

Citizens' participation in informal science activities in Malta

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Abstract: Science has a complex history in the Maltese Islands, sketched by who defines it, how it is conducted, and who engages with it. Citizens' science capital is a theoretical lens that explores uneven patterns in science participation (Archer et al., 2015). It delves into what influences individuals' perceived self-efficacy and how they engage with science and scientific research if and when they do. This paper will focus on three factors affecting Maltese residents' science capital: whether they attend science activities, which entities they visit, and their relationship with institutions that conduct Public Engagement with Science (PES). While the conceptual approach to theorising science capital was designed as a tool for use with school students, this analysis will extend the concept to citizens' participation in science activities in Malta in 2019/2020. A questionnaire was distributed to Maltese residents to determine their engagement with science and science activities. The specific results on residents' interest in science and their tendency to attend science activities will be presented in this paper. Most of the respondents expressed their interest in science (n = 461, 80.2%), with only a small sample of 69 respondents (12.0%) stating otherwise. The highest percentage of the respondents attending science activities were from the 18–24 age group (65.2%). The 55–64 age group had the lowest percentage (29.4%), followed by the 65+ group (32.7%). Results also show that 36.6% of the respondents had never visited Esplora, the Interactive Science Centre, and a further 7.7% were unaware of it. Activities can be more inclusive if entities conducting PES include citizens in the design of the activities. A national PES strategy might act towards a better-coordinated approach among stakeholders conducting PES.

Keywords: public engagement with science, informal science education, science capital

Rationale/Introduction

Science is a constantly evolving field that is defined in various ways by different scholars (Heintz, 2009). It can be seen as a collection of facts, observations supported by evidence (Reiss, 2004), and a process that follows a set of protocols known as the scientific method (Chalmers, 2013). In 2019, the United Kingdom's Science Council (2024) defined science as "the pursuit of knowledge and understanding of the natural and social world following a systematic methodology based on evidence". However, this definition does not consider the formation of scientific laws (Heintz, 2009). Albert Einstein noted that intuition, resting on a sympathetic understanding of experience, is needed to arrive at universal elementary laws. Science is considered a body of knowledge, practices, and a way of thinking (Broks, 2006). There have been arguments that socio-cultural forces and norms condition the nature of science. Western culture began in Ancient Greek and European culture, and indigenous knowledge was less valued than Westernised science (Cobern & Loving, 2000). The narrative of what counts as science and explanations of natural phenomena also varies in schools, especially in multicultural contexts (Cobern & Loving, 2000). Considering the issues explored with the stated definitions, a new definition is proposed for this study:

"Science tries to understand and explain the physical and natural world through deductive and inductive reasoning, observation and experimentation, formulation of hypotheses and laws set in a multi-cultural context sometimes driven by curiosity or need."

Scientific research serves multiple purposes, such as contributing to the economy, addressing health challenges, creating jobs (Gascoigne & Schiele, 2020; American Academy of Arts & Sciences, 2018; Davies & Horst, 2016; Department for Business Innovation & Skills, 2011), satisfying curiosity, and staying at the forefront of technological progress. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), fostering sustainable development through research and development is crucial for building greener and more inclusive societies globally (UNESCO, n.d.). The Responsible Research and Innovation (RRI) framework developed by the European Commission (EC) focuses on how scientific research is conducted, for what purpose, and who should be involved. RRI emphasises societal needs and the involvement of all actors in research and innovation. However, the ethical conundrum of when and how society needs to be involved in various stages of the research process remains a challenge (Schomberg, 2013). The latest definition of RRI by the EC aims to address this issue:

“...an approach that anticipates and assesses potential implications and societal expectations concerning research and innovation, intending to foster the design of inclusive and sustainable research and innovation” (European Commission, 2020, December 7).

