
ARTÍCULOS / ARTICLES

URBAN GEOGRAPHY EDUCATION AND GEOSPATIAL TECHNOLOGIES: STORYMAPS FOR PARTICIPATORY DESIGN LEARNING

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Abstract: Participatory design is defined as “a democratic process of lifelong learning, in which participants acquire knowledge about themselves, but also about the values and opinions of other participants” (Giaoutzi and Stratigea, 2011).

The methodology uses a quasi-experimental design to assess competencies (spatial, civic and digital thinking) before and after the intervention in the same subjects. Student’s t-test is applied for samples matched with SPSS to determine if there are significant differences between pre- and post-intervention. The size of the effect is measured with Cohen’s d. The sample is two hundred and forty-five students between the ages of 14 and 15 years of 3rd year of Secondary Education in Spain. This Student’s t-test shows a significant increase in the acquisition of the competencies assessed, with a large effect size according to Cohen’s d.

This study shows that the intervention based on participatory design, with the use of geotechnologies and story maps, significantly improves the acquisition and development of competencies in Geography students at this educational level. The results validate the hypothesis that participatory design enhances the use of geotechnologies and story maps in teaching-learning processes.

Key words: spatial thinking, story map, geospatial citizen science, spatial citizenship, participatory design.

EDUCACIÓN EN GEOGRAFÍA URBANA Y TECNOLOGÍAS GEOESPACIALES: STORYMAPS PARA EL APRENDIZAJE DEL DISEÑO PARTICIPATIVO

Resumen: El diseño participativo se define como “un proceso democrático de aprendizaje permanente, en el que los participantes adquieren conocimientos sobre sí mismos, pero también sobre los valores y opiniones de otros participantes” (Giaoutzi y Stratigea, 2011).

La metodología emplea un diseño cuasiexperimental para evaluar las competencias (pensamiento espacial, ciudadana y digitales) antes y después de la intervención en los mismos sujetos. Se aplica la prueba t de Student para muestras emparejadas con SPSS para determinar si hay diferencias significativas pre y post-intervención. El tamaño del efecto se mide con la d de Cohen. La muestra es de doscientos cuarenta y cinco estudiantes de edades comprendidas entre los 14 y 15 años de 3º de Educación Secundaria en España. Dicha prueba t de Student muestra un aumento significativo en la adquisición de las competencias evaluadas, con un tamaño del efecto grande según la medida de Cohen’s d.

Este estudio demuestra que la intervención basada en diseño participativo, con el empleo de geotecnologías y story maps, mejora significativamente la adquisición y desarrollo de las competencias en los estudiantes de Geografía de dicho nivel educativo. Los resultados validan la hipótesis de que el diseño participativo potencia el empleo de geotecnologías y de story maps en los procesos de enseñanza-aprendizaje.

Palabras Clave: pensamiento espacial, storymap, ciencia ciudadana geoespacial, ciudadanía espacial, diseño participativo.

1. INTRODUCTION

To enhance education and equip students with relevant skills for the 21st century, innovative technologies are necessary to provide an active and meaningful learning experience beyond theoretical knowledge. In this context, participatory design emerges as a powerful teaching strategy. Geotechnologies, such as GIS tools, and interactive story maps engage secondary school students in real-world exploration and analysis.

Designing learning experiences relevant and close to the student's environment, specifically in urban places, is an opportunity to actively involve students in the understanding and transformation of their environment. De Miguel González (2023) states that these classroom experiences contribute significantly to the development of competencies, particularly those related to geography and citizen participation.

From this perspective, the city becomes a natural laboratory where students can explore and apply geospatial knowledge in tangible ways, although the contribution of local learning processes in urban living labs to system-wide sustainability transformations is thus far less than expected (Scholl et al., 2022). In addition, participating in participatory design projects not only strengthens students' digital skills, but also promotes their ability to critically interact with their environment and actively contribute to the improvement of the local community (Ayala García, 2017).

The main objective of the proposed study is to investigate how an educational intervention based on participatory design, together with the use of geotechnologies and story maps, can positively influence the acquisition and development of geospatial, civic and digital skills in secondary school students.

