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Innovation Centre Researchers "Views on Issues of Science, Technology, Society and Innovation (STS + I)"

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAO designed the study and supervised the research work. Authors MAO, BV and EC, analyzed all the results and wrote the first draft of the manuscript. Authors AG, MS and MB performed the field data collection and managed the analyses of results. Authors MAO, BV and EC managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The Innovation Center in Semiconductors (CIS) started operations in July 2010, with objectives focused on research and development. By early 2011, the Center added an important academic activity supported by scientific research internships open to students from several universities and research centers across the country during the summer months. The main purpose of these internships is to evaluate the feasibility of innovative projects, to be carried out annually in the

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Center. The CIS also manages government research grants provided by the National Council of Science and Technology (CONACYT) through their Incentives for Technology Innovation Program; this category has been very successful since the internships provide strong technical support for the proposals.
To round up this Triple Helix program, a new Human Development program called Science, Technology and Society was incorporated to the scientific summer internships of 2014, with the aim of promoting development and consolidation of democratic practices and attitudes on issues of social importance related to technological innovation and their impact on improving quality of life in the region. This study allows to know the views on Science, Technology and Society from researchers, who participated in the scientific summer internship program from 2011 to 2014.

Keywords: Science; technology; society; researchers; views on science; technology and society.

1. INTRODUCTION

To enable social participation in this evaluation process, institutional mechanisms and human resource training are required. In this perspective, the Science-Technology-Society (STS) approach emphasizes the advantages of innovation in human life: technological breakthroughs in the medical field have increased life expectancy in most developed societies. Likewise, the STS approach represents a platform of knowledge and technical strength that can contribute to generation of productive employment and quality jobs, necessary for a socially sustainable economic growth; driven by a qualified workforce, based on knowledge and innovation, as well as the creation of good quality jobs to allow distribution of the benefits of this growth among the population; in turn generating a virtuous circle increasing purchase power and demand for goods [1].

1.1 The Triple Helix Model

Etzkowitz and Leydesdorff [2] posed a concept for economic growth and social transformation strategies generated from the interaction between university, industry and government. Based on this perspective called Triple Helix, derives the need for the university to determine, according to its Mission, the role it will play in its relations with industry and the institutional structure it needs to perform such role. Furthermore, the model suggests that it is the State´s responsibility to define the mechanisms through which they identify, communicate, and finance the innovation programs that arise both in the industrial and manufacturing sectors, as well as those derived from entrepreneurial university programs. This model recognizes the dynamic relationships between government, industry and university institutional spheres; where market forces, national and regional policies, institutional control, social mobility, level of technological development, geographical location, among others factors interfere [3].

Leydesdorff [4] sees universities, as quintessential sources of innovation, given the dynamic flow of potential inventors and skilled human capital that represents the passage of generations of students, over time, and provide that such strategies, help to strengthen interaction and networking between university and industry. The Triple Helix thesis (TH) promotes university-industry-government interaction as the key to join efforts and establish favorable conditions for innovation in a knowledge-based society. This leads to the allocation of a prominent role for the university sphere, seeing it as source of new knowledge and new technology Fig. 1.

1.2 The case of the Innovation Center in Semiconductors in Mexicali, Baja California, Mexico

The Innovation Center in Semiconductors (ICS), located in Mexicali, conducts research and development programs and incorporates academic activity through scientific research internships with students from several universities and research centers in the country. In the Scientific Summer internship the feasibility of annual innovation projects is evaluated. Some of these programs are funded by government research grants provided by the National Council of Science and Technology (CONACYT) [5] as a strategy of Triple Helix between government, industry, and university spheres.

Due to the geographic location of the city of Mexicali on Mexico´s border with the United States, the main activity in the external sector is manufacturing, so there is a large number of companies located here.

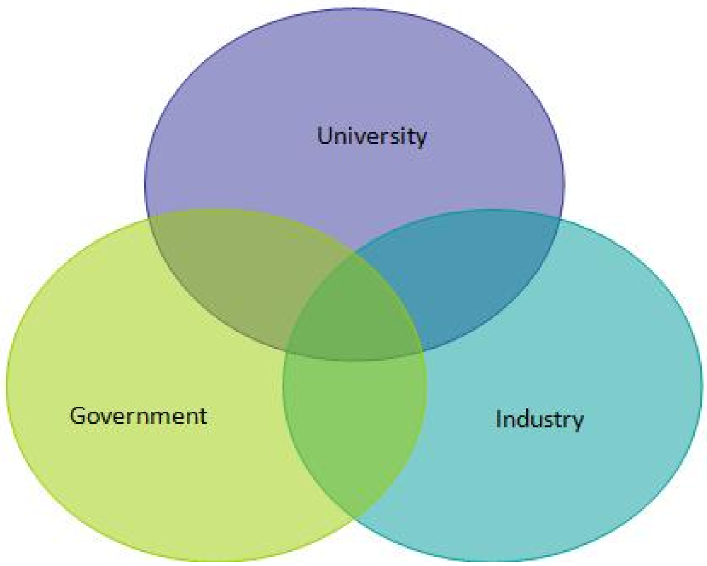

Fig. 1. Triple helix

This condition makes training of professional engineers essential, so they can develop competitively in different sectors such as: aerospace, electronics, appliance and medical products; as well as biotechnology, information technology, computing and communication, among others [6] Department of Economy.

