redin Revista Facultad de Ingeniería, Universidad de Antioquia, No. 80, pp. 21-30, 2016

The perception of colombians about science and technology according to their education level: professional and non-professional population

La percepción de los colombianos respecto de la ciencia y la tecnología según su nivel educativo: profesional y no profesional

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ARTICLE INFO
Received April 06, 2015
Accepted April 30, 2016

KEYWORDS
Public perception of science and technology, indicators of perception, education level

Percepción pública de la ciencia y la tecnología, indicadores de percepción, nivel educativo

ABSTRACT: This document discusses the results of the implementation of the Third National Survey on Public Perception of Science and Technology applied in Colombia. It analyzes the effect of education over some aspects related to the perception about Science and Technology of the Colombians, considering variables such as age and professionalization of the population. Methodologically, the research type is quantitative and descriptive; it uses statistical tools like frequency tables, histograms and subsampling techniques to avoid a biased comparison of the populations. The major findings presented are that the level of education acquired and the formal training actually have significance regarding the perceptions about science and technology in the studied population; it proved to affect the perception and attitude towards issues as the preference in the choice of a career for daughters and sons, the tendency for reviewing instructions and exploring the use of the information, the perception of whether the country works on science or not, and if people make science and technology. In the future, it will be required an approach based on differential studies, addressing the impact of the dissemination of science and technology.

RESUMEN: Este documento analiza los resultados de la aplicación de la Tercera Encuesta Nacional sobre Percepción Pública de la Ciencia y la Tecnología aplicada en Colombia. Analiza el efecto de la educación sobre algunos aspectos de la percepción sobre la ciencia y tecnología, teniendo en cuenta variables como la edad y la profesionalización de la población. Metodológicamente, el tipo de investigación es cuantitativa y descriptiva; utiliza herramientas estadísticas como tablas de frecuencias, histogramas y técnicas submuestreo para evitar una comparación sesgada de las poblaciones. Los principales hallazgos presentados son que el nivel de educación adquirido y la formación tienen realmente un efecto en lo que respecta a las percepciones sobre la ciencia y la tecnología en la población estudiada; se demuestra que se afecta su percepción y actitud en cuestiones como la preferencia en la elección de una carrera para hijas e hijos, la tendencia en revisión de instrucciones y exploración del uso de información, la opinión sobre si en el país se trabaja en ciencia o no y si la gente hace ciencia y tecnología. Se concluye sobre la importancia de futuros estudios diferenciales para el reconocimiento del impacto de la divulgación de la Ciencia y la Tecnología.

1. Introduction

The understanding of the perceptions of the citizens has evolved bringing several advantages to the countries that have given wide recognition to educate their societies in scientific topics, highlighting, among others, the importance brought by the participation of people in discussions about science and technology (S&T). Jenkins [1], states that no modern society is imaginable without the support of S&T, and that therefore most of the governments have placed a very high value on them as a means towards development. Indicators about public participation are of remarkable importance: "societal change cannot be accomplished without social engagement and participation" [2]. As stated by The Organization for Economic Co-operation

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ISSN 0120-6230
e-ISSN 2422-2844

DOI: 10.17533/udea.redin.n80a03

and Development -OECD [3, 4] it is to be expected that an educated and more participatory society would be more cohesive and its citizens would be actively engaged in civic activities, making informed decisions about science-related issues [5]. The scientific culture that ensures the engagement of citizens in science and technology has become a remarkable issue in the public discourse and the academic research concerns [4], leading to an emergence of disciplines and concepts related to science [7] such as: "scientific literacy" [8], "public understanding" [5], "public perception" [9], "awareness" of science and technology, public "engagement in" [10] or "attitudes toward" S&T.

This trend is nowadays a tradition throughout the world [11], and it is currently known as the Public Perception of Science and Technology [12], aiming to respond how societies perceive S&T, and to show the real bonding between society and S&T [13]. Since it has become evident that governments and the productive sector invest in science and technology because of the expected benefits, the countries are using these kind of surveys to approach these issues [14].

