

Research methodologies focused on urban planning and mathematical issues

Topic: Teaching Engineering

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Abstract:

This article aims to present an interdisciplinary approach about the research methodologies used at the civil engineering research field, in the domains of urban planning and mathematics. Actually, there are some similarities in between the research process features of urban planning and mathematics.

In fact, these both scientific subjects follow analogous tasks in their research process, which have the same starting point with the definition of the research problem and the final phase, based on the proposed solution. It joins scholars from the department of civil engineering and architecture, experts in spatial analysis and scholars from the department of mathematics of the University of Beira Interior.

Two case studies will be presented as examples of the application of these methodological approaches, both of them focused on the urban planning researches, associated with postgraduate teachings, one is related to a PhD thesis and the other one relates to a master degree dissertation.

Key-words:

Research methodologies, urban planning, mathematics, postgraduate teachings.

1. Introduction

This article is focused on research methodologies used at the civil engineering research field focused on the urban planning and mathematical issues. It is the result of an interdisciplinary approach gathering scholars from mathematics and urban planning subjects, responsible for teaching at the civil engineering degree, and PhD candidates in civil engineering having the urban planning as the research topic. In fact, the research methodology framework in many aspects is analogous in between the mathematics domain and the urban planning domain. These similarities are present on the phases of the research process which are used on these both scientific domains. Despite of the differences in terms of contents of the research tasks, the organization of the research process is really similar.

On the one hand, both subjects are basing their investigation tasks, starting with the identification of a research problem that should be solved by the researcher, as the first step. On the other hand, both subjects are organizing the research process based on several steps until the final phase which is the solution proposed in order to solve the problem in the case of mathematics or to mitigate the problem in the case of the urban planning.

2. Research methodology in urban planning

2.1 Research process framework

There are several ways of structure the research process regarding the urban planning domain. However, all of these different perspectives have a similar approach which is to define a starting point with the identification of a research problem, something that is not working well at the territorial dimension which is the study object.

Another similar aspect is the fact that the final step of the research is to propose the solution or solutions in order to diminish the starting point problem.

In between these two phases, the first and the last, the research process can vary according to the features of the analysed case study, the period of time defined for the analysis, or the scale of the investigation in territorial terms. Some authors [1] are suggesting that there are at least two analysis phases at the urban planning research, which are the following: 1st - data collection or retrieval. The referred author says that this step is “purely dedicate to research and laborious data retrieval and documentation” [1]; 2nd - mapping the phenomenon that is being studied. This author argues that this phase has a “preliminary importance” [1]; These two phases can be understood as being part of the research process of a case study of urban planning, in between the identification of the research problem or the territorial phenomenon that is going to be studied, which is the 1st step and the proposed solution which is the last step.

Despite of the different approaches, tasks or their contents defined to the research process as a whole, there are a common structure that could be followed as reference in the urban planning investigation. Therefore, the urban planning research could be seen has a process which is based on six main tasks, according to the following phases (Fig. 1):

- 1st - identification of the research problem or the territorial phenomenon, including the two tasks listed below:
 - a. case study;
 - b. pioneer examples;
- 2nd - literature review;
- 3rd - data collection or retrieval, including the following four tasks:
 - a. statistics data;
 - b. on-site analysis;
 - c. documentation of the spatial planning instruments and ordinances rules for the case study area;
 - d. inhabitants’ surveys promoting the public participation;
- 4th - diagnosis of the current situation mapping the phenomenon;
- 5th - A kind of cost-benefit analysis which refers in the urban planning domain to the framework of the problems and potentialities of the case study area, in order to find the solution which will be focused on suggestion to diminish the problems and suggestions to develop the potentialities;
- 6th - Final solutions or strategies.

