Geografía y Sistemas de Información Geográfica (GEOSIG). Revista digital del Programa de Docencia e Investigación en Sistemas de Información Geográfica (PRODISIG). Universidad Nacional de Luján, Argentina.

http://www.revistageosig.wixsite.com/geosig (ISSN 1852-8031)

Luján, Año 13, Número 21, 2021, Sección II: Metodología. pp. 1-16

ASSESSMENT OF PERCEPTION OF A SCHEMATIC REPRESENTATION OF AN INDOOR ENVIRONMENT WITH DISTINCT VISUAL LEVELS

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ABSTRACT

This study aims to understand the perceptions of users in relation to schematic representations of indoor environments built designed pictorial symbols combined with geometric symbols. The employment of distinct symbologies aims to create different visual levels, highlighting the elements of the environment that are used as reference points in orientation and navigation tasks. To determine how this type of representation stimulates users' acquisition of spatial knowledge, tests were conducted by means of basic map-reading tasks, which involved detecting, differentiating, and recognizing symbols. The tests indicated that the pictorial point symbols were the ones that were noted most by the participants, as well as geometric symbols present in clusters.

Keywords: Schematic map, Indoor environment, Visual hierarchy, Symbology, Perception.

RESUMEN

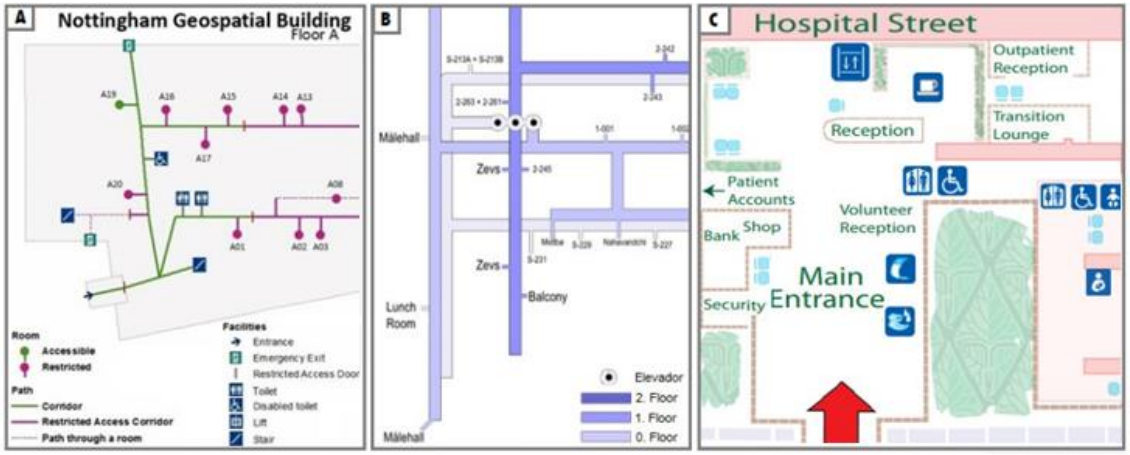
El presente estudio busca comprender la percepción de los usuarios en relación a representaciones esquemáticas de ambientes interiores diseñados con simbología pictórica combinada con simbología geométrica. El uso de diferentes simbologías tiene como objetivo crear diferentes niveles visuales, destacando los elementos del entorno que se utilizan como puntos de referencia en las tareas de orientación y navegación. Para determinar cómo este tipo de representación estimula la adquisición de conocimiento espacial por parte de los usuarios, se realizaron pruebas mediante tareas de lectura de mapas a nivel elemental, que involucraron detección, discriminación y reconocimiento de símbolos. Las pruebas mostraron que los símbolos de puntos pictóricos fueron los más notados por los participantes, así como los símbolos geométricos presentes en grupos.

Palabras claves: Mapa esquemático, Ambiente interior, Jerarquía visual, Simbología, Percepción.

INTRODUCTION

The ease of access to geospatial data through mobile devices, together with the growth in the use of this type of data, contributes to the emergence and increase in applications geared toward indoor mapping (Potigieter, 2015). The applications developed aim to help users understand the environment, as people generally feel disorientated in unknown or complex indoor environments (Si & Arikawa, 2015). To provide more convenient experiences for their customers and users, companies responsible for managing large environments, such as shopping malls and airports, have been building their own indoor mapping applications. Due to the diversity of elements and possible configurations for these environments, there is no universal solution about your representation (Gai & Wang, 2015), especially considering questions related to symbology. An indoor environment can be represented through schematic maps, which are linear abstractions designed to convey only the most important information about the environment. Due to their inherent simplicity and symbolic meaning, schematic maps facilitate the visual interaction with the user, since by highlighting only relevant aspects of the environment, interpretation of them is facilitated (Avelar, 2002). Studies geared toward the schematic mapping of indoor environments present different forms of representation. For example, Delazari *et al*. (2014) highlights the reference points present in the environment through the employment of pictorial point symbols (Figure 1A). Nossum (2013) uses variations in the size of room labels to highlight their importance, and so rooms with bigger labels have a greater level of importance (Figure 1B). Ryder (2015) creates a representation (Figure 1C) with different levels of visual hierarchy, employing pictorial point symbols with a blue background for the main reference points and with no background for the auxiliary reference points.

