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Scientific Culture and Innovation Units (UCC+i) in Spain: characteristics, impact, and production

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Abstract: The complexity and decontextualization of science and technology push citizens away from scientific culture, and reduce the latter's role in social decisions. To tackle this situation, Scientific Culture and Innovation Units (UCC+i) were created by the Spanish Foundation for Science and Technology (FECYT) in 2007. Over the past 15 years, these units have expanded in number, production, and budget. This study uses a non-experimental design to analyze their evolution, characteristics, and activities during that time. The results show the units' consolidation in both large and small research centers, with teams composed mainly of communication professionals and scientists. Their production is diverse and reaches a broad audience, especially young people and children, with dissemination primarily through digital media.

Keywords: Scientific Culture and Innovation Units (UCC+i); scientific dissemination; scientific literacy; scientific culture; citizenship education.

Unidades de Cultura Científica e Innovación (UCC+i) en España: análisis de sus características, impacto y producción

Resumen: La complejidad de la ciencia y la tecnología, junto con su descontextualización, aleja a los ciudadanos, generando brechas en la cultura científica y menor participación en decisiones sociales. Para abordar esto, en 2007 se crearon las Unidades de Cultura Científica e Innovación (UCC+i) dentro de la Fundación Española para la Ciencia y Tecnología (FECYT). En 15 años, estas unidades han crecido en número, producción y presupuesto. Este estudio analiza su evolución, características y actividades mediante un diseño no experimental. Los resultados muestran su consolidación en centros de investigación grandes y pequeños, con equipos de comunicadores y científicos. Su producción es variada y alcanza a un amplio público, especialmente jóvenes y niños, con una difusión predominante en medios digitales.

Palabras clave: Unidades de cultura científica e innovación; divulgación científica; alfabetización científica; cultura científica; educación ciudadana.

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Introduction

Scientific literacy as a social challenge

In these times when science is taking a major role in society as a fundamental tool to overcome the challenges facing humanity, it has become more necessary than ever to make the citizenry scientifically literate (Yacoubian, 2018; Portillo-Blanco *et al*., 2022). The Organisation for Economic Cooperation and Development (OECD) defines scientific literacy as "the ability to engage with science-related topics and science ideas as a reflective citizen" (OECD, 2015). This definition suggests that a scientifically literate individual would be able to seek the information needed to understand minimum scientific knowledge and develop global thinking, capable of managing the problems, options, risks and consequences of such advances, as well as acquiring a critical spirit to be able to question them (Pearson *et al*., 2010).

However, this need represents one of the most complex challenges of humanity, since scientific knowledge is growing exponentially both globally (Belli *et al.*, 2020) and in the national context (Abad-García *et al*., 2015; Alcaide *et al*., 2012; Bordons *et al*., 2018, 2020; Martínez-Galindo *et al*., 2019), which leads to the gap between science and society continuing to grow. The latest survey of Social Perception of Science and Technology, conducted in 2018 by the Spanish Foundation for Science and Technology reflected that only 14.2% of the population spontaneously expresses interest in science and technology issues (Lobera y Torres-Albero, 2019). These developments mean that, for example, a large part of the population does not know how to distinguish between science and pseudoscience (Hansson, 2008; Kasapçopur, 2020; San, 2019) or between fake news and real news, contributing to widespread misinformation that, on many occasions, is disseminated through social networks, increasing misinformation, partly due to its excess (infodemic) (Pérez-Dasilva, 2020; WHO, 2021) and, finally, hindering the process of differentiating between reliable and unreliable information. These shortcomings derived from a lack of scientific culture have become more noticeable since the health emergency situation derived from COVID-19, since the trust and understanding that citizens place in science determines many of their decisions, such as, for example, whether to get vaccinated or the correct use of masks (Motoki *et al*., 2021; Blanco-Fontao *et al.*, 2022, 2023).

In view of this situation, the dissemination and accessibility of science are necessary to educate citizens who can think critically, reason and, process information, and participate in the decision-making processes that this implies (Balakrishnan *et al*., 2022; Cajas, 2001; Estrada, 2011). For these reasons, knowledge hubs such as universities and research centers must commit to its disseminating knowledge, engaging with allocating resources to combat misinformation (Nakov *et al*., 2022; Patwa *et al*., 2021; Tianru *et al*., 2021).

Although experts share a great diversity of opinions on who should oversee this, this activity has traditionally been carried out by researchers in Spain (León, 1999), since they are in the best position to talk about their findings. However, despite researchers have traditionally led science communication efforts in Spain (León, 1999), this task is often undervalued in academic careers, with many scientists lacking the necessary training to effectively engage with broader audiences. This gap between scientific production and its social communication highlights the importance of establishing specialized units named *Scientific Culture and Innovation Units* (UCC+i) to ensure an accessible and impactful dissemination (Mora y Néstor, 2019; Muñoz, 1999).

