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A Mixed-Method Study of Attitudes of Social Scientists toward Nanotechnology in Pakistan

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ABSTRACT

Nanoscience and technology promises profound technical and socio-economic advancements for every country. Past experience, however, has shown that the success of an emerging technology is highly dependent on its' public acceptance including ethical, legal and social concerns. Accordingly, almost every megaproject on nanotechnology has incorporated a unit of social science in it to build connections between society and the field of nanoscience and technology in order to facilitate the process of public engagement, to assist public in becoming aware of benefits and risks involved and to produce people-friendly and people-oriented nano-products and systems. Ever since Pakistan entered the marathon in the last decade, it has been earnestly supporting research and development in nanoscience and technology and nano-education recently. The present social-scientific research was, therefore, designed to explore the potential role of social scientists in the field of nanoscience and technology in Pakistan by examining the attitudes of Pakistani Social Scientists toward Nanotechnology and understanding the demographic determinants of attitude formation for nanoscience and technology. Employing a concurrent mixed-method approach, a sample of 125 social scientists was contacted in person as well as through internet survey faculties. Results of quantitative data suggested that almost 77% of social scientists hold positive attitude towards nanotechnology, while females had more favorable attitude than males towards nanotechnology. Moreover, social scientists working as teachers, in the age group of 20-35, with Masters' degree, and working experience of 1 to 3 years have more positive attitudes toward nanotechnology. On the other hand, qualitative data showed that more than 50% Pakistani social scientists believe in potential benefits of nanotechnology for humankind and society, whereas, about 44% are of the opinion that socio-scientific support should be provided to the field. It is expected that the results will be helpful in understanding the attitudes of Pakistani social scientists towards nanotechnology and in planning the role of social sciences in the research and development of nanotechnology.

KEY WORDS: Nanotechnology, attitudes, social sciences, demographic determinants

INTRODUCTION TO NANOTECHNOLOGY

Nanotechnology refers to a field of research and development in which materials of sizes at nanoscale (what we now call as nanomaterials) and their structures are studied, controlled, manipulated, not only to create more efficient and sustainable products and systems but also to add value to them. Today, nanomaterials are used in numerous industries and products all over the world including textiles, sports, medicine, health care, food-agriculture, environment, renewable energy, electronics etc.

Because of its huge potential of applications and anticipated socio-economic impact, nanotechnology is considered as a key technology for the future, propelling governments globallyto invest billions of dollars on its research and development. As N.M. Butt (2012) pointed out "*Nano Science and Technology is a newly growing and fast emerging field with unlimited industrial opportunities and helping solve many problems of human welfare, may it be variety of consumer goods or health care etc. All countries the world over, particularly the industrially advanced countries, are trying to reap fast benefits from Nano-technology with a view to make their economy strong and leading, on one hand, and to dominate the economy of developing countries on the other hand. Several developing countries are also actively and keenly pursuing to establish nanotechnology laboratories in this field according to their own national priorities*."

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For the third world countries especially, nanoscience and technology holds special attraction: nanotechnology is expected to provide noteworthy social and economic advancements with limited resources and major unexplored entrepreneur opportunities. Pakistan has made several efforts in this regard. Over the last decade, many R & D laboratories have emerged independently to contribute in research on nanotechnology in Pakistan with the support of National Commission on Nanoscience and Technology (NCNST), Ministry of Science and Technology, Government of Pakistan. This resulted in many fore growths in general publication of Nanoscince and technology. Bajwa and Yaldram (2012) conducted a review of research on nanotechnology in Pakistan spanning a period of 2001-2010. Using bibliometric data analysis technique, their study came up with promising future of nanotechnology and research in Pakistan. For instance, they found that (i) the average rate of increase of publications is 29%, which is quite high compared to 23% world over (Roco, 2011); of the total publications, 10% researches are published on nanotechnology and associated parameters; among the top 15 institutes which are conducting research on nanotechnology, Quaid-i-Azam University, Islamabad is contributing the most, followed by PINSTECH, while PU and GCU are producing research in diversified subjects of nanotechnology. On the basis of their results, Bajwa and Yaldram concluded that "*research in nanotechnology is rapidly expanding in the universities of Pakistan*" (2012). Similarly, Pakistan is also making strides in providing formal nano-education degree programs at different levels in order to produce specialized human resource in the field of nanoscience and technology.

Nanotechnology and Social Sciences

Several references emphasize the importance of including social scientists in the development of nanosciences and -technology (see, for example, Roco& Bainbridge, 2001; Roco & Tomellini, 2002). It has been argued that since the field of nanotechnology has far-reaching beneficial as well as possible hazardous implications for health, economy, and environment and also involves ethical concerns at many levels (Berne, 2008; Gardner, Jones, Taylor, Forrester, & Robertson, 2010), '*there is a need to enable citizens to deal with these issues in an informed and independent way*' (Kahkonen, Laherto, &Lindell, 2011).Hence, the primary role of social scientists in this regard would be to bridge the gap between nanotechnology and public at large.