Figure 1. Schematic maps of indoor environments



Source: Adapted from: A - Delazari et al. (2014); B - Nossum (2013); C - Ryder (2015)

Despite the authors cited presenting different forms of representation, it is possible to note that all have in common the intention to create different visual levels by highlighting the elements they judge to be most important in the environment, such as reference points. These points are important to help the user understand and acquire

knowledge about the environment, since they support initial orientation in an unknown environment and are essential for navigation. In addition, the reference points help to develop the user's confidence when following a route, since by finding in the real environment the reference points indicated on a map, they can certify that they are following the expected path (Klippel & Winter, 2005; Vinson, 1999). Landmarks guide pedestrians and have a major impact on the efficiency of user interactions and the discovery of environments (Bauer & Ludwig, 2019) However, a map design often restricts the set of strategies that can be used to understand and communicate spatial information (Krukar *et al.*, 2020). Therefore, it is necessary to understand what is the best way to represent and highlight elements as important as the reference points. According to Sarot & Delazari (2020), indoor cartography has not received much attention despite the growth in this sector of mapping market. However, research indicates that there is a direct influence of symbology on spatial orientation and navigation process. In addition, the use of pictorial symbology can be an alternative to provide user with additional information to the decision-making process (Sarot & Delazari, 2018); (Antunes & Delazari, 2019).

In light of the above, the aim of this study is to analyze how perceptions occur of a schematic representation of an indoor environment with different visual levels, so that a representation helps user and minimizes problems related to spatial orientation and navigation process in indoor environment. It is important to understand the cognitive processes that involve use of maps and symbolism employed by user, as these elements serve to create and maintain integrated representations of space and, therefore, can provide a basis for finding successful paths and giving sense steering. These findings are essential to help people find their way efficiently, especially when time is a critical factor such as in emergency situations (Hund, 2016). Therefore, this study has practical implications for the design of schematic representations of indoor environments.

For this study, a schematic representation was generated with different visual levels to symbolize reference points, in a different way from the other elements of the map. For that, pictorial and geometric symbols were used. With this, it is expected to obtain information to guide efficient cartographic projects for purposes of orientation and navigation in indoor environments.

THEORETICAL FRAMEWORK

According to Toutziaris (2017), there are various ways of representing an internal environment, for example through the use of architectural blueprints; however, they contain a lot of information that overwhelms the user, as they were not created with the aim of navigation. Other representations are geared toward indoor navigation, for example "You Are Here" (YAH) maps, which have a conservative design, as they generally follow the guidelines of some entity or authority. The environment can also be represented by simplified architectural blueprints, which preserve the format of the environments and other non-relevant information, such as windows, is removed. Another form of representation is schematic maps, generally used in subway line representations, in which the features are simplified, passageways become lines, and the environments become points.

According to Bauer & Ludwig (2019), schematic maps are an adequate and efficient alternative for displaying location and path information. In addition, the simplicity of its representation is considered a positive point (Delazari *et al*., 2014). Schematic maps also have advantage of a simplified cartographic representation, which can be used mainly in indoor navigation systems and other location-based service applications (LBS). It can also be useful in support systems for facility management and various types of geographic information systems (GIS) (Gotlib *et al.*, 2020). In contrast, a use of more detailed maps makes user dedicate more visual attention to instructions, resulting in a greater amount of time spent on orientation task. (Bauer & Ludwig, 2019)

According to Gotlib *et al*. (2020), users need an accessible interpretation of content presented. Therefore, the cartographic methodology employed must enable effective transfer of information about space to unqualified user. The methodology includes, among other things, the principles of cartographic generalization, presentation of data at various scales, the use of graphs known conventions, or appropriate use of visual variables (Gotlib et al, 2020). Independently of the representation method developed, the symbology in these maps has a specific purpose, which is to help in navigation and enable the right extraction of information about the environment, making it possible for the map's user to adequately correlate the representation with the real world. Moreover, the symbology should enable the user to identify their location, estimate relative positions and distances, and develop knowledge about reference points and routes (Schmidt & Delazari, 2013).