From this perspective, the study of UCC+i not only provides knowledge about institutional structures for science communication but also invites reflection—within the field of *Science Education Didactics* (DCE)—on how scientific learning takes place in non-formal

contexts and how these strategies can be used to complement school-based educational processes. As Acevedo-Díaz (2004) reveals, science education should aim to foster a critical and participatory citizenry by incorporating the social dimension of science and technology into teaching. In this sense, UCC+i can be key allies for DCE, as they contribute to a more contextualized scientific education, one that is closer to social reality and focused on issues relevant to everyday life. This work is particularly relevant to the field of Science Education Didactics, as it shares with it the goal of improving access to scientific knowledge and fostering public engagement with science. UCC+i act as essential agents of informal science education, helping to build a critical and participatory scientific culture (Osborne y Dillon, 2008). Numerous authors within DCE have emphasized the importance of developing communication strategies that are accessible and adapted to a variety of audiences, especially young learners and underrepresented groups (Lenzer *et al.*, 2024). Therefore, analyzing the characteristics, productions, and evaluative approaches of UCC+i allows us to understand their role as institutions that, although outside the formal education system, contribute meaningfully to the development of scientific literacy, critical thinking, and informed decision-making—fundamental pillars of quality science education (Simonneaux y Simonneaux, 2012).

The UCC+i: background and institutionalization

Given this scenario, taking into account that the importance of dissemination and with the aim of creating bridges between scientific knowledge and citizenship, since 2011, under the protection of Law 14/2011, of June 1, on Science, Technology and Innovation (Gobierno de España, 2011), the formation of departments has been promoted within research centers, whose mission is to ensure scientific literacy in society. These departments, promoted and funded by the Spanish Foundation for Science and Technology (FECYT), are called Scientific Culture and Innovation Units (UCC+i) and have become one of the main agents for the dissemination and popularization of science and innovation in Spain (Fernández-Martínez y Pérez-Martínez, 2019).

Previously, there were already departments in charge of disseminating scientific knowledge (Ferrando, 2015), where this activity was developed almost exclusively by communication offices and press offices. In 2004, the Scientific Culture Area was created under the Spanish National Research Council (CSIC), considered the fundamental precursor of the UCC+i. Thus, in 2007, in the context of the Year of Science in Spain, the central government promoted, through the FECYT, the figure of the UCC+i with two fundamental objectives: to create offices for the dissemination of scientific culture and to strengthen and adequately guide the offices that were already carrying out this type of activity. Thus, and under the protection of a series of grants of 17 million euros, many institutions took the step of creating their UCC+i, forming a total of 53 units that year (Capeáns *et al*., 2012).

From that moment on, universities and research centers that endowed such a unit had an area and staff responsible for the promotion and dissemination of the science generated in that research center. Starting in 2009, with the aim of promoting the exchange of ideas and activities, the annual meeting Communicating Science in Network (ComCiRed) was convened. Two years later, in 2011, Law 14/2011, of June 1, on Science, Technology and Innovation, was passed, with which, for the first time, a legal text expressly alluded to scientific dissemination (Gobierno de España, 2011) and, in addition, a series of measures were listed to promote and strengthen scientific-technological dissemination and to value the efforts of the research community (Fernández-Martínez y Pérez-Martínez, 2019).

In the same year, the FECYT published the first edition of the "White Paper on Scientific Culture and Innovation Units (UCC+i)" (Capeáns *et al.*, 2012), which established the basic

criteria for defining a UCC+i in order to standardize its denomination. Thus, in 2012 a registration process was established to belong to the UCC+i network. The main requirements to join this official directory were: a) to consolidate a stable organization with a full-time manager, a budget that clearly showed the commitment of the research center to the UCC+i, and b) a level of activity appropriate to the objectives set and that depended on the type of activities that are carried out in a majority way. In that same year 69 units, already official, were attached to this body and in 2019, their number grew to 87 (Fernández-Martínez y Pérez-Martínez, 2019).

Thus, year after year, the UCC+i Network has continued growing and developing, both in number (currently 117) and in scope to society. Although many of the actions have been orchestrated at international or national level, the heterogeneity of the experiences carried out made the UCC+i Network increasingly richer.

These units have acquired a fundamental role in the transmission of the scientific knowledge generated and the new update of the "White Paper of the Units of Scientific Culture and Innovation" (Capeáns *et al.*, 2021) has defined the purpose of these units as being to contribute values such as: providing a service with a public vocation, open and innovative and focused on people (conciliation, equality and development), strengthening the link between science and society through actions that promote open and inclusive science, culture and science education, responding to the needs of society and the scientific, technological and innovation system; and, with a vision of the future, working for a society committed to science as a key value for its development. This variety of objectives means that the UCC+i differ greatly from one another, both in their lines of action and in the sector in which they specialize, the number and training of their workers, etc.

Analytical framework and objective of the study

For all these reasons, the general objective of the present study is to analyze the most relevant characteristics of the Scientific Culture and Innovation Units (UCC+i) in Spain. This will involve evaluating their structure, activities and productions, as well as the methods they use for science communication and the strategies for assessing their effectiveness.

To guide this analysis, the study adopts a theoretical framework based on the model proposed by Rossi *et al*., (2004), which distinguishes three key dimensions in program evaluation: efficacy, efficiency, and relevance. This model allows for a comprehensive understanding of the functioning and impact of the UCC+i beyond a merely descriptive approach.

- Efficacy: This dimension focuses on the evaluation of outcomes and achievements, including the reach of their activities, the assessment methods used (internal or external), and the real contribution to scientific literacy.
- Efficiency: This dimension refers to the resources available to the units—budget, staffing, and infrastructure—and how these are used in relation to their institutional context and the scope of their activities.
- Relevance: This dimension addresses the pertinence and quality of the actions developed by the UCC+i, their alignment with the needs of the target audience (especially youth and children), and the coherence between their mission and their actual productions.

