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Understanding, Knowledge and Perception of Nanotechnology among Private Universities' Students in Malaysia

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ABSTRACT

Modern day policy making demands to include citizens in the decision making process and this is crucial before the introduction of any emerging technology such as nanotechnology, the science and art of manipulating things at the atomic scale. Even though there is no comprehensive governing regulation, there are already more than 1600 consumer products in the market and thousands more are in the pipeline. Some European countries have already initiated some steps to regulate it. However, before taking any such step, this is important to assess citizen's view about this technology. This study aims at studying the knowledge, understanding, and perception of 490 students from four private higher education institutes of Malaysia. A questionnaire was distributed in this regard and it has been revealed that though there are some concerns as to the risk, a considerable number of students are aware of the term 'nanotechnology' (63.46%) and the presence of a number of consumer products in the market. More than 72% are in favour of its application and introduction in different sectors. However, the students do not possess sufficient knowledge about nanotechnology, and only 6% of the respondents claimed that they know this emerging technology very well, whereas, 49.38% replied that they know little and 33.26% only heard the term, but do not know about it.

Keywords:

Nanotechnology and nanoscience, enabling and emerging technology, public perception, policy and regulation, risk and safety

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1. Introduction

Nanotechnology is the wave of the future and researchers have been trying to apply this technology in almost all sectors of knowledge to produce something which will be lighter, stronger, powerful, more durable and commercially viable. The government of 106 countries [1] have already started national programs towards the future development of the country and to take lead in the world market of nanotechnology which will be between US\$27 billion [2], or US\$1 trillion [3], or US\$ 3 trillion in 2015 [4]. However, absence of internationally accepted legal framework to regulate and govern the possible consequences of application of nanoparticles raises concern. The regulators, academics and researchers are divided into platforms as to whether new legislation is required with simple or major modifications and amendments, or whether existing legislation is sufficient to regulate nanotechnology. Whatever the situation be in this regard, the public understanding and acceptance should be considered as one of the primary steps in relation to introduction of nanotechnology as a new and emerging technology in the market and to regulate it to avoid a situation like genetically modified foods and nuclear energy that the world community witnessed in recent past.

Modern states are welfare states and the governments have to give due weight to citizen's voice before taking any kind of initiative. Furthermore, the present governments are accountable governments and cannot simply spent money in different ventures of their own will without considering the public reaction which is reflected mainly in national elections. These one hundred and six countries, which have been being active in nanotechnology research and development, are presumably countries with vision and support of their citizens and since they are too concerned regarding the welfare of the citizens, they have started the process of investment in research and development and commercialization of nanotechnology enabled products. For this reason also, this is important to assess perception of the citizens.

Citizens who are at the center of all development activities should be made aware of all nanotechnology inventions and related information, otherwise it may have to embrace the fate of that of genetically modified foods in the United Kingdom (UK), agricultural biotechnology and nuclear power in the United States of America (USA) which were introduced with huge prospect but could not be successful as citizens were not included and ultimately this may create a "nano divide" identical to the "digital divide" and "genetic divide" which is now evident between many developed and developing countries [5].

In the Iranian Nanotechnology Database (Statnano), Malaysia holds a significant position where assessment is made on the basis of local sharing method i.e. calculation based on ISI Web of Science Publication where the total number of scientific publication was divided by the number of publications on nanotechnology [1]. Besides, Malaysia, a country of mixed race, religion and a center of people of different countries around the world, also aspires to be one of the top ten nanotechnology nation by 2020. All these matters encouraged us to take an attempt to consider the perception of students of four Malaysian higher education institutes, both local and foreign, who are the future leaders. This is expected that this will be a wonderful opportunity to judge the feelings of students of Malaysia and different others countries, race and religion about nanotechnology, though at least in a limited scale.

This paper is divided into mainly four segments in between the introduction and conclusion. Section 2 deals with different aspects of public perception and attitude and assessment, Section 3 sheds focus on the issue in the context of nanotechnology, Section 4 shares the overall state of nanotechnology development in Malaysia and Section 5 considers the result and findings of the questionnaire survey.

2. Assessment of Public Perception and Attitude

This is now an accepted practice that the public should be involved in the policy making and before introduction of any technology. In 2000, the Select Committee on Science and Technology of the House of Lords of the UK pointed out the necessity and demanded that the public to be consulted regarding science and technology policies [6]. The assessment of public perception by way of public consultation is simultaneously very popular now-a-days. For example, at the European level, the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) recently asked for public opinion. Even though the questionnaire, which was developed, is technical in nature, European Union (EU) citizens were made free to express their opinion till September 13, 2013.

Public perception has been assessed in a number of occasions, in a variety of instances and in the context of different countries, for example, in relation to food allergy [7], factors influence to take decision in favor of innovative food [8], risk [9,10], risk from biotechnology [11], risk of blood transfusion [12], food risk in the UK [13], climate change [14], water reuse [15], hazardous waste [16], technological risk [17], to investigate the relationship of students' understanding of science knowledge, attitude and decision making on socio-scientific issues (SSI), especially on the issues of nuclear energy in Korea [18], public perception relating to technology in Nigeria [19], biometric technology in Portugal [20], etc.