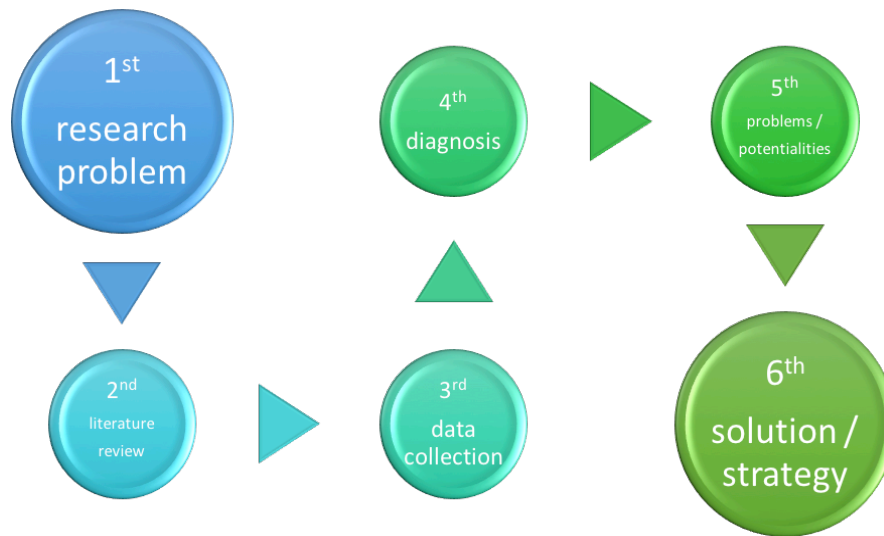


Figure 1 - Research methodology tasks in urban planning process.

The next section will be focused on the presentation of two case studies of the application of the urban planning methodologies, having as case studies Portuguese territorial contexts. These cases were developed at the Department of Civil Engineering and Architecture of the University of Beira Interior. They are both related to postgraduate teachings. The case study 1 is based on a PhD research and the other one is based on a Master degree investigation.

2.2 Case study 1: an urban planning approach in a PhD research

This first case study is part of an ongoing PhD Thesis in the domain of spatial planning, on the behalf of the doctoral programme of Civil Engineering, having the territorial analysis as the main research line.

It has as a starting point a step based on the literature review focused on the rethinking of the local governance, and the need for its efficiency, regarding the management of the building and urbanization projects, by the municipal authorities. The governance at the municipal level of the public administration, concerning the spatial planning process is generally inefficient, triggering several failures such as in terms of communication and information to the citizens in general. This problem happens either to the authors of the building and urbanization projects or to the land owners. In fact, the literature review that the governance depends on “the process of transmitting information through the communication technologies between authorities and citizens” [2].

In order to better understand this issue, there is the need of reflecting on the unsatisfactory conditions in which the governance regarding the spatial planning management is happening at the local level.

The contents of the spatial planning instruments and of the building and urbanization ordinances should be more available and disseminate among the public in general and in particular considering the authors of the building and urbanization projects and the land owners. This dissemination could be called a “new public service” [3] which will serve as an alternative for the “old public administration” as a “new public management” and a “new public service”. This new approach aims to reaffirm the values of democracy, citizenship and public interest as prominent aspects of any public administration, beginning with the recognition that the existence of an engaged and enlightened citizenship is critical to a more democratic governance.

According to the same author, this new model of public administration design should be materialized in the form of an interactive governance as a participatory management trend. This implies sharing and disseminating information in order to transform the stakeholders of the society (including the public and private realms) “allies in the search for better results, both regarding administrative performance and increasing democratic legitimacy” [4].

In this sense this research has defined as its 1st step the identification of the research problem, which is the governance inefficiency regarding the spatial planning process at the local level, considering the building and urbanization projects. Therefore, the main objectives of this investigation are based on the goal of finding strategies in order to reach a new spatial planning model in terms of governance at the local scale, in order to promote a better efficiency of the management process of the building and urbanization projects.

Many authors are spending ink advocating that a better information and communication to the citizens is a requirement of the governance in parallel to the increasing of the responsibilities in the decision-making process [5].

After a 2nd step focused on the literature review and a 3rd based on the data collection, this research has as phase 4th the goal of creating a catalogue with all the types of building and urbanization projects, that could be a reference at the urban planning process at local level. This catalogue is a key task in this research because of the following reasons: first of all, it represents a synthesis of the previous phases, given that it will represent all types of building and urbanization project that could be supervised and approved by local authorities; secondly because it can be used as a reference manual in all the 308 Portuguese local authorities (all over the country including Azores and Madeira islands and the continental territory), i.e. the municipalities, given that all the types of projects are represented in it.

The 5th methodological step of this research is related with the proposal i.e. the solution in order to diminish the identified research problem, contribution to increase the efficiency of the urban planning governance. This solution will be a guide of good practices showing how the several types of building and urbanization projects should be in order to respect the spatial planning ordinances, turning more efficient the municipalities governance in terms of territorial management.