The human visual-cognitive system is employed to perform map reading, in which the visual part is responsible for receiving information, by differentiating and detecting the symbology. The cognitive part is responsible for processing, decodifying, and storing the information (Santil, 2008). Thus, the perception of the map depends on the visual perception process and on other factors, including the nature, scale, and content of the map, the degree of complexity, and the conformity of the language of the map with cartographic principles (Żyskoswska, 2017; Żyskoswska, 2016). So that there is a quick informational exchange, it is necessary for the assessment of the map to be carried out correctly. With the aim of accompanying the need to convey information to specific audiences and achieve a particular objective, the formulation of suitable cartographic language is fundamental, correctly employing characteristics such as brightness, size, color, orientation, contrast, and spatial frequency (Żyskoswska, 2016). Thus, depending on how the visual variables are combined, it is possible to attract a user's selective attention, stimulating the selection of resources or objects, as well as their being recorded in the short-term memory. To create visual levels, variables can be used such as position, shade, saturation, and value, in order to make the objects visually prominent (Schmidt & Delazari, 2013).

MATERIALS AND METHODS

In order to carry out the tests, a test was prepared using a map produced in the QGIS software. The study area belonged to the Polytechnic Center Campus of the Federal University of Paraná. This was chosen as it is a complex environment with various spaces, and for which an efficient representation can help the orientation and navigation of people who frequent the environment, such as students, teachers, workers, and visitors, who circulate daily within the premises of the University.

Classification of Features

Antunes & Delazari (2019) identified that a study area contains 17 different types of features, such as classrooms, laboratories, and offices, among others (Table 1). In the study by Antunes & Delazari (2019), it was found that elements such as restrooms, stairwells, elevators, libraries, and commerce are considered as reference points. The features present in the study area were classified according to the similarly of their meanings. Therefore, eight classes were created, these being: teaching environment, administrative use, commerce, restroom, teachers' room, common use, vertical transportation, and others. Taking into account that within a same class no element should have greater representativeness than the other elements, the library, despite qualifying as a teaching environment, was defined as an exclusive class, called common use. The classes are described below:

Table 1. Classification of the features of the study area

Type	Class	Feature	Description
Environment	Teaching environment	Auditorium, Classroom, Study room, Laboratory, Museum, Academic administration	Places were classes and lectures are given, where one can study, and which enable the development of the student's capacity, through the exchange of experiences.
	Administrative use	Secretariat, Coordination	Environments that can provide support or help to the students through administrative tools.
	Teachers' rooms	Teachers' offices	Composed of teachers' rooms.
	Others	No information, exits	Environments that do not fit into the other categories, such as exits.
Reference Point	Commerce	Canteen, Stationer's, Restaurant	Places that are related with the sale of products.
	Restroom	Restroom (Male/Female/Mixed)	All the sanitary installations.
	Vertical transportation	Elevator, stairwell	Elements that enable movement between floors.
	Common use	Library	Common use area for students

Source: Own elaboration.

Proposed Symbology

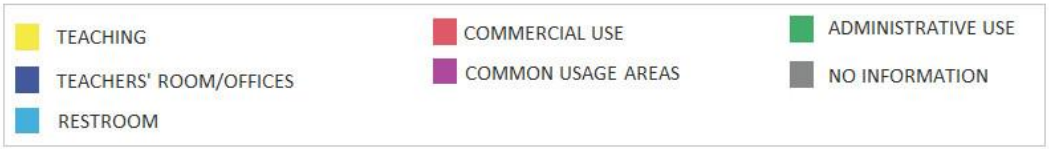
In this study, the map information is represented by two types of symbols:

Pictorial symbols: these were developed in black and refer to the reference points in the environment. All have a similar optical weight and are easy to associate with the elements represented, as Andrade & Sluter (2012) report that the understanding of a map is affected by the semantic relationships contained in the symbols. In addition, the optical weight, balance, visual organization, and borders affect the strength of the symbol's contrast.

Geometric symbols: these are represented with the same circular geometric form, however with a different shade and the same brightness, so that there are no visual levels between them.

The pictorial and geometric point symbology employed in this research was based on the work of Sarot & Delazari (2020), who developed point symbols geared toward indoor environments based on the Standardized Graphic Symbology developed by the International Organization for Standardization (ISO) and on the Tourist Symbology Manual. Moreover, Sarot & Delazari (2020) carried out tests to analyze the users' perception in relation to the association of colors employed in the symbology with particular indoor environments. For example, the users associated blue shading with restrooms and yellow with teaching. The results obtained are presented in figure 2.