According to Crow and Sarewitz (2001), nanotechnology has the potential to benefit diverse sectors such as agriculture, medicine, defense, and to bring about "*profound changes in society as a whole*." However, recent researches support the previous understanding that "*how nanotechnology is developed and commercialized*" (Gupta, Fischer, Lans, & Frewer, 2012) depends heavily on the perception and attitude of society towards its acceptance. While Bainbridge and Roco (2003) asserted that unless technological convergence takes place with social realms "*it is hard to see how humanity can avoid conflicts, such as those that marred the 20th Century, caused by limited resources for available technology and social differences within each country and across."* Analysis of public response to any new technology suggests that the success rate of that technology (such as genetically modified food, nuclear power) or product (such as mobile phones) relies on its societal acceptance (Frewer et al. 2004, 2011a; Van Kleef, Fischer, Khan, &Frewer2010). For instance, in 2011, Frewer and his colleagues investigating consumer acceptance of novel agri-food technologies found that foods characterized as being 'bioactive' and perceived as 'unnatural' were more likely to result in public rejection. Similarly, Kleef and colleagues (2010) found that there is a high level of acceptance of people of Bangladesh for mobile service and base station technology as it is perceived to be more beneficial than causing any health-related risks.

On the other hand, Bainbrigde (2003), in an attempt to find out public attitude towards nanotechnology, found that *"science-attentive members of the general public are very enthusiastic about nanotechnology, and a rather large number of ideas about its benefits have already entered popular culture."*

A number of researches conducted over the past few years in US show that almost half of their population is not aware of the
technology of nanosciences (Waldron, Spencer, &Batt, 2006; Kahan, Braman, Slovic, Gastil, & Cohen, 2009) and that "*low levels of public knowledge about nanotechnology have remained relatively constant since 2004* (Scheufele et al. 2009)" in US. Similar results were obtained by Vandermoere and colleagues (2010), who were investigating public opinion of German population towards nanotechnology. They also found that women and people with low education are least informed about this technology and in contrast to US studies, German people generally have an indifferent attitude towards nanotechnology. On the basis of this data, they concluded that it will be difficult to make the attitudes of German people more favorable towards nanotechnology.

In line with the above discussion, it is recognized that exploring the psycho-socio factors that influence the

development of public attitude towards nanotechnology would be a first step. As anticipated, a large body of evidence has accumulated over the past few years showing that gender, age, education, political orientation (Bainbridge, 2003), trust in scientists (Siergrist, Keller, Kastenholz, Frey, &Wiek, 2007), effects of media, religious beliefs, scientific knowledge (Ho, Scheufele, & Corley, 2011), cognitive and affective heuristics (Lee, Scheufele, Lewenstein, 2005), for instance, have been established as important determinants of opinion formation towards nanotechnology.

Researches have also highlighted the fact that social scientists can play an important role in creating awareness among common people about nanotechnology and help citizens formulate an informed and independent attitude towards nanotechnology (see, for instance, Roco, 2003; 2011; Roco& Bainbridge, 2001; Roco&Tomellini, 2002; Shapira, Youtie, & Porter, 2010). Moreover, evidence also points to the fact that in order to fully comprehend attitude formation, regional and contextual underpinnings must also be taken in to account (Gupta et al, 2012; Lee et al, 2005).

Results of such investigations imply that if the attitudes of people belonging to developed nations need to be created and enhanced, people of third nation perhaps will need comparatively more work and preparation. Realizing the significance of social scientists contribution in the development of technology of nanosciences, attempts are being made all over the world to educate and prepare general public in the basics of nanotechnology. For instance, a Nano Bank has been created by US National Science Foundation (NSF) to study the relationship of nanotechnology with society. In addition, in 2003, US incorporated the 21st Century Nanotechnology Research and Development Act (P.L. 108–153) into law "*with anexplicit mission to integrate societal concerns into nanotechnology R&D and encouragecitizen input* (Shapira, Youtie, & Porter, 2010)." As Shapiro et al (2010) pointed out, "*The US approach to incorporating societal perspectives into nanotechnology R&D investments emphasizes a close relationship between science and social science in theNanoscale Science and Engineering Centers (NSEC)*."

The Present Study

Keeping in line with above discussion, the present study was designed to investigate the attitudes of social scientists towards nanotechnology in Pakistan. It is believed that in order to promote the role of social scientists in the development of nanosciences and technology, the first step is to examine the attitudes of social scientists themselves. Specifically the present study focused on following research questions:

1. What are the general attitudes of social scientists towards nanotechnology?
2. Does attitudes of male social scientists differ from attitudes of female social scientists towards nanotechnology?
3. Are there any differences on attitudes of social scientists towards nanotechnology on the basis of age?
4. Does occupation affect attitudes of social scientists towards nanotechnology?
5. Does level of education affect attitudes of social scientists towards nanotechnology?
6. Are there any differences in attitudes of social scientists towards nanotechnology on the basis of department?
7. Does working experience affect attitudes of social scientists towards nanotechnology?

Method

In order to answer the above-given research questions, a mixed methods approach has been employed. Bainbridge (2003) has stressed on using mixed methodology in studying nanotechnology parameters by saying, "*Over the coming years, social scientists in a variety of fields should employ a diversity of research methods and analytical theories to chart and understand the growing significance of nanotechnology for modern civilization.*" Hence, in the present research, concurrent mixed methods design will be used. Concurrent mixed methods is a multistrand design in which both QUAL and QUAN data are collected at the same time and analyzed to answer a single type of research question (Creswell, 1994).