The international studies held in this field, currently improved with methodologies of validated surveys and statistical analysis, such as the agenda currently issued by the Network of Science and Technology Indicators – RICyT [15], analyze the interest and the attitudes of humans, the indicators, the importance attached to the science from the individual to the collective, the notions and concepts involved and the confidence of public in institutions. The connection between students and science and technology, (seen as interest, motivation or attitude), has also been a topic of major concern around the world [16] and is nowadays recognized as a very important issue for researchers in higher education [17]. There have been some changes in the surveys that measure the public perception of S&T; aspects relating to participation have shown that recently they concentrate on participation and confidence in science rather than in the public understanding of science and civic literacy [18-21].

The Administrative Department of Science, Technology and Innovation – Colciencias, has been leading this process in Colombia with studies that establish the opinions and perceptions of the citizens towards S&T, initiating 1994 with the first national survey, followed by the second survey, conducted in 2004 and continuing with the latest report corresponding to the year 2012. This paper reviews some issues related to the third study in Colombia [22], applied directly to 6.113 people in eleven cities. It was structured in a technical form of 74 questions in four sections: Interest and information on S&T; Attitudes and valuation; Appropriation of S&T and Policy and citizen participation. The sample design was probabilistic, multistage and stratified according to the Human Development Index (HDI) [23] to increase the accomplishment of statistical properties as the inference of results and the estimation of sampling errors. This is a considerable improvement of this survey over the last ones, since it includes sampling factors as literacy or education of the population to enhance the analysis of perceptions about S&T. It considers estimations with coefficients of variation lower than 10% for dichotomous variables with a probability of occurrence of at least 10% [22].

The statistical analysis designed for the novelty and contribution of this document required including variables and additional data that were not available in the reports published by the OCyT. The information publicly disclosed at the link http://encuestaapropiacion.ocyt.org.co/ [22] only displays data in percentage values. Therefore, it was necessary to request the support of the National Observatory of Science and Technology in the provision of the survey's full database report. The selection of the information used, was considered as the most relevant for the current needs of the paper and was made at the discretion and point of view of the authors.

Through statistical procedures, the main purpose of this paper is to study the incidence of the education level (professional and non-professional) on the perception about some issues related to S&T in the Colombian population. This contributes to establish if after processes of education people obtain new obtain new knowledge that changes their perceptions. Such consideration, responds to the British movement known as PUS ("public understanding of science"), with an orientation towards the assessment of capacity of the public in relation to their degree of attitude towards S&T., these measurements, with a long tradition in social psychology, aimed to support the following statement: "The more you know, the more you support science" [24].

2. Experimentation and methodology used for the research

The type of research used is quantitative and mainly descriptive. The research design considered to study, as unit of analysis, 6113 people, the target population of the Third National Survey on Public Perception of Science and Technology, applied in the year 2012 by Colciencias with the support of the Colombian Observatory of Science and Technology. Through a probabilistic sampling, this survey focused on the civil population older than 16 years of 11 capital cities of Colombia. The sample design was developed in multiple phases and stratified with respect to the Human Development Index (HDI), it allows measuring the level of human development of a given territory according to the longevity, educative level and standard of life of the population [23]. The main objective of this survey was to identify the policies and the opinion and attitudes of the Colombians about S&T, and to provide inputs to improve the processes of social appropriation of science, technology and innovation in Colombia.

To fulfill the requirements of the research, using the database provided, and under the criterion of the authors, all the questions related to educational issues in each dimension of the survey were selected and used for the study. Two great groups were settled: professional and nonprofessional, considering as professionals the respondents that had obtained an academic title of technologist, college student or postgraduate. As a consequence, the group of nonprofessionals was to be formed by the population that did not accomplish any of the mentioned academic titles.

3. Results and findings

The following results were obtained: The groups sample was composed by 1,245 professionals (20.37%) and 4,868 nonprofessionals (79.63%). As presented in Table 1, in the original study, the distribution of ages of these populations are quite different. The amount of young population, considered in the range 15 to 35 years, is almost a half in the professional group. But for the nonprofessionals, the young people share is slightly superior to the one third of this population.

Considering that the variable "age" is a determinant factor in the perception of many issues [25], and of technology itself [26] a random subsampling of the non-professionals was applied to obtain populations with very similar distribution of ages (see Figures 1 and 2).