This research not only seeks to demonstrate the effectiveness of this innovative methodology, but also to provide concrete evidence on how it can transform the educational process, making it more relevant, participatory, and aligned with the needs and realities of students and their community. In this way, the integration of participatory design with geospatial technologies and story maps not only promises to improve geography teaching and skills acquisition but also has the potential to empower students to become informed, critical, and engaged citizens of their socioeconomic and environmental environment on a "glocal" scale (Murga-Menoyo, 2015; 2020).

2. STATE OF THE ART

2.1. Participatory design as an innovative approach

Participatory design is an innovative pedagogical strategy aligned with the principles of the Active School, in which it was stated that the student is the active agent of their own learning, while the teacher serves as a mere guide and facilitator in the teaching-learning process.

Participatory design seeks to involve various actors, such as students, teachers, local communities and public administration, in a process of planning and designing spaces, both school (understood as those internal to the educational centre), and external and close to the educational centres, with the aim of creating friendly, inclusive, functional environments adapted to the real needs of those who use them. This is reflected in statements by companies that are experts in participatory design (Urban Dream Management, n.d.), which carried out the participatory design methodology in the city of Helsinki:

We believe cities and buildings should be built for – and with – their users. Bringing citizens, entrepreneurs and different active groups to the core of a design or development project is essential for the rise of creativity and vitality and the sense of openness in a city. It is key to developing desirable and sustainable urban plans, buildings or services that serve their users' needs.

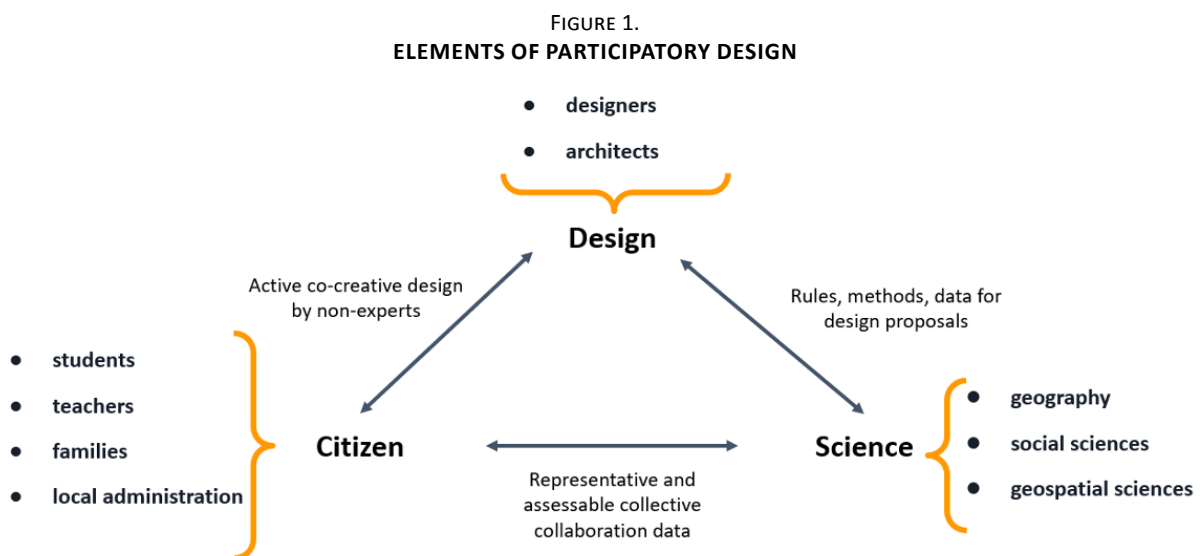
Participatory design is based on three axes (Clerc et al., 2019): political, educational and geographic.