2.3 Case study 2: an urban planning approach in a Master research

The second case study presented as an example of application of an urban planning methodological process is based on a research entitled “The challenges for smooth mobility in Covilhã” [6]. Covilhã is the case study city where this investigation took place, being part of a master dissertation.

The 1st phase of this research was the definition of the investigation problem, which was the challenges for the smooth mobility, having the particular case of a mountain city, where the problems of mobility in general are more serious and complex, considering the mountain topography.

The city of Covilhã is located on the southwest slope of Serra da Estrela, which is the highest mountain in the continental part of Portugal with nearly 2000 meters high. Its urban fabric is comprised in between 400 and 800 meters high, which results in a peculiar orography, where many of its streets are sloping, narrow and with a sinuous morphology. This situation is a further challenge for the implementation of a smooth mobility system, with a special focus on the pedestrians’ mobility, in order to make the city a better walkable place for all.

The research assumes that cities with higher quality of public space for people, more accessible and friendly, influence the participation of their inhabitants in the urban development [7], since they are more inclusive and provide a greater interaction of their people and communities.

The literature reveals [8] that in many cities all over the world, the majority of the public space is dedicated to the cars or other transports networks, including the parking areas. In

parallel to this problem, in many urban fabrics the conditions of the public spaces for pedestrians are poor in terms of constructive quality, having frequently a lack of maintenance works, and they are often not designed in a proper way, in order to guarantee the safety and comfort conditions for their users. Thus, the public spaces like these are not promoting an adequate mobility with an inclusive and universal accessibility.

After the literature review and the data collection, this research had as the 4th methodological step, a task based on making a diagnosis of the current situation mapping the phenomenon of the urban mobility in the city of Covilhã. Given that this is a mountain city, it has a set of several facilities for pedestrian mobility, public elevators and funiculars, which are free for the users and part of the paths system for pedestrians. Therefore, these facilities were considered as pivotal elements in the smooth mobility strategy.

Some special buildings with a particular use, such as schools, university departments, public services, hospitals, cultural landmarks, pedestrian bridges with particular interest for mobility, shopping or commercial areas and streets were catalogued as main attractiveness elements at the urban scale as a whole, which should be considered with a focal importance in the smooth mobility strategy.

The main results of this research have showed that currently there is in this city a very unfavourable reality for smooth journeys. This reality is a result of several aspects such as the following: the existent pedestrian paths do not connect the elevators and funiculars with the pedestrians' bridges; the streets, sidewalks, stairs or other pedestrian ways are in poor condition in terms of status of their conservation, having an inadequate width or several obstructions such as the urban furniture (lights, signs among others). Some authors were researching some similar subjects finding the same results. For example, there is one academic research [9] that is confirming the referred aspects, emphasising that in Covilhã only 8% of the crosses and 17% of the street segments are in reasonable conditions for the pedestrian walkability.

The last phase was a synthesis plan comprising a set of proposals in order to improve the smooth mobility system, articulated with other urban systems such as the public transports and other soft modes of movement such as the cycling paths network, in an attempt to seal the existing gaps of the contemporary city.

Finally, some new lifts and funicular routes were proposed, for pedestrian priority, promoting the traffic calming, the integration of bicycles, and cycling routes on softer slopes. If in a mountain city the challenges of soft mobility are complex, this research confirmed that is possible to find a set of several solutions, connecting all types of pedestrian paths working in an urban system as a whole, promoting the urban continuity.

3. Research tasks in mathematics issues

This section will be focused on the discussion about the definition of a set of research tasks in the mathematical domain, the different types of mathematical tasks and how these tasks are going to have influence at the learning of mathematics. The referred tasks are called investigative tasks. Therefore, among other aspects, the students' learning of mathematics issues, is related to the way how the scientific contents are transferred to them, the way how the activities are taking place in the classroom, and with the sort of works including practical exercises that are proposed to them by the teacher.

The research tasks are elaborate and given to the students by the teachers, and they are considered by many authors as one of the key pillars in the teaching-learning process. In this sense Pires [10] argues that the development of a mathematics class is influenced by several factors. For the author, these factors that greatly influences a "good" mathematical activity are the following: the organization and the affectivity in the academic institution; the social environment and the family perspective of the student; the way how the students think and approach the different contents of mathematics; the perception that students have on the academic institution; the way how the scholars are teaching and working on the various mathematical contents; the elaboration of practical exercises and tasks for students.