In line with this framework, the general objective can be divided into three specific objectives:

- Specific Objective 1 (Efficiency): To describe the main structural characteristics of the UCC+i by examining their organizational setup, staffing levels and qualifications, and the material and financial resources at their disposal.

- Specific Objective 2 (Relevance): To analyze the types of activities and programs carried out by the UCC+i for the dissemination and popularization of science, with attention to the target audiences, content focus and production formats.
- Specific Objective 3 (Efficacy): To evaluate the impact, scope and effectiveness of the UCC+i activities, the communication channels they use, and their strategies for assessing their influence on scientific literacy and the public perception of science.

Design and methodology

Description of the population and data collection

A total of 117 UCC+I are included on the FECYT website. Of these, 41.8% belong to universities and 58.1% belong to research centers. Data were obtained for the study from 43 of these, corresponding to 36.7% (full details of the UCC+i are available in supplementary material). This is the minimum sample size required when assuming a 95% confidence level and a 10% margin of error.

The study employs a mixed-method through a non-experimental descriptive design. To this end, an *ad hoc* questionnaire was used as a research tool. The survey has been used as both a quantitative and qualitative technique (Anguita *et al.*, 2003; Igartua y Humanes, 2004). According to Bravo (1997), the survey consists of a series of questions that allow specific information to be obtained. It also has the advantage of collecting data quickly, which makes this technique one of the most widely studied and used (Rowley, 2014). In this paper, the survey was carried out online, was self-administered and designed using the Google Forms tool.

For the drafting of the questionnaire items, a brainstorming session was carried out with a group of experts in teaching and learning of experimental sciences. To ensure the validity and relevance of the questionnaire items, the panel of experts was intentionally selected to provide diverse and complementary perspectives. It was composed of: one university professor with over ten years of experience in science education research, particularly in the development and evaluation of didactic resources and instruments, three faculty members from the Department of Physics and Chemistry, all with active involvement in scientific outreach and prior experience in educational innovation projects in non-formal education and one expert in science communication with both academic training and professional experience in institutional dissemination work, including coordination roles in UCC+i initiatives. This composition was not arbitrary but strategically assembled to reflect the intersection of science education, disciplinary expertise, and communication practices. The multidisciplinary profile of the panel was considered optimal to design a questionnaire aligned with the study's objectives, ensuring conceptual and contextual coherence in the selection and wording of items.

The questions were chosen and a draft was designed. Subsequently, a pilot test was carried out with a twofold objective: to determine the need to modify, add or eliminate questions and to detect possible flaws or limitations. Finally, the questionnaire was revised and, once it was reformulated, it was distributed through the person responsible for the Promotion of Scientific Culture at the FECYT, who was responsible for its dissemination, distributing it to all UCC+i.

The structure of the questionnaire was designed to gather data corresponding to the three dimensions of program evaluation proposed by Rossi, Lipsey, and Freeman (2004):

- Efficiency: questions related to the availability and management of resources, including the number and qualifications of staff, institutional affiliation, and the

organizational structure of the UCC+i (questions 1 to 5). These aspects are examined in relation to the scope and diversity of activities developed, in order to assess whether resources are being used efficiently.

- Relevance: questions concerning the type of activities developed, their thematic areas, target audiences, and types of scientific productions (questions 6 to 11). This dimension focuses on the alignment between the objectives of the UCC+i and the social, educational and institutional needs they aim to address. In this case, relevance is assessed by exploring whether the content, formats, and publics targeted by the UCC+i are appropriate and meaningful in the context of science education and public engagement. For example, identifying the predominance of certain thematic areas or the prioritization of young audiences allows us to understand how well the units respond to societal demands for scientific literacy and inclusive access to knowledge.
- Efficacy: questions that aimed to assess the reach, methods of dissemination, evaluation practices, and perceived impact of the UCC+i activities (questions 12 to 17). This dimension evaluates the extent to which the intended outcomes of the UCC+i are being achieved. In this study, efficacy is examined through indicators such as geographical scope, use of digital media, the presence (or absence) of evaluation mechanisms, and the units' capacity to reach different segments of the population. These elements provide insight into how effective UCC+i actions are in promoting scientific literacy and shaping public perceptions of science.

This structure enabled a more systematic interpretation of the responses and allowed results to be organized and analyzed according to these theoretical dimensions.

Data analysis

The results were analyzed with the SPSS statistical program (IBM), calculating their relative frequency as a percentage. In the case of the open-ended questions, they were categorized to achieve a description of the UCC+i as representative as possible.

Results

Of the 117 UCC+I registered with the FECYT, 43 completed the questionnaire, representing a response rate of 36.7%.

Efficiency

This section corresponds to the efficiency dimension of the analytical framework, which focuses on the resources and organizational structure of the UCC+i in relation to their institutional context and operational capacity. The results relating to the institution to which they are attached, number of workers, their training and total number of researchers were analyzed (Table 1).

