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Transversal integration of geohydrological risks in an elementary school in Brazil: A disaster education experiment

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ABSTRACT

Given the significant increase in geohydrological disasters over recent years in Brazil, education for disaster risk reduction (DRRE) has become an important resource in tackling the situation. This paper is aimed at contributing to field of DRRE through an experiment of integration of the theme of geohydrological disasters in formal education at elementary level, discoursing on its conception, execution and evaluation. The methodology, including the content, was conceived based on information collated from federal legislation, environmental education literature and the experience of the authors. The experiment was conducted with students of 10–11 years of age in an elementary public school in the municipality of Miguel Pereira, Rio de Janeiro state (Brazil). The aim was to apply a transversal, interdisciplinary perspective involving teachers from different discipline and the Municipal Department for the Environment and Civil Defence. The experiment was aimed at putting the methodology proposal for participative learning into practice, including the teaching strategy, content, duration time for each class, total course hours, extracurricular activities and teaching materials (booklets, games and mock-ups). The methodology was evaluated and approved by the participants, who expressed that its application was worthy of being continued.

1. Introduction

The Education Guidelines and Bases Law (LDB), the National Curriculum Parameters (PCN), the National Environmental Education Policy (PAA) and the National Education Plan (PNE) in Brazil evidence the importance of developing a problem-based, contextualised and interdisciplinary school education system enabling the formation of critical citizens able to transform their situation [1], which is also evidenced internationally [2–5]. Thus, the school as a formal teaching-learning space can develop and prepare the student for the exercise of citizenship. Such a school characteristic demonstrates the importance of integrating new aspects into its curriculum as a way of contributing to society through the use and multiplication of learning by students. Integration is provided for in the Brazilian PCN from the 6th to the 9th year of elementary education[1] through its cross-contaminating themes: ethics, environment, cultural plurality, health, sexual orientation and work and consumption [6]. According to Valencio [7]; the theme of socioenvironmental disasters can be addressed in schools through such themes.

Despite all the debate on the concept [8], disaster can be considered a stressful collective experience that disrupts the regular dynamics of social functions, demanding a readjustment of daily community life [9,10]. According to the literature, this event reveals the means by which society functions [9]. Thus, this event is an experiment which provides a second look at social organization [8]. If the disaster is intrinsically related to social dynamics [8], Education has a role to play given the fact that it may be viewed as a mechanism for transforming mentalities/mindsets and the local culture [11]. In general, this experience is associated to adverse events resulting from human beings and nature acting on a vulnerable ecosystem, causing human, material, economic or environmental losses and damage [12]. Key among disaster types are those associated with mass movements (landslides, debris flow, creep and movement of rock bodies), and floods, hereby denominated as geohydrological events, responsible for almost 90% of deaths and more than a third of those affected by disasters related to natural threats in Brazil between 1991 and 2012 [13].

Even with engineering works and determined non-structural actions for disaster risk reduction (DRR) associated to geohydrological events,

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[1] The equivalent to the first year for the middle school in United States.

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there is a background of continued increase in the magnitude and frequency of disasters [13,14]. Given the situation, there is a clear necessity to promote attitude changes among citizens to stimulate their conscience and participation in DRR management actions, essential for community resilience in the face of socioenvironmental disasters [5,8,15]. Thus, educational activity has a fundamental role to play in the discussion on disasters in the school environment, thereby promoting critical thinking among students. To achieve this, it is necessary to put in place a teaching methodology to develop such instruction and learning process. The theme is relatively recent, and education for disaster risk reduction (DRRE) initiatives in formal and informal environments are still in their infancy, requiring significant refinement [16].

The literature indicates increased interest among the international community in DRRE programs for children. In contrast to which, Johnson et al. [2] mentions that "… public education is failing to motivate adults to take preparedness measures." (p.108). Such a situation reinforces the importance of disaster education programs for children, as also suggested by UNICEF [17]; preparing them for a "… more proactive preventative approach to disasters." ([2]; p. 108), acting, then, as agents of change [3,14]. The authors also mention studies which concluded that disaster education for children produces benefits for children and the wider community. Thus, as there is an inherent relation of a disaster with the social dynamic, as previously stated by Quarantelli [8]; DRRE may be taken as education capable of "… empowering communities to engage in the development of prevention strategies to mitigate insecurities and stress …" (p. 109). After all, education is one of the risk-management strategies, contributing to the transformation of socioenvironmental vulnerability situations [8], through a process of awareness-raising [18].