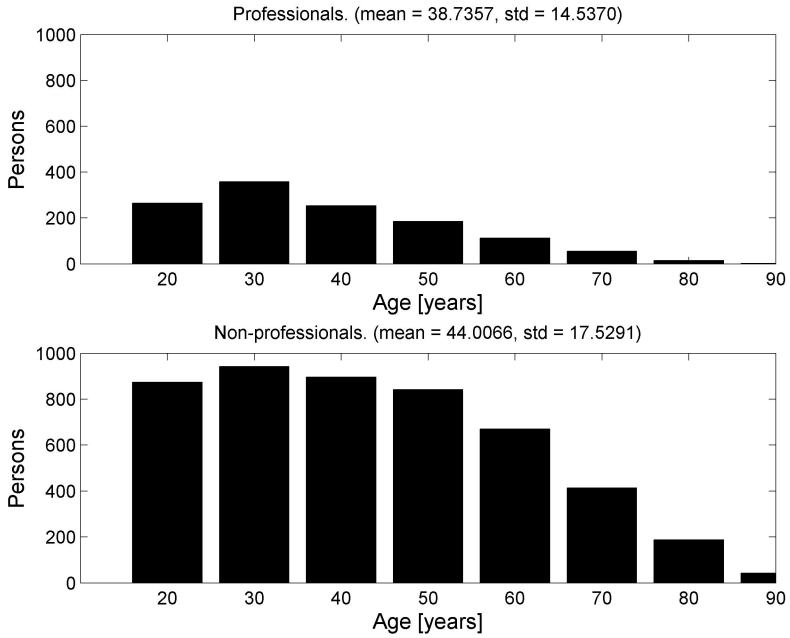

Figure 1 Original Histogram: Ages for the populations of professionals and non-professionals

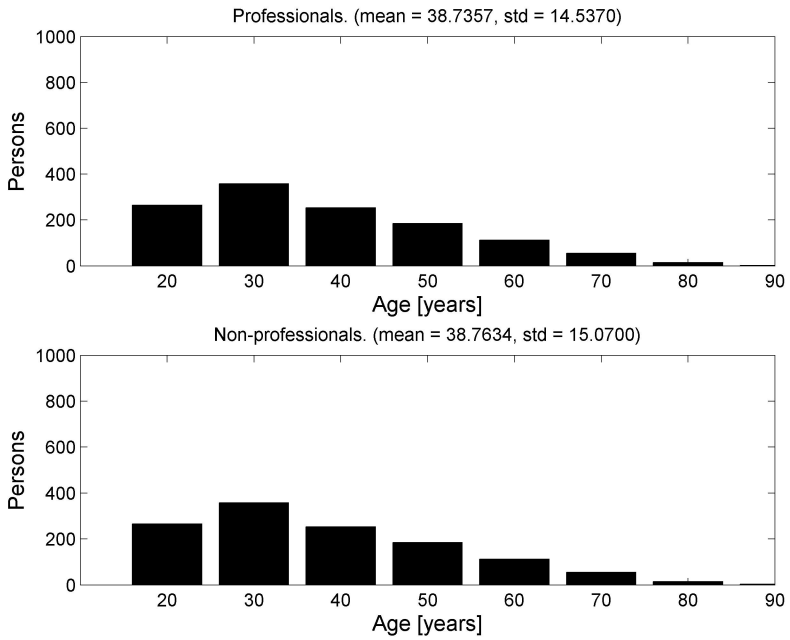

Figure 2 Histogram: Ages for the two populations showing the resampled populations

Table 1 Age distribution for the populations of professionals and non-professionals

Age Range	Professionals	Nonprofessionals
[15-35]	47%	35%
[35-95]	53%	65%
Total	**100%**	**100%**

According to the subsampling and to the segmentation of the population, in the following sections the frequencies for each dimension are analyzed.

3.1. Results in the dimension of interest in science and technology and the media

Under considerations related to educational facts, it was decided to investigate about the frequencies for the two most consumed mass media and the perception about whether some issues do inform or do not inform. The results are displayed in Table 2: Professional people consume mainly (82%) television. Their second media most consumed, in a much smaller percentage (of 8%) is the radio. The media less used by them are the press and magazines, each one with a percentage of 5% and 2% respectively. For the case of the nonprofessionals, the television is, similarly, the most consumed media, with a report of 93%, followed by the radio and the press. The Internet and the magazines were not referenced by this group of people.

