Consistency with the previous activity	35	6	41
	Suitability for expected learning	28	1	29
	Relevance	16	0	16
	Enforceability	12	0	12
	Structure	4	0	4
TOTAL	Attendance	161	16	177
	Percentage	90.96%	9.04%	100%

Source: Prepared by the authors.

It was found that in Portugal a significant proportion of practical science activities in primary education are "[...] expository/demonstrative practices, which raises the need to reflect on their effectiveness, since the active participation of students is conditioned. The remaining didactics are very limited or non-existent [...]" (Inspeção-geral da Educação e Ciência, 2020, p. 78). The activities proposed by the PEEC can contribute to the usage of feasible activities in a coherent and sequential manner, guaranteeing involvement from children.

ANALYTICAL DIMENSION "PLANNING"

In regard to the planning dimension (Table 4), it was possible to see that the positive aspects (96.46%) outweigh the aspects for improvement (3.54%). Only the detail/description parameter emerges as an aspect for improvement, where teachers mention aspects such as "include as much discussion as possible about the contextualisation video in the planning" or "give the teacher the solution and a short explanation of the subject." The teachers most often mentioned comprehension and organisation as positive aspects of the planning. In general, it can be said that the plans respect aspects such as structure, detail, simplicity, aesthetics and size that meet teacher needs.

As mentioned earlier, planning is essential to support teacher practices and activity. Several studies aimed at developing and making available educational science resources for primary education, in addition to resources for children, also provide guidance for teachers on how to conduct this activity (Mafra; Lima; Carvalho, 2015; Silva; Tenreiro-Vieira, 2015).

Table 4. Percentage level of suitability for the "Planning" dimension.

Dimension	Parameter	Frequency of assessment		Total frequency
		Positive	To be improved	
Planning	Comprehension/ ease of reading	52	0	52
	Organisation/ structure	31	0	31
	Detail/description	9	4	13
	Document size	9	0	9
	Aesthetics	5	0	5
	Relation to last year	3	0	3
TOTAL	Attendance	109	4	113
	Percentage	96.46%	3.54%	100.00%

Source: Prepared by the authors.

ANALYTICAL DIMENSION "CONTEXTUALISATION"

The assessment made on the contextualisation videos (Table 5), from the viewpoint of teachers is positive. The positive aspects (93.67%) stand out in relation to the aspects to be improved upon (6.33%). The positive aspects include those such as the usefulness, the situation, and the children's enjoyment. The aspects to be improved are focused on the usefulness, the situation and technical issues (sound), and the children's enjoyment, which did not always meet the teachers' expectations. This feedback made it possible to redo these videos and adapt them in terms of their usefulness, the situation portrayed and technical problems.

Table 5. Percentage level of suitability for the "Contextualisation video" dimension.

Dimension	Parameter	Frequency of assessment		Total frequency
		Positive	To be improved	
Contextualisation video	Status	52	4	56
	Use	44	4	48
	Enjoyment	26	2	28
	Adequate	23	0	23
	Aesthetics	16	0	16
	Duration	15	0	15
	Language	13	0	13
	Simplicity	10	1	11
	Technical	4	2	6
	School level	3	1	4
	Originality	1	0	1
TOTAL	Attendance	207	14	221
	Percentage	93.67%	6.33%	100.00%

Source: Prepared by the authors.

As mentioned, practical science activities in Portugal are decontextualised from the context and daily lives of children (Inspeção-geral da Educação e Ciência, 2020). In other empirical studies, teachers report that adding problems to the activity provokes an interest in children, fosters their involvement in the learning process and promotes meaningful and useful learning linked to the daily lives of children (Maffi et al., 2019).

ANALYTICAL DIMENSION "RECORD SHEET"

The "record sheet" dimension was the one that teachers were most vocal about improving (13.42%), as can be seen in Table 6. In this sense, the most prominent aspects for improvement were: the recording strategy, the size of the proposed record and, on three occasions, the existence of a record. Positive aspects include the registration strategy and the suitability of the registration proposal to its objective. In general, the recording proposals seem to fulfil their purpose in terms of their suitability for the children's level of education, being perceptible and stimulating the children's autonomy.

Table 6. Percentage level of suitability for the "Record sheet" dimension.

