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Malaysian tertiary level students and their understanding, knowledge and perception of nanotechnology

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ABSTRACT

Nanotechnology, being an emerging and enabling technology, can be utilised to exploit burgeoning opportunities in all aspects. Almost every kind of material with any feature can theoretically be developed using nanoscale technology and that is why countries around the world have been working relentlessly to exploit this. History suggests that unless the society and community welcome any newly introduced technology, that technology will have to embrace failure. Thus, the assessment of public perception towards emerging and enabling technologies like nanotechnologies is a routine activity in developed countries. Despite the fact such perception assessment activities were conducted in different countries, this has so far been not tested in Malaysia even though exploitation of nanotechnologies is a priority concern for the government. In this backdrop, this study aims to examine and assess the knowledge, understanding and perception of five public Malaysian university students towards nanotechnologies and their applications. Using a questionnaire survey, this study collected data from 530 respondents, of which 512 were analysed. Even though there are some general concerns as to the risk, safety and Halal application of the nanotechnology, a very good number of the students, irrespective of gender, nationality, religion, level of study, etc. are aware of the term 'nanotechnology' and could identify the benefits of nanotechnologies to them as direct consumers. Majority of the respondents are also aware of the presence of a number of nano-enhanced consumer products including cosmetic, automobile and computer accessories in the local market and more than 80% of the respondents favour the application and introduction of this technology in different sectors. Although the result of this study shows that the Malaysian tertiary level students, being the concerned segment of the society, are in favour of the usage and application of nanotechnology, adequate cautions should be taken by the policy makers to ensure the human health and environmental implications of engineered

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nanomaterials. Furthermore, attempts should be taken to make nanotechnology and its applications popular among the consumers by way of, inter alia, community outreach program, wide mass media coverage and introduction of specific academic course materials in different stages.

Keywords:
Nanotechnology and nanoscience,
Enabling and emerging technology,
Public perception, Policy and regulation,
Risk and safety

1. Introduction

Nanotechnology, the science and technology of manipulating materials at the atomic scale, is often sketched as 'the next industrial revolution after the internet'. It is an emerging technology and the study of nanoscience and nanotechnology is multi-disciplinary in nature which encompasses the understanding of fundamental physics, chemistry, biology and technology of nano-meter-scale objects. Thus, scientists from all sectors have been contributing relentlessly in different ways towards the responsible and sustainable development of nanotechnology. Nanotechnology enables the manufactures to convert the scientific knowledge to produce lighter, stronger, powerful, more durable and commercially viable products. As a result, more than a hundred countries, irrespective of size and economy, are already in the global race to utilize this nanotechnology for their future development as well as to become the market leader in different sectors [1]. Nevertheless, it is no more an issue of the scientists only as the hard earned contributions of the scientists are now exhibited in supermarket shelves as manufacturers have started to develop different products using engineered nanomaterials. For the manufactures the main concern will thus be the public acceptance of these nano-enabled products as rejection by the consumers will invite huge financial sacrifice.

Modern welfare states and governments need to remain vigilant and concerned with public support behind any kind of budget allocation, be it for technological, economic, cultural or social drive. The democratic governments are simultaneously accountable governments and thus, they cannot simply spend money in different ventures of their own wish without considering the public reaction which are usually reflected in national elections of these countries. Countries, which are active in nanotechnology research and development (R&D), e.g. United States of America, Japan, Australia, South Korea, Singapore and other European countries like United Kingdom and Germany are presumably countries with democratic credential with the vision and support of their citizens. Besides, the manufacturers also need to take precaution about their products, especially nano-enhanced end products that will be used by the consumers. The government, on the other hand, also needs to ensure that the end products developed using these technologies are safe for the consumers. For all these reasons, it is fundamental to assess the perception of the consumers. Keeping these in mind, this paper, which is a first of this kind, attempts to assess the perception of the Malaysian public university students with regard to this new technology and its diverse applications at the early stage of technology development. These students are selected as they are presumably the most updated segment of tertiary level students in the country and their level of knowledge may direct the policy decisions at the national level.