a) Political. The political axis refers to the choice of a specific society to be able to carry out a process of citizen participation, in which "subjects who are aware of a specific social reality, who internalize and understand the particular dynamics of their context and from this position themselves as citizens, with criteria and decision-making power, to become participants in social action and transformation and

guarantors of general welfare” (García Rodríguez & González Hernández, 2014, p. 375). In this political axis, the subjects must share decisions and reach agreements, establishing more horizontal than vertical relationships between the different entities that are part of the participatory design process, and thus there will be a reduction in hierarchical effects and an elimination of relations of domination. In this way, the agreements reached will be stronger, more rigorous and more responsible in the environment in which they operate. In this way, experts in aesthetics and theories of the arts (Pelta, 2022) affirm that co-design or participatory design is a process of collective creation that incorporates end users or stakeholders in the design of a product or service, collaborating throughout the process with experts and professionals in the field to find the most appropriate solutions to the needs and problems detected.

- b) Educational. This axis refers to the methods used to design spaces in and around schools, as well as to the training that all agents of the participatory process must receive students, teachers, families, management teams, local administrations. The didactic approach is under the umbrella of the pedagogy of co-construction, it is not a transmissive pedagogy, focused on disciplinary knowledge, and therefore exclusive of other educational processes, which are in line with constructivism and connectivism, both current educational paradigms and those that have occurred in the twenty-first century. For this reason, the didactic methods will seek the recognition of the skills of each person involved in the teaching-learning process, based on the principles of active pedagogy, through specific techniques that have an objective to achieve and that serve all subjects of formative, experiential and active learning, so that concrete actions can be carried out in the spaces within the educational centres and their surroundings.
- c) Geographical. This axis refers to microgeography characterized by studying a specific place, using a small scale, observing the details of the social, spatial and cultural reality in interaction. In the existing literature, we find several studies (Dennis, 2021; Farmer et al., 2020; Natanel, 2016; Rousset, 2021) who have used this research method in different planetary realities and in different temporal contexts. This means a framework for the construction of geographical knowledge, to develop skills related to geographical science itself and all the agents involved to accept new views on social problems and to be able to propose possible solutions to these problems.

In short, participatory design methodology is based on three pillars: citizenship, design and science (Figure 1), involving students, families, teachers and local authorities in a process of co-creation of school spaces and their urban environment in which they are located and with which they maintain intense social and spatial interaction, with the aim of adapting them to the needs of citizens.



Source: Own elaboration based on Mueller et al. (2018).

2.2. The use of geotechnologies in Geography classrooms

Geography, together with scientific research in geographic education and geospatial science, allow us to use geographic information technologies for the geolocation, definition and development of educational interventions in urban spaces. The principles of participatory design are specified in the use of geotechnologies using tools, but also, they are accompanied by methods, techniques and procedures aimed at the management of geographic information.

Geotechnologies are a significant resource in the teaching-learning process of students in the last years of Primary and Secondary. They allow the visualization and understanding of data in its spatial context, facilitating the linking of the student's previous knowledge with real geographical locations, which helps students to better understand geographical concepts. These tools allow maps and geographic data (geodata) to be explored in an active and experiential way, which encourages the participation and commitment of students with their immediate environment. In addition, they develop a set of competencies related to spatial thinking, geographic understanding, and spatial citizenship (De Miguel González, 2023; Álvarez-Otero et al., 2024), as well as a set of valuable technical skills, such as the management of georeferenced data (Álvarez Otero, 2020), the ability to use GIS in the Cloud (Buzo Sánchez, 2016; Guallart Moreno et al., 2020; Milson, 2011), GPS and its use in fieldwork (Gómez-Ruiz et al., 2021), and other tools related to geospatial thinking (Fleming et al., 2021; López Escolano et al., 2021).

These skills fulfil the requirements of the labour market and are easily transferable to other disciplines that use data that includes the information about the location of the data, and they are called geodata. These tools promote the collection, analysis, interpretation and visualization of geodata, encouraging citizen science among students, bringing scientific methods closer to citizens and promoting active participation of society in scientific processes. And, therefore, being transferable to Geography classrooms at different educational levels.

The use of geotechnologies can help develop a global awareness of the challenges and problems that occur in different places around the world, allowing students to understand global phenomena that allow them to participate locally. Hence, experts speak of "acting locally, thinking globally" (Murga-Menoyo, 2015; 2020; Murga-Menoyo & Bautista-Cerro, 2023). It is also promoted by international organizations, such as the United Nations in relation to education for sustainability (Puertas-Aguilar et al., 2021).