Dimension	Parameter	Frequency of assessment		Total frequency
		Positive	To be improved	
Record sheets	Registration	34	9	43
	Adequate	29	1	30
	School level	27	2	29
	Understanding	18	2	20
	Aesthetics	9	0	9
	Final	5	3	8
	Enjoyment	4	0	4
	Compared to last year	3	0	3
	Size	0	3	3
TOTAL	Attendance	129	20	149
	Percentage	86.58%	13.42%	100.00%

Source: Prepared by the authors.

In this study, the teachers highlight the possibility of recording moments of practical activity as a positive aspect. As highlighted in other studies, record sheets are essential for supporting children in the performance of practical activities at different times during the activity. For example, the study by Mafra, Lima and Carvalho (2015) states that the use of records supports the performance of experimental activities in a climate of reflection, facilitating the process until the problem question is answered. Although other studies (Clemente; Vieira; Martins, 2010; Paixão; Jorge; Martins, 2012) do not explicitly mention the benefits of recording sheets, these authors justify their use as a way of monitoring learning.

ANALYTICAL DIMENSION "TEACHING KIT"

In the "teaching kit" dimension (Table 7), it was possible to see that, in general, the positive aspects (80.83%) outweighed the aspects for improvement (19.17%). Among the positive aspects, the level of schooling, construction and originality stand out, although the latter is not as significant as the others. Costs and the quality of teaching kits were considered the most frequent aspects for improvement. In the case of costs, many of the kits mentioned are laboratory-resource materials (e.g. magnets, batteries) and their acquisition requires a certain financial investment.

Table 7. Percentage level of suitability for the "Teaching kit" dimension.

Dimension	Parameter	Frequency of assessment		Total frequency
		Positive	To be improved	
Teaching kit	Construction	53	12	65
	Costs	29	7	36
	School level	28	3	31
	Adequate	23	6	29
	Quality	17	9	26
	Original	6	0	6
TOTAL	Attendance	156	37	193
	Percentage	80.83%	19.17%	100.00%

Source: Prepared by the authors.

Several authors have shown that, from the teachers' point of view, one of the biggest obstacles to more practical activities in schools are financial issues, as there is a high cost for facilities and the acquisition of material resources (Bonito; Oliveira, 2024). In general, the resources presented here seem to contribute to the gap in the lack of teaching resources and their cheap acquisition. Even so, as one of the teachers said, "Even though it's difficult to acquire, once you've bought it, you'll have a kit for several years," making it a long-term investment.

ANALYTICAL DIMENSION "ASSESSMENT RECORDING TOOL"

In the dimension of "assessment recording tools", as can be seen in Table 8, the positive aspects (97.74%) stand out in relation to the aspects to be improved (2.26%). Of particular note is the ease with which the assessment tools can be filled in, read and interpreted and transported. The only aspects pointed out by teachers as being open to improvement were, in some cases, the high number of lessons included and the lack of space to record the names of all the children in the class.

Reis states that the assessment of learning in science "only becomes possible if it is done in a contextualised way, in real situations where skills can be observed in action" (Reis, 2021, p. 4). The assessment recording tools were one of the strategies made available so that assessment of the skills evaluated was intentional, continuous, interactive and contextualised, as suggested by Sousa and Santos (2022).

Table 8. Percentage level of suitability for the "Assessment recording tool" dimension.

Dimension	Parameter	Frequency of assessment		Total frequency
		Positive	To be improved	
Assessment recording tool	Filling	81	2	83
	Reading	45	0	45
	Transport	26	0	26
	Adequate	20	0	20
	Structure	1	2	3
TOTAL	Attendance	173	4	177
	Percentage	97.74%	2.26%	100%

Source: Prepared by the authors.

ANALYTICAL DIMENSION "DEVELOPED SESSION"

In regard to the session developed, as with the other dimensions, the positive assessment prevails over the negative (Table 9). Positive aspects include the children's emotions in relation to the activity (e.g. curiosity, enthusiasm...), the contribution of the activity to the children's learning and the possibility of their effective involvement. The duration of the activity is mentioned with some frequency as an aspect to be improved, sometimes it is pointed out as too long and at other times as too short. From the teachers' perspective, the type of activity is not always the most appropriate, mainly because they are not used to conducting research activities or field trips.