Participants

The participants for the present research work comprised of 125 social scientists. Data of survey questionnaire was collected from various departments of social sciences including psychology, education, English, sociology, finance, statistics, economics, philosophy and history. Among the total, 47 were males and 78 were females with the age ranging from approximately 20 to 65. Moreover, 5 participants belonged to

administrative department, 75 to teaching department, and 42 were students. Whereas, 60 participants had a degree of masters, 40 had MPhil degree, and 25 had PhD degree.

Instruments

Following instruments will be used for data collection.

1. Demographic Information Proforma (Appendix A)

Information about the general characteristics of the participants was acquired through Demographic Information Proforma (Appendix A). This proforma asked following questions from the participants: age, gender, department, education, position, working experience.

2. Attitudes of Social Scientists towards Nanotechnology Survey (Appendix B)

In the present research work, Attitudes of Social Scientists toward Nanotechnology Survey was developed to accomplish the objectives of the study. This questionnaire was based on the framework provided by Bainbridge who investigated public's opinion about nanotechnology (2003). His qualitative study resulted in 108 verbiage statements. Bainbridge (2003) suggested that these statements can be used to develop a closed-ended scale after identifying distinctive themes and that "*these statements can be used to assess attitudes of social scientists toward nanotechnology*." Bainbridge (2003) in his survey also proposed a list of provisional categories of the statements obtained through open-ended questions.

This list of statements was given to three judges familiar with thematic analysis procedures. They were instructed to place the statements into themes using the provisional categories proposed by Bainbridge (2003) and eliminating statements with overlapping content. The judges were also requested to select around 10-15 most representative items. After this exercise, the list of items thus obtained was converted into a closed-ended questionnaire, with 5-point response categories.

This survey questionnaire also included two open-ended questions (originally used by Bainbridge, 2003) in order to generate opinions of social scientists of Pakistan related to nanotechnology. Many researcher's believe that qualitative methods are an important tool for providing native's view (Geertz, 1973) and do not focus on how researcher perceives the study variables but how the *participant* perceives them (Jehn&Jonsen, 2010). Since, the researchers of the present study believe that this research work is an essential and initial step in identifying the potential role of social scientists in making connections between nanotechnology and public in Pakistan, the original responses will provide invaluable information for future planning in the field of nanotechnology. Moreover, research also suggests that cultural differences may also play an important role in the perception and attitude formation towards nanotechnology.

Procedure

The participants comprising of social scientists were approached through email service as well as in person. The demographic proforma and survey questionnaire were applied on the participants with specific instructions on how to complete the questionnaires. Afterwards, for the quantitative inquiry, the data were entered in to SPSS 19 to conduct descriptive and inferential analyses on it. Whereas, for qualitative data, cluster analysis technique was employed and the results were presented in the form of marked radar.

RESULTS AND DISCUSSION

To ascertain the internal consistency of the scale specially developed for the present study, Cronabach's Alpha (1951) was calculated. A coefficient of 0.75 showed that the scale indigenously constructed to measure attitudes of social scientists towards nanotechnology, is sufficiently reliable. While a mean score of 35 established average performance of the respondents on this scale. The results are presented in the Table 1.

Table 1

Reliability Analysis, Mean, and Standard Deviation Scores for the Scale Measuring Attitudes of Social Scientists Toward Nanotechnology (N = 125)

Scale	Cronbach's Alpha	*M*	*SD*
Attitudes of Social Scientists Toward Nanotechnology	0.75	35	12.5

Quantitative Analysis

In order to evaluate research questions of the present study, percentage, chi-square test and graphical presentation of data was used. Analysis of each research question along with its discussion is presented below.

Research Question 1: *What are the general attitudes of social scientists towards nanotechnology?*

In order to investigate the general attitudes of social scientists toward nanotechnology, a stacked bar graph for all response options against each statement of the questionnaire was generated. The results presented in Figure 1show that from a total of 125 social scientists, most of the respondents agree to the fact that nanotechnology has great benefits for human beings including medicine, electronics, communications, and can play a role in strengthening the economy of a country. Among the total of 10 items, 3 items were negatively worded. Close inspection of Figure 1 showed that respondents do not consider nanotechnology as threatening technology and social scientists do not agree to the fact that they are not knowledgeable about this field. However, on item no. 8, the responses are not clear. 48% respondents are not sure about the fact that nanotechnology has the potential to unleash unknown dangers, while 32% agree and 17.6 % strongly agree to it. One reason may be that the item was not understood clearly.