Regarding the type of institution to which the UCC+i are attached, it was observed that more than half of them are linked to universities (55.8%). These results are in line with the expectations, given the greater number of universities (49 of the 117 units) compared to other types of centers. Next are the units affiliated with other research organizations, which represent a third of the respondents. Finally, four of the surveyed UCC+i o are affiliated to the CSIC (9.3%), which has been counted separately due to its great scientific relevance (González-Albo *et al.*, 2012), as it is the most important research organization in the country and includes numerous research centers distributed throuhout Spain. Some of these centers have their own UCC+I, while others tend to group together to

disseminate their advances. It should be noted that the CSIC headquarters has the UCC+i with the highest number of workers, 20 in total, which is much higher than any other unit surveyed. Thus, the vast majority of the UCC+i have three or fewer employees (79.1%), of which 18.6% have only one.

With regard to the number of workers in the institution to which they belong, since most of them depend on universities, 72.1% have more than 200 workers; however, there are also institutions with fewer than 15 workers (4.7%) and, even so, they have UCC+i. In the intermediate ranges, only two units attached to institutions with a number of workers between 15 and 25 and between 25 and 50 responded, which represents 2.3% of the total sample.

In addition, the existence of a relationship between the size of the staff of the research organizations and the size of the staff of their UCC+i was evaluated, revealing a great heterogeneity in the size of the units, regardless of the size of the institution, a fact that may be striking. Thus, as can be seen in Figure 1, the most repeated number of workers is two, regardless of the number of researchers in the organization, with the calculated average number of workers per unit being three. This could be due to the fact that small organizations, which probably have fewer lines of research, need to make a greater effort to successfully disseminate their scientific activity and thus give them greater visibility.

The main fields in which UCC+i workers have been trained are journalism and communication (47.4%), followed by degrees related to science and engineering (28.9%). It should be noted that many of the workers in the science and engineering branch have a postgraduate degree in Science Communication, and some come from a professional career in science, with some units having up to three scientists among their workers, although the vast majority of them do not have any (67.7%). This combination of training in science

Table 1. Description of the UCC+i

Institutions to which they are attached				
Universities 55.8%		CSIC 9.3%		Others 34.9%
Number of employees of the institution they belong to				
Less than 15 4.7%	Between 15 and 25 2.3%	Between 25 and 50 2.3%	Between 50 and 200 18.6%	More than 200 72.1%
Number of UCC+i employees				
One employee 18.6%	Two employees 37.2%	Three employees 23.3%	Four employees 4.7%	More than four 16.3%
Employee qualifications				
Journalism and communication 47.4%	Sciences and Engineering 28.9%	Humanities and arts 4.1%	Others 19.6%	
Number of scientists among its employees				
None 67.4%	One 23.3%	Two 4.7%	Three 4.7%	

complemented by communication may seem to be one of the most suitable for these institutions. Furthermore, the results obtained suggest that these units are an important employment niche for this type of communication professionals and graduates in science or engineering of various kinds.

Much less represented are also workers with training in the humanities and the arts (4.7%). In the "others" section, a total of 19.6% of responses were observed, including workers without university degrees who, in many cases, come from professional training degrees related to communication.

Relevance

This section corresponds to the relevance dimension of the analytical framework, which evaluates the extent to which the activities, target audiences, and productions of the UCC+i respond to relevant scientific, educational, and societal needs. This includes the thematic focus of their programs, the alignment with public engagement goals, and the suitability of formats and audiences in fostering scientific literacy and broadening science communication beyond academic settings (Table 2).

Table 2. Relevance of the activities and productions

Main activity performed by the UCC+i					
General dissemination of scientific and technological knowledge 55.8%	Communication of RyD results 39.5%	Advice and training of research personnel in the dissemination of science and technology 4.7%	Research on the processes of social diffusion of RyD 0%		
Its main production is:					
News and press releases 44.2%	Audiovisual material 2.3%	Exhibitions, shows and artistic performances 4.7%	Conferences 4.7%	Courses, seminars, workshops and practical workshops 34.9%	Others 9.3%
Main source of financing					
Central Government 23.3%	Regional Government 27.9%	Local Government 0%	Private contracts 2.3%	Self-funding 37.2%	Other 9.3%
UCC+i execution budget					
Up to 25 000 € 14.8%	From 25 000 to 50 000 € 22.2%	From 50 000 to 100 000 € 40.7%	More than 100 000 € 22.2%		

Table 2 assigns the percentage of UCC+i according to the lines of action to which they are dedicated, as established in the "White Paper on Scientific Culture and Innovation Units (UCC+i)". It can be clearly seen that the general dissemination of science and the communication of RyDy results, with percentages of 55.8% and 39.5%, respectively, are the lines of action to which the units adhere most. These results are as expected, and are in line with those observed by the FECYT report published in 2015 (FECYT, 2015), where the origin and evolution of the units up to 2014 are evaluated, with at least one of these two lines being

mandatory for offices wishing to constitute themselves as UCC+i, without prejudice to adopting any of the remaining ones (Cápeans *et al*., 2012; Cápeans *et al*., 2021).

On the other hand, counseling and training of the PDI is developed by 4.7% of the units, while none investigates the processes of social diffusion of RyDyI. An interesting aspect would be for the UCC+i to dedicate part of their time and effort to train researchers who are interested in improving their dissemination skills, as also highlighted by Fernández-Martínez and Pérez-Martínez (2019). Likewise, it would be interesting for the units that have staff trained for this purpose to investigate the social perception of science and technology in general, and the progress generated in their own institutions.