Thus, integrating the theme of disasters, particularly those associated to geohydrological events into the school curriculum may result in the production of knowledge on the social construction of disasters, the natural and anthropogenic conditions to which they are associated, and disaster risk reduction actions at local level. Selby and Kagawa [19] briefly discuss six strategies for integrating the theme of disasters into the school curriculum, each with its benefits and drawbacks, indicating the possibility of development of these strategies not only by the state-level actor, but also by others. In respect of these strategies, Petal and Izadkhah [20] draw attention to the observation that "Ideally these are designed to fit into several specific course curricula, at specific grade levels, for a specific duration." (p. 2). Whether at national or municipal level, such efforts in favour of integration have a clear focus: the construction of resilient communities based on an approach permeating education as a whole and, more specifically, the learning process [18,20]. In short, according to this literature, such efforts may contribute to the formation of resilient citizens.

The matter falls into this perspective when discussing the experiment conducted in the South-Central political administrative region of the state of Rio de Janeiro, in the municipality of Miguel Pereira. This municipality is one of the 31 municipalities prioritised for geological risk analysis in the state in 2011, and the situation which required the Rio de Janeiro State Geological Service (DRM – RJ) to conduct mapping and produce the Slope Slide Risk Chart [21]. In addition to risks associated to mass movements, the municipality of Miguel Pereira is, according to the Rio de Janeiro State Natural Threats Map (2014/2015), susceptible to the threat of floods [22,23].

This context led to the conception and experimentation of a teaching method for integration of the geohydrological disaster into educational discipline content in the municipality, with an end to providing an understanding of the phenomenon of disaster based on access to knowledge, so that those involved are made aware of the challenge and develop mitigation and adaptation actions [19]. To apply this proposed teaching methodology, the 6th year of elementary education at the Governador Portela Municipal School of Professional Qualification (EMFPGP), located in the 2nd district of Governador Portela in the municipality of Miguel Pereira, was selected. According to the Rio de Janeiro State Geological Service, the district in which the school is situated presents geohydrological event risk areas [21].

The aim of this paper is to contribute to the debate on DRRE in vulnerable communities suggesting a teaching methodology for integration of the theme of geohydrological disasters into elementary education, using cross contamination, interdisciplinarity and presuppositions of problem-based education in the process of instruction and learning through the experiment conducted at EMFPGP. Following a brief conceptualisation of geohydrological disasters and DRRE in Brazil, this paper deals with the conception, application and evaluation of the DRRE method applied at the above-mentioned school.

2. Mass movements and hydrological processes in Brazil

The background on occurrence of disasters associated to mass movements and hydrological processes in Brazilian cities presents a considerable amount of human, material, economic or environmental losses and damage, and a very high quantity of people exposed to such threats [13,24,25]. Mass movements constitute the displacement of material covering the Earth's surface, such as soil, rocks, detritus and/or vegetation on hillsides and slopes, becoming part of the geomorphological evolution of these environments due to reduced resistance in the materials making up the land area and/or increased mechanical stresses thereon [26,27]. The natural conditions for mass movements are: mechanical soil and rock properties, relief (slope angle, form and amplitude), vegetation, climate and water level. Anthropogenic factors include cutting and filling, deforestation, waste and rubble disposal, pipe leakages, wastewater discharged onto surfaces, sanitary pits and inappropriate crop cultivation [28].

Hydrological processes considered in this paper are floods and flash floods, the former characterised by submersion of areas outside the normal limits of a watercourse in zones not normally under water. Overflow occurs gradually, normally brought about by prolonged periods of rainfall in the catchment. Flash floods take the form of concentrated surface run-off with higher transportation energy, which may or may not be related to areas dominated by fluvial processes. The phenomenon commonly occurs along roads installed upon former watercourses with a high hydraulic gradient and land areas with high natural declivity (uneven relief). Flooding may also result from a momentary build-up of water in certain areas due to problems with the drainage system, which may or may not be associated to river-system events [29].

3. Socioenvironmental conception of disasters

Anthropogenic actions related to disasters are, in the main, associated to vectors such as the manner in which spaces are occupied, becoming urban through forced expansion and growth of cities, along with the economic dimension of the global development model, conceiving capitalist lifestyles which tend to render society vulnerable [15,30]. Vulnerability is a set of different characteristics and circumstances (physical; economic; social; political; technological; ideological; cultural; educational, ecological and institutional) of an individual or community which makes it susceptible to suffering damages associated to a determined hazard, regardless of the degree of exposure thereto [12].

In the knowledge that risk is a combination of the susceptibility of a land area to potentially damaging events, exposure of the population to threats and its respective vulnerability, DRR actions should be geared towards mitigating the vulnerabilities produced by the above-mentioned vectors [5,8], given that actions to reduce susceptibility have been unsatisfactory in terms of efficiency. Thus, the DRR agenda should be integrated into the international development sustainability agenda even at local level [14,31].