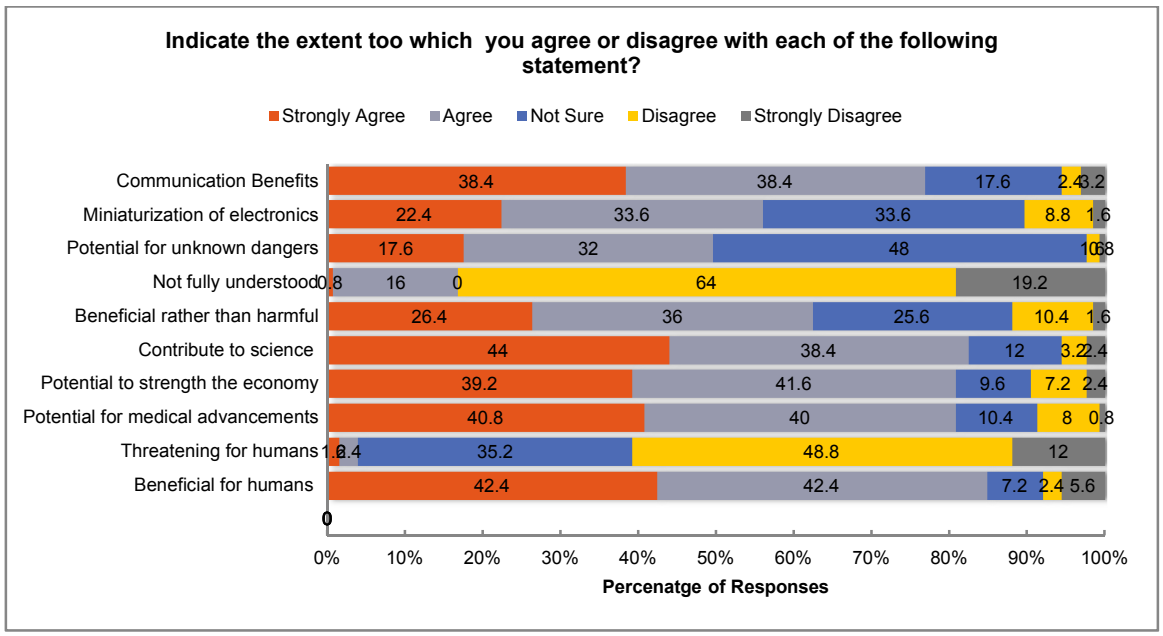

Figure 1: Percentage for Degree Agreement for Each Statement of Questionnaire of Attitudes of Social Scientists towards Nanotechnology

In order to develop a broader understanding of attitudes of social scientists about nanotechnology, a mean score was used to develop a cut off score to be used as to identify respondents with positive and negative attitudes. Bar diagram displayed that almost77% have positive attitude towards nanotechnology, while 23% have negative attitude. This difference is significant at 0.01 level with a χ^2 value of 35.91. This difference is also visible in Figure 2.

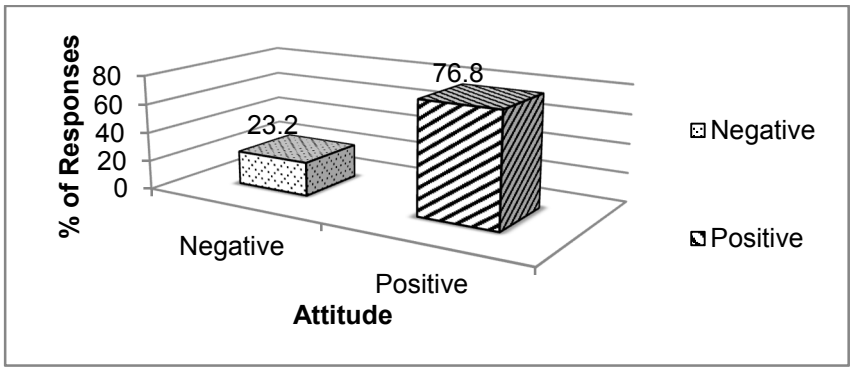

*Figure 2:*Percentage for Negative and Positive Attitudes of Social Scientists towards Nanotechnology

Research Question 2: Do attitudes of male social scientists differ from attitudes of female social scientists towards nanotechnology?

Data presented in Figure 3 shows frequency of male social scientists vs. female social scientists for negative vs. positive attitudes towards nanotechnology. Results suggest that females have more favorable attitude towards nanotechnology as compared to males. The difference between males and females was found to be significant ($\chi^2 = 19.02$, $p < .05$). Bar graph (Figure 3) also supported these interpretations. Among the group, males had more negative attitude towards nanotechnology than females. The results of the present study contradicted previous evidence. For instance, Bainbridge (2003) and Lee et al (2005) in independent studies found that women compared to men generally hold negative view toward nanotechnology. A number of explanations can be generated in this regard. None of the studies in the past have attempted to compare male and female social scientists view regarding emerging technologies. The results of present study may also be taken up to suggest that perhaps female social scientists use different cognitive processes in making decisions and evaluations compared to female laypersons.

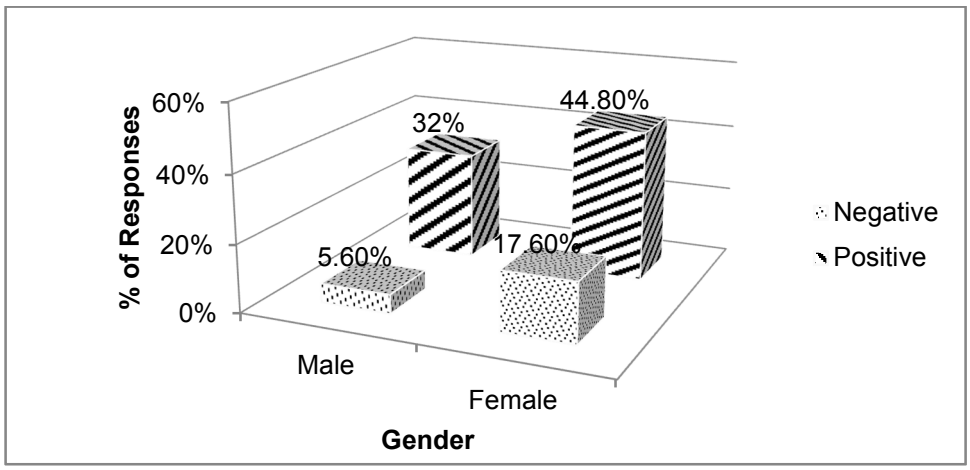

Figure 3: Gender Differences on Attitudes of Social Scientists towards Nanotechnology

Research Question 3: Are there any differences on attitudes of social scientists towards nanotechnology on the basis of age?