2.3. Storymaps as an educational and scientific resource

In the contemporary context of communication worldwide, there is a profuse variety of modes and means for the transmission of information. This diversification not only encompasses the numerous existing modes of communication but also extends to the multiplicity of approaches and strategies used for the dissemination of scientific results. In addition, there is a heterogeneity in the use of resources for teaching in different academic disciplines.

Faced with this reality, story maps become an ideal tool to tell a story visually, using storytelling techniques and integrating visual elements, such as maps, images, videos, figures, tables, text and other resources that can be included in the selected tool. In this way, they are tools that allow you to create and share interactive digital narratives through the combination of the multiple resources mentioned. These digital and geographic stories offer an effective way to communicate geospatial information in an engaging way, and therefore, it can be used for various purposes, both educational and scientific.

Storymaps in Education are a resource that provides a new way of presenting information to students, in a visual and attractive way and can be used to explain geographical concepts in a more dynamic way with a more active and participatory learning process. They can be used as a didactic resource by the teacher, in the style of many visual presentation tools, and as a product to be delivered and designed by the students, promoting digital skills. Creating this interactive content allows them to express their ideas and better understand the topics covered. In this way, teachers can teach abstract and complex concepts that occur in the real world and help students to contextualize information and understand geographical phenomena in their multiple territorial contexts. They are also seen as a beneficial digital tool to facilitate teamwork, cooperation, and collaboration among students, creating stories that integrate the investigations of all members of the group or group-class. The creation of interactive maps within story maps provides the opportunity to explore geospatial datasets, which contributes to the acquisition of geospatial, holistic and systemic analysis competencies and the search and filtering of the data that is incorporated into these maps.

Storymaps serve the different scientific disciplines as true tools for data collection, analysis, interpretation and presentation of scientific results in a more dynamic, visual and attractive format for the scientific audience. The communication of the results in this novel format makes the data and its analysis better received by the scientific community and the public, with visual narratives, which can be documented in the development and process of scientific activity.

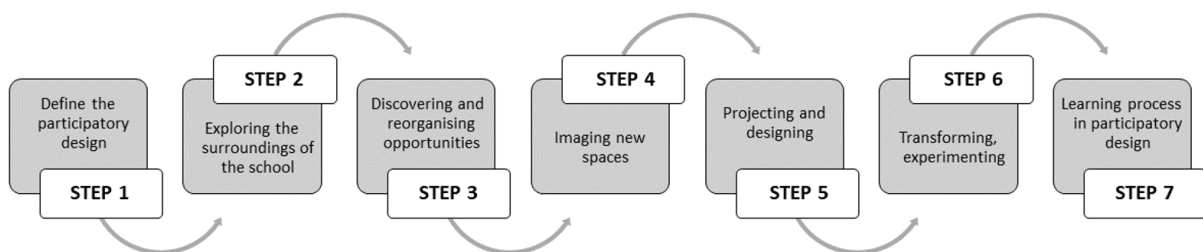
This dual purpose of storymaps has been reflected in different research in geography education and geography, with different themes: spatial thinking (De Miguel González et al., 2019), literature through digital cartography (De Lázaro Torres et al., 2023), the creation of didactic itineraries for teacher training (Martínez-Hernández et al., 2023), global change, (Leininger-Frézal et al., 2023), and even applied to other disciplines, such as archaeology (Pons Izquierdo et al., 2018) and literature (Buzo et al., 2023).