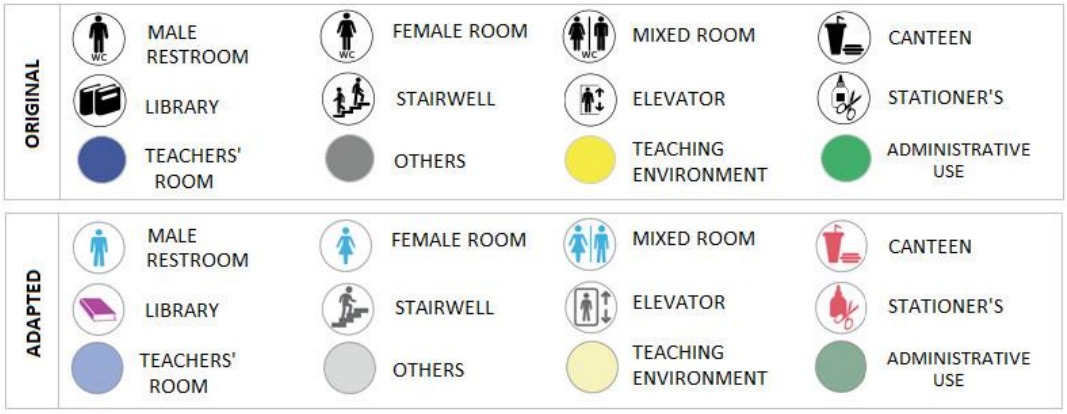
Figure 2. Colors and associations with the indoor environment



Source: Adapted from Sarot (2017).

The original symbols created by Sarot & Delazari (2020) and adapted for this study are presented in Figure 3. As can be seen, the restroom symbols were simplified and the textual information was removed, to avoid it becoming illegible depending on the scale of the text. The library, stairwell, elevator, and stationer's symbols were altered so that they had the same optical weight. Initially, all the pictorial symbols were black and in the adapted version they were represented with different colors. The colors employed in the pictorial and geometric symbols are the same ones determined by Sarot & Delazari (2020); however, the colors employed in the geometric symbols underwent an alteration in relation to saturation with the aim of making these elements stand out less. The employment of color contrasts can be useful in the creation of a visual hierarchy in maps, and according to Dent (1993) it is the most important element in the design of a thematic map, since it can lead to clarity, to legibility, and to figure-ground formation. Graphic differentiation can be obtained through shade contrast, saturation contrast, complementary color contrast, and by contrasting hot and cold colors (Dent, 1993).

Figure 3. Pictorial and geometric point symbols



Source: Adapted from Sarot and Delazari (2020).

The pictorial point symbols were used to illustrate the reference points, as according to Fiori & Almeida (2005), these representations present as an advantage the possibility of generating an image that is closer to reality, providing the user with a quicker and more pleasant understanding of the information. However, that only occurs if there is a semantic relationship between the symbol and the object it refers to, since if there is no communication it becomes invalid or misunderstood. The colors were used in these symbols so that elements of the same class had the same color, with the aim of facilitating the identification of similar elements. For example, female and male restrooms are represented in blue. The other classes were represented by circular geometric symbols, with no similarity with the phenomenon represented and with a high degree of abstraction. This means the user has to resort to the key to decodify the information presented (Fiori and Almeida 2005). According to Forrest & Castner (1998), point symbols that have a border are located more quickly. For that reason, the symbols developed have circular borders in gray, with a black background, since according to Fiori & Almeida (2005) this makes the symbols stand out in relation to the map's background, making them visually clearer.

User Tests

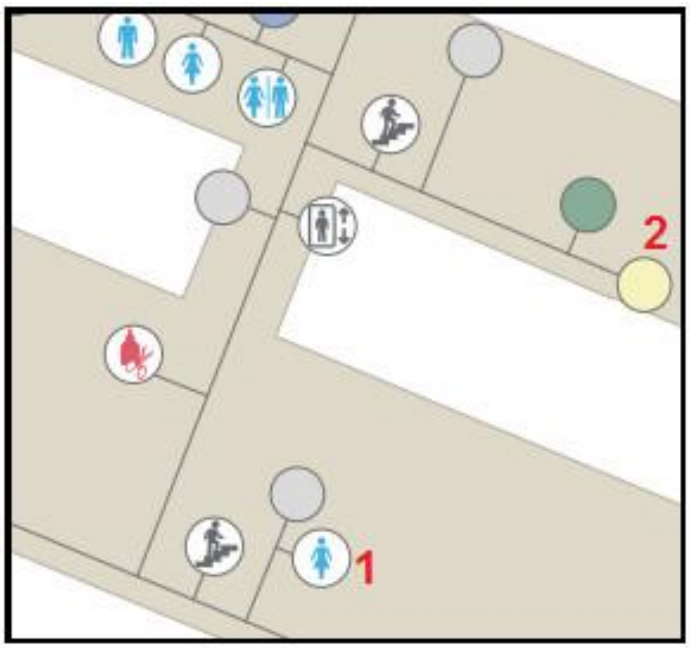
An online questionnaire composed of three sections was developed and applied to 30 participants. The first section is composed of the term of agreement, in which all the guarantees and conditions given to the participant in the execution of the test were presented. The second section is related with the characterization of the user, with questions such as age, gender, academic training, and if the participant is in the habit of using maps in their day-to-day, since not regularly using maps may imply abstraction difficulties and consequently greater difficulty in understanding the map (Sarot & Delazari, 2018). It was also asked whether the participants know the study area, as knowing the environment could influence their answers. The third and final section consisted of the tasks and at the end of that section an open-answer field was included so that the participants could leave their thoughts, if they wished. The maps employed in this research were produced to be seen in a digital environment and made available online together with the questionnaire, that could be answered via desktop or mobile. With the aim of facilitating the visualization of the maps made available and so they could be amplified.

