An Exploration of Students' Feelings Regarding the Use of Nuclear Energy – A Comparative Approach

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Abstract

This article presents the results of a comparative study of two groups of learners – group 1 (25 non-science students) and group 2 (25 A-level physics students). It explores the extent to which their feelings and emotions in conjunction with their knowledge about nuclear energy impacts and influences their views and feelings about the use of nuclear energy as an alternative source of energy. The findings reveal that after exposure to learning about topics in nuclear energy the non-science students were more accepting and open in respect of the use of nuclear energy than the science students. In fact, over 80% of the non-science students indicated that they would support nuclear energy as a viable alternative energy source while only about 45% of the physics students said that they would.

Introduction

Researchers in education agree that learning is influenced by feelings and emotions, but they also agree that feelings and emotions can, in turn, influence subsequent learning. Secondary school teachers have attested to both these notions; claiming that students can at times be very vocal and passionate about their feelings and emotions, when confronted with ideas and theories that contradict their views and challenge their emotional state (Hargreaves, 1998). They suggest further that learning about controversial issues can result in students developing very strong positions about certain topics after learning about them (Schutz & DeCuir, 2002). Zembylas (2002) posits that there is an inextricable interrelationship between the cognitive and the affective domains of learning and that this interrelationship is under researched and understated.

In light of this claim, Bearison & Zimiles (1986) is of the view that the exact manner in which feelings and emotions influence cognitive learning is tentative and ambiguous.In science education in Trinidad and Tobago, this interplay between the cognitive and the affective domains is brought into focus when teaching many controversial topics that form part of the science curriculum at both the primary and secondary school levels. Energy conservation, abortion, pollution, radioactivity and global warming are some of the topics in the secondary science curricula which demand that teachers adopt suitable methodologies in the classroom to achieve meaningful learning in these topics. Structured discussions and guided inquiry approaches are recommended when teaching such emotionally laden science topics so as to provide students with opportunity to express their views, feelings and emotions on the topics, without intimidation and judgment and to promote balanced learning outcomes in those topics.

Feelings and Emotions in teaching/learning in Science

Koballa (1995) notes that, the number of studies on attitudes toward school science has increased significantly since the 1970s and that in general these show that children's attitudes towards science appear to become less positive as they progress to the higher levels of learning. Many reasons have been offered to explain this perception (Maharaj-Sharma, 2007; Hargreaves, 1998; Wynne, 1991), but there still seem to be no clear indicators as to why students reject science the more they do it. Much research exist that explore issues related to strategies used in the science classroom (Hartman & Glasgow, 2002), and even comparison among students' attitudes in different subject areas (Thompson & Shirgley, 1986), but there is very little research which explores students' attitudes when they are taught topics that are controversial, or are exposed to topics that they perceive may have emotional consequences.

The concern in this work is to reveal the link between learning and feelings when students are exposed to the controversial topic of nuclear energy. According to Alsop et.al. 1998, controversial topics have the potential to foster 'depressive' mindsets and instill 'distaste' in the topic to the extent that these can hinder learning so much so that this target on the affective can 'drive out the cognitive' (Solomon 1995). Teachers in Trinidad and Tobago have claimed that they are faced with challenges linked to 'distaste' among students when they attempt to teach some of the controversial topics in the science syllabus documents. Some students tend to be very vocal about their rejection of the topic while others become withdrawn. It is this primary concern that motivated this work. Learning about nuclear energy and its application as an alternative source of energy is an emotive science topic and in this work the students' feelings about nuclear energy and its potential as an alternative source of energy will be investigated. The overarching goal of this work is to explore via comparative methodology the extent to which students' feelings and emotions about nuclear energy impacts upon and influences their views and ideas about the use of nuclear energy. Two research questions tailored the approach adopted in this work:

1. To what extent do feelings and emotions impact/influence **science** students' views and ideas about the use of nuclear energy?
2. To what extent do feelings and emotions impact/influence **non-science** students' views and ideas about the use of nuclear energy?