In order to answer this research question, Pearson correlation and frequency line graph were used. Correlation coefficient of -0.19 ($p < .01$) indicated that age and attitudes of social scientists towards nanotechnology are negatively related with each other. Analysis of stacked area graph (Figure 4) further showed that social scientists belonging to the age group of 20 to 35 have more positive attitude as compared to other age groups. Moreover, positive as well as negative attitudes towards nanotechnology decline with age.

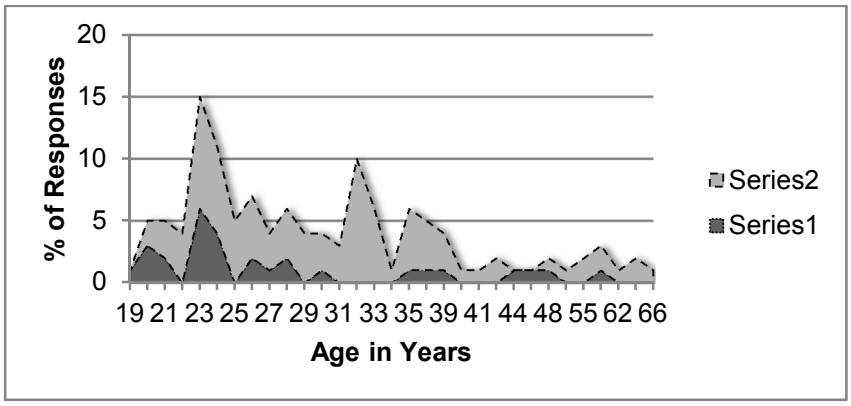

Figure 4: Age Differences on Attitudes of Social Scientists towards Nanotechnology

Past researches have indicated non-significant though negative relationship of age with general attitude toward nanotechnology. For example, Lee and his colleagues obtained a standardized regression coefficient of -0.01 for age. Moreover, the present study also showed that social scientists with an experience of 1 to 3 years had significantly more positive attitude towards nanotechnology than people with more working experience. Both results suggest a clear trend difference among young vs. old social scientists. It may be suggested that younger people engage in more risky decision making compared to older adults (Tatia et al, 2008), thus making them more supportive of emerging technologies.

Research Question 4:Does occupation affect attitudes of social scientists towards nanotechnology?

As regards research question no. 4, the results yielded a significant difference ($\chi^2 = 69.16$, $p < .01$) between occupation and attitudes towards nanotechnology. Figure 5 imply that social scientists whose basic occupation is teaching have positive attitude towards nanotechnology as compared to students and social scientists who are working in administration.

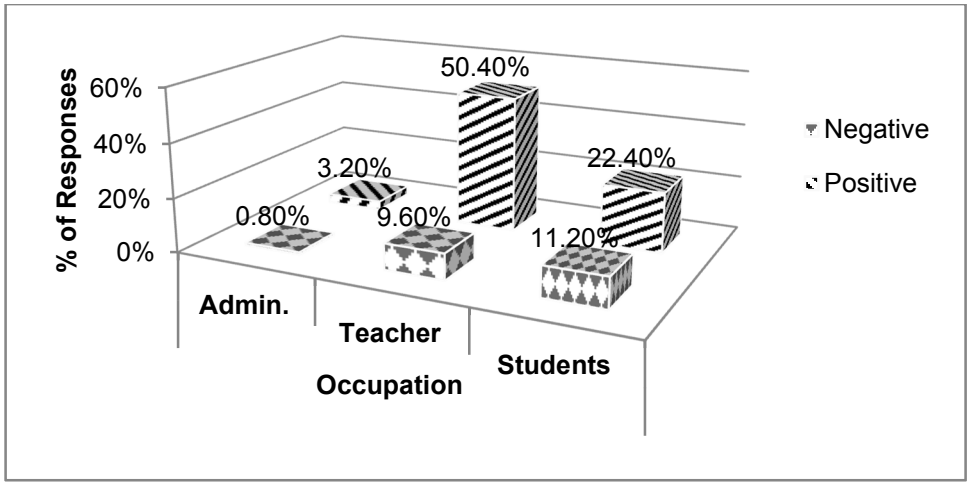

Figure 4: Occupation and Attitudes of Social Scientists towards Nanotechnology

Research Question 5: Does level of education affect attitudes of social scientists towards nanotechnology?

Figure 6 indicate that social scientists with Master's degree have more positive attitude toward nanotechnology compared to MPhil and PhD degree holders. However, the results were found to be significant at marginal level.