Tasks

Three tasks were carried out, the first two of which involved detecting symbols directly from the map, which was made available online, 15x18cm in size. The last task involved short-term memory, which was carried out without the help of the map.

Task 1 consisted of looking at the map, with no time limitation, and indicating which two symbols most attracted the user's attention. Task 2 consisted of describing a path between two pre-established reference points, as if explaining to someone who does not know the environment. An example of how to carry out the description was given according to Figure 4. For example, to go from point 1 to point 2, one possible description would be: "Leaving the female restroom (1), you should turn left, and then right. After the stairwell, turn right again, go straight, and after the elevator turn right. After passing a room for administrative use, at the end of the corridor you will find the teaching environment (2)."

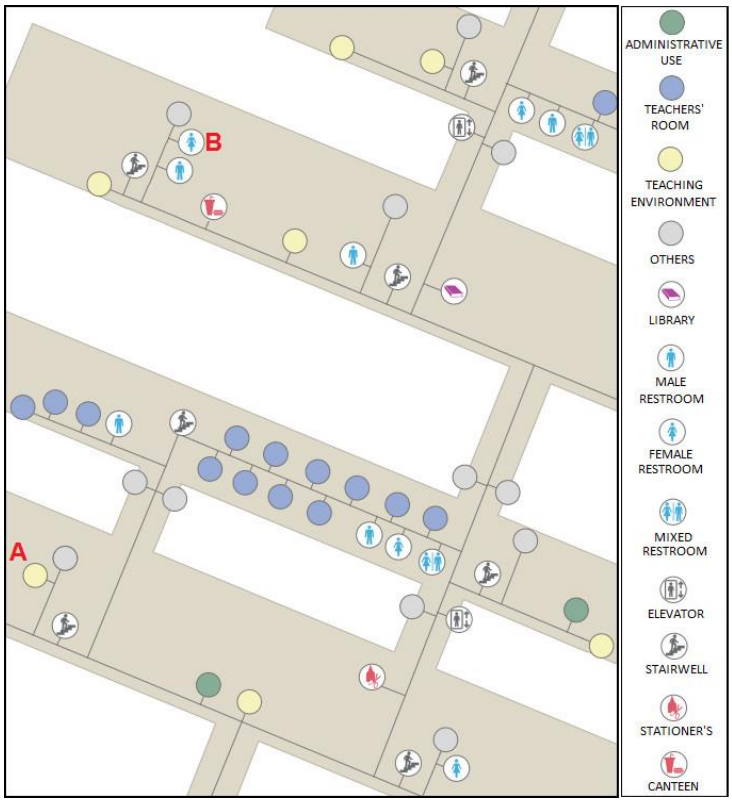
Figure 4. Example of the route description task



Source: Own elaboration.

Task 3 consisted of describing all the symbols that the participant remembered, and that task was carried out without using the map. The map employed in tasks 1 and 2 is presented in Figure 5.

Figure 5. Schematic representation of indoor environment used in tests 1 and 2



Source: Own elaboration.