In this work views on the nature of nuclear energy and the possibilities and issues associated with its use were sought. The views of a group of non-science students and a group of A-level physics students were respectively elicited by way of interviews and open-ended questionnaires. In each case the survey questions attempted to elicit what learners knew about nuclear energy in everyday context and what they perceived were the risks attached its use. Described herein are the data that connect knowing to feeling, in the context of findings by Wynne (1991) who suggests that there is a very real possibility that knowing about aspects of science that involves some personal or social risk can increase anxiety toward the topic to the point where the learner prefers not to consider the possibilities and alternatives that inevitably exist. Other research work suggests that there is a likely possibility that the more one learns about a topic, the more one is able to 'rationalize' and allay the concerns and anxieties that may have initially been invoked (Banks, 1994).

Two Surveys

The data discussed in this paper is derived from two groups of learners:

1. A sample of 25 non-science students in higher education;
2. A sample of 25 A-level physics students in three sixth for classes.

The surveys undertaken with each group were similar in most respects; but different primarily in the manner of administering. In each case the aim was to gauge respondents' attitudes towards aspects of nuclear energy. The questions asked and the approach adopted was slightly different for both groups. With group 1, an interview approach; guided by the 'Interviews-About-Scenarios (IAS); was used to examine respondents' broad and general views about nuclear energy. For the specialist physics students in group 2, a verbal questionnaire was used to sample students in three sixth form classes. A generous amount of time was spent with group 1 to work with the learners, and since they were not physics specialists, certain key issues related to nuclear energy was gradually introduced to them with the aid of pictures and relevant stimulus material.

The IAS tool (Appendix I) was used in a similar manner to the IAE tool (Gilbert, et. al., 1985), where line drawings were used to depict scenarios in order to stimulate interview conversations about a scientific phenomenon. The pictures included depiction of nuclear energy sources, nuclear reaction processes and nuclear power plants. These formed the stimulus and guided the focus of the interviews. The researcher/interviewer probed and explored comments made by the participants as far as possible to reveal their emotional stance in regard to each of the stimuli. Many of the scenarios involved the uses of nuclear energy in nuclear power plant to generate electricity. Some scenarios focused on the physical surrounding in the vicinity of the plant as well as the "nuclear exposure" to which workers were subjected. The purpose was to use the approach to capture, not so much, cognitive, but primarily affective data on the use of nuclear energy and to examine participants' conceptions of the scientific phenomenon and their associated emotions.

Twenty different scenarios were used with group 1. The scenarios were developed to facilitate broad discussions in 3 areas:

1. The general nature of nuclear energy;
2. The uses of nuclear energy;
3. The dangers associated with nuclear energy.

The 25 participants in this group (group 1) were undergraduates attending an institute of higher learning in south Trinidad. They were students studying a broad range of degree programmes outside traditional science courses; the majority of whom hold Advanced level qualifications in at least one science subject. All the participants in this group studied compulsory science up to form five (approximately age 16) and care was taken; in the sampling procedure; to ensure that they had all met the topic nuclear energy in their prior secondary schooling. By this criterion this group was labeled as 'Generally Informed Members of the Public' (GIMPs). The age of participants in this group ranged from 17-22 years.

Those in group 2 were all engaged in A-level physics learning in which nuclear energy was a topic in the course or programme they were pursuing. They were generally slightly younger than the participants in group 1; all having made a substantial commitment to study physics after the form five level. The average age of participants in this group was 17 years. This group was labeled 'Scientifically Informed Members of the Public (SIMPs). In surveying this group, time was a limiting factor; there was only little time to work with the students within their tight schedule of classes. They however, were much more attuned; from a cognitive perspective; to the issues related to nuclear energy, its uses and the associated dangers. With this group an open-ended 'written questionnaire' format (Appendix II) was used. This allowed for some elaboration of the answers in order to pursue lines of interest around each of the focal questions. Questions addressed areas such as: what do you know about nuclear energy? How would you feel about the use of nuclear energy as an alternative source of energy?