Within the manufacturing sector in Mexicali, a high percentage is represented by US companies, requiring innovative higher education programs in engineering, with teachers and students trained in interdisciplinary work and willing to actively participate in projects of technological development and innovation [7].

1.3 The Science, Technology and Society in Education

Educational guidance STS facilitates innovation in the curriculum of science and technology at all levels of education in accordance to the new goals for science and technology education that are required for the XXI century, for its effective implementation is necessary to change teaching practice from the role of teacher and learning strategies. The STS proposal is a field of study and research, and above all, an innovative general education proposal. From the first perspective is to better understand the science and technology in its social context, addresses the interrelationship between scientific and technological developments and social processes [8]. As a general educational proposal is a radical new approach to the curriculum at all levels of education, in order to provide training and knowledge, especially in values that promote responsible citizenship and democratic participation in the evaluation and control of the social implications of science and technology.

1.4 The Curricula for Science, Technology, and Society

The common denominator of the STS curriculum is to present science and technology integrated together in a social context, as explicit objectives aim to overcome the drawbacks of traditional science education, such as lack of students did science and technology, low enrollment in science and technology studies and the marked inequality affecting different groups in many countries (women, ethnic minorities etc.) STS education focuses on students, not learning units, try to facilitate the understanding of their experiences and phenomena that occur in everyday life, in ways that school learning is applied in technological and social environment and provide them democratic participation in decision-making on social issues related to science and technology. This general objective is focused on others as student's empowerment, development of intellectual skills, preparation for citizenship in local, national, and global levels, to make personal decisions, social and ethical formation and professionally responsible citizens in the community and work, and achieving more and better scientists and engineers.

STS education attempts to balance three types of objectives:

- Knowledge and learning skills for personal or cultural purposes.
- Processes of scientific and technological research.
- Develop values for professional, public, and political issues, either local or global.

The common objectives of many STS programs are:

- Increase scientific and technological literacy of citizens
- Generate science and technology interest in students.
- Promote social contextualization of scientific studies through the interactions between science, technology, and society.
- Helping students improve critical thinking, logical reasoning, creative problem solving, and decision making.

The contents of STS education are usually selected based on two criteria: one focusing on relevant scientific and technological issues that affect society (inspired by the pragmatic American tradition), and another on social and cultural aspects of science and technology, derived from the European academic tradition.

The former allows a better connection between student's interests and the faculties', but can lead to a partial and too specialized education due to its more specific nature. The second approach, (more general) could provide students with a more comprehensive and durable structure but far more often seen because treats STS relations from the perspective of other disciplines such as philosophy, ethics, sociology, history, cultural, and economic aesthetic [9].

2. METHODOLOGY

This study uses a quantitative method to know the views on Science, Technology and Society, researchers, who participated in the Scientific Summer Internship Program from 2011 to 2014 at the ICS; as part of the human development program called Science, Technology and Society, which was implemented in the center, in order to promote development and consolidation of democratic attitudes and practices on issues of social importance related to technological innovation and its impact on the improvement of quality of life in the region. For this pilot study, the full questionnaire mentioned above was used, but results of only three questions will be shown.

2.1 Tools

The design of the evaluation tool considered the structure of the, views on Science, Technology and Society (VOSTS) [10] and uses the model of multiple choice and standardized indexes [11]. Three questions were selected from the VOSTS based on their involvement in the topics addressed in the study.

Researchers had to answer the question presented based on a scale from nine preset points [12]. This score becomes an attitudinal index normalized according to the category of each statement previously identified and assigned by a panel of expert judges. According to Manassero and Vazquez [13] these questions may be: “appropriate”, if the sentence expresses an adequate and consistent opinion; “plausible”, if the statement is not entirely adequate or contains an aspect that is suitable; and “naïve”, if the proposed statement expresses aspects that are neither adequate nor plausible.

VOSTS allows respondents to express their own points of view on a wide range of STS topics. It uses a Likert scale with nine options, and then for analysis is summarized in five. The model used is of multiple response (MRM) where the person responds to the issues in each question and assess their level of agreement or disagreement with each of the phrases offered on a nine-point scale. Valued dimensions are presented in Table 1.