The RRI framework comprises five thematic elements, also known as ‘pillars’: public engagement, open access, gender, ethics, and science education (European Commission, 2020, December 7). Public engagement encourages dialogue between researchers, policymakers, industry, civil society organisations, non-governmental organisations (NGOs), and citizens on topics related to science and technology. Open access aims to provide scientific information to everyone free of cost, but this places an additional burden on researchers to cover the cost of publishing fees out of their own funds. The gender theme focuses on promoting equal economic independence for all genders, reducing the gender pay gap, advancing gender balance in decision-making, and putting an end to gender-based violence. The ethics theme aims to ensure integrity in research and innovation processes. Lastly, the science education theme aims to make science careers more appealing to younger generations, which would also help improve society's scientific literacy. The involvement of the academic community, governmental agencies, NGOs, and legitimate stakeholders in citizen science is crucial for addressing real-world issues related to biodiversity conservation and monitoring, innovation, technologies, and others (Hecker et al., 2018). Citizen science is an approach that is essential in this regard. This mechanism of applying scientific knowledge to meet society's collective responsibilities has proven to be effective in tackling complex challenges. A recent study by McKinley et al. (2017) highlights the significance of citizen science in engaging diverse groups in efforts to conserve biodiversity. Science communication events have been taking place for centuries, including Christmas lectures started by Faraday in 1825 in the UK (Bowater & Yeoman, 2013). Science communication, or popularisation, grew significantly in the 19th century and has been on the rise ever since. While popularisation is often used interchangeably with science communication (Bucchi, 2008), popularisation tends to focus on the deficit model of engagement rather than the participatory model of engaging citizens. Following World War II, governments worldwide took a central role in advocating for science and technology due to its impact on society (Gascoigne & Schiele, 2020; Gregory & Miller, 1998). Some governments, such as the UK and France, started investing in modern science communication, such as science museums, science weeks, and university training. In contrast, others, such as Germany, took on a more passive role, leaving it up to external organisations to lead the way (Gascoigne & Schiele, 2020). Although governments generally want to communicate science to their citizens, there have been instances where communication has been discouraged. This indicates that governments' need to communicate science may not always align

with citizens' needs. For example, during World War II, scientific research and technological development were primarily funded to achieve victory, with citizens' needs being secondary. Development and commercialisation were the top priorities (Macnaghten, 2020), while issues such as food scarcity received comparatively less attention.

Once the need to communicate science was established, stakeholders were tasked with figuring out how to do so in a way that aligned with government requirements.

International surveys help gauge how Maltese students are faring in science and mathematics education. International studies, such as the Trends in International Mathematics and Science Study (TIMSS), a comparative international study of mathematics and science achievement in 22 countries, found that in Malta, boys performed better in science than girls (Ministry for Education, 2019). However, the Programme for International Student Assessment (PISA) 2022 results assessing 15-year-old students showed that boys and girls performed similarly on average in mathematics in Malta, unlike the global trend (Organisation for Economic Co-operation and Development (OECD), 2022). Conversely, PISA results show that female students outperformed male students in science (Ministry for Education, 2022). The consistent gender trends in education are observed worldwide, including in the EU, as reported by the United Nations Economic Commission for Europe (UNECE) in 2019, and the EU European Commission's She Figures in 2021. These trends are also evident at the University of Malta (UM). Student undergraduate statistics from 2022/2023 at UM show that STEM graduates are overwhelmingly male-dominated in engineering (75.3% male) and ICT (82.6% male) courses (University of Malta, 2023). This is not the case when it comes to health sciences, with the majority being female (75.1% female), dental surgery (87.5% female), and medicine and surgery (64.8% female) (University of Malta, 2023).

One of the key objectives for governments (such as Australia and the UK) was to equip the students with the necessary knowledge and skills to effectively pursue their career aspirations in the fields of science and technology (Australian Government, 2017; Archer et al., 2015). Archer and colleagues (2015) adapted Bourdieu's concept of capital to science education, proposing a quantitative measure to assess individuals' science capital based on their science-related experiences, knowledge, attitudes, and resources across several domains. The concept of science capital included understanding students' scientific forms of cultural capital by looking at students' scientific literacy, science dispositions and symbolic forms of knowledge about the transferability of science qualifications. Furthermore, Archer et al. (2015), investigated science related behaviours and practices, such as media consumption and visiting informal learning environments, and science related to social capital, such as

knowing someone who works in science, parents' social standing, qualifications and so on.

While this adaptation to science capital has generated valuable insights, it has some limitations. The framework developed focused on individual characteristics, such as knowledge, attitudes, and experiences, and neglected to consider or overlooked structural inequalities and systemic barriers (Jensen & Wright, 2015). Furthermore, while demographics are considered, there is a lack of intersectionality that fails to account for the intersecting dimensions of identity, such as gender, race, and socio-economic status. The combination of these factors influences individuals' experiences in citizens' participation in science. Another critique of science capital is that it views students and citizens as lacking the necessary capital to engage in science, perpetuating a deficit model. Additionally, Archer's concept of science capital does not address the mechanisms through which the dimensions of capital influence citizens' participation. Inadequate attention to power dynamics within the scientific community and their influence on science engagement is also lacking (Jensen & Wright, 2015).

The capital of science in this study refers to the various forms of resources and assets available to citizens and publics. This theoretical lens provided this study with an understanding of how citizens' capital influences their participation in science activities and events. To analyse Maltese residents' participation in science and technology, the following equation developed by Bourdieu (1984) was applied – [(Habitus) (capital)] + scientific field = practice¹.