Methodology

Phase I

Participants in group 1 had met the topic nuclear energy in earlier secondary schooling and an examination of the syllabi documents revealed that they would have been taught about the nature of nuclear energy including fission and fusion reactions as well as the dynamics involved in the use of nuclear energy as an alternative energy source. Dangers and precautionary measures associated with nuclear energy were also on the syllabi documents at that level. With this 'prior' knowledge in mind, the GIMPs were interviewed using the adaptation of the IAS interview protocol.

Participants in group2 (SIMPs) all had a working knowledge of nuclear energy – it was one of the compulsory topics on their syllabus which they had already covered in the classroom setting. These participants were asked to complete the questionnaire in Appendix II, which dealt with identical issues as those covered in the interview with the GIMPs.The interview protocol and the questionnaire were piloted with 100 individuals in each respective group before being administered to the participants in this work.

Phase II

One week after the completion of phase I, the GIMPs and the SIMPs were invited (on a Saturday) to view a 60-minute interactive video in which details of the nature of nuclear energy, its use as an alternative energy source and the precautions that should be followed when using nuclear energy in power plants to produce electricity were presented. Potential dangers associated with nuclear energy were also explored in the interactive video (IAEA Publications, 2010).On the following Saturday (one week after viewing the video), both groups were again invited; this time to participate in a one-day workshop/seminar led by a distinguished physics lecturer from the University of the West Indies, St. Augustine, Trinidad. Similar issues related to nuclear energy – its use in electricity generation; dangers and precautions associated with its use – were explored and discussed in the open forum provided in the seminar.

Phase III

Two weeks after the seminar the GIMPS were re-interviewed using the same (adapted) IAS interview protocol and the SIMPs were asked to complete the questionnaire for a second time. The interview responses obtained from the GIMPs before and after the intervention (video & workshop/seminar) were transcribed and qualitatively analyzed to determine the views of the GIMPs in relation to their learning of nuclear energy. Questionnaire responses obtained from the SIMPs before and after the intervention were coded and labeled and these too were qualitatively analyzed to gauge the view of the SIMPs.

Findings

Interview transcriptions (GIMPs) and questionnaire responses (SIMPs) were independently analyzed to determine what were participants' feelings regarding nuclear energy. In both instances, special care was taken to ensure that codes and labels assigned were reflective of the actual feelings participants conveyed in the responses. Several labels were assigned and some of these were eventually combined to give main themes. The themes that emerged from the data included feelings related to being 'scared', 'unsafe', 'threatened', 'uneasy', 'worried', 'concerned' and 'panicky'. There were some participants who did not seem to be bothered either way; these participants were included in a theme called 'indifferent'.In response to question 3 on the interview protocol (which corresponded to question 3 on the questionnaire), the findings reveal that after the video/seminar intervention there was generally a decrease in the number of GIMPs who felt scared, unsafe, threatened, worried and panicky if nuclear energy was being used to provide their power source. There was however, an increase in the number who said that they felt concerned and indifferent after the intervention in regard to the same question. Interestingly, there was no change in the number of GIMPs who felt uneasy, before and after the intervention. (See Figure I).