Among other reasons, socioenvironmental disasters occur due to the

existence or lack of a more effective action on the part of actors, particularly the State, which could reduce through public policies [17], in communities rendered vulnerable, the consequences of events and/or damages such as those of a geohydrological nature. The outcomes of this State relationship with society in terms of meeting the demand to mitigate disaster risks could, for example, include dead, injured, displaced and homeless people, and destruction of public and private property, not to mention natural assets. This demonstrates a process of social construction of vulnerabilities, where the actions (and lack of actions) of the State-level actor have contributed to an irresponsible spread of cities onto natural-event risk areas [36], having more effect on the less favoured population [7,10]. Such manner of thinking about disasters has led to a shift in beliefs in the concept that attributes fatalities caused by humans to nature. By moving away from this paradigm, one no longer puts everything down to nature and resigns oneself to the fact [26,32], placing the issue on another level – that of the responsibility of social actors in the public arena [30,36]. Consequently, what is at stake in the DRR governance scenario is, above all, the ethics of responsibility among actors – as is the case of the State-level actor – to act through preventive risk management in addition to emergency response, the latter more characteristic of late-developing urban areas [33].

Thus, the socioenvironmental conception characterises geohydrological disasters in the community as a result of natural conditions associated to anthropogenic aspects which reflect the absence of the State. Given this concept, in which disaster risks emerge from complex interactions between physical processes and social systems, the correct way to address disaster risk reduction is through an interdisciplinary approach [15,34].

Among the international guidelines on reducing risks, the Hyogo and Sendai frameworks for disaster risk reduction proposed by the United Nations International Strategy for Disaster Reduction [11,14] calls for local community engagement in DRR. In order to achieve this goal, the framework emphasises the importance of certain priority actions, such as increasing community knowledge, integrating DRR into formal and non-formal education, enhancing collaboration among people at a local level and empowering local authorities to work with communities on DRR. Furthermore, the international DRR community, through the Hyogo and Sendai frameworks, calls attention to the "… need to shift the focus from response to disaster preparedness and prevention. Incorporating disaster risk reduction into educational activities at the policy and operational levels will encourage this shift." ([17]; p. 7).

Considering the characteristics of the social system mentioned above, non-structural actions such as changing public attitudes, awareness and participation in DRR actions are required to achieve community resilience and more efficient DRR management. In this context, education plays an important role, bringing together different social actors to deal with and participate in DRR management, including the general public, government agents, scholars and decision-makers.

Given this scenario, construction of knowledge through the process of teaching-learning, including the natural and human conditions of such events, naturalisation of disasters, the capacity of the individual to contribute to risk reduction and the need for effective State intervention in communities rendered vulnerable become pressing, and may result in individual and collective actions for transformation of the social environmental situation and, consequently, the reduction of disaster risks and the contribution to qualification of critical players. Questioning the educational methodology to be adopted for this purpose is essential, however, given that the topic is increasingly being included in school curricula without any basic consensual methodology to be followed, as observed by Selby and Kagawa [16,19].

4. Disaster risk reduction education (DRRE)

The literature appears to reinforce the need to motivate target DRRE program groups to be proactive and aware of their vulnerability conditions which, for some authors, would place such education on a level of not limiting itself to an approach to the theme of natural hazards. Petal [35] states, for example, that DRR education serves "… to convey an understanding of the natural and environmental conditions and the human actions and inaction that lead to disaster, to stimulate changes in individual and group behaviour, and to motivate advocacy and raise expectations of social policy to reduce these threats." (p. 286). On this point it is worth remembering the importance of considering the social or anthropogenic dimension of disasters, along with the capacity for transformation of citizens and the biophysical reasons for these phenomena.

DRRE can be delivered through formal, non-formal and informal education [36]. According to Shaw et al. [36]; formal education is that "… provided in the system of schools, colleges, universities and other educational institutions …", while non-formal education is "… any organized and sustained educational activities …" (p. 2/3) taking place outside educational institutions. DRRE in formal education is provided for in documents such as the Sendai Framework [14], which in turn is the result and part of a historical process to construct a field of knowledge and an agenda for DRR, continuing the Hyogo Framework for Action (HFA - [11]). With this framework it is hoped that, in the period between 2015 and 2030, the aim of substantially reducing the risks of disasters and loss of life, livelihoods and health, along with the economic, physical, social, cultural and environmental assets of people, companies, communities and countries [14], will be achieved. This agenda therefore determines a pathway of international actions which influence or inspire decision-making at national, state and local level with a view to mitigating disaster risks, enabling dialogue between, at minimum, the environmental agenda and that of DRR [37,38].

Regarding the integration of DRR into formal education, Selby and Kagawa [16,19] pointed out that from 2009 to 2011, few countries have achieved the HFA priority of using education to build a culture of safety and resilience at all levels. This suggests that even if countries are keen to respond to this HFA priority, there are misunderstandings about how to integrate DRR into curricula and implement them. Two themes to be addressed in DRRE are suggested in the literature: the risk of disasters and mitigating actions to reduce damages [2]. Further, authors suggest inclusion of content on preparation to face the challenge in addition to social aspects involved in the disaster risk construction process [35]. This is due to the manner in which notions of disaster and risk management are being addressed in the international scenario, primarily based on the HFA, reinforced by the Sendai Framework.