Habitus is a term used to describe a product of socialisation that affects individuals on a personal level. It not only organises practices and perceptions but also creates a structured framework based on logical classification, which itself is a result of the internalisation of social class divisions (Bourdieu, 1984, p. 170). Capital refers to the resources one can possess, including economic, social, cultural, and symbolic assets. In the context of this paper, the field refers to a specific area of study, namely science. Practice refers to the actions and behaviours of relevant stakeholders within the Maltese PES.

Methodology

The overall study aimed to gather Maltese residents' attitudes and perceptions of science through a survey. This was a multi-component survey, with a questionnaire being one tool.

¹ Adapted version of Bourdieu's capital.

Questionnaire design

This paper will focus on three aspects of the final questionnaire. The selection of the questionnaire as an instrument was based on its ability to generate accurate information and to collect data from the right stakeholders (Beatty et al., 2019). The use of a questionnaire in quantitative research has three main benefits: it explains fine differences between people, provides a consistent way of measurement, and allows for correlation analysis (Bryman, 2016). While the descriptive survey used in this study was not designed to demonstrate causal relationships between variables (Oppenheim, 1992), it indicates the opinions held by citizens over the age of 18. The questionnaire was either self-administered or took the form of an informal, structured interview.

The majority of the questions were close-ended, making it easy for participants to complete and analyse. Only one open-ended question was included, asking citizens what they think of science. This 13-item questionnaire (see Appendix) consisted of three sections and took around 10 minutes to complete. The first section gathered demographic data such as age, gender, current hometown, nationality, highest education qualification, and whether they belong to any NGO. This data was used to define the sample and to compare it to other variables. The second section included questions about citizens' attitudes towards science, their interest in science, and whether they have ever worked in a science-related field. This section provided a snapshot of the respondents' interests in relation to science. The third section asked citizens about their level of engagement with science, including whether they attend activities/events related to science, their frequency of attendance, their preferred learning medium, and entities to learn about science. The final question asked how well-informed they feel about science, research, and technology. Respondents used a Likert scale to answer the last three questions, ranging from Strongly Agree to Strongly Disagree with an option of Prefer not to say, ensuring unidimensionality (Oppenheim, 1992).

Data collection

The questionnaire and consent form were sent to the University Research Ethics Committee at the University of Malta for approval, and this was obtained in September 2019. A pilot survey was conducted, and feedback was obtained from respondents about the questions asked (Jensen & Laurie, 2016; Creswell, 2014). The study followed ethical guidelines and obtained feedback from nine respondents of various ages, genders, and work backgrounds to improve the survey questions. Data was collected on the level of understanding, completion time, and overall comprehension of the survey questions. The final survey was distributed at various events, including scientific and cultural festivals as indicated in Table 1. The survey questions

were available online (Zoho survey) and offline survey options were available on tablets and mobile phones.

Type of data collection	Event ²	Frequency	Percentage
Physical	Science in the City (SITC)	126	21.9
	Notte Bianca	38	6.6
	Birgu Fest	50	8.7
	Natalis Notabilis	48	8.3
Total Physical		262	45.6
Online	English version without Facebook ad	216	37.6
	English version with Facebook ad	68	11.8
	Maltese version without Facebook ad	19	3.3
	Maltese version with Facebook ad	10	1.7
Total Online		313	54.4
Final Sample Size	Total Physical and online	575	100.0

Table 1: Physical and online data collection through different sources

Due to the COVID-19 pandemic, physical data collection was no longer feasible in 2020, necessitating a risk mitigation plan. As a result, an online version of the questionnaire was created, and minor cosmetic adjustments were made to ensure its suitability for online administration. From August 29th to September 30th, 2020, the questionnaire was distributed on various popular Facebook pages and groups in Malta using convenience and snowball sampling methods. Despite their non-random nature, these methods allowed for a broad range of participants to be included in the study (Creswell, 2014; Jensen & Laurie, 2016). However, it should be noted that these sampling methods pose a risk of producing results that are not representative of the target population. To address this, measures were taken to ensure a representative sample by stratifying the sample according to gender and age, and targeted Facebook ads were used to increase the number of male responses and reach out to respondents over the age of 65. Whilst acknowledging limitations of convenience and snowball sampling, these methods were deemed necessary to

² Science in the City is a science and arts festival that takes place in Valletta, the capital city. Notte Bianca is one of Malta's biggest annual arts and culture festivals and is held in Valletta. Birgu Fest is a festival of light that illuminates Birgu's winding medieval streets in the South of Malta. Natalis Notabilis is a Christmas market that is in the west of Malta (Rabat).

ensure a large number of participants and a more comprehensive understanding of the research topic.