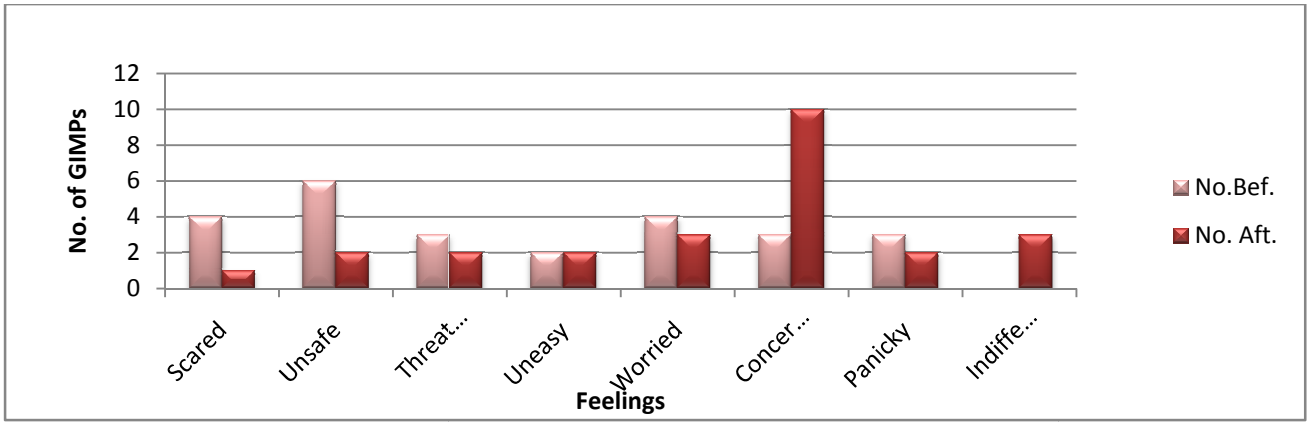

Figure I: Feelings of the GIMPs toward using nuclear energy, before and after the intervention.

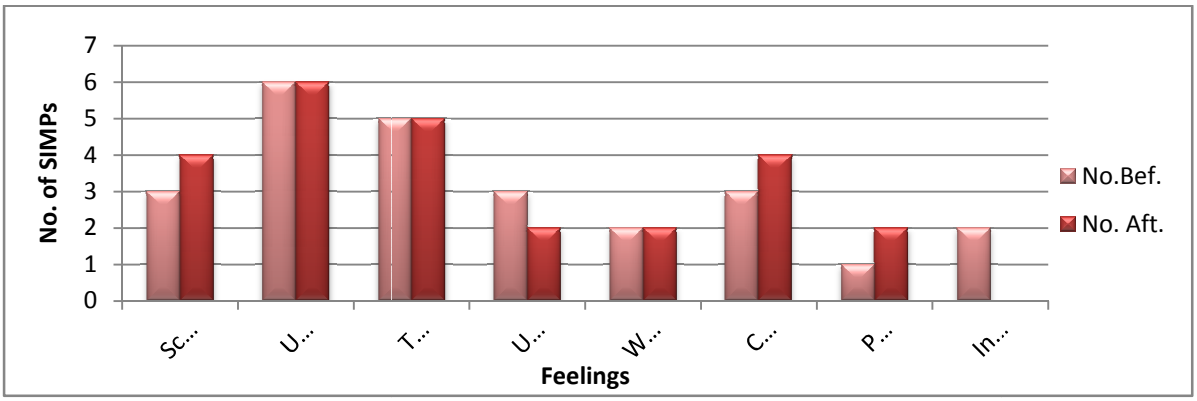

Figure II: Feelings of the SIMPs toward using nuclear energy, before and after the intervention.

Among the SIMPs, there was a reduction in number after the intervention only in regard to feelings of uneasiness and indifference while there was an increase in the number who felt scared, concerned and panicky after the intervention. The number of SIMPs who felt unsafe, threatened, and worried before and after the intervention was unchanged. (See Figure II).

The GIMPs

Interview responses obtained from the GIMPs suggest that many of them had limited understanding of the consequential use of nuclear energy as an alternative source of energy and that after being exposed to the video presentation and the interactive seminar that their 'misinformation' was clarified and they gained a better understanding of 'possibilities' and 'potential' of the nuclear energy. Their knowledge and understanding about the topic before the intervention was influenced to a large extent by 'hearsay' and general information obtained from the print and electronic media – much of which were not based on empirical research and data and which they suggest may have had 'questionable scientific integrity'. The increased understandings gained by the GIMPs seem to have lead to a greater appreciation of nuclear energy as an acceptable alternative energy source and a less resistive approach to its usage.Responses obtained from the GIMPs (after the video seminar intervention) in support of this claim are given below:

"…nuclear energy can be dangerous …but if proper precautions are taken….this could be a viable alternative power source…"

"I'm concerned about the dangers associated with the use of nuclear energy…but I know a lot more now so I feel less scared…"

"…now that I've seen the video and obtained answers to some questions that troubled me I would feel much safer …even if my power source came from nuclear energy"

Detailed analyses of the interview responses were used to categorize the GIMPs as "**Scientifically Literate (SL),** "**Moderately Scientifically Literate (MSL)** and "**Poorly Scientifically Literate (PSL)**, as per the working definitions in Table I.