Table 9. Percentage level of suitability for the "Session developed" dimension.

Dimension	Parameter	Frequency of assessment		Total frequency
		Positive	To be improved	
Session developed	Children's emotions	104	0	104
	Learning	49	7	56
	Involvement	31	3	34
	Strategy	28	9	37
	Completion	6	0	6
	Duration	5	10	15
TOTAL	Attendance	223	29	252
	Percentage	88.49%	11.51%	100.00%

Source: Prepared by the authors.

Teachers say that the activities developed stimulate children's involvement, providing multiple learning opportunities in science. This factor seems to contribute to the perceived problem of usually transmissive and expository strategies that only mobilise children's knowledge (Inspeção-geral da Educação e Ciência, 2020). In addition, teachers report that hands-on practical science activities provoke positive emotions in children. This data, similar to the study by King et al. (2015) shows that this type of activity stimulates positive attitudes in children (surprise, interest, joy), promoting meaningful learning.

CONCLUSIONS

The aim of this article is to present and describe the methodology used to develop didactic science resources for the PEEC primary school. The conclusions of this study, in turn, deal with two key aspects: the evaluation of EDR as the methodological approach adopted for the development of the PEEC products and the evaluation of PEEC activities designed from the perspective of the end-user teachers.

The main motivation for choosing the EDR was that it is a study assumed to be transformative, practical, useful and with a concrete action plan for real problems, unlike other traditional approaches that do not possess this purpose so vehemently. Some of the EDR characteristics were decisive for the quality of the PEEC resource development process, namely:

- Iterative cycles. One of the peculiarities of the EDR is its iterative nature. The possibility of working in this way was essential for the development of quality educational resources with the possibility of a constant cycle of design, implementation, evaluation, fine-tuning and redesign to the satisfaction of all those involved.
- Multidisciplinary team. The privilege of building a team of experts to scientifically validate the resources, teachers to explore the activities and teaching resources with their classes, and experts in design, programming and accessibility allowed for different visions, know-how and contributions.
- Training evaluation. The possibility of working directly with teachers and their classes and the feedback resulting from their use as users made it possible to identify and overcome aspects for improvement. Although there are no standard tools to collect data for this training evaluation, the reflective conversations before and after the sessions between the teachers and the PEEC researcher-creator and the teacher responses to the final questionnaires for each session stand out. This cycle of evaluation has allowed PEEC resources to be constantly improved.

The study concluded that PEEC resources, from the perspective of end-user teachers, support the implementation of practical activities in the context of primary school science teaching. It was clear that the positive aspects outweighed the negative ones. In general, the positive aspects for each of the dimensions stand out: i) Activity - appropriateness at the level of schooling for which it is intended and the coherence of the activity with the one previously proposed; ii) Planning - The comprehension and ease of reading and its organisation and structure; iii) Contextualisation video - Usefulness of the video and the situation portrayed; iv) Recording sheet - Recording and its suitability for the purpose; v) Teaching kit - Easy to build and affordable; vi) Assessment recording tool - Easy to fill in and read and; vi) Session developed - The children's emotions and contribution to the development of the children's science learning.

The aim is to evaluate the contribution from exploring PEEC resources in learning for children who are participants in this study. In this way, we hope to highlight the potential of practical activities in science, specifically, PEEC resources, so that this potential can become a contribution of qualitative, varied and contextualised educational science resources that can be used by teachers and adapted to their context and children. The first results seem to corroborate the important contribution of these resources in influencing the practices of science teachers, facilitating the exploration of experimental science teaching from the earliest years of schooling. It is suggested that these educational science resources be used and evaluated in other schools across the country to test their suitability.

One of the ways to combat inertia towards change is to make available teaching proposals that can support teachers' science practices, which lead to better and more learning in science for their students. Providing the resources developed as part of this project is a contribution and a step forward in encouraging teachers to make practical science activities more regular, with the aim of contributing to the promotion of children's scientific literacy from the earliest years of schooling.

REFERENCES

ADITOMO, A.; KLIEME, E. Forms of inquiry-based science instruction and their relations with learning outcomes: evidence from high and low-performing education systems. **International Journal of Science Education**, London, v. 42, n. 4, p. 504-525, 2020. DOI: http://doi.org/10.1080/09500693.2020.1716093.