3. METHODOLOGY AND SAMPLE

The methodology is identified with the development of a quasi-experimental design based on the steps of participatory design approach. This approach involves the development of phases (Figure 2):

- 1) Define the participatory design. Students gain a commitment to learning and understanding concepts related to participatory design, using collaborative tools (Mentimeter, Jamboard).
- 2) Exploring the surroundings of the school. In this phase, they detect the needs of the spaces surrounding the school and possible novel changes in the spaces inside the school. To do this, they use Qfield to take the different points geolocated on a web map.
- 3) Discovering and reorganising opportunities. In this phase, they filter the collected data and organise the spatial solutions for the school surroundings in the same Qfield application.
- 4) Imagining new spaces. In this phase, they organising the needs of the possible new spaces inside the school, with the use of Padlet and Miro tools.
- 5) Projecting and designing. In this phase, they design the spaces providing innovative ideas with images of resources, materials, colours; including these solutions on the school's plans in the Miro tool.
- 6) Transforming, experimenting. Students record a video to document the learning process, with all the evidence they have produced from step 1 to step 5.
- 7) Learning process in participatory design. For this last step, students and teachers use ArcGIS StoryMap to create the learning story, from the detection of previous ideas on participatory design to possible spatial solutions for the school surroundings and on the school's own plans.

FIGURE 2.
STEPS OF PARTICIPATORY DESIGN



Source: Own elaboration.

In the intervention, the evaluation is carried out by teachers by assessing the following competencies: Spatial Thinking (STEM competence); Participation Social (Citizenship competence); DigComp: information and data literacy; DigComp: digital content creation; DigComp: communication and collaboration; DigComp: safety; and DigComp: problem solving, considering a descriptor for each of them (see Table 1); before (pre-test) and after (post-test) of the same subjects. Teachers evaluate each descriptor of each competence on a scale of 0 to 5 points, where 0 is not possessed or does not acquire it, and 5 is acquired in a very significant way.

TABLE 1.
DESCRIPTORS OF THE COMPETENCIES EVALUATED

Spatial Thinking (STEM competence)	Student learns how to understand and to reason about the spatial structures in and around the school.
Participation Social (Citizenship competence)	Student learns how to behave responsibly regarding digital participatory design.
DigComp: information and data literacy	Student learns how to check that the information they find online is reliable and accurate.
DigComp: digital content creation	Student learns how to create digital content.
DigComp: communication and collaboration	Student learns how to give credit to others' work they have found online.
DigComp: safety	Student learns how to behave safely online.
DigComp: problem solving	Student learns how to solve problems using digital technologies.

Source: Own elaboration.

4. RESULTS

To test this hypothesis, Student's t-test is performed for samples matched or related to the SPSS statistical program to the results observed by the teachers to check if there were significant differences before and after the intervention (pre-test and post-test). To check the effect size of the sample, Cohen's d is applied, which is interpreted as a negligible effect ($0.00 < 0.20$), small ($0.20 < 0.50$), medium ($0.5 < 0.80$) and large (0.80 or more) (Cohen, 1988).

The sample has been selected in a non-probabilistic way, consisting of 245 participants ($n=245$), students in the 3rd year of Secondary Education (ESO), aged between 14-15 years, and who have Geography as a compulsory area in the curriculum.

The alternative hypothesis (H1) is that the difference between the means of the competencies is different from 0 and the null hypothesis (H0) is the difference between the means is equal to 0. Since the computed p-value is less than the significance level $\alpha=0.05$, the null hypothesis is rejected (H0) and the alternative hypothesis is accepted (H1). The risk of rejecting the H0 null hypothesis when it is true is less than 0.01%.

A t-test of matched samples was performed to determine if there was a significant difference in competencies; and in this way, compare the scores of the competencies (Table 2): (a) Spatial Thinking (STEM competence); (b) Participation Social (Citizenship competence); (c) DigComp: information and data literacy; (d) DigComp: digital content creation; (e) DigComp: communication and collaboration; (f) DigComp: safety; and (g) DigComp: problem solving.