Pilisuk et al. [17] conducted a public opinion survey in three cities of California to assess the extent of public concern over risks associated with modern technologies. A considerable number of respondents were concerned with all the areas they included, and found that the concern was more widespread among women and wide widespread among the less educated. To gather information on emerging technologies, the respondents relied heavily on television news and newspapers for information and made variations in terms of reliability of information received from different sources.

Earlier the world community witnessed that genetically modified food was introduced and could not be sustained, nuclear energy was tried to be introduced, but received huge protest because the public perception was not adequately considered. Once the citizens as consumers turned back the government tried to do many things but all went in vein and even the President of Zambia who was offered this genetically modified organisms (GMOs) rejected to accept this 'toxic food' and he preferred that his citizens would rather strive but would not take this food [21].

3. Public Perception, Public Attitude and Nanotechnology

The mass people, the ultimate beneficiaries and stakeholders of all scientific developments should be made aware of the technology which is going to be introduced and their acceptance of the technology is greatly influenced by the way they perceive the technology. Therefore, the assessment of public perception and attitude are vital in the development of the technology like nanotechnology. Very recently, the Nano center directors from around the world gathered together and put emphasis on public perception [22]. This reflects the crucial aspect of this issue.

Right to know is constitutionally guaranteed and citizens have the right to know the chemicals used in different consumer products and where there are application of nanotechnology. Assessment of perception and understanding of nanotechnology of experts, researchers, public, citizens, students etc. in relation to nanotechnology, its risk and benefit, etc. started back to early 2000s, which is systematically reviewed in 2010 [23]. As a continuation of demand of the Select Committee on Science and Technology of the House of Lords stated above, public perception of nanotechnology from different perspective have been documented in a number of researches, inter alia, [24–36] etc.

Gupta et al. [37] conducted a comparative study to assess expert views on societal responses to different applications of nanotechnology in different countries with different economic and regulatory environments. Chen et al. [38] revealed that perceived benefits and risks of applying nanotechnology determine the public attitudes toward nanotechnology applications.

Apart from these researches, similar researches were conducted in different countries around the world, for example, inter alia, Iran [39], Australia [40], Taiwan [38] and so on. Some of the countries like Germany [41], Japan [42], have made this practice a continuous one and have been assessing the perception of citizens through government machineries in almost every year. In the UK, recent study revealed a significant increase of knowledge about nanotechnology from 29% in 2004 to 48% in 2011 [43].

A number of methodological instruments have been used so far all over the world to assess the perception of the people regarding nanotechnology, including simple survey, face-to-face survey, telephone survey, online studies, pre-post survey based experiments, expert opinion etc. [44–47]. Furthermore, the Organization for Economic Co-operation (OECD) has come up with some suggestions on how to assess public perception in 2012 [48].

Some of the researches which were conducted in different countries around the world to assess public perception are shared in Table 1.

Table 1
 Instances of Assessment of Public Perception

Author	Country in context	Methodology	No. of respondents	Primary focus	Major findings
Priest, 2006 [49]	USA and Canada	Telephone survey	1200 from USA and 2000 from Canada	Assessment of public opinion and knowledge	Social and cultural differences influence the acceptance of new technology.
Zimmer <i>et al.</i> , 2008 [41]	Germany	Computer assisted telephone interview	1000	To assess the knowledge, acceptance on the basis of application, perception of risk-benefit relationship, etc.	50% of the people are not familiar with nanotechnology, majority of people considered that benefits were great than risk, majority of respondents had good impression about nanotechnology.
Kishimoto <i>et al.</i> , 2010 [42]	Japan [2005-2009]	Questionnaire survey [Internet]	Total 3961 [1276 (in 2005), 681 (in 2006), 681 (in 2007), 647 (in 2008), 676 (in 2009)]	To assess perception, attitude, and behavior of the general people about nanotechnology	95% of the respondents were aware of nanotechnology for the years 2006-2009 and 80% of the respondents were in favour of nanotechnology.
DIISR, 2011 [50]	Australia [2005-2011]	Telephone interview. Qualitative interviews [in the year 2008, 2009, 2011]	1000 each [in 2005, 2007, 2008, 2009, 2011]	To assess community awareness and attitude towards nanotechnology	Knowledge/awareness level increased from 51% in 2005 to 76% in 2011, but stable from 2008.