Some authors consider the interdisciplinary approach to be paramount in addressing complex themes in modern times, although it is still complicated to define it [39]. As the DRR question is environmental in nature and, therefore, complex and geared towards problem-solving, this requires an interdisciplinary approach to be "… A major driving force in scientific innovation that can lead to a restructuring of the landscape of disciplines …" [40]. From this perspective, authors such as Japiassu [41]; Max-Neef [42] and Pohl and Hadorn [43] further propose transdisciplinarity as a fitting approach to complex, 21st century problems.

In their 2009–2011 study, Selby and Kagawa [16,19] highlighted that there is very little evidence of the implementation of any interdisciplinary approach and community involvement in DRR education, which can weaken its effectiveness. They therefore suggest an interactive, "in practice", affective and participatory learning process. The implementation of a transversal perspective can thus be a way of overcoming the traditional singular approach. Besides the importance of an interdisciplinary approach, Shaw et al. [44] emphasise the role of innovative educational resources (observations, experiments and perspectives of problem resolution) in disaster reduction education. Zhu

and Zhang [18] highlight the need for attractiveness and considering local characteristics in disaster education activities.

Considering the evaluation of DRRE programs or projects, Johnson et al. [2] state that "… there is very little formal evaluation of these programs and their effectiveness achieving desired learning and behavioural outcomes. Although research in this area is growing, there is currently no scholarly consensus on what counts as credible evidence of effectiveness of disaster education programs for children." (p. 108). This demonstrates that the aspect of evaluation is not being explored as it could be by DRRE programs or projects.

DRRE in Brazil is based on Law 12.608 of 10th April 2012, which regulates the National Civil Protection and Defence Policy/PNPDEC – [31], including among its objectives the development of a national disaster prevention culture aimed at awakening the national conscience to disaster risk. In its Article 3, Sole Paragraph, the Policy clearly defines the requirement of its central theme:

> "… To be integrated with policies on land management, urban development, health, the environment, climate change, water resource management, geology, infrastructure, education, science and technology and other sector policies, with a view to promoting sustainable development." [31].

It should further be noted that, in its Article 29, Paragraph 7, the PNPDEC [31] states that "elementary and high-school curricula should include the principles of civil protection and defence and environmental education, integrated into compulsory content".

This means that, in addition to the sustainability paradigms, the DRR and environmental education (EE) agendas are interconnected through the curricula of these two types of instruction, recognising the contribution of latter to the effectiveness of the former. In respect of education, DRR actions seek fundamental elements for their implementation through the important contribution of Law No. 9.795/1999 [45]. Regulating environmental education in Brazil, this law provides on the approach to socioenvironmental content in the formal and non-formal environments, providing an opportunity for cross-contamination of the EE and DRR agendas. Developed at all levels and in all modalities through ongoing, permanent integrated educational practices, EE is not a discipline [45,46], but enables schools to apply an interdisciplinary approach (Article 8, Paragraph 3) as a strategy to motivate awareness-raising on the environmental question through integration of the dimension in content (Article 8, Paragraph 3), including in this dimension, therefore, the question of DRR.

5. Proposed methodology to integrate disaster education into elementary teaching

5.1. Basis of proposed methodology

Considering previous discussions on the role of education in DRR, this section provides supplementary aspects that were essential in conceiving the teaching methodology hereby proposed. The research method used to formulate the DRRE methodology proposal considered previous experiments with content topics and teaching materials, in addition to the Sendai Framework priorities, interdisciplinarity and transversality as principles. Furthermore, it should be noted that the assumptions proposed by Petal [35] on DRRE advocate not only addressing the natural and environmental aspects, but also the human issues.

In order to include DRRE in school curricula, there are different possible teaching methodologies [2,16,18,19,44,47,48]. The proposed methodology described herein was primarily based on the experiments of Mendonca et al. [49] and Mendonca and Valois [47] and on the pedagogic strategy of transversality, interdisciplinarity and presuppositions of the problem-based approach conception as suggested in the literature. Indeed, these are EE principles according to the concept issued by the Intergovernmental EE Conference in Tbilisi, Georgia [46] as EE is centred on practical day-to-day problems and their solutions.