Table I: Categories of the GIMPs

Category	Working Definition	Number of GIMPs
Scientifically **L**iterate **(SL)**	Person can ask, find or determine answers to questions derived from curiosity about everyday experiences. The **SL has the ability** to describe, explain and predict natural phenomena and is **able to read with understanding,** articles about science in the popular press and to **engage in social conversations** about the validity of the conclusions (Miller 1998)	13
Moderately **S**cientifically **L**iterate **(MSL)**	Person can ask, find or determine answers to questions derived from curiosity about everyday experiences but has **some difficulty** describing, explaining and predicting natural phenomena. The **MSL can read and understand**, articles about science in the popular press **but is reluctant to engage in social conversations** about the validity of conclusions from scientific work (Inferred from Miller 1998)	9
Poorly **S**cientifically **L**iterate **(PSL)**	Person can ask, find or determine answers to questions derived from curiosity about everyday experiences but has **great difficulty** restating explaining or predicting natural phenomena. The **PSL can read but may not totally understand,** articles about science in the popular press and **will not engage in social conversations** about the validity of the conclusions (Inferred from Miller 1998)	3

The following is an excerpt from Melinda – an example of a GIMP – who was categorized as Scientifically Literate; **SL,** based on her interview responses:

Interviewer: *How would you feel if nuclear energy was being used to provide your power source?*
Melinda*: Now I won't worry too much about it; I understand the need to use renewable energy and I guess if all the necessary precautions are taken and there are regular checks and maintenance in place it will be o.k.*

Interviewer: *Do you feel nuclear energy is a dangerous thing?*

Melinda*: No, not really based on what I learnt from the video and the workshop… it could be dangerous but it not necessarily is….*

Interviewer*: Will your feelings and emotions impact your future learning about nuclear energy?*

Melinda*: Certainly; but for the better. I'm now so intrigued, I would like to learn so much more about nuclear energy and how it can be developed and used as an alternative to fossil fuels.*

Stacy was categorized as a Moderately Scientifically Literate; **MSL,** in light of her responses which are as follows:

Interviewer: *How would you feel if nuclear energy was being used to provide your power source?*

Stacy*: While I have seen enough to make me feel safer about the use of nuclear energy as a power source, I will still panic if I knew that nuclear power is the main source of power I have to depend on…things can still go wrong and there are immense dangers that could result…*

Interviewer*: Do you feel nuclear energy is a dangerous thing?*

Stacy*: I still feel it's pretty dangerous even with all the information I've received…though I know that safety is a major concern in the use of nuclear energy as an alternative energy source.*

Interviewer*: How will your feelings and emotions impact your future learning about nuclear energy?*

Stacy*: I will take every bit of information that comes my way with a bit of skepticism.*

Carl's responses led to him being categorized as Poorly Scientifically Literate; PSL. Carl's responses are given below:

Interviewer: *How would you feel if nuclear energy was being used to provide your power source?*

Carl*: I will panic and feel mostly unsafe. I know the information presented tried to paint a different picture….that says that nuclear energy is a fairly safe energy source and that it can be used to provide power in a safe way, but I will prefer not to have nuclear energy provide my power source.*

Interviewer*: Do you feel that nuclear energy is a dangerous thing?*

Carl: *Yes I do. The video was nice and the workshop was interesting, but I am not convinced in my mind that nuclear power is really an acceptably safe way to go….*

Interviewer*: How will your feelings and emotions impact your future learning about nuclear energy?*

Carl*: I've seen some [from the video] but I'm not sure I really want to know anything more…in fact what I have seen has really made me very scared about the mere possibility that this form of energy will be a possible consideration in the future.*

It would seem that while the intervention may have led to a large number of GIMPs (>50%) exiting the experience with positive feelings toward a controversial topic in physics – nuclear energy – there were some GIMPs who continued to express feelings of uncertainty and scare toward the topic. As indicated, this group of participants (GIMPs) would have entered the study with limited, perhaps misconceived notions about aspects of nuclear energy and while the majority of them expressed negative feelings/emotions at the start, there was a general decrease in the number of GIMPs with sustained negative feelings after the intervention.