BECTA. **Quality principles for digital learning resources**. Coventry: BECTA, 2007.

BERNARD, P. *et al*. Influence of in-service teacher training on their opinions about IBSE. **Procedia: Social and Behavioral Sciences**, New York, v. 77, p. 88-99, 2015. DOI: http://doi.org/10.1016/j.sbspro.2015.02.343.

BONITO, J.; OLIVEIRA, H. O trabalho prático no ensino das ciências: uma abordagem à evolução histórica. **História da Ciência e Ensino**: Construindo Interfaces, São Paulo, v. 27, p. 3-21, 2024. DOI: http://doi.org/10.23925/2178-2911.2023v27espp3-21.

BONITO, J.; OLIVEIRA, H.; CARNEIRO, C. Teaching on rock deformation: contributions from practical activities. *In:* DEL VALLE, S. I. V.; ADOLFO, G. (ed.). **Ciências humanas:** estudos para uma visão holística da sociedade. Curitiba: Editora Artemis, 2023.

BRETES, S.; CORREIA, M. Conceções e práticas de educadores de infância e de professores do 1.º Ciclo acerca do ensino experimental das ciências. **Revista da UI_IPSantarém**, Santarém, v. 6, n. 1, p. 21-36, 2018. DOI: http://doi.org/10.25746/ruiips.v6.i1.16104.

CACHAPUZ, A. Educação em Ciências: contributos para a mudança. **Vitruvian Cogitationes**, Maringá, v. 3, n. 2, p. 64-80, 2022. DOI: http://doi.org/10.4025/rvc.v3i2.65705.

CACHAPUZ, A. Educação em ciências: pensar o todo. **Revista Internacional de Pesquisa em Didática das Ciências e Matemática**, Itapetininga, v. 4, e023006, 2023. Disponível em: https://periodicoscientificos.itp.ifsp.edu.br/index.php/revin/article/view/933. Acesso em: 5 jan. 2025.

CARDOSO, A. *et al*. Princípios pedagógico-didáticos para a conceção de recursos educativos digitais: análise do recurso cozinhar a aprender. *In*: DIAS, A.; LOUREIRO, C. (ed.). **Práticas de Integração Curricular nos 1.º e 2.º Ciclos do Ensino Básico**. Lisboa: Escola Superior de Educação de Lisboa, Instituto Politécnico de Lisboa, 2022.

CAVADAS, B., *et al*. **Criação de recursos educativos digitais eficazes**. Santarém: EduApp, 2023.

CHEN, J.; COWIE, B. Scientists talking to students through videos. **International Journal of Science and Mathematics Education**, Dodrecht, v. 12, n. 2, p. 445-465, 2014. DOI: http://doi.org/10.1007/s10763-013-9415-y.

CLEMENTE, M.; VIEIRA, R.; MARTINS, F. Educação para o Desenvolvimento Sustentável no 1.º Ciclo do Ensino Básico – propostas didácticas no âmbito das ciências. **Indagatio Didactica**, Aveiro, v. 2, n. 1, p. 5-42, 2010. DOI: http://doi.org/10.34624/id.v2i1.4575.

CONSELHO NACIONAL DE EDUCAÇÃO – CNE. **Estado da Educação 2021**. Lisboa: CNE, 2022.

COUTINHO, C. **Metodologia de investigação em ciências sociais e humanas:** teoria e prática. Coimbra: Edições Almedina, 2014.

CRUZ, M. A. **Questões Sóciocientíficas Controversas para a promoção do Ativismo Social em Física e Química**. Lisboa: Instituto de Educação da Universidade de Lisboa, 2015.

DESIGN-BASED RESEARCH COLLECTIVE. Design-based research: an emerging paradigm for educational inquiry. **Educational Researcher**, Washington, v. 32, n. 1, p. 5-8, 2003. http://doi.org/10.3102/0013189X032001005.

ESPADA, W. The Role of the Scientific Community in School Science Education. **Red de Revistas Científicas de América Latina**, Venezuela, v. 32, n. 8, p. 510-515, 2007. Disponível em: https://www.redalyc.org/articulo.oa?id=33932803. Acesso em: 31 dez. 2024.