Transversality presumes the integrated treatment of themes and knowledge areas, and a commitment to interpersonal and social school relationships with questions couched by themes such as ethics, cultural plurality, the environment, health, sexual orientation and local topics in order to obtain coherence between the values exposed in the experience provided by the school to the students and the intellectual contact with such values [6]. As a cross-cutting theme, the environment provides a window of opportunity for teachers of disciplines in the 6th year of elementary education (Arts, Science, Physical Education, Geography, History, English, Mathematics and Portuguese) to expose the students to content on geohydrological disasters. As an example of interdisciplinarity in this study, the mathematics teacher, on instructing on construction of a mock-up of a community with geohydrological risks, can draw on knowledge of calculations from his or her discipline, along with cartography knowledge from geography. Cross-contamination may also occur on the environmental theme, for example a text on environmental preservation in a Portuguese class could create a forum for discussion with the students, using the knowledge of the teacher, the discipline and the student in an interdisciplinary manner. Depending on the teacher, cross-cutting themes may be included in more than one class and two-month period of the educational year, provided it is planned into the pedagogic curriculum.

In proposing this teaching methodology, efforts were made to address the topic from an interdisciplinary point of view as indicated by UNESCO [46]; which affirms that such an approach is required to enable education to reflect the complexity of ecosystems. In this regard, according to Japiassu [41]; interdisciplinarity is characterised by the intensity of exchange between specialists and the degree of real interaction among disciplines within a single study. Additionally, it is worth remembering that interdisciplinarity is "… a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession." [50], so that this perspective does not deny the specialities, but seeks to go beyond disciplinary limits and is, therefore, a bridge between fields of knowledge from each discipline and a means to answer complex modern day questions to which such fields alone cannot adequately respond. This is due to the fact that we are dealing with the inherent nature of problems - their complex character.

Consequently, in the field of education, the interdisciplinary practice assumes:

> […] A deconstruction, a break with tradition and the day-to-day school task-based approach. The interdisciplinary teacher moves in flexible borderline regions where the "I" coexists with the "other" without relinquishing any of their characteristics, thereby providing for interdependence, sharing, meeting, dialogue and transformations. This is the movement of interdisciplinarity characterised by attitudes before knowledge ([51]; p. 65).

In this sense of the "I" and the "Other" in school tasks, a dimension emerges: that of the "Other-student" as a subject of knowledge, transcending the "border" of knowledge as something which belongs exclusively to the "I-teacher". Fazenda [52] points in this direction when affirming that "In school interdisciplinarity, the notions, ends, skills and techniques seek to favour, above all, the learning process, respecting the knowledge of the students and its integration". In the methodology proposed for DRRE activities in the municipal school to which we refer, the aim was also to include dimensions from outside the classroom on integrating the knowledge of public administrators (Municipal Environmental and Civil Defence Department) who work in the specific area.

The concepts of transversality and interdisciplinarity enable a relationship to be formed between knowledge in the teaching-learning process. The very act of teaching considers assumptions of the concept of problem-based education, just as Environmental Education advocates [6,46].