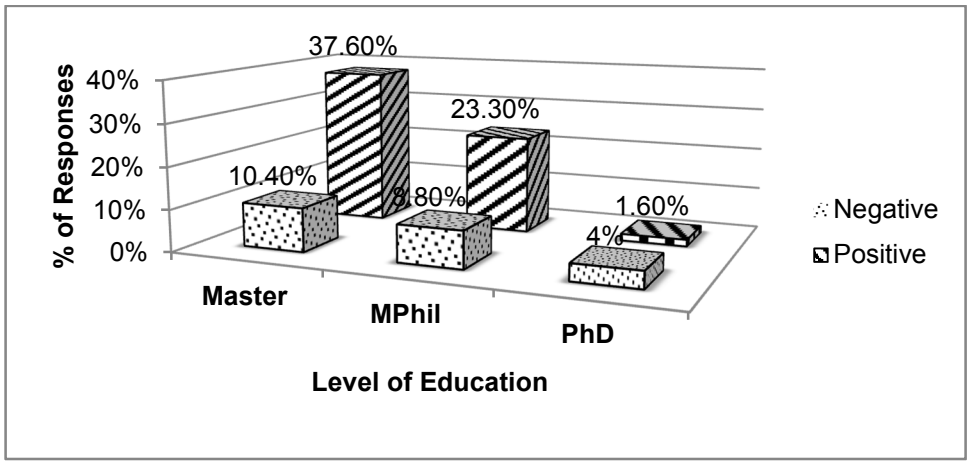

Figure 5: Level of Education and Attitudes of Social Scientists towards Nanotechnology

Similarly, the results also indicated that social scientists holding Masters' degree had significantly positive attitudes towards nanotechnology. While, among the rest, PhD participants had least favorable attitude towards nanotechnology. This result also points to the implication that older, more experienced, and highly qualified social scientists are less open and flexible for new technologies than younger people.

Research Question 6: Are there any differences on attitudes of social scientists towards nanotechnology on the basis of departments?

The χ^2 value of 175.46 with .331 level of significance showed that belongingness to different department does not affect attitudes towards nanotechnology. Results depicted in Figure 6 revealed that psychologists and experts in finance have more positive attitudes towards nanotechnology than educations, economists, and sociologists. Cross-comparison also showed that among the whole group, statisticians have most negative view.

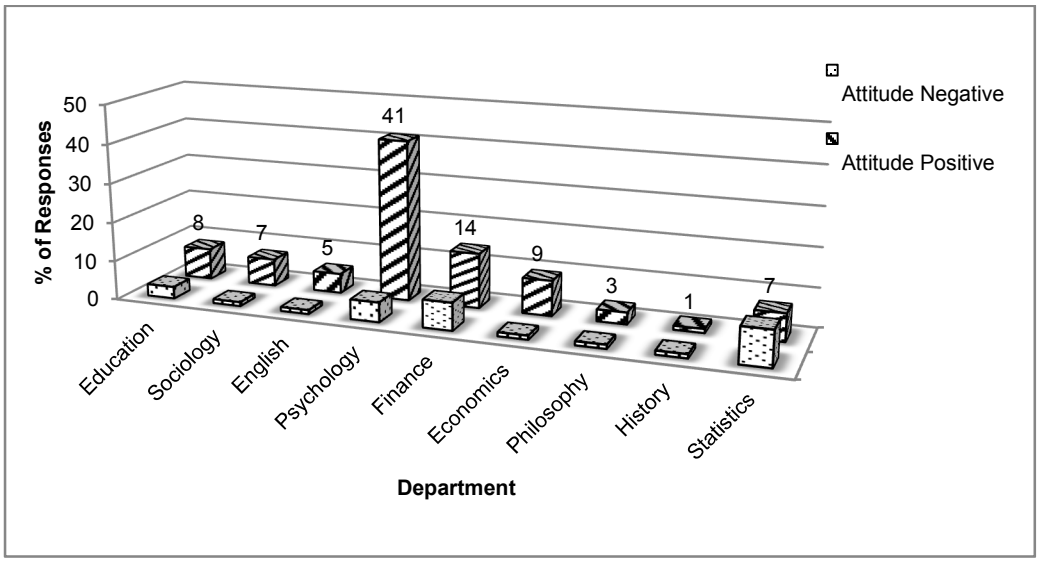

Figure 7: Departments and Attitudes of Social Scientists towards Nanotechnology

Research Question 7: Does working experience affect attitudes of social scientists towards nanotechnology?

A negative correlation of -0.22 between experience and social scientists' attitude towards nanotechnology indicate that attitude towards nanotechnology declines with work experience. Figure8suggests

that social scientists with working experience of 1 to 3 years have most positive attitudes toward nanotechnology than other social scientists with more experience. In fact, social scientists with more than 20 years of working experience have least positive attitude.