FALLON, G. Forging school-scientits partenerships: a case of easier said than done? **Journal of Science Education and Technology**, New York, v. 22, n. 6, p. 858-876, 2013. DOI: http://doi.org/10.1007/s10956-013-9435-y.

FERREIRA, M.; MÜNCHEN, S. A contextualização no ensino de ciências: reflexões a partir da Educação do Campo. **Revista Insignare Scientia** - RIS, Chapecó, v. 3, n. 4, p. 380-399, 2020. DOI: http://doi.org/10.36661/2595-4520.2020v3i4.11825.

FERREIRA, S.; SARAIVA, S. Complexity of practical work in Portuguese primary science textbooks. **Investigações em Ensino de Ciências**, Porto Alegre, v. 26, n. 3, p. 281-297, 2021. Disponível em: http://hdl.handle.net/10400.26/38974. Acesso em: 31 dez. 2024.

HARLEN, W. **The Case for Inquiry-based Science Education (IBSE)**. Italy: InterAcademy Partnership (IAP), 2021.

INSPEÇÃO-GERAL DA EDUCAÇÃO E CIÊNCIA – IGEC. **Gestão do Currículo:** Ensino Experimental das Ciências. Relatório 2018. (I/01004/DSAG/22). Lisboa, Portugal: Inspeção-geral da Educação e Ciência, 2020.

INTERNATIONAL SCIENCE COUNCIL. **Unleashing science:** delivering missions for sustainability. Paris: International Science Council, 2021.

KATO, D. S.; KAWASAKI, C. S. As concepções de contextualização do ensino em documentos curriculares oficiais e de professores de ciências. **Ciência & Educação**, Bauru, v. 17, n. 1, p. 35-50, 2011. DOI: http://doi.org/10.1590/S1516-73132011000100003.

KEOGH, B.; NAYLOR, S. Concept cartoons, teaching and learning in science: an evaluation. **International Journal of Science Education**, London, v. 21, n. 4, p. 431-446, 1999. DOI: http://doi.org/10.1080/095006999290642.

KING, D. *et al*. Emotionally intense science activities. **International Journal of Science Education**, London, v. 37, n. 12, p. 1886-1914, 2015. DOI: http://doi.org/10.1080/09500693.2015.1055850.

LANKOW, J.; RITCHIE, J.; CROOKS, R. **Infographics:** the power of visual storytelling. New Jersey: John Wiley & Sons, Inc., 2012.

LOCORO, A. *et al*. Static and interactive infographics in daily tasks: a value-in-use and quality of interaction user study. **Computers in Human Behavior**, Oxford, v. 71, p. 240-257, 2017. DOI: http://doi.org/10.1016/j.chb.2017.01.032.

MAFFI, C. *et al*. Contextualização na aprendizagem: percepções de docentes de ciências e matemática. **Revista Conhecimento Online**, Novo Hamburgo, v. 2, p. 75-92, 2019. Disponível em: https://periodicos.feevale.br/seer/index.php/revistaconhecimentoonline/article/view/1561. Acesso em: 05 jan. 2025.

MAFRA, P.; LIMA, N.; CARVALHO, G. S. Microbiologia no 1.º ciclo do ensino básico: uma proposta de atividade experimental sobre higiene das mãos. *In*: SEMINÁRIO INTERNACIONAL DE EDUCAÇÃO FÍSICA E SAÚDE: PERSPETIVAS DE DESENVOLVIMENTO NUM MUNDO GLOBALIZADO, 11., 2015, Porto. **Anais [...]** Porto: Escola Superior de Educação, 2015. p. 500-507.

MARTINS, I. P. Educação em Ciência, Cultura e Desenvolvimento. *In*: PAIXÃO, M. F. (ed.). **Educação em Ciência, Cultura e Cidadania**: Encontros em Castelo Branco. Alcains: Alma Azul, 2006.

MARTINS, I. P. Revisitando orientações CTS/CTSA na Educação e no Ensino das Ciências. **Revista APEduC**, Vila Real, v. 1, n. 1, p. 13-29, 2020. Disponível em: https://apeducrevista.utad.pt/index.php/apeduc/article/view/63. Acesso em: 31 dez. 2024.