Rahimpour <i>et al.</i> , 2012 [34]	Iran	Focus Group Discussion [in 2011] Questionnaire survey	683	Assessment of public perception about nanotechnology	Age, educational level and career influence the knowledge level of city dwellers.
Satterfield <i>et al.</i> , 2013 [51]	USA	Representative national phone survey	1100	Whether perception about new technologies are uncertain or mobile	Presentation of risk information after benefit information is vital for acceptance of new technologies and the chance is lower if risk information is presented before benefit information.
Chen <i>et al.</i> , 2013 [38]	Taiwan	Self-reported questionnaire survey	888	Factors influencing risks and benefits perceptions of nanotechnology forming public attitudes towards nanotechnology application	Public attitude is developed on the basis of perceived benefits and risks of application of nanotechnology, attitude towards technology and knowledge.
Sahin and Ekli, 2013 [52]	Turkey	Questionnaire survey	1396	Awareness, factual knowledge, opinion and risk perception of 6 th , 7 th and 8 th grade students in Turkish Middle schools	74% of the 6 th , 7 th and 8 th grade students in Middle schools were aware of nanotechnology, and almost half of the students voted that the benefits outweigh risks of nanotechnology.

In one of the very largest empirical study in USA, Curral *et al.*, [53] attempted to explore the factors that drives perception. In that study 4,543 respondents were selected from national web survey, 1004 respondents were taken from random digit telephone dialing survey. The study did not consider nanotechnology in general rather the respondents were asked specific questions as to products containing nanoparticles i.e. drug, skin lotion, automobiles tires and refrigerator containing new gas coolant. It was found that the citizens of USA are relatively neutral about nanotechnology and there is scope of window to educate people about the risks of benefits.

Since Germany and the USA are the largest investors in the field of nanotech research in Europe and North America, in a recent study in the German and USA context, the researcher found that the perception of nanotechnology depends on the place where the respondent is living [54]. It was further found that Germans are in search of short term effect of science and technology and in contrast, the Americans are more adventurous.

A recent study [55] conducted by the University of Wisconsin-Madison revealed that sharing of different definitions to individuals will allow them to come up with their different level of support for nanotechnology. In that research, the participants were given one of the three definitions of nanotechnology i.e. the first definition focused nanotechnology's novel applications, the second one considered its risks and benefits, and the last one included both applications and risks and benefits.

It was observed that the inclusion of nanotechnology's benefits in the definition would allow the readers to support nanotechnology and would be reluctant to acquire more knowledge on it. However, if risks and benefits are included in the definition, then readers would be more interested to gather further knowledge and less willing to support nanotechnology. However, to a science student with a science degree in college, these changes in definition do not change their attitude.

Countries around the world have been taking different initiatives also to involve citizens in the development process of nanotechnology. To explore the public perceptions around the topic of nanotechnology, in 2008 the Center for nanotechnology in Society at Arizona State University and its collaborators at North Carolina State University conducted the nation's first National Citizens' Technology Forum on the topic of nanotechnology and human enhancement [56]. Germany, through its Federal Institute for Risk Assessment (BfR) has been assessing public perception as to nanotechnology and representation of nanotechnology in German media since 2007. In its extended investigation through a program called NanoView, it has been revealed in November 2013 that the word 'nanotechnology' was not known to the majority of the respondents [57].

Australia conducted its first public perception assessment survey in 2005 and since then this is a continuous process and the Department of Industry, Innovation, Science, Research and Tertiary Education is entrusted with the responsibility. In its latest report of 2013, based on a survey of 1000 adults, on community perception of emerging technology-nanotechnology, it was found that 49% of respondents opined in favor of benefits of nanotechnology over its risks, whereas only 6% of the respondents hold the opposite view. The awareness of people increased to 87%, which was only 51% in 2005. Moreover, it was revealed that the respondents trusted the scientists and science organizations most, then the government agencies and regulators and NGOs and on industry groups and media, they have the lowest reliance [58].

Thailand has taken a number of initiatives to include citizens in the introduction and development of nanotechnology in the country. The country has further adopted the Nanosafety and Ethics Strategic Plan (2012-2016), focusing on, inter alia, promotion of public participation. Before finalizing the Plan, the National Nanotechnology Center (NANOTEC) within the National Science and Technology Development Agency (NSTDA) arranged a public hearing session. The NANOTEC has been arranging different programs to make citizens aware of nanotechnology and its application with the assistance of the Public Awareness and Training Section of NANOTEC and Teacher Training of Nanotechnology Network (TTN). With such programs the organizers inform students about different safety aspects of nanotechnology. Earlier, the National Innovation Agency of the country has promoted Environment-friendly cloth bags coated with 90-300 nm TEFLON particles in 2007 and Nanosilver-coated traditional Thai outfit in 2008.

However, there are opposite findings too. Lin *et al.*, [59] attempted to develop instruments to assess public knowledge of nanotechnology (PKNT), public attitudes toward nanotechnology (PANT) and conduct a pilot study for exploring the relationship between these two and found that the public has a tendency of suspicion towards government and industry for which there is no relationship with their levels of knowledge about nanotechnology.

Such findings create real challenges for the policy makers. In the UK, a new survey of Royal Statistical Society and King's College London revealed that the policy makers are in real challenges as to how to make good policy based on public perceptions [60]. The reason is that the public are often wrong. In such situations an informed public perception can be a solution where the public will be made aware of effects of emerging technologies which will allow them to take their decision.