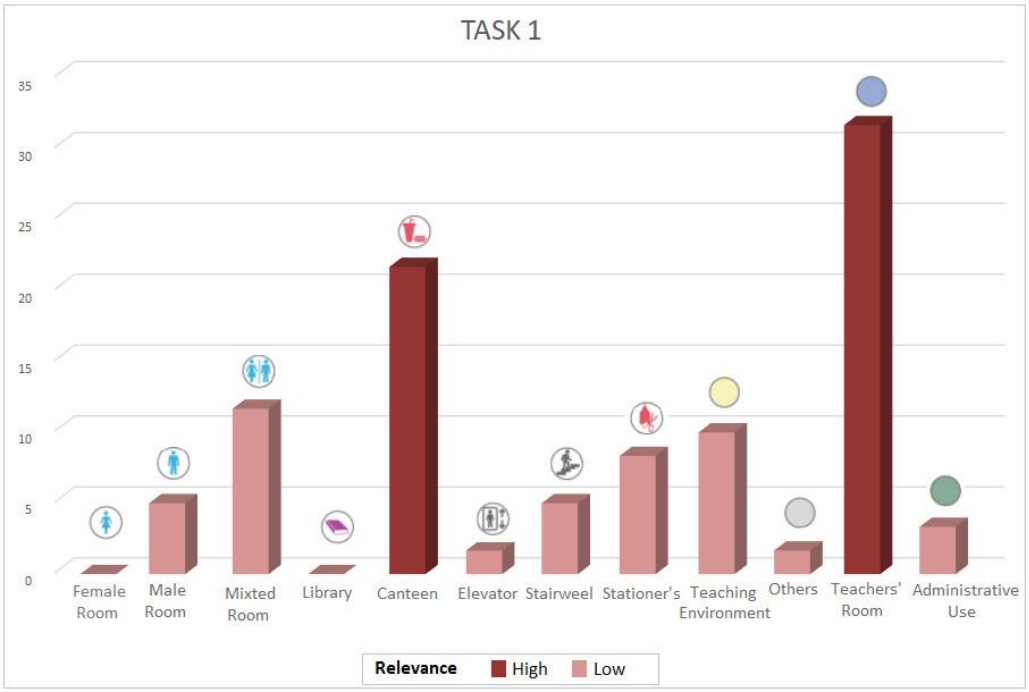
Therefore, the users' answers are obtained in different ways: in task 1 through a direct question; in task 2 the elements that stand out are obtained indirectly through the elements mentioned in the route, and in task 3 through the description based on the participants' memory. Despite the tasks being elaborated in different ways, all have the same objective: to provide information for understanding which elements really stand out and how the user's perception occurs.

Visual perception involves neurosensory processes, involving the eye and short-term memory. As such, they operate independently of the spectator's consciousness and significantly influence the information received by the user of the map (Żyskoswska, 2016).

RESULTS

In task 1, each one of the 30 participants indicated the two symbols that most drew their attention. Among the 60 answers obtained, it was found that for 32% of the users the symbols described corresponded to the teachers' rooms class as being the most perceived and in second place with 22% was the canteen. Figure 6 presents all the percentages obtained for each symbol in task 1. Female restroom and library were not mentioned by any of the participants.

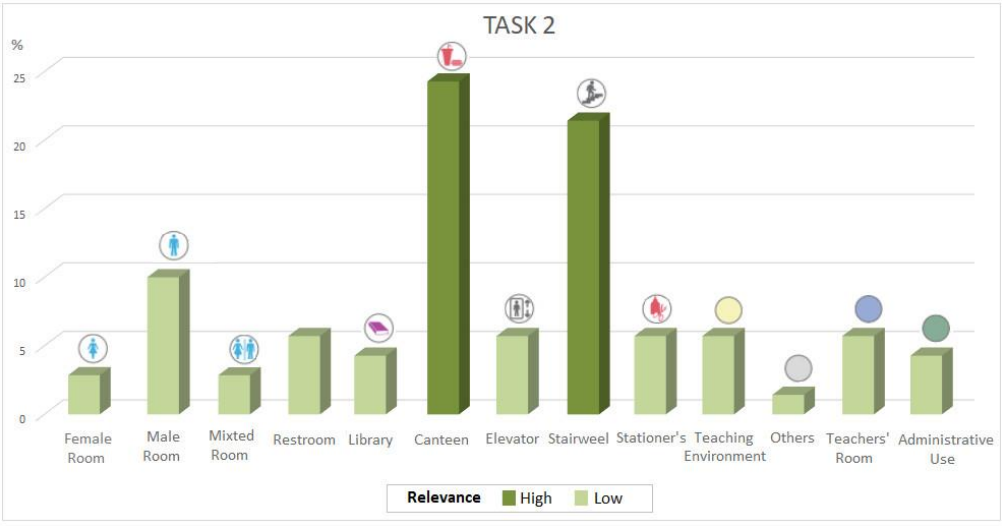
Figure 6. Most attractive symbols



Source: Own elaboration.