According to the previous idea, the scholar should develop several tasks according to the level of knowledge of the student and he/she should be focused on a mathematics approach that has real and significant basis.

The tasks to be proposed should have intuitive and inductive characteristics, in order to allow the student in a quick way, to be able to identify some known mathematical patterns which will allow him to reflect and to expose his/her ideas, giving him/her the pleasure in finding the solution.

The way how the scholar is going to define the research tasks and to encourage the students' achievements, is very important in order to enable a meaningful learning activity among the students.

According to some authors [11], a research task has four dimensions, which are the following: its degree of difficulty; its structure; its context; and the time that is required for its acquisition. Despite of the importance of all these aspects, this paper will explore deeply the first two dimensions of the research tasks; their structures and their degrees of difficulty; which are linked to four types of mathematical tasks, according to the same reference, which are the following features: exploration, exercise, problem and research.

Regarding the exercises and the problems, these two aspects are tasks that have a similar nature and with the same structural dimension, with the exercises having a lower level of difficulty in relation to the problems. Regarding the research and the exploration they are structurally open tasks. However, the explorations are easier than the investigations.

For other authors [12] the different types of research tasks strongly contribute to the learning process, as referred to in the following citation: "Tasks of a more closed nature (exercises, problems) are important for the development of mathematical reasoning in students, since this reasoning is based on a close and rigorous relationship between data and results. Regarding the tasks of a more accessible nature (explorations, exercises), they allow all students to achieve a higher degree of success, contributing to the development of their self-confidence. About the tasks of a more challenging nature (investigations, problems), they are indispensable for students to have an effective mathematical experience. Finally, the open tasks are essential requirements for the development of certain particular skills of the students, such as autonomy, the ability to deal with complex situations (...)".

In terms of methodological approaches in mathematics, the concepts of problems and investigations are similar, but they perform different functions. On the one hand, the term "problem solving" is related to the activity in which the solution is sought for a certain problem, using various procedures. On the other hand, the term "research" refers to an activity that seeks to respond to certain situations in a broader way.

According to this idea, Polya (1977, cited by Pires [10]) says that: "The resolution of a problem involves: (1) understanding the problem; (2) design a resolution plan; (3) execute the plan; (4) reflect on the work done." (Fig. 2)

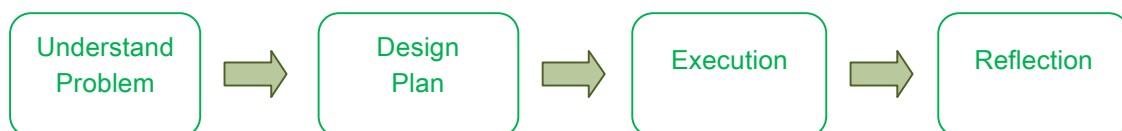


Figure 2 - Steps of the resolution of a mathematical problem.

Other authors such as Ponte, Oliveira, Cunha and Segurado (1998, cited by Pires [9]) stated that: "A research has a diverse approach, including: (1) formulating the question to investigate; (2) to formulate conjectures on this issue; (3) testing the conjectures and eventually reformulating them; (4) validate and communicate the results." (Fig. 3)

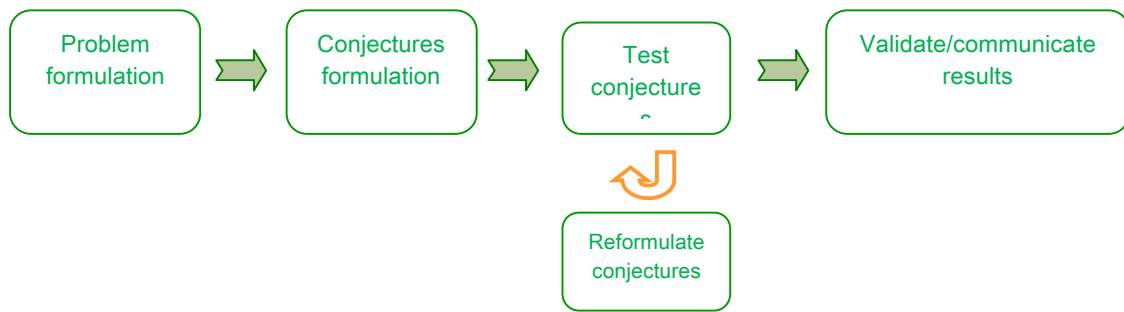


Figure 3 - Diverse approach of a mathematical research.