2.2 Study Subjects

In the period of 2011-2014 for internships on the Scientific Summer Program, a total of 19 researchers were involved, 13 men and 6 women, as shown in Fig. 2.

Table 1. Taxonomy of attitudes STS

Topic	Dimension	Subtopic	Question
External sociology of science	Influence of science and technology on society	Economic Welfare	40531
Internal sociology of science	Scientist characteristics	Motivations Underrepresentation of women	60111 60611

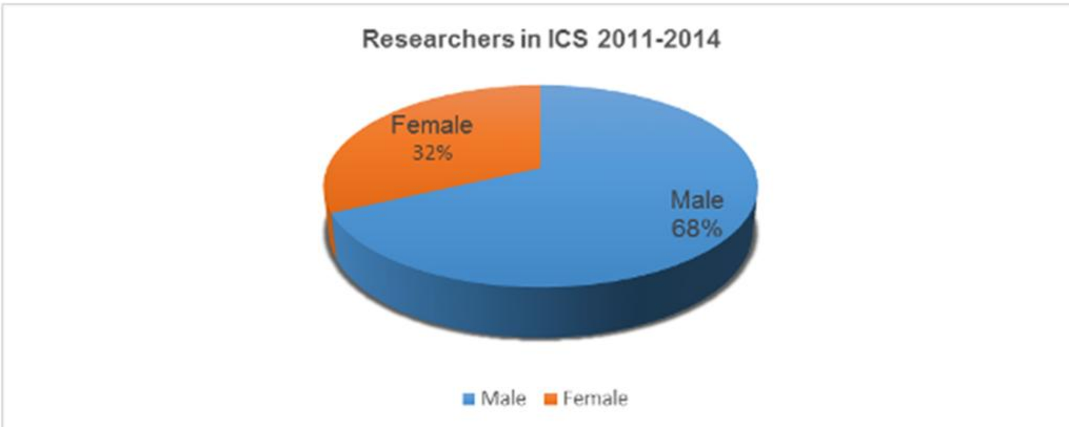

Fig. 2. Researchers in ICS 2011-2014

3. RESULTS AND DISCUSSION

For indexes obtained, a positive value near the maximum scale (+1) represents a more informed and appropriate attitude. On the other end, a negative value close to (-1) is interpreted as a more uninformed and naive attitude towards the evaluated question. The results of opinion for the dimensions studied were as follows:

> The questionnaire has a format that presents the topic of each question and contains several statements in relation to the different positions on the dimensions. Raw scores were assigned to the claims according to the following scale: to the degree of disagreement 1, 2 and 3; and 4, 5 and 6 for undecided; 7.8 and 9 for the degree of agreement.

3.1 Influence of Science and Technology

Question 40531, refers to the benefits of technology in society. Table 2 shows an example of possible responses evaluated for this dimension.

Table 2. Response options for the economic well worth the question 40531

40531	More technology will improve the living standards of our country:	Category
A	yes, because the technology has always improved the standard of living and there is no reason not to do so now.	N
B	yes, because the more we know , the better we can solve our problems and take care of ourselves	P
C	yes, because the technology creates jobs and prosperity. The technology helps to make the most efficient life more enjoyable, and more fun.	N
D	yes, but only for those who can use it. More technology will destroy jobs and cause more people below the poverty line	A
E	yes and no. More technology would make more pleasant and more efficient life, but also cause more pollution, unemployment and other problems. The standard of living can improve quality of life but may not	A
F	no, because we are irresponsible with the technology we have now ; as examples we can cite the excessive production of weapons and misuse of natural resources	P

The “appropriate” option was chosen by most researchers. This was, "yes but only for those who can use it”. The other options fall within the “plausible” and “naïve” categories. Table 3 shows results of attitudinal indexes by category.

3.2 Motivation for Scientists

Question 6011, refers to scientist are motivates to work hard. Table 3 shows an example of possible responses evaluated for this dimension.

Table 3. Mean and standard deviation by attitudinal index question 40531

Attitudinal index by category	Mean	Standard deviation
Appropriate	0.200	0.050
Plausible	-0.200	0.300
Naive	-0.475	0.075

Results for question 60111 regarding scientists motivation, indicate that most researchers chose the "appropriate" options referring to gaining recognition. Positions on personal motivation related to discovery of new ideas or inventions were less considered.

3.3 Underrepresentation of Women

Question 60611 refers to representation of women in science. Table 6 shows an example of possible responses for this dimension, as well as the categories to which each response belongs.