The main production generated in the UCC+i are news and press releases (44.2%), followed by courses, seminars and conferences (34.9%). On the other hand, the least represented productions are conferences (4.7%) and audiovisual material (2.3%). These results are reasonable if analyzed from the point of view that the majority productions reach the public more easily, either by dissemination through the Internet or by the interactivity and interest they can arouse among the general population.

To better understand their productions, UCC+i identified their three most successful activities, with 35 units responding. The most mentioned were the *European Researchers' Night* (15 mentions), *Science Week* (14), and the *International Day of Women and Girls in Science (11F)* (11), all globally promoted events supported by organizations such as the UN, widely embraced by UCC+i.

Many UCC+i consider their own initiatives successful, including workshops, contests, fairs, and exhibitions. Notable examples include science dissemination workshops by FUNDECYT-PCTEX, *MasterChem* from the University of Murcia, which engages students and teachers in chemistry experiments, and *Exposcience Unileon*, a University of León event showcasing research group activities. Activities aimed at groups of children and adolescents, open days at research centers or universities and lecture series have also been highlighted.

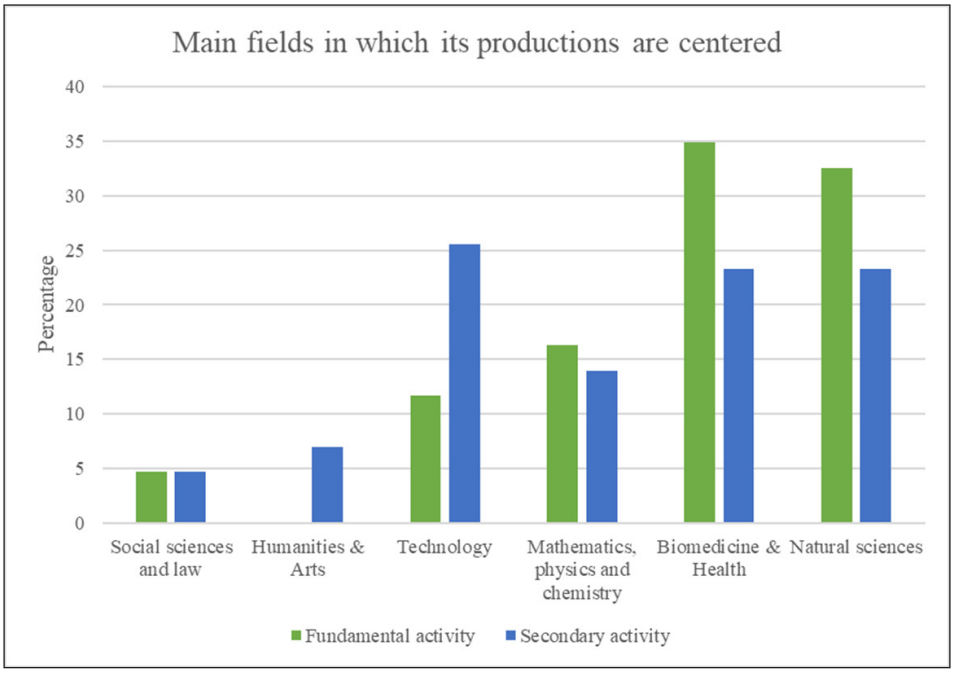

Figure 1. Main fields in which its production is focused.

UCC+i activities align with the focus of their host institutions (Figure 1), primarily disseminating Science and Technology (95.8%), with Biomedicine and Health (34.9%) and Natural Sciences (32.6%) being the most prominent fields. In contrast, disciplines under "Letters" represent only 4.7%, mainly Social and Legal Sciences, while Humanities were not reported as a first choice. As a secondary focus, Science and Technology remained dominant (86%), with Technology increasing to 25.6% and Humanities reaching 7%. This trend reflects the common perception of science as knowledge about nature, with only a few UCC+i covering literary topics alongside scientific and technological content.

In addition to the issues discussed above, in the study of the activity of the UCC+i it is essential to evaluate the type of institution that finances them. Thus, depending on the budget they have, they will be able to set certain objectives for the dissemination of scientific activity. The main response is self-financing, which represents 37.2% of the total and is understood as direct aid from their institutions (very variable amounts among the different units). This is followed by regional aid, which is received by 27.9% of the units, and state aid, which is received by 23.3%. In the case of the autonomous communities, as they are competent in education, it is possible that they may offer calls for funds to which the UCC+i may have access. As for state aid, it is likely that it will be offered by the FECYT: the UCC+i al, being connected through the UCC+i Network, which depends on the FECYT, would have easy access to this aid. Although the funds allocated have not done so, the success rate of these aids has been growing from 2008 to 2014 uninterruptedly (FECYT, 2015). At a great distance from them, private contracts stand out, accounting for 2.7%, and local funding, which has been nonexistent in the UCC+i surveyed.