The individuals who declined to complete the questionnaire typically cited time constraints, a perceived inability to contribute to scientific research, or simply a lack of interest. The data exhibits a standard distribution in terms of age and gender, except for the older age groups (55-64 and 65+). Some participants declined to participate as they were not Maltese citizens or did not reside in Malta.

Data analysis

The quantitative data was meticulously cleaned and inputted into IBM SPSS Statistics 26 for analysis. Various statistical tests were conducted, depending on the type of sample and whether it achieved normality, as outlined by Jensen and Laurie (2016). For instance, the Chi-squared test was utilised to examine the association between two categorical variables, such as NGOs/science festivals and museums and frequency of attendance. Meanwhile, the Friedman test was employed to compare mean rating scores among several related statements, such as preferences for learning about scientific developments and research. As the data was both ordinal and categorical, one-way Anova could not be used to determine the p-value. Instead, the Kruskal-Wallis test was implemented to compare mean rating scores among several independent groups that were clustered by age, gender, and other factors. Finally, thematic analysis (Braun et al., 2019) was used to analyse the open-ended questions.

Limitations

Regrettably, it was not possible to engage extra data collectors due to time limitations and their unavailability. Despite this challenge, a significant number of responses were gathered, resulting in a well-rounded sample. It is worth noting that the online survey had some limitations, such as the difficulty of maintaining a refusal log, limited internet access for certain demographics, and the exclusion of those who were illiterate. Additionally, the online questionnaire did not capture any informal conversations that may have yielded additional insights. However, these limitations were somewhat mitigated by the fact that nearly half of the sample was collected through physical means. This paper only deals with who is attracted to scientific events and the use of surveys tends to limit the richness of taking a more holistic approach to understanding the perceptions and attitudes of citizens towards science and technology

Results

Most of the respondents were female (284, 51.3%), while 279 respondents (48.7%) were male. A spread of different age groups was only achieved for the 25-34 and 55-64 age group as shown in see Table 2. The sample population was representative in terms of gender, and certain age groups.

Most respondents had a high level of education, with the highest percentage of the sample (39.7%) having obtained a post-graduate degree as their highest level of education and the lowest percentage representing the respondents with only a primary level of education (0.9%). Most respondents have never worked in a science related field ($n = 297$, 52.2%), while those that were currently working in a science related field represented 26.5% of the sample with 11.2% of the responses representing those that have worked but were currently not working in a science related field.

Age	Maltese questionnaire		Maltese census 2019		Z-score	P-value
	Frequency	Percentage	Frequency	Percentage		
18-24	92	16.0	39414	9.2	5.670	<0.001
25-34	119	20.7	92933	21.6	0.536	0.589
35-44	126	21.9	79959	18.6	2.040	0.041
45-54	120	20.9	60567	14.1	4.669	<0.001
55-64	68	11.8	61971	14.4	1.767	0.077
65+	50	8.7	95050	22.1	7.748	<0.001
Total	575	100.0	429894	100.0		

Table 2: Respondents' age compared to the Maltese 2019 census

The results are now presented under three themes, namely: (i) interest in science; (ii) attendance to science activities; and (iii) perceptions of knowledge.

Interest in science

The majority of the respondents expressed their interest in science ($n = 461$, 80.2%), with only a small sample of 69 respondents (12.0%) stating that they are not interested in science. There is no statistical significance between gender and interest in science, and Table 3 shows that most respondents are interested in science regardless of gender and age. Those respondents with a secondary level of education are the group with the least percentage (41.7%) with respect to interest in science, but then the percentage is significantly higher for diploma (84.7%), undergraduate (84.1%) and post-graduate (91.8%), as shown in Table 3. Respondents who do not work in a science related field are still interested in

science (71.0%), even though interest in science is higher when participants work in a scientific field (99.3%).