4. Nanotechnology and Malaysia

The government of Malaysia sets its visions to be one of the top ten nanotechnology nations by the year 2020 and have already taken a good number of initiatives with specific focus on research and development. The Intensification of Priority Research Areas (IRPA) program of the Eighth Malaysia Plan (8MP), administered by the Ministry of Science, Technology and Innovation (MOSTI), identified nanotechnology as one of the 14 research priority areas. The country spent more than RM 140 million IRPA grants on different projects on nanotechnology till 2005, allocated RM 1 Billion under the 8MP and RM 2.5 Billion under the 9MP and intended to increase the amount significantly in the 10MP [61].

With such investment, the country has strengthened the infrastructure too. Around 15 universities established well-equipped Nano science centers, many students in these universities are conducting nanotechnology research, more than 500 scientists are actively involved in nanotech research in five center of excellence established in different universities. A National Nanotechnology Directorate and National Nanotechnology Initiative (NNI), Malaysia was also established with the vision, "Nanotechnology for sustainable national development of science, technology, industry and economy". The government has also incorporated nanotechnology as a national priority in the Ninth Malaysia Plan by the Cabinet and proposed the establishment of National Nanotechnology Centre by the MOSTI. Moreover, the government has published the National Nanotechnology Statement in July 2010 where the Fourth theme in the statement is to 'uphold regulations and acts' relating to nanotechnology.

Apart from government initiatives, private companies that have already invested or in the process of investment in commercial production of products using nanotechnology. Already few companies in Malaysia both from government and private sector claim to invest in nanotechnology. These entities include the Malaysian Palm Oil Board, Malaysian AgriHI-Tech Co. Ltd., Nanopac (M) Pte. Ltd., Usains Holdings Pte. Ltd., Industriatech Corp. Ltd., Unitechnologies Pte. Ltd., UPM Holdings Pte. Ltd., UKM Technologies Pte. Ltd., Pakar Management Tech. Pte Ltd., Silterra Malaysia Pte. Ltd., Sime Tyre Pte. Ltd. [62].

On the other hand, along with Nanopac (M) Pte. Ltd., AZO Nano.com listed two more companies as Malaysian suppliers of nanotechnology and these companies are Ai-Nano Sdn. Bhd, Enviro Health Synergy Sdn Bhd. [63]. Additionally, the US Project on Emerging Nanotechnologies listed that two Malaysian companies have already commercially used nanotechnology in badminton racquets (PROTECH SPORTS) and cosmetics i.e. Nano Anti Ageing Cream and Nano Magic White Body (Soxton Enterprise) and their products are available in the market [64]. Nanowerk listed two more companies which are commercially producing products i.e. Arc Flash Corporation and Crest Group [65].

Like other hundred countries of the world there is no nano specific legislation in Malaysia and the government has set up the nano roadmap and set up a number of centers for excellence in different universities and research centers. When this is very inspiring, this is also crucial that the perception and understanding of the citizens are considered.

5. Methodology

A questionnaire based on similar kind of questions considered in different countries was developed with some very basic questions and it was served among the students of the four higher education institutions in the private sector in Malaysia i.e. Alfa College (AC) of Seremban [also known as 'Kolej Teknologi Alpha'], Universiti Tenaga Nasional (UniTEN), Multimedia University (MMU), Limkokwing University of Creative Technology (LKW). Of these institutions, Alfa College (AC) is a

private college, Multimedia University is the first private university of the country, Limkokwing University of Creative Technology, a private international university has its branch in Malaysia and Universiti Tenaga Nasional is a university fully owned by Tenaga Nasional Berhad (National Energy Ltd.) which is the largest power company in the Southeast Asia. These four institutions were selected to assess the understanding, knowledge and perception of students of different types of higher education institutions. The authors have previously carried out similar study with different group of students from public universities, and the findings are published in [66].

Before sharing the overall findings and result of this research, it may be pertinent to share Malaysian national official statistics on higher education. In relation to higher education institutions and students, the recent Malaysian official statistics are summarized in Table 2.

Table 2
 Official statistic of higher education institutions and students in Malaysia [67]

No.	Item	Total	Percentage (%)
1	Type		
	Private Colleges	414	73.92
	Private Universities	37	6.60
	Private University Colleges	20	3.50
	Branches of Foreign University	7	1.25
	Public University College	1	0.17
	Public Universities	20	3.57
	Polytechnics	24	4.28
	Public Community College	37	6.60
2	Nationality		
	Local	520,979	95.20
	International	26,008	4.80
3	Level of Education		
	Undergraduate	467,573	85.50
	Post graduate	79,414	14.50
4	Gender		
	Male	215,900	39.50
	Female	331,087	60.50

This official statistics reflects that in the higher education institutes the foreign students are less than 5% and local students are more than 95% and undergraduate students are more than 85% and post graduate students are less than 15% of the total number of students and the male and female student ratio is 4:6. In terms of religion, 61.3% of the citizens follow Islam, 19.8% Buddhism, 9.2% Christianity, 6.3% Hinduism, and 1.3% follow Confuciasm, Taoism and Tribal religion, 0.4% follows other religion, 0.7% does not have any religion and the religion of 1.0% is unknown [68].