In task 2, which consisted of describing the route between points A and B, 70 symbols were mentioned, including 4 restrooms that were mentioned with no differentiation of type, whether female, male, or mixed. In this task, five participants reported their descriptions without using symbols, using only indicative descriptions of direction (right and left) and counting corridors. The symbols most mentioned in the route descriptions were canteen and stairwell with 24% and 21%, respectively. Figure 7 presents all the percentages obtained for each symbol, where the initial elements A (teaching environment) and B (female restroom) were not counted when mentioned by the participant.

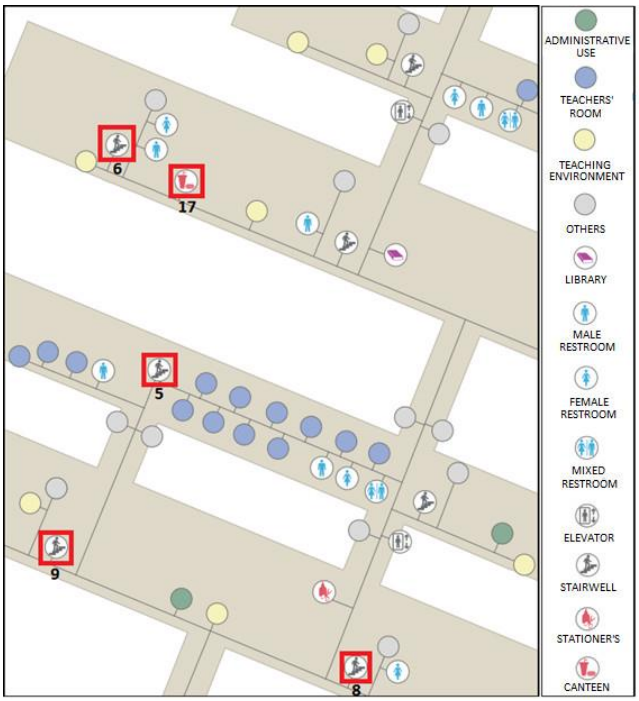
Figure 7. Most cited symbols



Source: Own elaboration.

This task enabled the location of the elements that were mentioned most as reference points to be spatialized and identified. Figure 8 presents those features as well as the number of times that they were mentioned. In the route description task and indirect obtainment, the pictorial symbols were the ones most mentioned. In general, in that task it can be perceived that the pictorial point symbols are the most noted, since they were mentioned 116 times; the geometric symbols were only mentioned 36 times.

Figure 8. Environments most mentioned in task 2

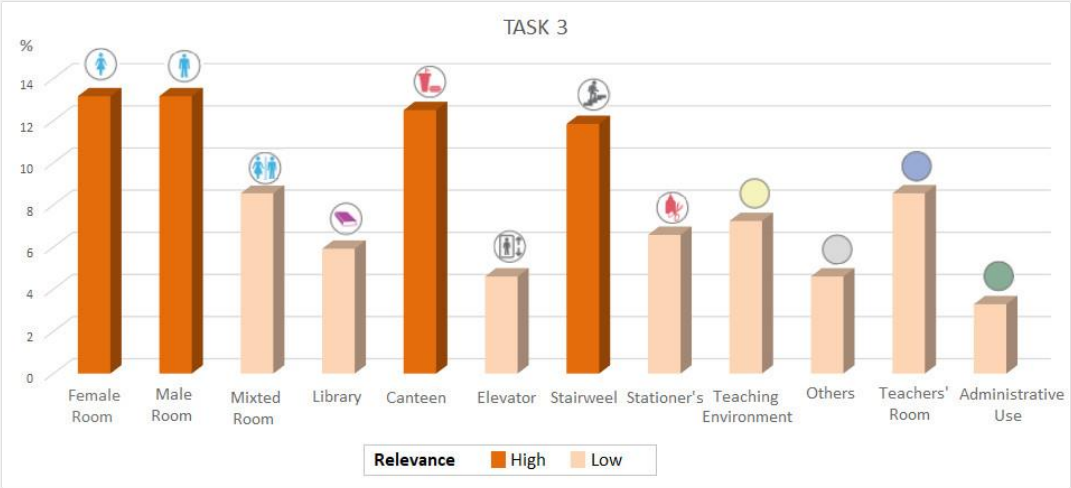


Source: Own elaboration.

Sarot & Delazari (2020) analyzed the symbology preference on the part of the users and employed in the tests a map that contained black pictorial symbols for the most important elements of the environment; the other environments were symbolized by texts. By employing a similar test to the one applied in this research, which consisted of the route description, Sarot & Delazari's (2020) results indicated that pictorial symbols that appear with greater frequency on the map are more noted than others that have the same function but appear in lesser quantity on the map. For example, stairs and elevators perform the function of movement between floors, but the stairs were mentioned more times both in this research and in that of Sarot & Delazari (2020).