MCKENNEY, S.; REEVES, T. C. **Conducting educational design research**. Abingdon: Routledge, 2012.

MCKENNEY, S.; REEVES, T. Systematic review of design-based research progress: is a little knowledge a dangerous thing? **Educational Researcher**, Washington, v. 42, n. 2, p. 97-100, 2013. DOI: http://doi.org/10.3102/0013189X12463781.

MUHAIMIN, A. *et al*. Science teachers' integration of digital resources in education: a survey in rural areas of one Indonesian province. **Heliyon**, London, v. 6, n. 8, e04631, 2020. DOI: http://doi.org/10.1016/j.heliyon.2020.e04631. PMid:32793838.

NAVARIDAS-NALDA, F. *et al*. The strategic influence of school principal leadership in the digital transformation of schools. **Computers in Human Behavior**, Oxford, v. 112, p. 106481, 2020. DOI: http://doi.org/10.1016/j.chb.2020.106481.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT – OECD. **Evolution of Student Interest in Science and Technology Studies**. Policy Report. Paris: OECD, 2006.

PAIXÃO, F.; JORGE, F.; MARTINS, H. Uma atividade criativa com luz e sombra no 1.º Ciclo do Ensino Básico. **Indagatio Didactica**, Aveiro, v. 4, n. 1, p. 203-225, 2012. DOI: http://doi.org/10.34624/id.v4i1.4244.

PLOMP, T. Educational design research: an introduction. *In:* PLOMP, T.; NIEVEEN, N. (ed.). **Educational design research.** Enschede: SLO, 2013. p. 10-51.

RAMOS, *et al*. **Portal das Escolas** – Recursos Educativos Digitais para Portugal: Estudo Estratégico. Lisboa: GEPE, 2010.

RAMOS, J. L. *et al*. Modelos e práticas de avaliação de recursos educativos digitais. **Cadernos SACAUSEF 2**, Lisboa, p. 79-87, 2008.

RAMOS, J. L.; TEODORO, V. D.; FERREIRA, F. M. Recursos educativos digitais: reflexões sobre a prática. **Cadernos SACAUSEF**, Lisboa, v. 7, p. 11-34, 2011.

RAMOS, L. B. C.; ROSA, R. R. S. O ensino de Ciências: fatores intrínsecos e extrínsecos que limitam a realização de atividades experimentais pelo professor dos anos iniciais do Ensino Fundamental. **Investigações em Ensino de Ciências**, Porto Alegre, v. 13, n. 3, p. 299-331, 2016. Disponível em: https://ienci.if.ufrgs.br/index.php/ienci/article/view/444. Acesso em: 31 dez. 2024.

REEVES, T. C. Design research from a technology perspective. *In*: VAN DEN AKKER, J. *et al*. (ed.). **Educational design research**. London: Routledge, 2006.

REIS, P. Desafios à educação em ciências em tempos conturbados. **Ciência & Educação**, Bauru, v. 27, p. 1-9, 2021. DOI: http://doi.org/10.1590/1516-731320210000.

RODRIGUES, A. V. *et al*. Laboratórios de Ciências: análise diagnóstica em escolas públicas portuguesas. **Indagatio Didactica**, Aveiro, v. 10, p. 31-46, 2018. DOI: http://doi.org/10.34624/id.v10i5.11107.

RODRIGUES, A.; PEIXINHO, J. P.; SILVA, P. C. Recursos educativos digitais para o ensino básico: partilha de experiências, desafios e reflexões para o futuro. **Boletim da AIA-CTS**, Aveiro, n. 18, p. 38-42, 2023.

SALEHJEE, S.; WATTS, M. **Becoming Scientific** –Developing Science across the life-course: Stories and insights for the journey. Cambridge: Cambridge Scholars Publishing, 2020.

SANTANA, R. S.; CAPECCHI, M. C.; FRANZOLIN, F. O ensino de ciências por investigação nos anos iniciais: possibilidades na implementação de atividades investigativas. **Revista Electrónica de Enseñanza de las Ciencias**, Cádiz, v. 17, n. 3, p. 686-710, 2018. Disponível em: https://dialnet.unirioja.es/servlet/articulo?codigo=6608285. Acesso em: 31 dez. 2024.