This evidence is reflected in Table I, which shows that 22 of the GIMPs (13 – SL and (9- MSL), in other words 88% of the GIMPs, exited the experience displaying greater openness to the topic.

Three out of the 25 GIMPs were classified as PSL and as sampled responses (above) show, GIMPs in this category had negative feelings toward aspects of nuclear energy – either having remained with the views/feelings they brought into the study, or having developed them after engagement in the work.

The SIMPs

This group of participants entered the study with various degrees of scientific content knowledge in general and various degrees of knowledge and understandings about the aspects of nuclear energy including its origin, its potential as an alternative energy source as well as factors involved in its use to generate electric power and the possible dangers and precautions associated with its use. Despite the obvious stronger subject-content knowledge base in the topic (as compared to the GIMPs), the SIMPs seemed to display a more "cautious" approach in responding to the questionnaire after the intervention, and while at least 2 SIMPs were indifferent before the intervention, none of them indicated that they felt this way after. In fact more SIMPs indicated that they felt scared, concerned and panicky after the intervention and the numbers that felt unsafe, threatened and worried about nuclear energy being used to supply their power remained unchanged after the intervention.

What is interesting however and somewhat surprising is that, based on Miller's (1998) working definition of Scientifically Literate (SL), only 24% of the SIMPs could have been categorized as SL (compared to 53% of the GIMPs), based on the respective responses given. Furthermore, 32% of the SIMPs were labeled MSL and 36% labeled PSL by Miller's (1998) criterion, based on their questionnaire responses. This revelation is somewhat provocative as it seems to suggest that even though the SIMPs were more knowledgeable about the topic, that they appeared to have some obvious reservations about adopting nuclear energy as an acceptable alternative source of energy. Elaborated responses obtained from their questionnaires; after the intervention; such as those shown below seem to support this notion:

***SIMP 1**: "…many feel it is a viable alternative to fossil fuels…but there are other options that I feel would be safer and less potentially dangerous…."*

***SIMP 2**: "If nuclear energy is used to provide my power source I would be very concerned…and worried…I would feel unsafe…"*

***SIMP 3**: "Advocates say that if properly managed and run nuclear power plants can be safe… I guess that is true to an extent…but I still feel in the final analysis it can be a very dangerous thing"*

***SIMP** 4: "…if I had a say in the matter…I would not support the use of nuclear energy as an alternative source for power generation…"*

***SIMP** 5: "…the presentations were very educational and while both sides of the issue were presented… my own view is that nuclear energy …while it might have tremendous potential…it is still not my choice for the way forward…."*

***SIMP** 6: "I know too much about the negatives that could result from the use of nuclear of energy to generate power for me to feel comfortable about its use…"*

These responses clearly suggest that among the SIMPs many were resistive to the use of nuclear energy. It was impossible to say exactly what was the origin of this resistive feeling since this group was surveyed by way of open-ended questionnaire so that the analysis was based only the responses given. The absence of an interview type approach restricted any opportunity for probing the responses given. According to Koballa (1995) however, the SIMPs knew 'so much' about the 'negative consequences' associated with the topic even before the intervention so that while the intervention may have had some impact, this influence served only to further concretize their initial understandings and feelings about the topic. In many instances, as Koballa (1995) says, if the initial understandings are flawed or limited, and the initial feelings are negative the 'new' knowledge and understandings presented are 'colored' by the existing ones to the extent that the new information makes little or no difference in ideas, perceptions and feelings regarding the phenomena.

Detailed analysis, involving coding and categorizing of words and phrases of the responses given by the SIMPs, revealed that only 11 or 45% of the SIMPs, displayed openness and acceptance to the use of nuclear energy as an alternative energy source.