In task 3, of the 152 symbols recorded by the 30 participants, the most mentioned ones were male restroom, female restroom, and canteen, which were equally mentioned by 13%, and stairwell, which was mentioned by 12%. Therefore, these elements are the most mentioned among the other elements presented in Figure 9. Thus, the memory task also shows that the pictorial point symbols are more easily remembered, with the four most mentioned elements in this task being pictorial.

Figure 9. Most remembered symbols



Source: Own elaboration.

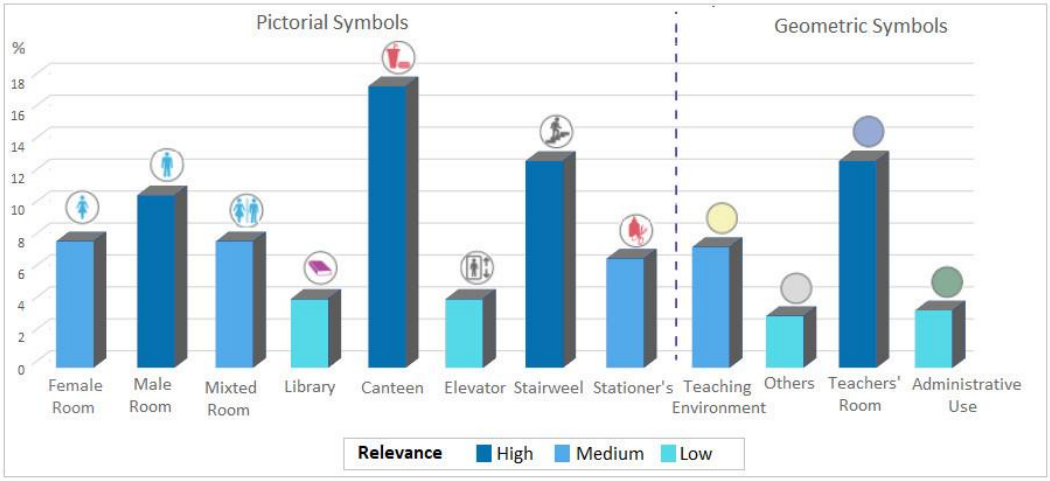
Adding up all the answers obtained in the three tasks executed, 278 symbols were mentioned, 202 of which were pictorial and 76 geometric, therefore 73% of the most noted symbols on the map presented are pictorial.

Based on these results, we can conclude that the pictorial symbols stood out in relation to the geometric ones, thus creating a visual hierarchy and, thus, they can be used in combination when the wish is to emphasize only certain environments of interest.

In the final analysis of the results, it is noted that the pictorial symbol that represents the canteen is the most seen element, with it standing out in all the tasks. The location of the symbol and the color may explain its prominence in relation to the others, since red draws more attention (Bertin, 1986). According to Andrade & Sluter (2012), the symbols that are read first by users are generally positioned at the top part of the map in relation to the optical and geometric center, which is where the canteen symbol is found.

Analyzing the results obtained in all the tasks together (Figure 10), it is concluded that the most mentioned elements were “canteen,” “stairs,” and “restrooms,” which are pictorial, and “teachers’ rooms,” which has a geometric representation. The least mentioned ones were the “others,” “administrative use,” “library,” and “elevator” class.

Figure 10. Integrated result of all the tasks



Source: Own elaboration.

FINAL CONSIDERATIONS

MacEachren (1995) recognizes the need to employ multiple map-reading and analysis tasks to analyze the effectiveness of a map, since using a single criterion may not successfully reflect perceptions of the information on the map. It was observed in this study, through the results obtained, that different tasks can result in different answers. For example, in the direct indication task, the geometric point symbols of the teachers' room class stood out, due to the cluster created by these symbols. According to Andrade & Sluter (2012), cluster refers to the perceptive combination of similar elements whether due to proximity or similarity, which is the case that occurs with the symbols from the teachers' rooms class.

But the pictorial symbols were the ones that were most mentioned in the tests, therefore it is concluded that pictorial symbols are seen first, since they are easy to decodify and remember when compared with geometric symbols, which in turn are hard to decodify, requiring constant consultations of the map's key. However, the layout and location of the symbols may make a particular element stand out more than others.

Therefore, the hypothesis raised in this study was verified, as pictorial symbols used in the representation together with geometric symbols generated a visual hierarchy, and the pictorial symbols were the ones that drew most attention and were retained in the participants' memories. We thus conclude that the combined use of different symbologies is an efficient technique and should be employed only when there is the need to highlight particular elements.

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Recibido: 17 de marzo de 2021

Aceptado: 6 de julio de 2021