6. Findings

6.1 Respondents' Demography

Response of a total of 490 Questionnaires [the percentage is shown in parentheses] i.e. 100 from AC [20.40%], 158 from MMU [32.24%], 70 from UniTEN [14.28%], and 162 from LKW [33.06%] were evaluated (see Figure 1). Of them 257 were male [52.44%], 230 were female [46.93%], 1 was bisexual and 2 did not answer. 236 respondents were from the age group of less than 20 years [48.16%], 241

were from the age group of 21-30 [49.18%], 9 were from 31-40 years [1.83%], 2 were from age group 41-50 [0.40%], 1 was from the age group of 51-60 [0.20%], and 1 did not answer [0.20%].

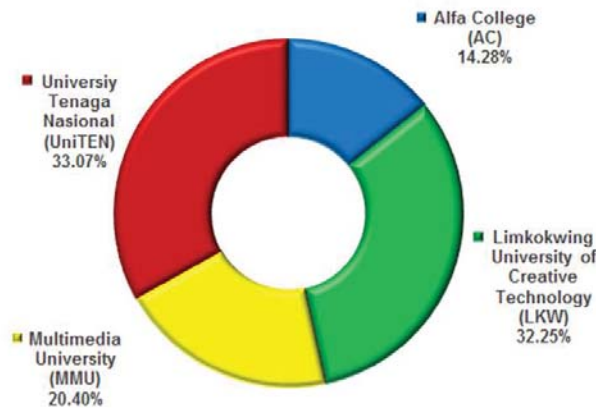


Fig. 1. Institutional Background of the Respondents

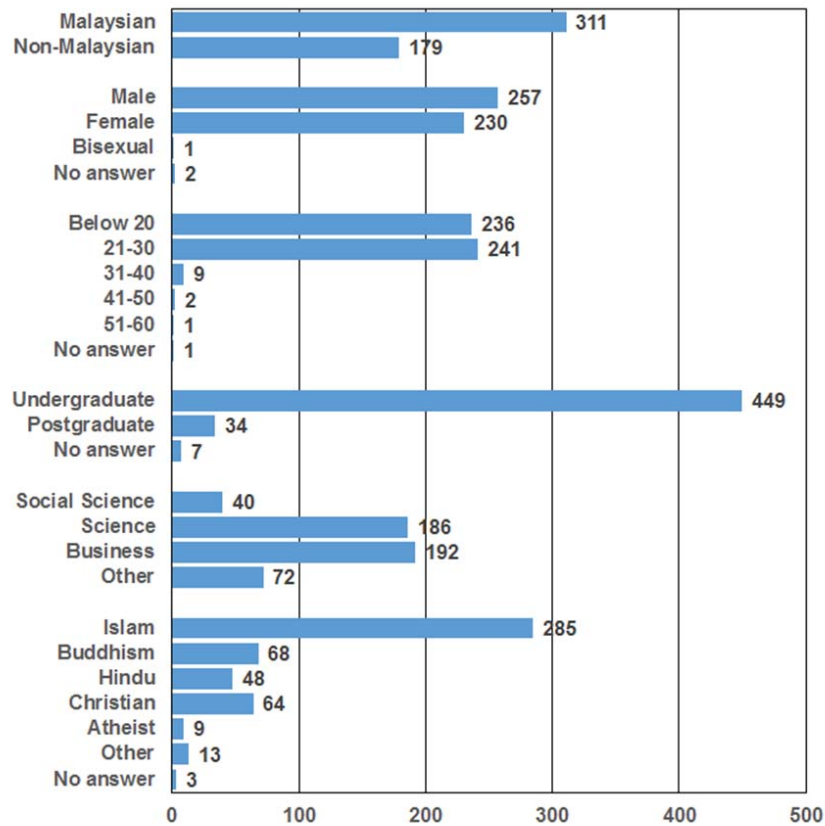


Fig. 2. Basic Information about the Respondents

Out of total 490 respondents, 311 were Malaysian students [63.46%] and 179 were non-Malaysian i.e. international students [36.53%]. 186 students were from science background [37.95%], 40 were from social science background [8.16%], 192 were from business background [39.18%] and 72 were from other background [14.69%]. 449 respondents were undergraduate students [91.63%], 34 were post graduate students [6.93%], and 7 students did not answer to this question.

In terms of religion, 285 respondents were Muslims [58.16%], 68 were Buddhists [13.87%], 64 were Christians [13.06%], 48 were Hindu [9.79%], 9 were atheist [1.83%], 13 were followers of other religion [2.65%] and 3 were reluctant to answer [0.61%].

In order to assess whether there is any relationship between the practice of religion and the acceptance of nanotechnology, the respondents were asked how serious they are in practicing religion and 131 respondents replied that there are very religious [26.73%], 269 were moderate [54.89], 58 respondents told that they have faith but they do not practice the religion [11.83%], 9 were atheist [1.83%] and 23 respondents were not interested to answer to this question [4.69%]. This information is presented in Figure 2.