SEGEL, E.; HEER, J. Narrative visualization: telling stories with data. **IEEE Transactions on Visualization and Computer Graphics**, New York, v. 16, n. 6, p. 1139-1148, 2010. DOI: http://doi.org/10.1109/TVCG.2010.179. PMid:20975152.

SILVA, M.; TENREIRO-VIEIRA, C. Educação para o Desenvolvimento Sustentável: atividades com orientação CTS/ PC no 1.º CEB. **Indagatio Didactica**, Aveiro, v. 7, n. 1, p. 96-114, 2015. DOI: http://doi.org/10.34624/id.v7i1.2620.

SILVA, P. C.; RODRIGUES, A. V. Desenvolvimento de uma proposta curricular de ciências para os primeiros anos de escolaridade: fundamentos, processo e produto. **Revista on line de Política e Gestão Educacional**, Araraquara, v. 27, e023072, 2023. DOI: http://doi.org/10.22633/rpge.v27i00.18275.

SILVA, P. C.; RODRIGUES, A. V.; VICENTE, P. N. Currículo de ciências para o ensino primário: uma análise comparativa entre Portugal, Inglaterra, Estados Unidos, Austrália e Singapura. **Education Policy Analysis Archives**, Tempe, v. 31, n. 97, p. 1-25, 2023a. http://doi.org/10.14507/epaa.31.8192.

SILVA, P. C.; RODRIGUES, A. V.; VICENTE, P. N. Práticas de Ensino Experimental das Ciências no 1.º Ciclo do Ensino Básico em Portugal: uma análise dos relatórios da Inspeção-Geral da Educação e Ciência. **Praxis Educativa**, Santa Rosa, v. 18, n. 1, p. 1-22, 2023b. DOI: http://doi.org/10.5212/PraxEduc.v.18.21358.062.

SOUSA, M. T.; SANTOS, L. Avaliar para aprender em ciências experimentais. **Revista Portuguesa de Educação**, Braga, v. 35, n. 2, p. 190-210, 2022. DOI: http://doi.org/10.21814/rpe.21275.

STUBBERFIELD, L.; BARTON, T. **Primary science education beyond 2021-what next?** London: Wellcome, 2021.

SUDUC, A. M.; BIZOI, M.; GORGHIU, G. Inquiry based science learning in primary education. **Procedia:** Social and Behavioral Sciences, New York, v. 205, p. 474-479, 2015. DOI: http://doi.org/10.1016/j.sbspro.2015.09.044.

TEIG, N.; NILSEN, T. Profiles of instructional quality in primary and secondary education: patterns, predictors, and relations to student achievement and motivation in science. **Studies in Educational Evaluation**, Amsterdam, v. 74, p. 101170, 2022. DOI: http://doi.org/10.1016/j.stueduc.2022.101170.

TSAI, S. T.; HUANG, H. Y.; CHANG, T. W. Developing a motion infographic-based learning system for effective learning. **Education Sciences**, Basel, v. 10, n. 9, p. 247, 2020. DOI: http://doi.org/10.3390/educsci10090247. https://www.mdpi.com/2227-7102/10/9/247. Acesso em: 31 dez. 2024.

WANG, F.; HANNAFIN, M. J. Design-based research and technology-enhanced learning environments. **Educational Technology Research and Development**, Netherlands, v. 53, n. 4, p. 5-23, 2005. DOI: http://doi.org/10.1007/BF02504682. Disponível em: https://link.springer.com/article/10.1007/BF02504682. Acesso em: 31 dez. 2024.

WOO, H.; KIM, J.; LEE, W. Development of curriculum design support system based on word embedding and terminology extraction. **Electronics**, Basel, v. 9, n. 4, p. 608, 2020. DOI: http://doi.org/10.3390/electronics9040608. Disponível em: https://www.mdpi.com/2079-9292/9/4/608. Acesso em: 31 dez. 2024.

Authors' contributions

PCS: Design, analysis, assessment of the proposed activities, conception of data collection and analysis tool as well as writing of the manuscript; AVR: Validation of proposed activities, data collection and analysis tool and co-authorship of the manuscript.

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