New technology like nanotechnology cannot be debated or discussed by scientist only or alone, there is a need for wider public participation as the case with other technologies for example, nuclear energy, genetically modified organisms (GMO), embryonic stem-cell research and biotechnology. Technological perception of mass has been assessed in a number of occasions, in a variety of instances and in the context of different countries, for example, *inter alia*, in relation to food allergy

[2], food nanotechnology [3], factors influence to take decision in favour of innovative food [4], risk [5,6], risk from biotechnology [7], risk of blood transfusion [8], food risk in the United Kingdom (UK)[9], climate change [10], water reuse [11], hazardous waste [12], technological risk [13], 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 [14], public perception relating to technology in Nigeria [15], and biometric technology in Portugal [16], etc.

Assessment of perception and understanding of experts, researchers, public, citizens, students etc. in relation to nanotechnology, its risk and benefit, etc. are also documented in a number of research, *inter alia*, [17–23] etc. and in the context of different countries, e.g. Iran [24,25], Taiwan [26] and Australia [27]. Gupta et al. [28] 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. Besides, countries like Japan have made this practice a continuous one and have been assessing the perception of citizens almost every year [29]. In the United Kingdom, such assessment has been conducted after regular interval, for example, one study was conducted in 2004 and another was conducted in 2011 [30]. In general, it was found that perceived benefits and risks of applying nanotechnology determine the public attitudes toward nanotechnology applications [26]. Thus, all these studies were conducted to assess how the consumers are ready to welcome this new technology.

Malaysia is a country with high prospect in terms of nanotechnology application, and R&D, especially because of the competence of the country in the areas of chemicals and electrical and electronics [31]. The government has been investing and allocating budget in this area almost at the same time with other developed countries. The government has established a number of Center of Excellences (CoEs) in different higher education institutes [31]. Already more than 400 consumer products containing the word 'nano' in the product name are listed in the product inventory maintained by the government agency. In this context, it is very timely to consider what the public are thinking in this regard. In such research, even though it would be desirable to include people from all strata of the society, this study considers the understanding, knowledge and perception of the Malaysian students from five public universities, as they were considered as the best sample for the study and also for the reason that these student are the future leaders and at the same time conscious segment of the citizens. The objectives of this study are as follow:

1. To explore whether the university students are familiar with 'nanotechnology'
2. To examine their knowledge and level of understanding about 'nanotechnology'
3. To find out their impression and perception about nanotechnology
4. To identify the relationships of familiarity with nanotechnology with the respondents' demographics

2. Malaysian public universities as a case

Malaysia aspires to be one of the top ten nanotechnology nation by 2020. The Intensification of Priority Research Areas (IRPA) programme of the Eighth Malaysia Plan[2], which is administered by the Ministry of Science, Technology and Innovation (MOSTI), identified nanotechnology as one of the 14 research priority areas. Up to 2005, Malaysia spent more than MYR 140 million IRPA grants on different projects on nanotechnology [32]. The government allocated MYR 1 billion under the Eighth Malaysia Plan and MYR 2.5 billion under the Ninth Malaysia Plan and intended to increase the amount significantly in the Tenth Malaysia Plan [31,33].

[2] A Malaysia Plan is an economic plan developed by the Government of Malaysia. It spans for a duration of five years. For example, the Eight Malaysia Plan covered the economic development between 2001 and 2005.

Significant advancement in the field of nanotechnology in Malaysia can also be noticed. Around 15 universities established well-equipped nano science centers and hundreds of students in these universities are actively involved in conducting research related to nanotechnology. It is estimated that more than 500 scientists are actively involved in nanotechnology research in the Centers of excellence established in different universities. The government has established the National Nanotechnology Center (previously known as National Nanotechnology Directorate) and National Nanotechnology Initiative (NNI) 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 [34]. Moreover, the government has published the National Nanotechnology Statement in July 2010.

In the Iranian Nanotechnology Database (Statnano), where assessment is made on the basis of local sharing method[3], Malaysia holds a significant position in the Asian context [1]. It also gives an indication on the willingness of the academics and researchers to explore the possibilities of this enabling technology in different sectors for the socio-economic development of the country.