Finally, the execution budgets that the units have (not including personnel hiring costs) were studied. In this case, the question was open-ended and not obligatory, and a total of 28 responses were obtained. The results were very variable and are presented categorized in different ranges according to the amount, thus 14.8% of the units had budgets of up to 25,000 euros, between 25,000 and 50,000 responded 22.2% of them, between 50,000 and 100,000 the majority of them, representing 47.7% of the responses, and those with more than 100,000 euros represented 22.2%. Although the differences between units range from 4 000 € for the UCC+i of the Geological Mining Institute to 250 000 € for the unit at the CSIC headquarters, the average per unit that can be observed in this study is 78 000 €. This figure can give an idea of the scope and importance that the work of the UCC+i is taking in our country, since, if we estimate, through this data, the total amount of the 117 registered units, the amount of implementation costs would exceed 9 million euros.

Efficacy

This section corresponds to the efficacy dimension of the analytical framework, which focuses on assessing the outcomes and impact of the UCC+i activities. It considers the geographical and social scope of their actions, the dissemination methods used—particularly through digital and traditional media—and the evaluation strategies employed. This dimension seeks to determine the extent to which the UCC+i contribute to improving scientific literacy and fostering a scientifically informed public.

Most activities have a national reach (44.2%), facilitated by digital technologies, especially after COVID-19. Regional events (30.2%) are common due to in-person participation, while international initiatives (20.9%) gain prominence through globally recognized events like the *European Researchers' Night*, *11F*, and *Science Week*. Local activities (4.7%) have the least impact, likely due to the broader reach of universities and research centers.

As for the target audience of the UCC+i actions (Figure 2), it can be seen that young people and children are the main recipients of the activities, possibly those focused on interactive

workshops, shows and school support materials. The UCC+i focus their efforts on these actions since numerous studies have been published that evidence a better perception of children and young audiences towards science if they are motivated (Villareal-Romero *et al.*, 2019). Next is the media and communication agencies, which makes sense because in both professions they focus on continuous learning and dissemination of the latest advances in science (Badia y Chumpitaz-Campos, 2018) followed by the scientific community, others and teaching personal.

In order to implement their science dissemination efforts, the UCC+i use various means of dissemination. Valuable information can be obtained from their study on how they disseminate science, both that generated in their institution and knowledge in general, 46.5% of the units surveyed use their institutional websites to disseminate their activities and, in addition, they are very active in social networks (37.2%). This demonstrates the strength of new technologies for science communication (Ruíz, 2004; Sánchez, 2012). Next, and at a great distance, are dissemination through the press (11.7%), others (4.7%) and, finally, radio and television with null representation. In this regard, if we group together the means of dissemination supported by the Internet and the traditional ones, they would correspond to 83.2% and 16.4%, respectively. These results corroborate, as noted above, that the use of new technologies as a vehicle for the dissemination of science communication is currently growing, displacing traditional media (Nisbet y Scheufele, 2009; Lesen, 2016; Davies y Hara, 2017).

Regarding social media use, Twitter is the most utilized platform (76.9%), followed by Instagram (14.0%), Facebook (7.0%), and LinkedIn (2.3%). Twitter spans various age groups (Jiménez-Hidalgo y Fernández-Morales, 2014), though Facebook and Instagram have broader user bases (Maldonado-Martínez *et al.*, 2019). Twitter's popularity among scientific journals (Sánchez-Santamaría y Aliaga, 2019) may stem from its rapid access to scientific news (Denia, 2020). Surprisingly, LinkedIn sees minimal use, despite its relevance in professional and educational fields (Durango, 2014). Additionally, UCC+i do not leverage automation tools that enable simultaneous posting across multiple platforms.

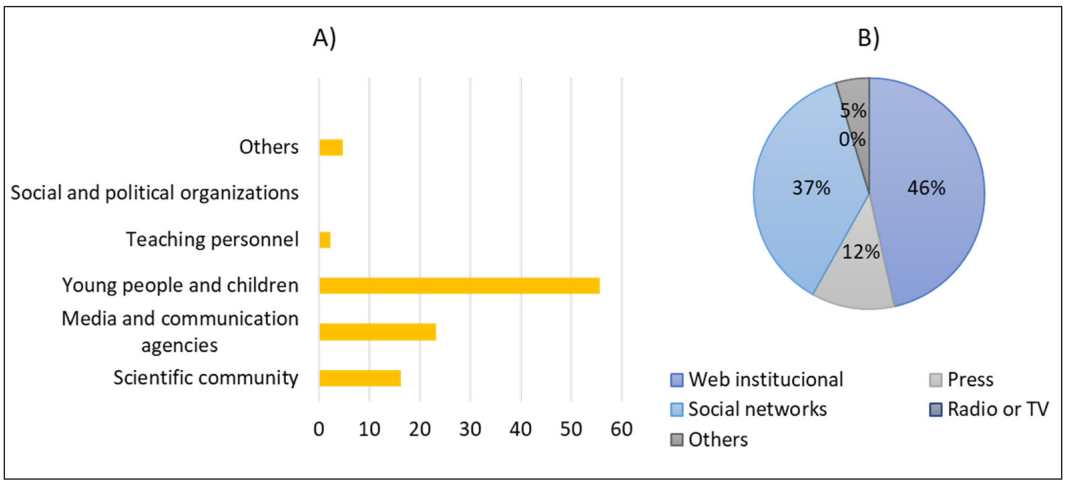

Figure 2. A) Main target groups of the activities. B) Media of dissemination of the contents of the UCC.

Most UCC+i (70.1%) do not have an expert panel, likely due to the high number of journalists and science communication professionals in their teams. When needed, experts would primarily be tasked with handling media interactions and facilitating connections between researchers and the press.