Variable	Yes	No	Don't know	Total	P-value
Gender					
Male	234 (84.8%)	30 (10.9%)	12 (4.3%)	276 (100%)	0.060
Female	225 (77.9%)	39 (13.5%)	25 (8.7%)	289 (100%)	
Total	459 (81.2%)	69 (12.2%)	37 (6.5%)	565 (100%)	
Age					
18-24	78 (87.6%)	7 (7.9%)	4 (4.5%)	89 (100%)	0.018
25-34	97 (81.5%)	18 (15.1%)	4 (3.4%)	119 (100%)	
35-44	102 (82.3%)	19 (15.3%)	3 (2.4%)	124 (100%)	
45-54	94 (79.0%)	12 (10.1%)	13 (10.0%)	119 (100%)	
55-64	49 (73.1%)	11 (16.4%)	7 (10.4%)	67 (100%)	
65+	41 (83.7%)	2 (4.1%)	6 (12.2%)	49 (100%)	
Total	461 (81.3%)	69 (12.2%)	37 (6.5%)	567 (100%)	
Education level					
Primary	4 (80.0%)	0 (0.0%)	1 (20.0)	5 (100.0%)	0.014
Secondary	25 (41.7%)	25 (41.7%)	10 (16.74)	60 (100.0)	
Sixth Form	40 (69.0%)	11 (19.0%)	7 (12.1%)	58 (100.0%)	
Diploma	127 (84.7%)	13 (8.7%)	10 (6.7%)	150 (100.0%)	
Undergraduate	53 (84.1%)	7 (11.1)	3 (4.8%)	63 (100.0%)	
Postgraduate	201 (91.8%)	12 (5.5%)	6 (2.7%)	219 (100.0%)	
Other	10 (90.9%)	1 (9.1%)	0 (0.0%)	11 (100.0%)	
Total	460 (81.3%)	69 (12.2%)	37 (6.5%)	566 (100.0%)	

Table 3: Respondent's interest in science categorised by gender, age, and education level

The patterns identified through the responses of what citizens think of the word 'science' were divided into four categories: subjects/topics, feelings, scientific process, benefits and other.

In the first category, mentioned various topics and subjects within science, including Physics (n = 71), Biology (n = 61), and Chemistry (n = 60). The second category, feelings, consisted of words that respondents used to express their emotions towards science, such as interesting (n = 26), fun (n = 16), and curious (n = 15). While most of the feelings associated with science were positive, some respondents also used words such as difficult (n = 7) and breakdown (n = 3). The third theme reported respondents' words related to the scientific process, including skills, data collection, observation, experimentation, and coming to a conclusion. The word that appeared most frequently across all four themes was experiments (n = 119), followed by discovery (n = 41) and laboratory (n = 26). The fourth theme identified was benefits, which included words declaring the advantages of science and technology, such as future (n = 30), advancement (n = 17), and education and learning (n = 19). The other category included any

words that did not fit within the other four categories, such as Einstein (n = 4). The word that appeared most frequently overall was experiments, which was written 107 times, followed by physics (71 times) and knowledge (63 times).

The Internet is significantly more popular as a learning tool than TV and science events, which in turn are significantly more popular than newspapers, radio, podcasts, and blogs (see Table 4). These mean rating scores vary significantly since the p-value is approximately 0 and is less than the 0.01 criterion (level of significance).

Learning sources	Friedman Test		
	Sample Size	Mean	Std. Deviation
Internet	575	4.20	0.840
Science events	575	3.86	0.927
TV	575	3.83	0.957
Blogs	575	3.20	1.052
Newspapers	575	3.12	1.065
Podcasts	575	3.12	1.091
Radio	575	2.98	1.107

$\chi^2(6) = 808.36, p < 0.001$

Table 4: Preferred mode of learning from different sources

Attendance to science activities

Table 5 reveals that the majority of the respondents never attended science activities (n = 297, 51.9%), while 262 respondents (45.8%) reported that they attended such events.

Moreover, according to the data in Table 5, there is no significant correlation between gender, nationality, or current hometown and attendance at science-related events. However, it is worth noting that the 18–24 age group had the highest attendance rate (65.2%), followed by the 25–34 age group (50.8%). The older age groups had lower attendance rates, with the 55–64 group at 29.4% and the 65+ group at 32.7%. This suggests that younger people are more likely to attend science events. It is also interesting to note that education level plays a role, with respondents holding undergraduate (59.4%) and postgraduate degrees (55.0%) attending more frequently than those with primary (20.0%) or secondary education (16.7%).

More than half of the respondents (52.2%) have reported visiting both the National Museum of Natural History and the Malta Maritime Museum (51.5%), as well as the Malta National Aquarium (46.5%) at least once.