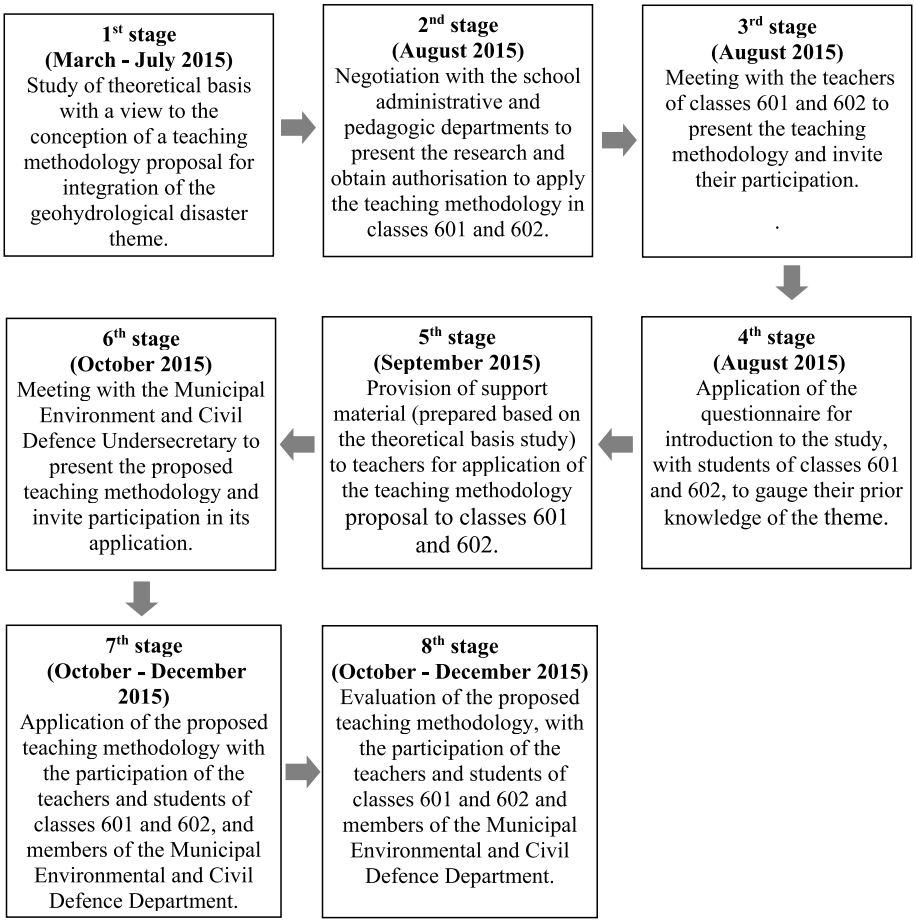

Fig. 1. Flowchart for DRRE experiment conducted at EMFPGP.

Presuppositions of the problem-based education concept promote dialogue and value the knowledge and experiences of students during classes enabling them, together with the teacher, to develop a critical view of the world in which we live [53], primarily of their own realities [46]. This is one of the objectives of elementary education in Brazil, according to the National Curricular Parameters: "to question the situation by formulating problems and seeking to solve them, using for this purpose logical thinking, creativity, intuition and the capacity for critical analysis, selecting procedures and verifying their adequacy" ([6] p. 69).

5.2. Development stages of the experiment

Research for conception, application and evaluation of the teaching methodology geared towards integrating the theme of geohydrological disasters into the curriculum of the 6th year of elementary education was undertaken based on consultation of environmental education (EE) legislation and literature, and education for disaster risk reduction (DRRE), including trials in Brazil and other countries. The experiment conducted at the Governador Portela Municipal School (EMFPGP), em Miguel Pereira, Rio de Janeiro State, involved establishment of a theoretical basis, meetings with participant institutions, prior consultation of the students and application of the teaching and assessment activities, as shown in Fig. 1 below.

6. Results and discussions

6.1. Employment of the proposed methodology

The aim of this section is to describe the implementation process for the proposed methodology and specify its final product, i.e. the participative production of materials in line with the methodology, which was applied between August and December2, 015,[2] involving: two classes of 25 students each - 29 female and 21 male; 10–11 years of age - of the 6th year of elementary education at EMFPGP; 9 regular teachers of all disciplines to these classes; and to external members from the Municipal Environmental and Civil Defence Department.

In August 2015, meetings were held with school directors and the teachers to present the project, obtain authorisation from the school to apply it and consult the teachers on the possibility of participating. After authorisation was given by the school and agreement from the teachers to participate, each teacher received a support pack to prepare and deliver their classes, including: lesson plan and respective content, digital media with scientific articles, booklets, glossary, legislation and videos on geohydrological disasters. A professor with expertise in this latter type of disaster contributed to the support material and definition of the teaching materials. Still in August of that year, prior to commencement of the educational activities, a semi-structured questionnaire was applied to the students to obtain a general idea of their prior knowledge and experience on the theme of geohydrological disasters. Three questions were put: two requiring them to comment on images from disasters associated to mass movement and flooding, and the third on risk.

In October, November and December 2015, the educational project activities were conducted. Practical classes involving exposure and

[2] This is the second semester of the school year and coincides with the period prior to the summer rains which, normally, is the season of highest rainfall, a contributing factor in the occurrence of hydrogeological events.

Table 1
Class content for proposed teaching methodology.

Discipline/activity	Compulsory content for 4th 2-month period (6th year)	Content of teaching methodology proposal		Duration (h)
		First class - Dialogue-based exposition	Second class - Practical	
Geography	Atmosphere and biosphere	1. Concept of disaster; 2. Characteristics of the main types of mass movement and hydrological processes; 3. Characteristics of relief, hydrography, vegetation and geohydrological risks in the municipality of Miguel Pereira; 4. Characteristics of a community with geohydrological risks.	Formulation of speaking community maps showing risks of mass movements and hydrological processes, to be used as a basis for the booklet.	3.0
Sciences	Environmental impacts	Concepts of Disaster, vulnerability, threat, hazard and risk perception.	Practical activity on Perception of the degree of risk using speaking maps made during the practical Geography class.	1.5
Arts	Symmetry	Characteristics of populations most vulnerable to geohydrological disaster risks.	Creation and design of characters to be used in the booklet and game, as residents in a situation of vulnerability to geohydrological risks.	1.5
Portuguese	Text composition	Concepts and dialogues/narratives, and the importance of dialogue on the theme of geohydrological disasters.	Preparation of dialogues and narratives for the booklet on the principles of civil protection and defence and environmental education, which may contribute to disaster risk reduction.	3.0
Mathematics	Decimal numbers	Natural and anthropogenic conditions associated to the dynamics of mass movements and hydrological processes, and the prevention actions to be carried out in the community.	Construction of a mock-up to represent a community with housing in a risk situation in terms of slopes and watercourse banks, and simulation of a mass movement and hydrological process.	3.0
History	Roman Empire	1. The historical process of Brazilian urbanisation; 2. The concept of unregulated urban spread; 3. The concept and importance of environmental history.	Construction of environmental history based on the community created and represented by students in the speaking maps.	1.5
English	Simple present with vocabulary on health and unhealthy foods.	Presentation of DRR concepts in English [12].	Translation of and dialogue on concepts of DRR terminology [12].	1.5
Physical Education	Indoor Football	The importance of the Community Civil Protection and Defence Group (NUPDEC).	Preparation of Q and A for the game on geohydrological disasters, based on the work of NUPDEC.	1.5
Field activity (Municipal Environment and Civil Defence Department)	Not a discipline.	Presentation of the work of Miguel Pereira Civil Defence.	Risk Analysis in the area around the school.	1.5
Final presentation	Not a discipline.	Presentation of activities carried out and teaching materials produced (booklet, game and mock-up).		2.0