The different types of tasks are related to each other although it is not easy to distinguish them. Ponte [11] also emphasizes that a certain task can be at the same time an exploration or an exercise, independently of the level of knowledge of each student.

Considering the mathematical scientific field, the different types of research tasks help and enable students towards a better understanding of mathematics issues, challenging them to renew and to innovate their mathematical ideas, motivating them to further researches, to design new strategies and to develop their way of thinking.

One aspect of utmost importance regarding the scholar role is the differentiation of the several tasks, which are recommended to the students, related to the nature and the social environment in which the academic institution and the student are inserted. Thus, the students can realize the application of mathematics in their social context. The scholar should propose to the students, tasks that encourage them to discover new mathematical results, looking for solutions that they can perceive what they are doing and why are they doing that, motivating them in order to have a special taste for this subject.

According to the same reference, Ponte [11] emphasizes that, in addition to the diversity of the research tasks to be proposed to the students by the scholar, they must have a logical and organized sequence in order to allow the students to duly acquire mathematical concepts, to understand the used methods and formulas, knowing how to relate them properly.

In this way, there is the necessity of applying the investigative tasks in the classrooms, allowing the students by themselves to look and to try to find the right solutions, understanding how mathematics is constructed.

In summary, given that the mathematics is mainly learned by practicing and not simply by looking at concepts, the research tasks strongly contribute to the learning process of mathematics.

Authors such as Braumann and Hadamard (cited by [13]) are showing how important is to engage the students in the research tasks. Research assignments advance students and create a more developed way of thinking, awakens them with an innovative and correct mathematical way of looking and thinking in methodological terms.

In civil engineering domain or in other research fields where mathematics is part of the contents, to carry out an investigation requires to take into account various steps and assumptions. In this terms there are some references [13] suggesting the need of considering four key moments, in the process of execution of a mathematical investigation, which are the following listed below.

The first aspect covers the recognition of the situation, which is the preliminary exploration and the formulation of questions. The second moment refers to the process of formulating conjectures. The third phase includes testing and possible rephrasing of conjectures. The latter refers to argumentation, demonstration and evaluation of the work done during this process.

In this process, the scholar needs to plan the classes contents, for each phase of the research subject. In this regard, Ponte [10] says that the scholar can plan the beginning of the investigation, but the end cannot be planned. About this idea some authors [13] are arguing that the development of a research class can be done in the three following stages: (i) introduction of the task, (ii) research, (iii) discussion of the results. However, there are several ways to complete these stages depending on the options of the scholar and the skills of the student.

4. Conclusions

This article has tried to show that the methodological approach of scholars in the domain of mathematics must ensure that whole students in the classroom are in tune, perceiving the meaning and purposes of each research task. The scholar has the role of explaining to students in a subjective way what should be done in each research task, allowing them to find an objective conclusion regarding each task. The teacher should be able to find strategies in order to motivate the students to carry out the research tasks, giving some details of how the students should proceed, without showing them the final solution, which must be found by the students.

Among other aspects, such as the student engagement or the scholar skills, in the learning process, the success of a classroom focused on a research topic is related to the familiarity and harmony of students regarding the presented contents of each research task. The scholar should be able to listen, to validate and to include in the tasks contents, whenever is possible, the point of view and the opinions presented by each student, stimulating them to a healthy discussion, considering their backgrounds, skills, or previous knowledges. During this activity, the scholar has the role of a moderator, a referee, understanding the difficulties and the evolutions of the students, in the learning process.

Finally, as this article is intending to show the research process framework has several tasks which are the same despite of the particularity of the subject. Both analysed scientific domains, the urban planning and the mathematics have as research process requirement, a starting point based on the problem formulation or identification. In parallel they both have as the expected final point the systematization of the solution.

However, if in the case of the mathematics research field the identification of the solution usually means the end of the process, in the urban planning field this final step of the research is at the same time another starting point, which corresponds to transferring the proposed strategies to the territorial reality. Consequently, the application of the solutions to a case study area, will contribute to foster a monitoring process of the previous proposals, adjusting and adapting the proposed strategies.

5. Acknowledgements

This work was supported in part by FCT - Portuguese Foundation for Science and Technology through the C-MADE, Centre of Materials & Building Technologies and through the Center of Mathematics and Applications of University of Beira Interior, within project UID/MAT/00212/2013.

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