6.2 Familiarity with the Word 'Nanotechnology'

In reply to a question on whether the respondents heard the word 'nanotechnology', 311 respondents replied that they have heard the word 'nanotechnology' [63.46%], while 16 respondents have never heard the word [3.26%], 88 respondents replied that they might have heard [17.95%], 30 respondents answered that they might not have heard the word [6.12%] and 45 respondents were not sure whether they have heard this or not [9.18%] (see Figure 3).

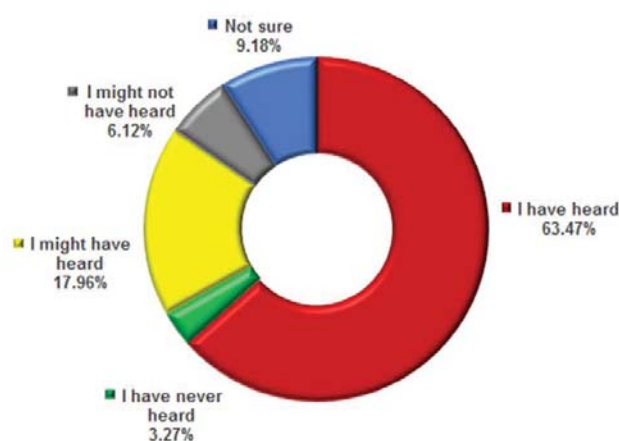


Fig. 3. Familiarity of the term 'nanotechnology'

6.3. Students' Level of Understanding about Nanotechnology

Next, the respondents were asked to answer their level of understanding about the concept 'nanotechnology'. Only 30 respondents replied that they know it very well [6.12%], 242 respondents know a little about nanotechnology [49.38%], 163 respondents heard the word 'nanotechnology', but do not know what is it [33.26%], 55 respondents do not know what it is [11.22%].

The respondents were asked whether they purchased any product in recent times containing the word 'nano' and 104 students replied affirmative [21.22%], 168 respondents replied in the negative [34.28%], 204 students were not sure [41.63%], and 14 students did not answer to this question [2.85%].

6.4 Students' Impression about Nanotechnology

Finally, the students were asked about their impression about nanotechnology and 353 students replied in favor of 'good' [72.04%], 91 replied that this impression depends on usage [18.57%], only 15 respondents replied that the word gives a 'bad' impression [3.06%] and 31 respondents were not sure or unable to answer the question [6.32%]. The information is presented in Figure 4.

Impression about any emerging technology helps to develop the perception of it. Specifically, for nanotechnology, a question was asked about its impression. It was revealed that out of 512 respondents 413 respondents i.e. more than 80% respondents replied that the word 'nanotechnology' gives a good impression. Taking into account the impression with the level of knowledge, it is interesting to share that 85% of the students showed good impression about nanotechnology even though they do not have enough knowledge. The overall finding on the impression about 'nanotechnology' with different criteria is shared in Table 3.

From this Table 3, it can be seen that 80% of the respondents who have heard nanotechnology have good impression about it and 88% of the respondents who favoured nanotechnology are either very religious or moderate.

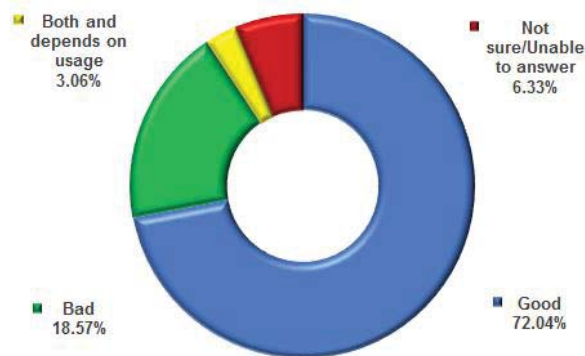


Fig. 4. Impressions about nanotechnology

6.5 Relationships between Familiarity with Nanotechnology and Respondents Demographic

In an attempt to find out whether there is any relationship as to familiarity of nanotechnology with different criteria in the context of Malaysia, of the 389 respondents who heard the word 'nanotechnology', it was found that 250 were Malaysian students [64.26%] and 139 were foreign students [35.73%]. Around 190 were male [48.84%] and 199 were female [51.15%]. In terms of age, this subgroup can be divided as follows: 28 aged below 20 years [7.19%], 279 aged in between 21-30 [71.72%], 57 aged in between 31-40 [14.65%], 21 aged in between 41-50 [5.39%] and 4 aged between 51-60 [1.02%].

It can be inferred from the result that Malaysian local students are relatively more aware of nanotechnology comparing to their counterpart. However, there is no difference in knowledge in terms of gender and the knowledge level of male [48%] and female [52%] is almost similar. However it seems that the undergraduate students and the students from the age group of 21-30 are more familiar with nanotechnology.

The findings in this regard are shown in Table 4.

7. Discussion

Academic background of the students has great role towards shaping their perception regarding any technology. This is equally true in relation to the policy makers i.e. their decisions in policy-making are influenced by their educational and career paths [69]. This is also confirmed from our study as it was revealed that the students with science background are more familiar and favourable to nanotechnology, followed by the students from social science and business background. Perhaps it is due to the fact that study materials of students of social science and business do not contain sufficient information on this issue and in all these five universities either specialised nano centers are established or courses are offered to science and engineering students.