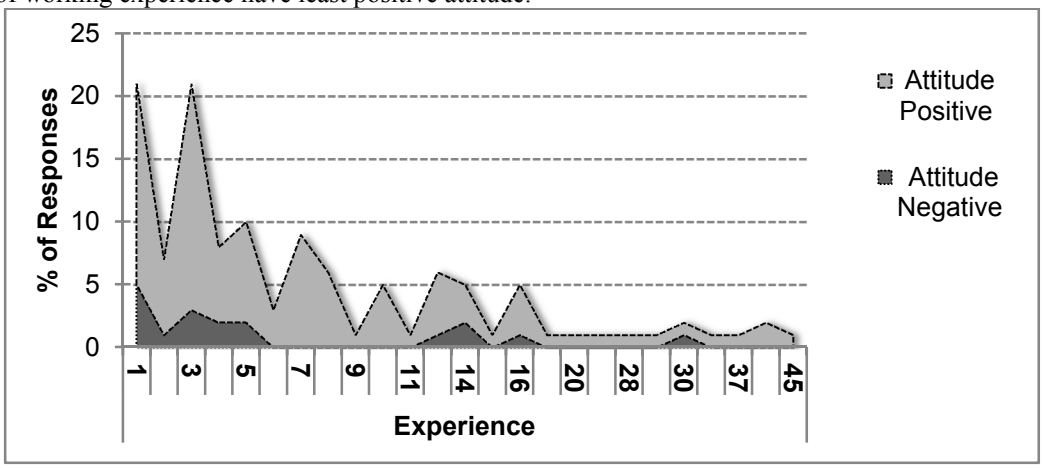

Figure 8: Experience and Attitudes of Social Scientists towards Nanotechnology

Qualitative Analysis

In order to develop an in-depth understanding of Pakistani social scientists attitudes toward nanotechnology, two open ended questions were also posited to the respondents. However, they were given a free choice to answer the questions. Initial analysis showed that 68% of the participants had provided their opinions to the queries. After obtaining the responses, cluster analysis technique was employed to analyze results.

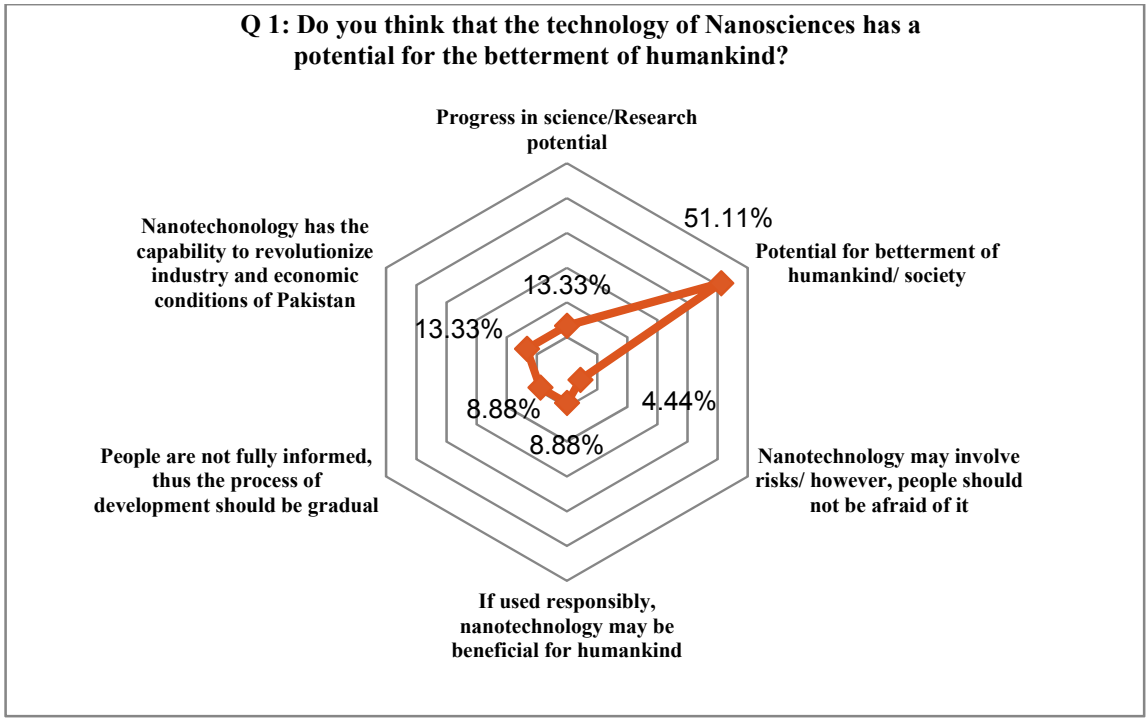

Figure 9: Relative Frequency Percentage for Each Cluster

Results presented in Figure 9 indicate the relative frequency percentage calculated for each cluster on responses of first question. When asked about the potential benefits of nanoscience and technology for humankind and society, 51.11% participants replied in total agreement, 13% highlighted the capability of nanotechnology in revolutionizing the industry and economic conditions of Pakistan, another 13% of the group think that nanotechnology can enhance progress in science and has research potential. On the hand, three themes related with risks involved emerged though with small relative frequencies.

The second open-ended question invited responses on possible social and scientific support for research and development in the field of nanotechnology. Figure 10 show that 44.4% of the respondents believe that that not only social and scientific support but financial support should also be provided to such projects. While 22.22% social scientists have proposed that the support should come from Pakistan government also. Similarly, 11.11% believe that substantial efforts are required to benefit from this field. Almost 17% respondents believe that since people are not generally aware about the technology, awareness programs should be launched. Interestingly. 5.55% of social scientists have pointed out the need of education in nanoscience and technology, implying that respondents are well-aware of the socio-economic advantages of nanotechnology.