Variable	Yes	No	Do not know	Total	P-value
Gender					
Male	117 (42.2%)	154 (55.6%)	6 (2.2%)	277 (100.0%)	0.267
Female	143 (48.8%)	143 (48.8%)	7 (2.4%)	293 (100.0%)	
Total	260 (45.6%)	297 (52.1%)	13 (2.3%)	570 (100.0%)	
Age					
18-24	60 (65.2%)	30 (32.6%)	2 (2.2%)	92 (100.0%)	<0.001
25-34	60 (50.8%)	55 (46.6%)	3 (2.5%)	118 (100.0%)	
35-44	58 (46.0%)	64 (50.8%)	4 (3.2%)	126 (100.0%)	
45-54	48 (40.3%)	69 (58.0%)	2 (1.7%)	119 (100.0%)	
55-64	20 (29.4%)	48 (70.6%)	0 (0.0%)	68 (100.0%)	
65+	16 (32.7%)	31 (63.3%)	2 (4.1%)	49 (100.0%)	
Total	262 (45.8%)	297 (51.9%)	13 (2.3%)	572 (100.0%)	
Education level					
Primary	1 (20.0%)	3 (60.0%)	1 (20.0%)	5 (100.0%)	<0.001
Secondary	10 (16.7%)	49 (81.7%)	1 (1.7%)	60 (100.0%)	
Sixth Form	25 (43.1%)	32 (55.2%)	1 (1.7%)	58 (100.0%)	
Diploma	61(40.7%)	85 (56.7%)	4 (2.7%)	150 (100.0%)	
Undergraduate	38 (59.4%)	25 (39.1%)	1 (1.6%)	64 (100.0%)	
Postgraduate	122 (55.0%)	95 (42.8%)	5 (2.3%)	222 (100.0%)	
Other	4 (33.3%)	8 (66.7%)	0 (0.0%)	12 (100.0%)	
Total	261 (45.7%)	297 (52.0%)	13 (2.3%)	571 (100.0%)	

Table 5: Respondents' attendance to science activities categorised by gender, age, and education level

Interestingly, the majority of participants who stated they attend whenever they have time chose the National Museum of Natural History (19.2%) and Esplora (18.8%), indicating that these places are definitely worth revisiting. Furthermore, a significant percentage of participants (22.9%) who attended the Science in the City (SITC) festival reported revisiting the event annually. On the other hand, most of the respondents have never attended science activities held by NGOs, with the largest percentage of respondents not attending attributed to Café Scientifique Gozo (69.5%), followed by Kids Dig Science (67.5%), Malta Café Scientifique (62.8%), and CineXjenza (60.6%).

Perceptions of knowledge

Overall, participants felt well informed about science, technology, and innovation (56.3%), while 29.3% felt uninformed or extremely uninformed, and 29.3% are neutral. There is a statistically significant difference between gender and how well-informed citizens feel about science, technology, and innovation, with males scoring significantly higher than females (3.64 vs 3.32; p-value < 0.05). While both genders indicated how informed they felt about science, self-perception was higher for males than females.

One statistically significant finding was the difference between genders in their self-perceived knowledge of science, technology, and innovation. Males (3.64) rated themselves higher than females (3.32). Both genders expressed interest in science, but males felt more knowledgeable. All the mean rating scores are above 3 which means that there is an overall perception that the population is well informed about science, technology, and innovation, with the over 65 age group having the highest percentage (3.68) and the 55-64 age group having the least mean rating score (3.14). Table 6 also shows that the higher the level of education, the higher the perception is about how well informed respondents feel towards science, technology, and innovation.

Variable	Sample size	Mean	Std. Deviation	P-value
Gender				
Male	268	3.64	0.848	<0.001
Female	274	3.32	0.884	
Total	542	3.48	0.880	
Age				
18-24	86	3.64	0.734	0.046
25-34	113	3.49	0.907	
35-44	118	3.45	0.883	
45-54	114	3.48	0.924	
55-64	65	3.14	1.029	
65+	47	3.68	0.556	
Total	543	3.48	0.880	
Education level				
Primary	5	3.40	0.548	0.053
Secondary	59	3.12	0.966	
Sixth Form	55	3.51	0.717	
Diploma	140	3.42	0.937	
Undergraduate	64	3.44	0.833	
Postgraduate	207	3.62	0.856	
Other	12	3.50	0.798	
Total	542	3.48	0.880	

Table 6: Perception of how informed they are with science, technology and innovation categorised by gender, age and education level

Discussion

The perception of science by Maltese residents plays a crucial role in determining its relevance, role, and accessibility in society. The decisions taken by individuals in society, such as whether to take a vaccine or pursue a career in STEM, are influenced by their perceptions of science. Overall, this survey

indicates that a high proportion of Maltese residents feel well informed or fairly informed about science. This is further corroborated by the popularity of Science in the City, an annual science festival that attracts a large number of people in Malta (MISCO International Ltd., 2019). However, there is a noticeable disparity in attendance at science events among citizens with different levels of education. Most of the population that does not attend science activities in Malta only have a secondary level of education, and they view science as too complex to understand (MISCO International Ltd., 2019). Jensen et al. (2021) conducted a study on the European Researchers' nights in Ireland, Malta, and the U.K., which also found that science events attract attendees with a higher level of education. Malta had the highest percentage of attendees with higher qualifications compared to the other two countries, suggesting that citizens might view science as difficult or for the cognitively gifted. Maltese residents' perception that science is limited to laboratory settings creates a misleading distinction between what is considered scientific and what is not. Although this study did not specifically examine citizen science, this method of involving citizens in the production of scientific knowledge can promote their active participation and engagement (Mckinley et al., 2017).