It is very aspiring to reveal that that the tech-savvy Malaysian university level students are aware of nanotechnology as more than 75% of the total respondents in this study had already heard the word 'nanotechnology'. One may find that the rate is quite higher than some other similar research conducted in other parts of the world [70]. Nevertheless, the findings of our study is similar study with studies conducted in Japan [42] and Australia [71]. The reasons behind such result may be that the respondents were students of the top universities of the country and also students who were comfortable with the topic responded to the questionnaire and other studies conducted in other part of the world were conducted between 2004-2009 [70] when people had less knowledge on nanotechnology. However, the issue of great concern is that only 14% respondents were very confident that they know about nanotechnology very well and remaining 85% respondents were not.

From these 85% respondents, 57% of the respondents know a little about this. The students who know about nanotechnology could answer that nanotechnology can be utilized in the field of medicine, diagnosis, electronic, automobile, cosmetic and other. Therefore, the policy makers should consider to take initiative to make students and other stakeholders about nanotechnology. Such an initiative will enable the policy makers to help raise public awareness, provide information regarding research findings, provide input for future policymaking, attract younger people to science, etc. The Malaysian policy makers can consider the Planning Guide for public engagement and outreach in nanotechnology developed by the OECD as a ready reference as the Planning Guide was developed following effective methodology [72].

In replying to the question as to the source of their knowledge of nanotechnology, it was found that academic courses and media played significant role to make them aware about nanotechnology. It may be pertinent to mention here that we made an initial scanning on the archive of the two most popular newspapers of Malaysia i.e. New Straits Times and the Sun, and found that these newspapers covered very few reports on different inventions fueled by nanotechnologies around the world. Therefore, it can be assumed that the students got such information from other types of media like TV, radio, websites, blog and social media sites etc., It is a matter of serious concern that these newspapers were unable to focus on reporting the risks and benefits of nanotechnology.

Religion is an important cognitive shortcuts or heuristics, which enables someone to make sense of issues with low level of knowledge and study revealed that people who are less religious are more positive about nanotechnology comparing to people who are more religious [73–75]. We did not find this proposition correct in Malaysian context, as in our study even very religious or moderately religious respondents possess good impression about nanotechnology.

When 123 students replied that they used a product containing the word 'nano', they were asked an optional question relating to the type of products they used. The respondents answered different products ranging from cosmetic goods to computer chip, from anti-age cream to automobile, but could not exactly mention the name of the products. While referring to the name of cosmetic, many respondents referred to 'nanowhite' [76], which is listed in the product inventories developed and

maintained by the Malaysian regulators i.e. National Pharmaceutical Regulatory Agency, Ministry of Health and Malaysian Halal Product Directory maintained by the Halal Hub Division of the Jabatan Kemajuan Islam Malaysia (JAKIM) [Malaysia Islamic Development Department].

8. Conclusion

Science may decide what is safe or not but the society and consumers at large will decide what will be accepted or not. In this age of information and technological advancements, stakeholders are more careful about their wellbeing and they search for information from different sources. Therefore, it will not be wise to take any policy initiative without involving them and keeping them in the dark. Consumer acceptance and the regulatory issues will dominate and dictate nanotechnology's growth in the future [77]. Public perception is crucial for the regulation and the funding in the field of nanotechnology. Assessment of public perception is very important to understand the risk communication strategy [78]. It will further assist to understand the message to be given to the public and the appropriate authority to share such message as sharing of message by the wrong authority may compel public to refuse nanotechnology [21].

The present study is the first of this kind in the context of Malaysia. Malaysia has joined the race of nanotechnology research and development and the government of Malaysia also has been investing huge amount of money with a view to attain a significant position in this area. This is good that as an upgraded segment of population, the students of Malaysia are well aware of nanotechnology. However, taking into account the product, e.g. 'nanowhite', 'nano-nano' candy, which available in the market as suggested by the respondents the regulators of Malaysia should consider whether the products actually contain nanoparticles in true sense, or they just use the word 'nano' for attracting consumers as the word has a great banding value.

The government should also initiate program to make citizens aware of different aspects of nanotechnology. The Swiss focus group on nanotechnology took initiative called *publifocus* to increase the awareness level of the consumers [29]. Besides, the number of initiatives taken by neighboring country Thailand can be considered where the government has taken number of initiatives to aware and involve citizens regarding nanotechnology. Citizens can be included through training, meeting, awareness raising etc. Similar glaring example is NanoJure of UK where citizens were included. In USA, one study found out that citizens' proper knowledge will allow them to welcome new technologies and deliberative exchange of information cannot minimize their prior strong emotional reactions. This shows the importance of well-planned and moderated consensus conferences or "Citizens' Technology Forums" (e.g., [79]) that maximize the range of views and also control the emotional involvement of the participants [80]. Same practice of massive consultation is also found among the OECD countries in its latest report no. 34 of 2012 where all the member countries considered the importance of public consultation with due care and conducted number of stakeholders' consultations. Therefore, the Malaysian government should similarly consider to include citizens by involving them in similar kind of programs.