dialogue were planned, along with the use of teaching resources (video and image) across all disciplines of the 6th year of elementary education, namely: Arts, Science, Physical Education, Geography, History, English, Mathematics, and Portuguese. The scheduled class content is presented in Table 1 below. In October 2015, a meeting was held with the Municipal Undersecretary for the Environment and Civil Defence, seeking the participation of members of this body in the educational field activities. Finally, a presentation was scheduled to demonstrate and apply the teaching instruments to the school community as a result of the work carried out. The expected total duration of educational activities with the students was 15.5 h, but it was noticed during the experiment that it took 20 h (Table 1).

As can be seen in Table 1, practical classes within the disciplines consisted of producing teaching instruments such as booklets, games and mock-ups in order to enhance attractiveness in the learning process. The booklet, important for communication, was a result of practical activities in the disciplines of Geography (speaking maps), Arts (characters), Portuguese (dialogues and narratives) and History (environmental history). The educational game resulted from the practical Physical Education class. The mock-up, which enabled representation of the geographical space, was a product of the practical Mathematics class. These teaching instruments are didactic resources for the teacher to use in facilitating understanding of the complexity of the situation.

Extra-class activities and the final presentation of the products developed and used during activities are also part of the teaching methodology, given that they were conceived as stages to potentialise integration of the geohydrological disaster theme. Field activity is an important strategy for the teaching of Sciences, and valuable for EE, given that it is conceived as a day-to-day practice. This activity enables exploration of conceptual, procedural and behavioural content, but requires adequate preparation and integrated work among the professionals involved, through interdisciplinarity [54]. This fieldwork also included participation of members of the municipal protection and civil defence body to enrich the teaching-learning process, while placing interaction at the forefront of risk management.

The final demonstration enabled awareness-raising and the sharing of knowledge and experience of the theme, along with disaster risk reduction actions between the project participants and other members of the school community.

6.2. - evaluation of DRRE method conducted

The evaluation of the DRRE methodology aimed at qualitatively measuring learning and process outcomes (execution and implementation). Behavioural outcomes which could assess proactive engagement in risk reduction actions ([2] e 2016) were not measured. The evaluations were carried through observations, questionnaires and interviews [2]. state that there is no scholarly consensus on what counts as credible evidence of effectiveness of DRRE programs for children in order to achieve desired learning and behavioural outcomes. According to Zhu and Zhang [18]; “school disaster education has no obvious effect on improving student awareness and ability of risk aversion and disaster prevention” (p. 1028), thereby contributing to this lack of consensus.

During the educational activities, the non-structured observation technique was used, forming the basis for evaluation of the teaching methodology and learning by the students with no predefined observation schedule. In addition to this evaluation method, the eight participating teachers, two external members from the municipal authority and the fifty students were interviewed by means of semi-structured questionnaires after conclusion of the DRRE experiment. The aim was to gather opinions on the time commitment for the disciplines, the participation of each discipline in the DRRE activity and the ease of execution, along with awareness-raising of the theme among students, while verifying whether the methodology promotes a forum for discussion on the theme with the students. Interviewees were given five response options, varying from very poor to very good. This questionnaire also allowed interviewees to freely give their opinions. The evaluation was based on interpretation of the percentage distributions of the answers to each question and the opinions offered in the different questionnaires.

A semi structured questionnaire was also applied to participants in the final demonstration (teachers and students) to evaluate the activities carried out, teaching instruments (booklets, games and mock-ups) and their personal relationship with the theme. The involvement of children and teenagers as evaluators of DRRE experiments follows the trend of other studies, with evaluations mort repeatedly carried out by students between 7 and 18 years of age [2].