Malaysia, a pluralistic society, is very lucrative and a prospective destination for higher studies, which attracts students from around the world. All these factors i.e. intention and support of the government, dedication of the academics and researchers and presence of students from different parts of the world encourage us to take an attempt to consider the perception of students of Malaysian Public Universities, both local and foreign, male and female, post graduate and undergraduate who are the future potential citizens of the respective countries. It can be anticipated 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 in a limited scale.

3. Methods and methodology

3.1. Study design

In any survey pertaining to gather ideas about the understanding, knowledge and perception of any area, it is important to collect data from a good number of respondents to generalise the idea. A total of 1000 questionnaires were emailed among the undergraduate, post graduate, doctorate and post doctorate students of five public Malaysian universities. But due to the funding constraint, the sample was not bulk as expected. Nevertheless, the sample was reliable enough for descriptive analysis [35]. The study was carried out between the months of April 2013 until July 2013. Based on the response, an analysis was conducted to assess the knowledge, understanding and perception of the respondents regarding different aspects of nanotechnology**.**

3.2. Study population and sample

There are 20 public universities in Malaysia. Five public universities are purposefully chosen due to connection and easy accessibility of the researchers. A total of 50,000 students study at undergraduate, graduate, post graduate, doctorate and post doctorate level in these five universities. Altogether 1000 questionnaires were emailed among the students of five universities, 530 were returned. The return rate was less than 60% due to final examination in all public universities at the period of data collection. Data from 512 respondents was finally analysed as 18 questionnaires were found incomplete. Gay et al. [35] said, "If the population is 50,000, a sample of 1% would be more

[3] The local sharing method is calculated based on ISI Web of Science Publication where the total number of scientific publication was divided by the number of publications on nanotechnology [1].

than adequate". Sample size 381 was determined for 50,000 population, 382 for 75000 population and 384 for 100,000 populations [36]. Thus, our sample size for this study is more than adequate that can truly represent the total population.

The issues of level of study, gender and religion, etc. have significant impact in developing perception about any emerging technology [37–40]. Therefore, before sharing the overall findings and result of this research, it may be pertinent to share Malaysian national official statistics on higher education. There are 20 public universities in the country where 5 of them are regarded as research universities. In relation to higher education institutions and students, the recent Malaysian official statistics are presented in Table 1.

Table 1
Official statistic of higher education institutions and students in Malaysia [41].

No.	Item	Total	Percentage (%)
1	**Nationality**		
	Local	589,998	95.53
	International	27,619	4.47
2	**Level of Education**		
	Undergraduate	480,352	77.87
	Post graduate	101,524	16.44
	Others	35,741	5.79
3	**Gender**		
	Male	236,302	38.26
	Female	381,315	61.75

This official statistics reflects that 95% of the students are local students with the remaining 5% are from foreign countries. Undergraduate students represent more than 77% of the total students and the balance corresponds to the post graduate students. The male and female student ratio is almost 4:6. On the other hand, in terms of religion, 61.3% of the citizens are Muslim, 19.8% are Buddhist, 9.2% are Christians, 6.3% are Hindus, and 1.3% follow Confuciasm, Taoism and Tribal religion. About 0.4% of the students believe in other religion, 0.7% does not have any religion and the religion of 1.0% is unknown [42].

3.3. Assessment tools: Validity and reliability

A structured self-developed questionnaire was used for the study. The content validity was ensured taking into account the opinion of five experts in this area. Expert suggestions were followed ins and outs. A pilot test was also done among 20 students of one public university and some revisions were made based on their feedback. The reliability of the items of the questionnaire was tested and Alpha value was in between 0.85 to 0.95. Items less than alpha value 0.40 were either modified or omitted to suit the situation in Malaysian context.

3.4. Data collection

The questionnaire was served among the students of the five public universities i.e. University of Malaya (UM), International Islamic University Malaysia (IIUM) [also known as “Universiti Islam Antarabangsa Malaysia (UIAM)”], Universiti Putra Malaysia (UPM), University of Malaysia, Perlis (UniMAP) and Universiti Kebangsaan Malaysia (UKM). All the questionnaires in UM, UniMAP and

UKM were sent electronically through universities' official group e-mails and part of the questionnaires to UPM and IIUM were distributed and collected both manually and electronically.