The study of nanotechnology being a multi-disciplinary one, the Malaysian policy makers should consider the inclusion of issue in the course materials of different academic courses. In future researches, the perception of people from all sectors, e.g. experts, researchers, consumers, etc. should be considered. Future research may also consider the citizens' impression and perception on nanotechnology sharing with them some information and without any information.

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Table 3
 Detail breakdown on the impression about 'nanotechnology'

	Good [Total 413]		Bad [Total 9]		Both [Total 63]		Not sure [Total 27]	
	Rate	%	Rate	%	Rate	%	Rate	%
Nationality								
Malaysia	259	62.71	5	55.55	50	79.36	15	55.55
Non-Malaysian	154	37.28	4	44.44	13	20.63	12	44.44
Gender								
Male	212	51.33	4	44.44	18	28.57	12	44.44
Female	201	48.66	5	55.55	45	71.42	15	55.55
Age								
Below 20	42	10.16	-	-	6	9.52	1	3.70
21-30	288	69.73	9	100.00	47	74.60	15	55.55
31-40	61	14.76	-	-	7	11.11	8	29.62
41-50	17	4.11	-	-	2	3.17	3	11.11
51-60	5	1.21	-	-	1	1.58	-	-
Education								
Undergraduate	253	61.25	7	77.77	47	74.60	14	51.85
Post Graduate [Masters]	111	26.87	2	22.22	11	17.46	8	29.62
Post Graduate [PhD]	45	10.89	-	-	5	7.93	5	18.51
Post Doctorate	2	0.48	-	-	-	-	-	-
No answer	2	0.48	-	-	-	-	-	-
Discipline								
Social Science	107	25.90	1	11.11	26	41.26	18	66.66
Science	264	63.92	8	88.88	24	38.09	7	25.92
Business	30	7.26	-	-	13	20.63	1	3.70
Others	12	2.90	-	-	-	-	1	3.70
Religion								

Islam	308	74.57	8	88.88	43	68.25	21	77.77
Buddhism	58	14.04	1	11.11	9	14.28	2	7.40
Hindu	20	4.84	-	-	3	4.76	-	-
Christian	16	3.87	-	-	5	7.93	1	3.70
Atheist	10	2.42	-	-	2	3.17	2	7.40
Taoism	1	0.24	-	-	-	-	-	-
Not to answer	-	-	-	-	1	1.58	1	3.70
Seriousness in Religion								
Very Religious	128	30.99	2	22.22	20	31.74	9	33.33
Moderate	232	56.17	6	66.66	35	55.55	13	48.14
Have Faith but do not practice	36	8.71	1	11.11	6	9.52	1	3.70
Atheist	10	2.42	-	-	1	1.58	3	11.11
Other [not interested to share this info]	7	1.69	-	-	1	1.58	1	3.70
Familiarity with Nanotechnology								
I have heard	332	80.38	6	66.66	36	57.14	14	51.85
I have never heard	7	1.69	1	11.11	7	11.11	6	22.22
I might have heard	60	14.52	-	-	11	17.46	4	14.81
I might not have heard	3	0.72	2	22.22	4	6.34	2	7.40
Not sure	11	2.66	-	-	5	7.93	1	3.70
Level of Knowledge								
Very well	63	15.25	2	22.22	6	9.52	1	3.70
Know a little	248	60.04	4	44.44	30	47.61	12	44.44
Heard but do not know what is it	93	22.51	-	-	13	20.63	7	25.92
Don't know what is it	1	0.24	-	-	2	3.17	3	11.11
Never heard	1	0.24	-	-	-	-	-	-
Not sure	7	1.69	3	33.33	12	19.04	4	14.81

Table 4
 Relationships between familiarity with nanotechnology and respondents' demography

	I have heard	I might have heard	I have never heard	I might not have heard	Not Sure
	[Total 389]	[Total 75]	[Total 20]	[Total 11]	[Total 17]
Nationality	Rate	%	Rate	%	Rate
Malaysian	250	64.26	9	45.00	13
Non-Malaysian	139	35.73	11	55.00	4
Gender					
Male	190	48.84	11	55.00	6
Female	199	51.15	9	45.00	11
Age					
Below 20	28	7.19	2	10.00	1
21-30	279	71.72	9	45.00	7
31-40	57	14.65	7	35.00	3
41-50	21	5.39	2	10.00	1
51-60	4	1.02			1
Education					
Undergraduate	232	59.64	8	40.00	7
Post Graduate [Masters]	109	28.02	9	45.00	2
Post Graduate [PhD]	44	11.31	6	30.00	2
Post Doctorate	2	0.51			
No answer	2	0.51			
Discipline					
Social Science	97	24.93	14	70.00	9
Science	263	67.60	2	10.00	1
Business	22	5.65	4	20.00	1
Other	7	1.79	2	26.66	5