Summary Comments and Discussion

There is evidence from this work, to suggest, that some students can arrive at equilibrium between their wariness of the issues and an informed view of matters involved, when exposed to scientific knowledge, engagement and explanations regarding controversial topics - the data indicated that this was obvious among many of the GIMPs. If this is an appropriate goal – a balanced combination of impassioned knowledge and informed feeling – then we need to know considerably more about the ways of learning in the context of feelings and emotions and also more about the way science learning occurs among individuals with a strong science background compared to individuals with a weaker science background.

It would seem that there is need to consider carefully these two positions – the role of feelings and emotions and the way science learning occurs – when developing approaches to teach controversial science topics. Whatever the approach/strategy adopted, it is obvious that it should facilitate learning; in controversial topics; in ways that will not only promote students engagement but that will also encourage students to consider several possibilities in attempts to arrive at a desirable state of 'informed equilibrium'. This work serves to present what might be described as 'starter evidence' for what it is that either 'turns on' or 'turns off' students from physics in general and certain controversial topics – such as nuclear energy – in particular. Given that many students easily get 'pumped-up' about controversial issues; which can serve either to further engage them in learning or alternatively to disengage them from altogether learning about the topic; it is teachers' responsibility to initiate discussion through carefully selected strategies that will promote the former rather than the latter.

It is not uncommon for students to appear to remain as quiet recipients when learning about topics that may have emotional impact on them, but as indicated by Alsop & Watts (2000), this may not necessarily be a bad thing. In fact it is quite possible that many of these silent recipients could be engaged in thoughtful reflection and mental assimilation. That having been said, it cannot be ignored that some silent recipients may be engaged in quiet disinterest or even cynicism (Alsop & Watts, 2000). The implicit suggestion here therefore, is that greater exposure to knowledge on controversial topics may serve to diminish some of the negative emotions attached to the topic for students who are experiencing new learning in the topic, as was seen with the GIMPS, but conversely, this increased learning can exaggerate negative emotions toward the topic for those students for whom the learning may not be entirely new; as was seen among the SIMPs.Overall, the findings of this work reveal that after being exposed to factual information, the GIMPs were more accepting to the idea of using nuclear energy.

In fact more than 80% of the GIMPs felt this way as compared to only 43% of the SIMPs who indicated that the use nuclear was acceptable to them. In this regard, these findings are consistent with those reported by Koballa (1995) and Alsop & Watts (2002).The researcher's view is that a consideration of the affective dimension in the teaching of controversial topics in physics is often neglected and as such serves to portray physics as an inhumane discipline. While we may not wish to portray a sanitized, antiseptic view of science/physics; as teachers our goal should be to achieve an appropriate balance of accurate and measurable cognitive outcomes as well as critical affective awareness for our students. To this end, sound content delivery coupled with informed excitement and animated understanding may need to assume comparable weighting in delivering classroom instruction, not only in science classrooms but in classrooms across all curriculum areas.

This effort to explore the intricate relationship between cognition and emotion in all learning and to strike the desired delicate balance of them both will continue to be a challenge for our teachers. It is the researcher's view that with sufficient, well-placed commitment, teacher creativity and a positive attitude, the challenge will no doubt be surmountable for our teachers.

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Appendix I

Adaptation of the IAS protocol administered to the GIMPs

Interview Questions

1. What do you know about nuclear energy?
2. What are your feelings about the use of nuclear energy as an alternative energy source?
3. How would you feel if you knew that nuclear energy is being used to provide your power source?
4. Do you feel that the use of nuclear energy is a dangerous thing? Explain fully what you mean.
5. How would you feel about the use of nuclear energy as an alternative source of energy for power generation? Explain fully.

[Responses were probed where they were unclear or where further elaboration was needed]Appendix II

Questionnaire administered to the SIMPs

1. What do you know about nuclear energy?
   ……
2. What are your feelings about the use of nuclear energy as an alternative energy source?
   ……
3. How would you feel if you knew that nuclear energy is being used to provide your power source?
   ……
4. Do you feel that the use of nuclear energy is a dangerous thing? Explain fully what you mean.
   ……
5. What would be your feelings about the use of nuclear energy as an alternative source of energy for power generation? Explain fully.
   ……