- a) We found statistically significant differences in Spatial Thinking (STEM) competence, where the pre-test scores ($M=2.12$; $SD=1.02$) were lower than post-test scores ($M=3.88$; $SD=0.92$); $t(244) = -21.27$, $p < .001$, $d=1.29$.
- b) We found statistically significant differences in the competence of Social Participation (Citizenship competence), where the pre-test scores ($M=2.06$; $SD=0.79$) were lower than post-test scores ($M=3.87$; $SD=0.86$); $t(244) = -26.90$, $p < .001$, $d=1.06$.
- c) We found statistically significant differences in the DigComp: information and data literacy competency, where the pre-test scores ($M=1.83$; $SD=0.57$) were lower than post-test scores ($M=3.84$; $SD=0.82$); $t(244) = -35.25$, $p < .001$, $d=0.89$.
- d) We found statistically significant differences in the DigComp: digital content creation competency, where the pre-test scores ($M=1.93$; $SD=0.56$) were lower than post-test scores ($M=4.00$; $SD=0.88$); $t(244) = -34.44$, $p < .001$, $d=0.94$.
- e) We found statistically significant differences in the DigComp: communication and collaboration competency, where the pre-test scores ($M=1.88$; $SD=0.59$) were lower than post-test scores ($M=3.76$; $SD=0.86$); $t(244) = -32.57$, $p < .001$, $d=0.90$.
- f) We found statistically significant differences in the DigComp: safety competence, where the pre-test scores ($M=1.85$; $SD=0.50$) were lower than post-test scores ($M=3.88$; $SD=0.86$); $t(244) = -34.32$, $p < .001$, $d=0.93$.
- g) We found statistically significant differences in the DigComp: problem solving competence, where the pre-test scores ($M=1.60$; $SD=0.57$) were lower than post-test scores ($M=4.00$; $SD=0.82$); $t(244) = -40.56$, $p < .001$, $d=0.93$.

TABLE 2.
COMPARISON OF THE SCORES OF THE COMPETENCIES IN THE TWO STAGES (PRE-TEST AND POST-TEST)

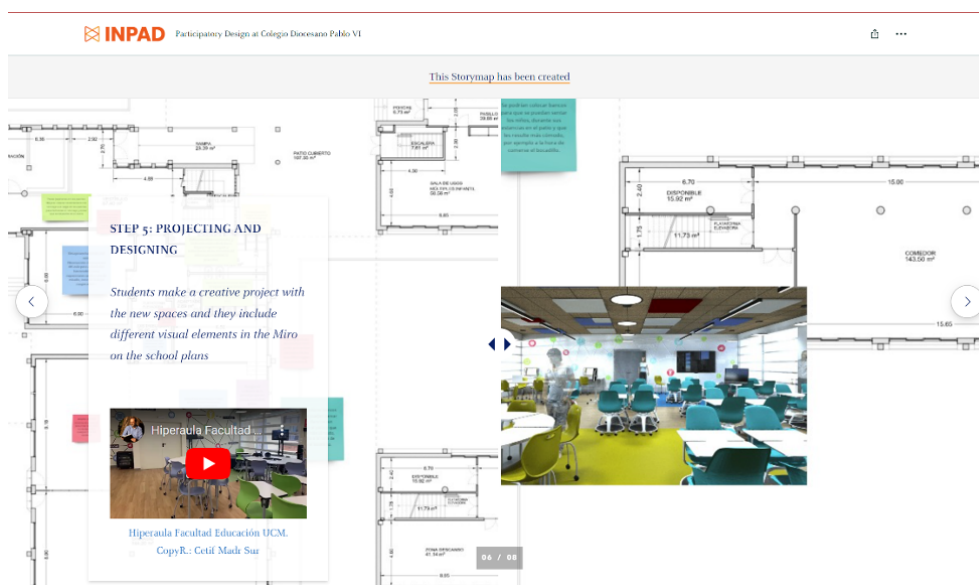
Competencies	M (SD) Pre-test	M (SD) Post-test	t-test	p	d
Spatial Thinking (STEM competence)	2.12 (1.02)	3.88 (0.92)	-21.27	<.001	1.29
Participation Social (Citizenship competence)	2.06 (0.79)	3.87 (0.86)	-26.90	<.001	1.06
DigComp: information and data literacy	1.83 (0.57)	3.84 (0.82)	-35.25	<.001	0.89
DigComp: digital content creation	1.93 (0.56)	4.00 (0.88)	-34.44	<.001	0.94
DigComp: communication and collaboration	1.88 (0.59)	3.76 (0.86)	-32.57	<.001	0.90
DigComp: safety	1.85 (0.50)	3.88 (0.86)	-34,32	<.001	0.93
DigComp: problem solving	1.60 (0.57)	4.00 (0.82)	-40.56	<.001	0.93

Note: According to statistics, equal variances for all results ($p>0.05$). M: Mean; SD: Standard deviation, t-test: Student's t-test for related samples, p: significance; d: Cohen's d.