Table 2 Frequencies for the most consumed media

Media	First Option Reported	
	Profesional	Non profesional
Televisión	82%	93%
Radio	8%	6%
Press	5%	1%
Magazines	2%	0%
Internet	3%	0%
Total	**100%**	**100%**

When the population was asked whether some subjects inform or not, the answers were analyzed in issues as Cinema, Art and Culture, Sports, Economy and Companies, Medicine and Health, Environment and Ecology, Shows, Astrology and Esotericism, Education, Policy, Religion, and Science and Technology. In most cases, it was found a greater perception corresponding to the professionals, believing that these subjects inform. The most dissimilar results are found in the perception of education, where the professionals think in a 90% that it does inform and the nonprofessionals say it does in a 75%. For professionals, science does inform in a 84% whereas for the nonprofessional it only does in a 56%. The tendency found so far changes to opposite for the case of astrology and esotericism. In this particular issue, the professionals believe that it does inform in a 26% whereas the nonprofessional believe it does in a 23%. For purposes of analysis, it is important to stand out that this subject is the one of lower percentage in both populations.

Table 3 Frequencies of the preferences of career for daughters and sons

Career	Preference for Daughters				Preference for Sons			
	Professionals		Non Professionals		Professionals		Non Professionals	
	Yes	No	Yes	No	Yes	No	Yes	No
Engineering	83%	17%	87%	13%	88%	12%	91%	9%
Physics	55%	45%	63%	37%	59%	41%	67%	33%
Medicine	85%	15%	91%	9%	83%	17%	89%	11%
Pedagogy	57%	43%	69%	31%	50%	50%	62%	38%
Sociology	50%	50%	59%	41%	48%	52%	58%	42%
Agronomy	49%	51%	61%	39%	56%	44%	66%	34%

Table 4 Frequency for each activity made by the population

Activity	Professionals			Non Professionals		
	Yes	No	DA	Yes	No	DA
a. Attention paid to instructions of use	91%	9%	0%	82%	15%	3%
b. Reading the consumption data in bills	78%	21%	1%	76%	21%	3%
c. Reading contraindications in medicine	90%	10%	0%	85%	13%	2%
d. Consulting the dictionary or Internet	88%	12%	0%	62%	36%	2%
e. Asking purpose for personal data	83%	14%	3%	72%	20%	8%
f. Searching about risks of a diet.	49%	19%	32%	40%	23%	37%

Table 5 Frequencies for the actions chosen by the population

	Activity	Professionals	Non Professionals
a.	To look for the person in charge to discuss on this issue	22%	25%
b.	To get together with the neighbors	27%	29%
c.	To inform a health or environmental control agency	40%	27%
d.	To report it on the radio or television.	6%	6%
e.	To call the police	3%	9%
f.	To wait until the authorities react	2%	3%
g.	To do nothing.	0%	1%
	TOTAL	100%	100%

3.2. Results in the dimension of attitudes and valuation of the public about science, technology and innovation

Table 3 shows the preference regarding the careers for sons or daughters:

For the daughters, the greater preference for the professionals (85%) as much for the nonprofessional (91%) is medicine. For the sons of professionals, their preference reports Engineering with 88%, whereas the nonprofessional support engineering with a 91%.

3.3. Results in the dimension of social appropriation of science and technology

In this dimension, it was decided to analyze the results for the activities listed and resumed in Table 4.

The previous frequencies show a greater tendency in the professionals (91%) to review instructions and to research about the use of the information than on the nonprofessionals (82%). The last activity, related to the risks of diets seems to have importance for both groups.

3.4. Results in the dimension of citizen participation

A question was selected related to the actions the population would take if a very polluting company was installed in their neighborhood affecting the health of the community. The results are shown in Table 5.

As it can be seen, the answers refer to a relative interest of citizens, to get together with their neighbors and carry out some action for reporting to an organism of health or environmental control (about pollution levels that affect the health of the community). This last variable is the most representative, 40% reported by professionals compared to 27% for nonprofessionals.

3.5. Results in the dimension of policies

Two results were analyzed: Whether there is science made in Colombia or not, and if the respondents know what Colciencias is. In both, there is a marked tendency of an affirmative opinion in the professionals, with a 79% than in the nonprofessionals, reporting these last a 72%. With respect to what Colciencias is, with a 52%, the professionals claim to know what it is. Only 15% of nonprofessionals know about it.