The results gleaned from these evaluation tools indicate that:

- The questionnaire outcomes indicated that the teachers and members of the Municipal Environmental and Civil Defence Department approved the proposed teaching methodology to integrate the geohydrological disaster theme; more than 98% of students also expressed their approval, in terms of the following characteristics of the methodology: lesson planning, content, course hours, teachers' support materials, the teaching method, didactic resources, classroom and extra-class activities.
- The transversality aspect enabled the theme of geohydrological disasters to permeate the curriculum of subjects in the 6th year of elementary education. Interdisciplinarity allowed the content to be taught through the exchange of knowledge between disciplines, without denying the specialities of each. The teaching methodology proposal, applying assumptions on the concept of problem-based education, promoted dialogue and valued the knowledge and experience of the students during the lessons, as advocated by FREIRE [53]. This approval demonstrates the possibility of continuing the proposal in both a transversal and interdisciplinary manner.
- The booklet, game and mock-up, produced during application of the teaching methodology, were evaluated by means of a semi structured questionnaire applied during the final demonstration at the school. For all the teachers and members of the Municipal Environmental and Civil Defence Department, along with 93.7% of the students, the booklet, game and mock-up have the characteristics to develop the teaching-learning process on the theme, evidencing their importance in assisting the teacher and stimulating learning among the students.
- The final demonstration by the students enabled awareness-raising and sharing of knowledge and experience with participants on the theme.
- Classroom observations identified that the teachers and Municipal Authority members applied interdisciplinarity, transversality and the assumptions of problem-based education. In respect of the students, it was observed that they actively participated in discussions on the theme and in activities, showing their interest in the theme. This was also demonstrated in their questionnaire responses and, furthermore, the teachers, Municipal Authority members and the students expressed interest in continuing with application of the DRRE methodology.

Finally, the proposed educational activities were designed to respond to recommendations in the literature that DRRE should be innovative; to encourage students to participate in the learning process; to link the theory to experiments and observations in order to connect the learning environment to reality/the community; and to implement a transversal and interdisciplinary approach. In this light, the method developed may subsidize implementation of DRRE actions on a wider scale, but should be adapted to local specifics (social, economic, cultural and biogeophysical.).

7. Closing remarks

This paper seeks to contribute to the debate on DRRE particularly in Brazil, based on the development of a proposed educational methodology in respect of geohydrological disaster risk reduction for the 6th year of elementary education in a public school, located in the municipality of Miguel Pereira (Rio de Janeiro State, Brazil) during 2015. Guided by international and national literature on Environmental Education and Disaster Risk Reduction, and in an effort to contribute to development of scientific knowledge in the area of DRRE, the key principles of this proposal were: a problem-based, cross-cutting and interdisciplinary approach to integrating the theme into this 6th year; and not only address the natural and environmental aspects, but also the human issues. The proposed methodology involved planning and preparation of activities, description of the pedagogic content and the practical, dialogue-based exposure classes in each of the eight formal curriculum subjects (Arts, Science, Physical Education, Geography, History, English, Mathematics and Portuguese), with total class time of 20 h, including field activity and the participation of institutions involved in risk management.

Based on application of this teaching methodology, which involved teachers from the school, a professor with expertise in geohydrological disasters and a local risk management institution (Municipal Environmental and Civil Defence Department), the students had the opportunity to discuss the theme of geohydrological disasters. This type of learning can, in an ongoing manner, contribute to disaster risk reduction through its multiplication by students and participation of the school community in actions carried out within the school environment, such as the final presentation of the learning tools (booklet, game and mock-up) produced during the pedagogic activities of the study. Considering that examples of this type of experiment are still scant in the country in question and, primarily, in the Southeastern region (where Rio de Janeiro is situated), this experiment provides possibilities to reproduce it, nonetheless ensuring it is adapted to local specificities.

Highlighted by the literature as a point to be further explored in DRRE programs, the evaluation of this methodology identified the reach of the learning proposed on the theme of geohydrological disasters among students. Assessments by the teachers, Municipal Authority members and the students on the proposal, along with observation by the authors, indicate a high level of acceptance and commitment among those involved throughout development of the methodology. It is suggested that the question of evaluation be considered, chiefly in terms of defining an outcome indicator, which should express the efficiency of the educational program not only in terms of a knowledge-based outcome, but also in respect of assessing the learning process and behavioural outcome including improvements in response to and recovery from an actual disaster and in advocacy of social policies to disaster risk reduction.

Finally, this type of study may provide benefits for communities vulnerable to disasters by equipping them to deal with the risks through access to technical knowledge on the theme, thereby applying the priorities for action set by the Sendai Framework, such as Priority 1 “Understanding disaster risk” and Priority 2 “Enhancing disaster preparedness” [14] and in the National Civil Protection and Defence Policy (PNPDEC - [31]).

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