3.5. Fieldwork period

Between the dates of 15 April 2013 and 31 July 2013, 5 participating universities were identified and questionnaires were distributed. The respondents were requested to return the on-line questionnaires in 4 weeks. Time was first extended for 4 weeks and then for another 6 weeks. Thus, it took more than 3 months before final closing of the questionnaire. A few questionnaires were also collected manually within the same period of time.

4. Findings

4.1. Respondents' demography

A total of 512 respondents took part in the survey, as indicated in Table 2 [the percentage is shown in parentheses]. The breakdown of the respondents' universities is as follows (see Figure 1):

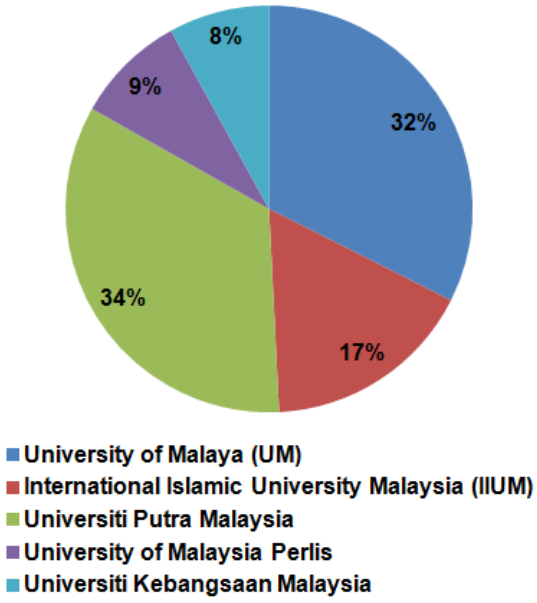

Fig. 1. Distribution of respondents.

166 from UM [32.42%], 86 from IIUM [16.79%], 174 from UPM [33.98%], 45 from UniMAP [8.78%], and 41 from UKM [8.00%]. From the total, 246 were male [48.04%] and 266 were female [51.95%]. In terms of age group,49 respondents were from the age group of less than 20 years [9.57%], 359 were from the age group of 21-30 [70.11%], 76 were from 31-40 years [14.84%], 22 were from age group 41-50 [4.29%], and 6 were from the age group of 51-60[1.17%].

A total of 330 Malaysian students [79%] and 182 non-Malaysian i.e. international students [21%] took part in this survey. A vast majority of them were from science backgrounds (58%), 31.44% were from social science backgrounds, 8.78% were from business studies backgrounds and the balance were from other backgrounds. In terms of education level, the responses from undergraduate, masters, PhD and post doctorate students were 62.89%, 25.58%10.74% and 0.39% respectively. 2 respondents did not answer to this question.

Table 2
Respondents demography

Background	Frequency	Percentage (%)
Universities		
Universiti Malaya (UM)	166	32.42
Universiti Putra Malaysia (UPM)	174	33.98
International Islamic University Malaysia (IIUM)	86	16.79
Universiti Kebangsaan Malaysia (UKM)	41	8.00
Universiti Malaysia Perlis (UniMAP)	45	8.78
Nationality		
Malaysian	330	63.67
Non-Malaysian	182	35.35
Gender		
Male	246	48.04
Female	266	51.95
Age Distribution		
Below 20	49	9.57
21-30	359	70.11
31-40	76	14.84
41-50	22	4.29
51-60	6	1.17
Education Level		
Undergraduate	322	62.89
Post Graduate Masters	131	25.58
Post Graduate PhD	55	10.74
Post Doctorate	2	0.39
No answer	2	0.39
Discipline		
Social Science	161	31.44
Science	297	58.00
Business	45	8.78
Other	9	1.75
Religion		
Islam	380	74.21
Buddhism	70	13.67
Hindu	23	4.49
Christian	22	4.29
Atheist	10	1.95
Taoism	2	0.39
Not to answer	5	0.97
Religious Seriousness		
Very Religious	158	30.85
Moderate	288	56.25
Have Faith but do not practice	44	8.59
Atheist	10	1.95
Other [not interested to share this info]	12	2.34

In terms of religion, 380 respondents were Muslims [74.21%], 70 were Buddhists [13.67%], 23 were Hindu [4.49%], 22 were Christians [4.29%], 10 were atheist [1.95%], 2 were followers of Taoism [0.39%] and 5 were either reluctant to answer or believe in different religion [0.97%].