4. Discussion

When social issues are related to education matters, there are important implications; it is worth reviewing that if this kind of studies supports the importance of education in the opinion of a population, it becomes viable and more plausible to recommend to the government the implementation and strengthening of training and educational programs.

For the aimed contribution of this paper, it would be very relevant to start a review of these results in the light of changes or evolution of variables in the previous surveys conducted in Colombia; in this regard, just like it has been discussed by Daza, Lozano and Bueno [11], the discussion should be focused initially on the descriptive and not on the analytical level. This has a technical reason: The three surveys were conducted in historic moments of different contexts, with different objectives, questionnaires, methods and sampling designs. These facts bring out that any comparison would become risky and complex. In consequence, It is worth noting that under the proposed descriptive analysis, although there have been some changes, from the socio-demographic point of view, the sample sizes have been increasing, from 1,000 in 1994 to 1,503 in 2004 to finally 6,113 in year 2012. These three samplings have reflected, in a relatively uniform manner, the characteristics of the Colombian population, reporting a slight higher percentage of women population and few people with high economic level. On the issues of education, for all three surveys, the population reported as maximum

level of studies the High School, with percentages slightly greater than 40%, highlighting that for the 2012 survey, the percentage of people with post-graduate education has increased, reaching the 17.1% [11]

With respect to the relevance of this type of topics, the discussion could also be nourished by the contributions of Daza, Lozano, and Bueno [11]. They stated that "an indicator of the importance this topic has acquired can be observed in the increasing robustness of the surveys in their sampling designs and their form of application" [11]. For more than 20 years, the importance of surveys at national level has been undeniable, especially when they approach issues related to development. In the case of Social Perception of S&T, the main contribution presented by the OCyT was the disclosure and dissemination of information and data related to the perceptions of the Colombians. Nevertheless, like it has been stated, by this Organization, It is to be expected that the results of this survey serve the current research in issues of perception and social appropriation of S&T and sustain policies and actions aimed at strengthening the social appropriation of S&T in the country [22]. In order to accomplish this, it is necessary to complement these studies with more specific research, focusing on aspects such as the connection between perception and demographic profiles. This is precisely the significance and aim of the present paper, trying to complement the remarkable work of the OCyT by approaching the issue of the relationship between the educational level and the perception about S&T.

Some demographic variables such us age, affect the perception of humans in many issues [25, 26], in consequence and for the purposes of comparison needed in the research, the idea presented in the methodology section, about using a subsampling technique to try to reduce the possible bias that could be present due to the two dissimilar age structures found at the beginning (see Table 1), was proved to be convenient: Maintaining the population as it was in the preliminary sampling, would not allow showing the effect of age in the opinion, neither the effect of the technological advances along with education, creating what is called a "possible confusion" or "confounding" [27]. The idea of "matching" the two groups of population through a re-sampling exercise and therefore avoiding the bias or the possible confusion was very accurate and improved the validity of the assumptions made.

Even though, it is common to hear from people that education has an effect on their view and perception of life, and currently the public deals with statements that suggest that education is one of the most critical determinants of success for individuals and society [28], this should not be taken for granted and the social scientists should monitor, reflect and deepen on these issues periodically through the use of reliable mechanisms as surveys and methods of statistical analyses like the ones used in the present research. This could be helpful when considering the contributions made by authors such as Allum, Sturgis, Tabourazi and Brunton [24] and Shukla and Bauer [29] who indicate that perception and feelings of the people about science show variations depending on the culture. According to them, it is possible to distinguish two cultural trends that affect this phenomena; in one hand, the so called "industrial societies", where it is perceived that to a greater grade of knowledge there is greater acceptance towards science and on the other hand, the "post-industrial societies", characterized by its high educational and economic level, where a greater grade of knowledge does not necessarily generate a better attitude towards science, for this group, there is a significant distrust felt by people, translated in to a scientific skepticism that impacts the perception that the public has about science.