As Hodson (1998) points out, it is important to recognise that scientific literacy is more than just possessing knowledge and skills of understanding. Citizens construct their views from the sources available to them, reliable or not, and they need to be seen as critical thinkers rather than passive ones (Diezmann & Watters, 2002; Linn, 2004). Hence, it is imperative to tailor science education to cater to cognitive development that encompasses emotional, aesthetic, moral, and spiritual needs (Hodson, 1998). By making science pertinent to the daily lives of individuals, both young and old, can be captivated, and science education should strive to engage diverse audiences (Baram-Tsabari & Osborne, 2015).

According to the survey findings, age emerged as a significant determinant of attendance at science-focused events. It is possible that younger audiences tend to have more leisure time and fewer commitments and are more likely to be reached through social media promotions – a platform that is predominantly used by the younger demographic (European Union, 2023). In Malta, while Facebook caters to a wider age group [16-34 (97%), 35-54 (96%) and 55+ (92%)], TikTok [16-34 (58%), 35-54 (46%) and 55+ (36%)], and Instagram [16-34 (74%), 35-54 (90%) and 55+ (42%)], are primarily popular among the younger population aged below 30 years (MISCO International Ltd., 2023). This finding highlights the importance of understanding the user demographics of different social media platforms when formulating targeted marketing strategies. The inclusion of student organisations and student participation in the SITC festival could also be contributing factors.

According to the findings, it appears that those who identify as females in Malta feel less informed about science, technology, and innovation than males. This discrepancy could have a negative impact on the number of females pursuing STEM courses. Furthermore, studies such as TIMSS (2019) (Ministry for Education, 2019) and PISA (2022) (OECD, 2022), as well as undergraduate statistics from UM, suggest that a student's self-perception can influence their choice of studies and career. Gender biases and stereotypes may be contributing to this phenomenon, hindering girls and women from pursuing further education and careers in STEM fields (McKinnon & O'Connell, 2020). Additionally, the media's portrayal of STEM as a male-dominated field may also be perpetuating this stereotype (Niemi & Pitkänen, 2017; Chimba & Kitzinger, 2010).

The results indicate that the internet is a popular medium for acquiring scientific information, which is supported by the MISCO International Ltd.'s study conducted in 2019 (51.5%). Facebook is another popular medium. The internet has the potential to serve as an equaliser, but it can also lead to the distortion of research. The internet provides a platform for collaboration and competition between various institutions, disciplines, and individuals (Trench, 2008). It allows institutions to display their accomplishments online, enables niche disciplines to connect through email, and facilitates online discussions where individuals can participate in critical arguments and debates. It is imperative that individuals cultivate the ability to scrutinise the sources they rely on for information, beginning at a young age. These critical thinking skills are essential for active participation in society and for effectively discerning valuable information. Entities such as science centres, museums, festivals, and NGOs need to focus on using these popular platforms to reach to wider audiences and publics. Museums can offer a platform and be seen as popular public spaces for transformative learning (Mayo, 2013).

Hughes (2018) noted that STEM retention is linked to citizens' science identity, which is integral to an individual's confidence, interest, and sense of belonging in the world of science. According to Archer et al. (2015), science capital plays a crucial role in shaping one's science identity and can even lead to cultural shifts. Unfortunately, stereotypes can impede individual beliefs and discourage people from pursuing or maintaining careers in STEM fields. Although this particular study did not examine families' attitudes towards science education, I concur with the notion that positive family views on the subject can influence students' interest in pursuing STEM studies and engaging with science beyond the classroom, regardless of whether they choose to continue their academic pursuits or not.

Perceptions built when young and during primary school greatly affect students' career choices later on (Archer et al., 2015). This is a complex issue, and stereotypes and other factors, such as support, affect students' career

choices. However, while the concept of science capital can give educators and science communicators a tool to broaden access to science capital and contribute to cultural transformation, it does not acknowledge the power of the entities that conduct PES.