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. 158 respondents replied that there are very religious [30.85%], 288 were moderate [56.25], 43 respondents told that they have faith but they do not practice the religion [8.59%], 10 were atheist [1.95%] and 12 respondents opted not to answer to this question [2.34%].

4.2. Familiarity with the word 'nanotechnology'

In reply to the question on whether the respondents have heard the word ‘nanotechnology’ (see Figure 2), 389 respondents replied that they have heard the word ‘nanotechnology’ [75.97%], while 20 respondents never heard the word [3.90%]. Meanwhile, 75 respondents replied that they might have heard [14.64%], 11 of them answered that they might not have heard the word [2.14%] and the rest were not sure whether they have heard this word or not [3.32%].

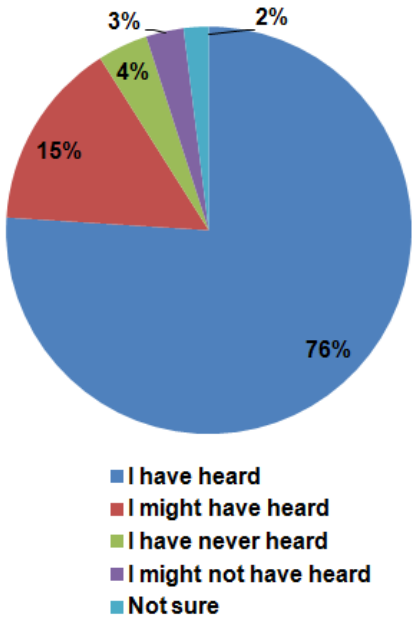

Fig. 2. Familiarity of the term ‘nanotechnology’.

4.3. Students' level of understanding about nanotechnology

Next, the respondents were asked to answer their level of understanding about the concept of ‘nanotechnology’. 72 respondents replied that they know it very well [14.06%], 294 respondents know a little about nanotechnology [57.42%], 114 respondents heard the word ‘nanotechnology’, but do not know what is it [22.26%], 12 respondents do not know what it is [2.34%] and 20 respondents never heard the word [3.90%].

After that, the respondents were asked whether they purchased any product in recent times containing the word ‘nano’ and 123 students replied affirmative [24.02%], 237 respondents replied in the negative [46.28%] and 152 students were not sure [29.68%].

4.4. Students' impression about nanotechnology

Finally, the students were asked about their impression about nanotechnology and the result is presented in Figure 3. 413 students replied in favour of 'good' [80.66%], 63 replied that this impression depends on usage [12.30%], only 9 respondent replied that the word gives a 'bad' impression [1.75%] and 27 respondents were not sure or unable to answer the question [5.27%].

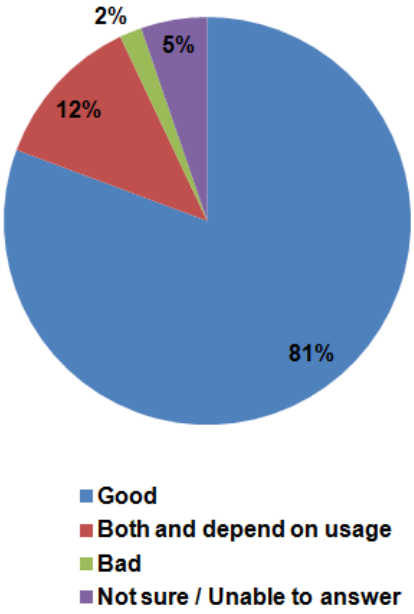

Fig. 3. Impressions about nanotechnology

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 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.

4.5. 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%].

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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]	
Nationality	Rate	%	Rate	%	Rate	%	Rate	%
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

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.

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Table 4
Relationships between familiarity with nanotechnology and respondents' demography.