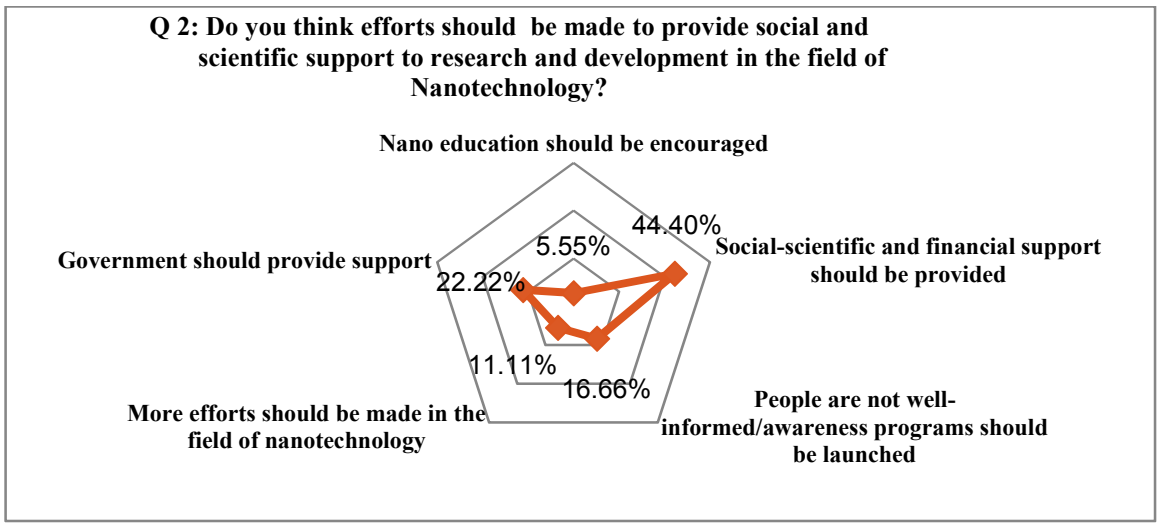

Figure 10: Relative Frequency Percentage for Each Cluster

These themes support the quantitative data of the present study that generally the attitudes of social scientists towards nanotechnology are positive and that they are aware of applications of this technology in various fields. In addition, the social scientists are also aware of the possible risks involved and are also cognizant of the fact that in-depth information on nanoscience and technology is generally lacking. These indigenously generated themes can also be used to modify the scale used in the present, to make the questions more representative of Pakistani population. However, comparison of indigenously generated themes with the ones produced by Bainbridge (2003) (Figure 1), indicate that the content of themes broadly overlap.

Conclusion

The purpose of the present investigation was, therefore, to explore social scientists' attitudes towards nanotechnology in Pakistan. In order to achieve this objective, a mixed-method approach was employed. To obtain information on demographics related with attitude formation, quantitative data was gathered through two questionnaires. The first questionnaire comprised of demographic information sheet in which gender, age, education, department, occupation and work experience of the participants were enquired. In the second questionnaire, attitudes of social scientists towards nanotechnology was assessed through ten item scale. Each item was anchored on 5-point rating scale. Items number 2, 7, and 8 were negatively worded to control for acquiescence tendency among participants.

To find out demographic differences on attitudes of social scientists towards nanotechnology, chi-square test and frequency distribution graphs were utilized. The variables gender, level of education, department, and occupation were treated as discrete variables, while age and work experience as continuous variables. In order to develop positive and negative categories of attitudes of social scientists towards nanoscience, a mean score of 35 was used as a cut off score. Respondents scoring above a score of 35 were categorized as having positive attitude, whereas respondents with scores below 35 were identified as having negative attitude. Results showed that social scientists generally have positive attitude (77%) towards nanotechnology than negative attitude (23%). This conclusion also received support from the qualitative data obtained in the present study. The results of content analysis clearly indicated that social scientists in Pakistan not only have knowledge about the field of nanotechnology but are also aware of the potential benefits and risks involved in it. Chi-square analysis yielded significant results for gender, age, occupation, experience, and level of education on nanotechnology. No attitude differences were observed on the basis of departments.

Future research may elaborate on understanding the possible explanations for the observed differences. By and large, the present study indicated that generally social scientists are aware of nanotechnology and have a favorable view toward it. Like any other emerging technology, public opinion can influence the government's decision for funding steering new advancements and programs in this field. Moreover, it also appears that political, regional, and economic factors also contribute to public acceptance towards new technologies. Since Pakistan is a poor country, nanoscience and technology may hold enormous promises for its ailing social and economic conditions. Thus Pakistani people may have different worries like lack of energy, drinking water, quality of living, high unemployment rates compared to their counterparts in industrialized countries, therefore, they may be more flexible to technologies like nanotechnology to improve economic conditions in a shortest and cheapest way possible. As Gupta and his colleague (2012) recently observed that "*nanotechnology has a potential to become transformative technology…it presents unmatched opportunities to develop new products and services, may result in longevity, public health benefits, and more sustainable production, but on the other raises concern, fear, and anxiety among the public. Understanding the socio-psychological factors would allow contextualization of its development and implementation, and potentially facilitate allocation of resources in areas of application relevant to the wider needs of society."*

The results of present study suggest two distinctive groups of social scientists with positive and negative attitudes towards nanotechnology. However, there were certain limitations of the present research work. A large sample selected on the basis of random sampling technique rather convenient sampling would have provided more representative opinions of social scientists towards nanotechnology.

Secondly, future research can also focus on the dynamics and processes involved in formation of positive or negative attitude towards nanotechnology. For instance, cognitive factors, affective variables and the role of media in the development of attitude along with investigation on level of religiosity may lent a better understanding of social scientists attitude towards nanotechnology. In addition, cross-national research may also be initiated to understand geo-political and cultural determinants of attitudes toward nanotechnology.

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