The research presented other interesting results related to common preferences. Since the 1950s, Television, as we know it, has had an important share in society's mass media consumption. This study showed that until now, despite the considerable effects and benefits of substitute technologies [30], for the Colombians, the most consumed mass media, has been the television. This is an observable tendency for more than 20 years; in the survey in 1994 it was the most consumed mass media with a share of 42%, followed by the press with 34% [11]. According to the results of the present research, the most recent survey shows a greater tendency of this opinion in the nonprofessionals. The Internet consumption is the second referenced option by the professionals, whereas the radio is used by most of the nonprofessionals.

Regarding the interests of information and the type of information people get, it is worth noting that internet has made a notable change during the past 20 years; when comparing the results obtained in 1994, and 2004, it is clear that the consumption of the press and magazines has been replaced by internet, due to the increasing number of digital publications [11].

It becomes interesting to deepen in these results by discussing that despite the preference of the two populations on television, there is a difference between the perceptions of the two groups in the use of the communication services to inform them or entertain them. The statistical analysis made, showed that professionals perceive, in greater weight, that communication services inform better than entertain. Education and science are the subjects that are perceived to inform rather than to entertain for the two populations, with a greater perception on the part of the professionals. It was not possible to discuss possible changes in time in this regard, because this question was included only in the last version of the survey.

It is worth mentioning that so far, regarding the researches about public perception of science and technology, Colombia has been inserted in the global community, maintaining a research line that can be homologated with other countries. This can be observed in the changes made over time to the survey, presenting at 2012 a questionnaire that aims to maintain the similarity with studies in other countries, especially in Iberoamerica [11]. This fact enables the comparability with the international community avoiding biases caused by methodological differences.

As an expectation for future research, it could be worth to deepen in other differential studies derived from the surveys, reviewing aspects such as the differences in the results by gender, race and socio-economic stratum. In addition, it would be interesting to consider comparative analysis based on the size of the main cities in the same country.

Contrasting the results of the research with the findings of Vergara in the context of another country (Mexico) [31], expressed in terms of the importance of education for the development of the ability to understand S&T, it becomes evident that for Colombia, the results remain supporting the hypothesis that education and training bring benefits for science, economies, governments, individuals and people's intellect. The author suggests that a truly informed and favorable public opinion can increase the tolerance of society towards the scientists and research firms, which facilitates and encourages the provision of public funding.

For authors as Valencia "science is the systematic attempt to produce true propositions about the world" [32]. The value of science for countries has been an undeniable and widely debated. Since the early 1900's [33] there were important publications such as the Poincaré and Halsted's, Durant, Evans and Thomas's [34]. They stated that a country that values science has advantages in the international technological competition and can strengthen the direct link between public science appreciation and the ability to influence decisions internationally. This sets another point for future discussion reviewing the results about the perception of whether Colombia works on science or not, (79% affirmative in professionals and 71% affirmative in nonprofessionals).

When discussing the preferences about the media, the professionals choose internet and non-professionals choose radio. This finding is of particular importance; it can be inferred, that the media generates behavioral patterns regarding the development of the public opinion. Internet has brought changes in the content and the way that public opinion is formed. "The public is no longer a receiver, it is also an issuer" [35].

Analyzing the preference, as parents, to choose a career for their children, the Colombian population reported at 1994 in a 83% that they would choose Chemistry [11]. The most recent survey shows a change with a relative uniformity between medicine (88.16%) and engineering (83.78%). When contrasting these data to the results for both populations, the greater preference for a career for their daughters in the professionals and for the nonprofessionals is for medicine. For the sons of professionals, their preference reports engineering with 88%, whereas the nonprofessional support engineering with a 91%.

It could be said that these results coincide with previous studies about the scientific vocation in certain cities of Colombia: A comparative study about the scientific vocation for the cities of Bogota and Cali, cited by Osorio and Hernández [36], found that regarding the careers preferred by students, the engineering area has a relevant weight in their professional projection. The areas of engineering and health have a greater interest in the city of Cali, while in Bogotá engineering has a heavier share followed by the social sciences. This study allowed estimating the preferences for pursuing certain career are high, the results showed an outstanding share for engineering and health, and, in contrast, a very low value for natural sciences. The low performance in the preference of a career in sciences confirmed that scientific vocation is related to the construction of attitudes in science, where the role of the school making science interesting and fun is very important [36]. This fact has been reflected in international studies applied in the European Union; the lack of interest of young people in science careers is associated with the lack of attractiveness of the science classes, added to the lack of interest caused by their low wages. Most of the reasons claimed by the students differ from a cause related to a bad image of science [37]. The role of the University in the creation of the critical thinking of the people is important since it allows the citizens to discern their judgments from the simple repetition of a speech issued and manipulated with an obvious bias, by different media of communication. To strengthen future studies in this regard, it might be interesting to approach researches that contribute to establish the role and importance of the education as a society reproducer.