This study delved into the role of science perception among Maltese people. This perception affects the relevance and accessibility of scientific advancements in society. The study shed light on the unequal attendance of citizens with varying education levels at science events. In our experience as reflective practitioners, science education must cater to emotional, aesthetic, moral, and spiritual development. Furthermore, this study highlighted the influence of gender biases and stereotypes on the underrepresentation of women in STEM fields, while highlighting the significant impact of a family's positive outlook on science education in shaping students' interest in pursuing STEM studies. Additionally, this study acknowledges the internet's popularity as a medium for scientific knowledge acquisition but cautions against the potential distortion of research.

Conclusion and Recommendations

Current efforts in PES are fragmented and inconsistent. While science capital is a helpful tool for science educators to empower citizens and students, its potential is only beginning to be realised. Examining power dynamics between science entities and PES in society, as Bourdieu emphasised, is essential. Further local research should explore how educational institutions may be reinforcing cultural biases through the participation of a scientific elite. Other studies could investigate the role of media and industry in shaping citizens' attitudes towards science and PES. To encourage greater engagement, entities involved in PES should involve citizens in the design and implementation of activities and research processes. Further research into targeting diverse minorities with a focus on under-represented groups in science courses will give further insight as to how to attract a more diverse group of students within STEM. In order to better understand the impact of gender stereotypes on career choices, future research could investigate fields with a greater gender imbalance, as these fields may be more likely to reinforce gender norms. The same applies to citizens and understanding why certain publics are disengaged from attending public science events or engaging with science news. Further research could also incorporate the role of race and socio-economic background in citizens' participation in science. A national PES strategy could bring stakeholders together for a more cohesive approach towards RRI and the implementation of citizen science.

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Appendix - Science Residents Survey

Consent

I have understood the information provided in the information sheet and I'm willing to participate in this study by filling in this survey.

Section 1: General information

1) Age ____

2) Gender *Options: Female/Male/Other*

3) Nationality: _____

4) Current Hometown: _____

5) Highest Education Qualification: *Options: Primary, Secondary, Sixth form, Diploma, Undergraduate degree, Post graduate degree, Prefer not to say*

6a) Are you a member of any organisation (e.g. Friends of the Earth, Greenhouse, Action for Breast Cancer Foundation)? *Options: Yes/No/Prefer not to say*

6b) If yes - Which organisations are you a member of? If not please write N/A (Open-ended question)

6c) If Yes: Follow up question: What is your role within this organisation? *Options: Administration, Active member, Member but not active, Senior member, Not a member, Other (please specify)*

Section 2: Attitude towards science

7) What 3 words come to mind when you hear the word 'Science'?

8) Are you interested in science? Yes/No/ I do not know/Prefer not to say

8a) If yes, which aspects of science interest you? If not please write N/A (Open-Ended Question)

9) Have you ever worked in the science related field?

Options: Yes, I currently work in a science related field, Yes but not anymore, No, I do not currently work in a science related field, No, I have never worked in a science related field, Prefer not to say

Section 3: Level of engagement with science

10) Do you attend any activities/events related to science? *Options:*

Yes/No/I do not know

11a) How frequently have you attended science centres/museums and science festivals? *Options: (Matrix Choice) Esplora, Life Sciences park, Malta national aquarium, National Museum of Natural History, Malta Maritime Museum, Science in the City, Science in the Citadel, Other please specify*
Every year, Whenever I have time, Once, Never, Not Aware of centre/festival, Prefer not to say

11b) How frequently have you attended events organised by non-governmental organisations (NGO's), over the past year? *Options: Matrix Style*

CineXjenza, Café Scientifique Gozo, Malta Café Scientifique, Kids Dig Science, Other (Please specify)

Every event, Whenever I have time, Once, Never, Not aware of NGO, Prefer not to say

12a) I prefer learning about science developments and research through:

Options: Likert Scale Strongly Agree to Strongly Disagree (Matrix Style) and Prefer not to say

Internet, Newspapers, TV, Radio, Podcasts, Blogs, Science events, Other (Please specify).

12b) I prefer learning about science developments and research from:

Options: Likert Scale Strongly Agree to Strongly Disagree (Matrix Style) and Prefer not to say

Government (e.g. Ministry for Education and Employment), Malta Council for Science and Technology (MCST) (e.g. Esplora), Non-governmental organisations (e.g. Birdlife & Astronomical society of Malta), Media (e.g. PBS), University of Malta, Malta College of Arts, Science and Technology (MCAST), Industry, Other (Please specify).

13) How well informed do you feel about science, technology and innovation?

Options: Likert Scale

Extremely well informed, Informed, Neutral, Not informed, Extremely uninformed, I do not know