Evaluation is a key aspect of UCC+i dissemination work. All but one unit assess their activities, mostly through internal self-evaluation, with only one relying on an external agency. Common evaluation methods include questionnaires, media impact, participant numbers, web visits, and social media engagement. The choice of method varies depending on the activity type, making it difficult to establish a clear preference.

Discussion

This study set out to analyze the characteristics, activities, and communication strategies of the UCC+i in Spain, guided by a theoretical framework based on the evaluation dimensions of efficiency, relevance, and efficacy (Rossi, Lipsey, y Freeman, 2004). The following discussion presents the main findings according to each of the three specific objectives defined in the study.

Based on the Specific Objective 1, which aims to elucidate the efficiency of resources and organizational structure in relation to their size and staff, the results reveal significant diversity in the organizational structure and size of these units. Most UCC+i are linked to universities, which was expected given the number of universities compared to other types of research centers. However, it is also observed that there are UCC+i in smaller institutions, with fewer than 15 employees, indicating a significant commitment to scientific dissemination regardless of the size of the institution (González-Albo *et al.*, 2012). This heterogeneity in size and structure suggests that the needs and available resources vary widely, which could influence each unit's ability to effectively carry out its activities.

Further examination of staff composition reveals important asymmetries in resource allocation. A large number of units operate with very limited human resources—79.1% with three or fewer staff members, and 18.6% with only one employee—even in institutions with over 200 workers. This condition reflects not only institutional disparities but also raises concerns about sustainability and effectiveness of the scientific and outreach output of the UCCs, suggesting a disconnect between institutional size and investment in science communication infrastructure.

Regarding staff qualifications, their distribution may hinder the integration of research content with communication strategies and limit the development of interdisciplinary teams capable of addressing complex educational and scientific goals. As highlighted by Sánchez-Mora y Macías-Néstor (2019) and Muñoz (1999), the lack of balance between content expertise and communication skills can affect the depth and relevance of public science communication. Similarly, León (1999) notes that communication carried out exclusively by non-specialists' risks prioritizing visibility over rigor, a tension still evident in the current UCC+i landscape.

These structural and compositional aspects are crucial for understanding the efficiency of the UCC+i, as they directly influence their operational capacity and the strategic mobilization of resources toward the fulfillment of their missions.

In terms of the relevance (Specific Objective 2), the UCC+i mainly focus on the general dissemination of science (55.8%) and the communication of RyD+i results (39.5%). This aligns with the priorities established by the FECYT and reflects the central role these actions play in improving scientific literacy and public engagement with science (Capeáns *et al.*, 2012). However, it is concerning that only 4.7% of the units are dedicated to training and advising research personnel in communication, and none report conducting research on the social diffusion of science and innovation. These figures suggest that UCC+i activities remain framed within a functional, unidirectional model, emphasizing transmission over

dialogue, and public visibility over educational depth (FECYT, 2015; Fernández-Martínez y Pérez-Martínez, 2019).

Likewise, the content areas prioritized by the UCC+i are highly concentrated in Science and Technology, with Humanities and Arts representing only 4.7% of the reported focus. Such disciplinary imbalance suggests a restrictive vision of what constitutes scientific culture, potentially reinforcing public perceptions that marginalize interdisciplinary or humanistic contributions to societal challenges (Maldonado-Martínez *et al*., 2019).

Finally, the ability of UCC+i to sustain and expand their activities is closely tied to funding structures. The reported budgets vary widely—from €4,000 to €250,000—with an average of €78,000 per unit, and 37.2% of units, relying on self-funding. This variability creates asymmetries in institutional capacity and continuity. Units with greater financial and organizational stability are more likely to experiment with innovative formats, establish collaborations, and evaluate long-term impact. Conversely, those with minimal resources may be forced to prioritize short-term visibility, limiting the transformative potential of their interventions. These disparities highlight the importance of considering financial context as a structural factor in the evaluation of program relevance.

The effectiveness of UCC+i activities (Specific Objective 3) is mainly evaluated through internal self-assessments, using evaluation questionnaires, media impact, participant numbers, and social media analytics. This limited diversification is also reflected in the communication formats used. The UCC+i rely predominantly on written products, such as news and press releases (44.2%), and face-to-face formats, including courses, seminars, and workshops (34.9%). Although these methods are effective in reaching audiences familiar with institutional channels, they do not necessarily engage groups that consume science through more dynamic or interactive platforms. Audiovisual content (2.3%) and artistic or performative formats (4.7%) are marginal, despite their proven ability to foster engagement through emotionally resonant or narrative-driven strategies (Lesen, 2016; Davies y Hara, 2017). This suggests that the current production landscape is still shaped by a traditional understanding of science communication, which may limit its accessibility and impact, particularly among underrepresented groups.

A relevant aspect for assessing the relevance of UCC+i lies in their alignment with the audiences they aim to reach. The data confirms that the primary target audience is youth and children, which is consistent with educational research highlighting the importance of early contact with science to cultivate interest and positive attitudes (Villareal-Romero *et al*., 2019). However, the near absence of initiatives aimed at adult, senior or socially excluded populations raises concerns about the democratization of access to scientific knowledge, especially in contexts of digital inequality or limited cultural capital (Nisbet y Scheufele, 2009). This narrow scope in audience design could hinder the capacity of UCC+i to promote inclusive, participatory science cultures.