The results about citizen participation could be discussed on the basis of the stated by Osorio (2014) about public participation in the third survey [38]. The author highlights that the perception towards the participation of Colombians ranges between medium to low level of favorability, which implies going from certain interest in the control of scientific activity as long as it could be an object of citizen intervention, to a lower level where such intervention on the science is delegated to the competent authority, in addition to considering some incompetence to participate in matters of science. Direct actions, in both expressions of a techno-scientific activism, have a high significance with respect to the forms to deal with contemporary techno-scientific problems [39]. The percentages of non-professionals with a 29% and 27% of professionals regarding this issue, give the response to a qualitative added value, which points out the interest in the perception towards the participation. While statistically higher responses, where two population groups delegate the intervention, would reflect a perception towards the participation of low level.

In the National Survey of 2012, 52% of professionals have heard about Colciencias, on the other side, only 13% of nonprofessionals know what Colciencias is. According to this analysis, if these answers were deeply analyzed, it could be possible to infer that the ignorance about this Organization or its roles is one of the main possible causes why the respondents did not associate it to the functions of regulation of science and technology. About its role, the most common answers found were: i) to make researches on science and technology (86.59%), ii) to finance the science and the technology... (84.36%) and iii) to formulate policies of S&T (81.21%) [11]. The results provided evidence about the fact that the level of education represents a

significant feature in the determination of the perception about science and technology, this trend was found in most of the answers reported.

5. Conclusions

The education and formal training actually has significance regarding the determination of the perceptions about Science and Technology in the population of the studied country. With respect to the interest in science and technology and the media, the first choice for both populations is the television, having a higher weight for the nonprofessionals. Analyzing the second option, the difference according to the level of education is remarkable, presenting a report of the internet by the professionals and of the radio by the nonprofessionals.

In terms of the dimension of attitudes and valuation, the education degree influences the response of the population; the preference in the choice of a career for daughters is medicine. The choice of professionals is the same for their sons, while nonprofessionals support engineering.

In the dimension of social appropriation, there is a marked and greater tendency in professionals for reviewing instructions and explore the use of the information over the nonprofessionals.

Regarding the dimension of citizen participation, the two groups believe that Colombia works on science. According to the national survey, people do not play an active role and they participate little in citizen actions, it only obtained a percentage near 15%.

About policies in Science and Technology, 79% of the respondents consider that in Colombia people make science whereas a 21% consider the opposite. When asking if people make technology, the answers were that 32.18% consider that they do not and only the 48.13% consider the opposite. 93.73% of the respondents think that it is important to make science and 92.24% to make technology [11]. In consequence, it is consistent to conclude that for the population studied, the educational level represents a significant feature in the perception about S&T. In the future, it will be required an approach based on differential studies in greater depth, addressing new hypotheses about the role of different populations in the society and the relationship between this and the recognition of the importance of the dissemination of science and technology.

It is important to find variables of segmentation to support the arguments found in the first results of the survey. This means that the perception might not be consider important by itself and that it is necessary to give value to the role of the educated people and their contributions.

6. Acknowledgements and disclaimer of authorship

The authors wish to express their gratitude to the National Observatory of Science and Technology, and to the Colombian Administrative Department of Science, Technology and Innovation - Colciencias, for the provision and authorization for the use of the relevant data used in the present paper, like the databases belonging to the Third National Survey on Public Perception of Science and Technology. The acknowledgements also consider the valuable participation of the University of Cauca and the University of Valle, these two institutions provided and facilitated the academic goods necessary to develop the research described. This report was prepared for academic purposes. The writing, methodology, results, discussion and conclusions of this document are of total responsibility of the authors and do not compromise or represent the views of Colciencias, the OCyT, or any other participant.

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