Phrases A, B, and C, belong to the naive category (N), which represents denial of scientists of these statements. Statements D, E, F, G, belong to the “appropriate " category (A), which means that their content matches the views of experts in the field. The H sentence corresponds to the "plausible" category (P) indicating that scientists say the ambivalent character of this sentence.

The opinion of researchers reflected the prevailing belief that there is no reason to have more male scientists than female scientists, since both are equally capable of being good at science and the opportunities today are similar; which is set within the "plausible" category.

Table 4. Response options for the motivations of scientists valued at the issue 60111

60111	Most scientists are motivated to strive a lot in their work. The main reason for their personal motivation for doing science is:	Category
A	earning recognition, because otherwise their work would not be accepted.	A
B	earning money, because society pressures to scientists to strive after financial rewards.	N
C	acquiring bit of fame, fortune and power, because scientists are like anyone else.	P
D	satisfying their curiosity about the natural world , because they like to learn more and solve the mysteries of the physical and biological universe.	P
E	solving curious problems for personal knowledge AND discover new ideas or inventing new things for the **benefit of society** (for example, medical cures, answers to pollution, etc.). Together these represent the main personal motivation of most scientists.	P
F	unselfish inventing and discovering new things for technology.	N
G	discover new ideas or inventing new things that benefit society (for example, medical cures, answers to pollution, etc.)	N
H	It’s not possible to generalize because the main personal motivation of scientists varies from scientist to scientist.	A

Table 5. Mean and standard deviation by attitudinal index

Attitudinal index by category	Mean	Standard deviation
Appropiate	0.175	0.075
Plausible	-0.300	0.356
Naive	-0.300	0.268

Table 6. Response options for representation of women, valued at the issue 60611

60611	Today, in our country, there are many more male scientists than female scientific. The main reason for this is:	Category
A	males are stronger, faster, brighter and better concentrate on their studies.	N
B	males seem to have more scientific abilities than females, who may excel in other fields.	N
C	males are just interested in science than females.	N
D	the traditional stereotype held by society has been that men are smarter and dominant, while women are weaker and less logical. This prejudice has caused more men to become scientists, even females are just capable in science as males.	A
E	the schools have not done enough to encourage female to take science courses. Female are just as capable in science as males.	A
F	until recently , science was thought to be man' s vocation. (Women didn't' fit television's stereotype image of scientist.) In addition, most women were expected to work in the home or take on traditional jobs. (Thus, men have had more encouragement to become scientists.) But today this is changing. Science is becoming a vocation for women, and women are expected to work in science more and more.	A
G	women have been discouraged or not been allowed to enter the scientific field. Women are as interested in science and are as capable as men; but established scientists (who are men) tend to discourage or intimidate possible scientific	A
H	There is NO reason for having more male scientists than female scientific. Both sexes are equally capable of being good scientists, and the opportunities today are equal.	P

A high percentage of researchers think that schools have not done enough to encourage women to choose science courses. This expression is realistic, since only 32% of the participants in the Scientific Summer Internships are women. Table 7 shows results of the attitudinal indexes by category.

Table 7. Mean and standard deviation for attitudinal index

Attitudinal index by category	Mean	Standard deviation
Appropriate	0.413	0.129
Plausible	-0.100	*
Naive	0.517	0.125

*Note: * There was only one "plausible" answer*

4. CONCLUSION

Assessing views about Science, Technology and Society (STS) represents a valuable contribution to Triple Helix projects, where the participation of the productive and service sector are combined, along with Higher Education Institutions. Understanding of the internal and external sociology of science in relation to the three questions evaluated can be measured based on results for global attitudinal index means where we can conclude that attitudes, and practices of researchers at the Innovation Center consider that science and technology do contribute to economic welfare of society.

In the particular case of internal sociology dimension of science and technology, it was found that the researchers agree with their views on scientists´ motivation to do their work, and on participation of women in the field of science and technology.

The study provides feedback for the Human Development Program called Science, Technology and Society, in terms of attitudes, and practices in matters of social importance related to technological innovation. Likewise, this study provides important elements in relation to researchers 'conception on the impact of their work improving quality of life of the region.

The general analysis of results shows that the views are close to value (+ 1) in the "appropriate" attitudinal indexes in the dimension "Influence of science and technology", and "scientists´ motivations". As for gender equality, researchers´ statements show attitudinal indexes closer to negative values (-1).

Results allowed to identify that views about the women´s participation in the field of science and technology, should be aligned to the appropriate positions raised by experts; through strategies such as: dissemination of research results by gender; promoting women´s participation in STS projects from the levels of higher education and through its collaborative research internships in the productive and service sectors; defining policies that support development of innovation projects involving women and recognition of the history of women.

The study must be continued in order to get information from a major sample, until now only 19 subjects were included and they comprise the participant researchers in the first three years for the program operation.

ETHICAL APPROVAL

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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