While these methods may be useful for immediate operational feedback, the lack of external evaluation mechanisms significantly limits the objectivity and validity of the conclusions drawn (Jiménez-Hidalgo y Fernández-Morales, 2014). As emphasized by Sánchez-Mora y Macías-Néstor (2019), relying exclusively on internal indicators can lead to biased or incomplete representations of impact, making it difficult to identify strategic improvements or justify continued investment.

The results indicate that most UCC+i operate on a national (44.2%) or regional (30.2%) scale, with dissemination strategies that prioritize digital platforms, such as institutional websites (46.5%) and particularly Twitter (76.9%). While this demonstrates a good level of adaptation to digital environments (Ruíz, 2004; Sánchez, 2012), it also reveals important

gaps. Platforms like TikTok, widely used by younger audiences, are absent from their communication strategies, raising concerns about the alignment between dissemination channels and target publics (Maldonado-Martínez *et al*., 2019). The limited use of formats tailored to the habits and expectations of today's youth may reduce the capacity of the UCC+i to effectively promote scientific interest among new generations.

Another significant shortcoming concerns the nature and scope of impact evaluation. Although nearly all units conduct some form of self-assessment, only one reports engaging an external agency for this task. Moreover, most evaluations are limited to reach metrics—such as the number of attendees or web visits—without examining the educational or attitudinal impact of their activities. As recent studies emphasize (Blanco Fontao *et al*., 2022, 2023), assessing changes in understanding, attitudes or critical thinking skills is crucial when the intended aim is to contribute to scientific literacy, particularly in educational contexts.

Integrating external, mixed-method evaluations that combine quantitative and qualitative tools would enhance both the credibility and the formative utility of impact assessments (Denia, 2020). This could include pre/post activity tests, interviews with participants, or stakeholder feedback mechanisms. Evaluations of this kind are essential to distinguish between visibility and true social transformation—a distinction that is often blurred in science communication metrics (Nisbet y Scheufele, 2009).

Finally, the availability and stability of funding also influence efficacy. As indicated, budgets vary greatly between units, with an average of €78,000, and a high degree of dependence on self-funding (37.2%), followed by regional and national public support. While some units benefit from robust institutional backing, others operate with precarious resources. This variability not only affects the scope of activities but also limits long-term planning and evaluation capacity (FECYT, 2015, 2016). Strengthening the effectiveness of UCC+i thus requires greater financial stability, accompanied by accountability mechanisms that allow the measurement of real educational and social outcomes.

Limitations and future directions

This study provides a valuable internal overview of the UCC+i in Spain, but it presents some limitations. The data were obtained through a self-reported questionnaire, which may introduce bias and does not allow for external validation of the impact claimed. In addition, the absence of perspectives from beneficiaries or stakeholders limits the understanding of the real educational and social value of the activities carried out.

Future research should incorporate external assessments, qualitative methods, and triangulation with user perspectives to evaluate outcomes more comprehensively. It would also be useful to explore contextual factors—such as science policy or institutional support—that may influence the performance of UCC+i. Finally, fostering closer links between UCC+i and the field of science education research could help align their practices with broader educational goals and promote greater theoretical and methodological robustness.

Conclusions

This study has provided a comprehensive analysis of the Scientific Culture and Innovation Units (UCC+i) in Spain, focusing on their organizational structure, types of activities, and communication strategies, as well as their mechanisms for evaluating impact.

In terms of efficiency, there is great heterogeneity in the size and structure of the UCC+i, with a large number of units operating with minimal staff—often in institutions with

considerable research capacity. While most staff are trained in communication, the absence of scientific personnel in over two-thirds of the units may compromise the interdisciplinary quality of their outputs. These findings suggest an uneven institutional commitment to science communication, and point to the need for more balanced, sustainable staffing strategies that support the educational and scientific roles of UCC+i.

Relating to the relevance, UCC+i primarily carry out traditional dissemination activities, such as press releases and face-to-face workshops, with limited use of audiovisual or digital-native formats. Their thematic focus is heavily centered on science and technology, with little presence of the humanities or cross-disciplinary content. Although many units target young audiences—aligned with educational objectives—the narrow scope of audiences and formats may limit the social inclusiveness and transformative potential of their actions. Additionally, financial disparities among units affect their capacity to innovate and diversify their programs.

Finally, the effectiveness of UCC+i is mainly assessed through internal, short-term indicators such as participant numbers or media metrics. The lack of external evaluation, or of tools to assess learning and perception changes, limits the ability to determine their real impact on scientific literacy and public engagement. The absence of systematic mechanisms to monitor outcomes undermines institutional learning and accountability, highlighting the need for more robust, independent and formative evaluation models.

Overall, the UCC+i represent a consolidated and valuable infrastructure for science dissemination in Spain. However, for these units to fully realize their potential as agents of informal science education and public engagement, it is essential to advance toward: a more balanced integration of scientific and communicative expertise, the diversification of formats, themes, and audiences and the adoption of rigorous, multidimensional evaluation practices.

These changes would strengthen the strategic alignment of the UCC+i with national and international goals for science communication and education, helping them contribute more effectively to a scientifically literate and critically engaged citizenry.

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