The results of the paired-sample t-test reveal a significant increase in the scores of all seven competencies after the intervention, with a large effect size (Cohen's d) across all their competencies. These results indicate that the intervention had a very positive impact on the development of all the competencies assessed before and after the intervention, both by the statistical analysis of Student's t-test and by the size of the effect. This positive impact is given in the competences of geography (Spatial Thinking, STEM competence; $d=1.29$); in the citizenship competencies (Citizen competence; $d=1.06$); and in the digital competencies through the areas evaluated: DigComp: information and data literacy with $d=0.89$; DigComp: digital content creation, with $d=0.94$; DigComp: communication and collaboration, with $d=0.90$; DigComp: safety, with $d=0.93$; and DigComp: problem solving, with $d=0.93$.

These statistical results of acquired competences are clearly demonstrated in the story maps created collaboratively by students and teachers in various educational settings. These story maps serve as tangible evidence of both the scientific and educational value of the participatory learning process. They not only highlight the development of essential skills but also reflect the progression of spatial thinking, spatial citizenship, and digital competence among participants. As depicted in Figure 3, these visual representations

FIGURE 3.
AN EXAMPLE OF STORY MAP OF PARTICIPATORY DESIGN



Source: Own elaboration and 3rd year ESO students. Link: <https://arcg.is/XP8bG>

encapsulate the integration of theoretical knowledge and practical application, offering a comprehensive overview of the learning outcomes achieved through active engagement and exploration. Furthermore, they illustrate how digital tools can enhance the understanding of spatial relationships and foster a deeper connection with civic issues.

5. CONCLUSIONS

This study has shown that the intervention based on the participatory design methodology, together with the use of geotechnologies and story maps, with the objective of improving the school surroundings has a very significant impact on the acquisition of geospatial, citizen and digital skills in Geography students in the 3rd of ESO. The results obtained throughout the research validate the main hypothesis: participatory design effectively enhances the use of geotechnologies in teaching-learning processes, contributing significantly to improving the acquisition of these competencies.

Through the implementation of this innovative methodology, students have not only acquired geographical knowledge but also benefit from a higher-order cognitive process, in which they analyse, understand, evaluate and create their own learning evidence, which in turn shows the scientific results in the teaching-learning processes. The participatory design methodology has allowed students to connect and integrate with their immediate environment, participating in decision-making processes in a collaborative way and promoting a more critical and committed understanding of their socio-economic and environmental reality.

The integration of geotechnologies and story maps into participatory design has not only enriched geography teaching, but has also empowered students, enabling them to develop as informed, critical, and active citizens, capable of addressing problems on a “*glocal*” scale. These results highlight the importance of adapting educational practices to the needs and contexts of students, ensuring that learning is meaningful and aligned with the challenges of the 21st century.

In future research, this intervention could be replicated in other socio-educational contexts, to compare the findings with larger samples, as well as to explore the long-term effects of the intervention. The application of this methodology in various disciplines and areas of other educational levels could also be explored to evaluate its effectiveness in different contexts. Likewise, it would be valuable to investigate the impact of other additional variables, such as the role of the teacher, the training and education of the teacher, or to evaluate the same competencies with other didactic strategies that emanate from active teaching.

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DECLARACIÓN DE CONFLICTO DE INTERESES

No hay conflicto de intereses.

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DECLARACIÓN DE CONTRIBUCIÓN DE AUTORÍA

Javier Álvarez-Otero: Conceptualización, Curación de datos, Análisis Formal, Investigación, Metodología, Software, Validación, Visualización, Redacción – borrador original, Redacción – revisión y edición.

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