	I have heard [Total 389]		I might have heard [Total 75]		I have never heard [Total 20]		I Might Not have heard [Total 11]		Not Sure [Total 17]	
Nationality	Rate	%	Rate	%	Rate	%	Rate	%	Rate	%
Malaysian	250	64.26	53	70.66	9	45.00	5	45.45	13	76.47
Non-Malaysian	139	35.73	22	29.33	11	55.00	6	54.54	4	23.52
Gender										
Male	190	48.84	33	44.00	11	55.00	6	54.54	6	35.29
Female	199	51.15	42	56.00	9	45.00	5	45.45	11	64.7
Age										
Below 20	28	7.19	12	16.00	2	10.00	1	9.09	6	35.29
21-30	279	71.72	56	74.66	9	45.00	7	63.63	8	47.08
31-40	57	14.65	7	9.33	7	35.00	3	27.27	2	11.76
41-50	21	5.39			2	10.00			1	5.88
51-60	4	1.02								
Education										
Undergraduate	232	59.64	60	80.00	8	40.00	7	63.63	15	88.23
Post Graduate [Masters]	109	28.02	9	12.00	9	45.00	2	18.18	2	11.76
Post Graduate [PhD]	44	11.31	6	8.00	3	15.00	2	18.18		
Post Doctorate	2	0.51								
No answer	2	0.51								
Discipline										
Social Science	97	24.93	35	46.66	14	70.00	9	81.81	4	23.52
Science	263	67.60	25	33.33	2	10.00	1	9.09	8	47.05
Business	22	5.65	13	17.33	4	20.00	1	9.09	5	29.41
Other	7	1.79	2	2.66						

5. Discussion

Academic background of the students plays 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 [43]. This is also confirmed from our study as it was revealed that the students with science backgrounds are more familiar and favourable to nanotechnology, followed by the students from social science and business backgrounds. 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 [44]. Nevertheless, the findings of our study is similar study with studies conducted in Japan [29] and Australia [45]. 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 while other studies conducted in other part of the world were conducted between 2004-2009 [44] 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 others. Therefore, the policy makers should consider to take initiative to educate 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, attack 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 [46].

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 [40,47,48]. 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 with different products ranging from cosmetic goods to computer chip, from anti-aging creams to automobile, but could not exactly mention the name of the products. While referring to the name of cosmetic, many respondents referred to 'nanowhite' [49], 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].

6. Conclusion

Assessment of public perception is crucial for the regulation and funding in the field of emerging and enabling technology like nanotechnology. A proactive inclusion of the general citizens into the regulatory debate is unavoidable in the field of emerging technologies especially nanotechnology [50]. Support of the public is essential for the success of programs for the exploitation of emerging technologies like nanotechnology as consumer acceptance and the regulatory issues will dominate and dictate nanotechnology's growth in the future [51]. Science may decide what is safe or not but the society and consumers at large will also play an important role in the acceptance of any technology. In this age of information and technological advancements, stakeholders are more careful about their wellbeing. Therefore, it will not be wise to take any policy initiative without involving them and keeping them in the dark. Thus a perception study of this kind can assist the policy makers to design and implement such programs in a more pragmatic way. Simultaneously, the manufactures and scientists should also consider this at the very early stage.

This study was an attempt to assess the perception, knowledge and understanding of five public Malaysian university students as the students are the influential part of the larger community. Already the findings of similar kind of studies are reported in the context of different countries, with diversified methodologies and approaches. It is the first of its kind in the Malaysian context, where the respondents were not asked anything about the risks associated with nanotechnology as it was anticipated that it would be pre-mature given the fact that even the science community is yet to reach any final conclusion as to the potential risks and harms arising out of engineered nanomaterials. In a situation, where this is still lack of consensus as to the theory-based research to assess public perception of nanotechnology [52], it is anticipated that the findings of this research will contribute towards reaching a conclusion at the global level. The findings of this research is even relevant as most of the public perception research in this field are conducted in North American and European countries.

It is very significant finding that majority of the respondents (75%) have already heard the word 'nanotechnology', though 85% of them do not know about nanotechnology very well. However, they have been using nano-enhanced products available in the Malaysian market and are aware of several categories of products that can be developed using nanotechnology.

In future research, 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 as to the risks and benefits of nanotechnologies.

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