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SCIENCE EDUCATION: ATTITUDE DEVELOPMENT IN SCIENCE MUSEUMS/CENTRES

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The generation of positive attitudes toward science among school students is crucial, since without it all other aspects of achievements are likely to be limited. The present study argues that science museums/centres have far-reaching potential in this regard, but the researches carried out thus far have failed to produce consistent and convincing results. This paper discusses the factors that might be responsible for this situation, and makes a number of recommendations that can be attempted in the future studies.

Introduction

Science and technology permeate society. The swift changes science and technology bring to society result in rapid changes in society itself. In the future, our dependence on science and technology can only increase as the progress continues and many areas of science and technology are at a more exciting and productive stage than ever before. The influences of science and technology in our everyday activities are increasing astonishingly, yet the gap between science and the public is widening. Universally, the avoidance of science and technology is becoming something like an obsession among school students. In majority of the classrooms, science teaching is too abstract and dogmatic - that is, astronomy without stars; botany without flowers; geology without landscapes; and optics without lenses and prisms - to make students understand science and have an inclination towards it. In the present, there can be seen a widespread concern among educators and governmental leaders for the erosion of science education in schools.

As a remedial strategy, a growing body of research emphasises the need of nurturing positive attitudes to science among students during the early school education. Koballa and Crawley (1985) suggest that students' acquisition of positive attitudes cannot be assumed to result from simply learning facts. In his Factors Affecting Schools' Success in Producing Engineers and Scientists (FASSPES) project, Woolnough (1994: 29) finds that the extra-curricular schools - those schools which encourage extra-curricular and stimulating activities (guest lectures, science club, science competition, visits, work experience in science-based industry and home experiments) - send a large proportion of their students onto higher education to continue their science and engineering. Woolnough's finding is based on the data collected (through questionnaires) from 132 heads of science and 1021 sixth formers. He also substantiates his finding from the data gathered from interviews of 87 students. Such studies suggest that some under achieving students may really get on with science very well if they were given personal satisfaction in it through the injection of 'a little extra bit' over and above syllabus.

Among teachers and students, field trips are gaining incredible popularity. The importance and educational potential of science museums, particularly of hands-on settings, known as 'science centres', has been and is being increasingly recognised worldwide. Over the years, hands-on science museums are being established at an impressive rate all over the world, including developing countries. For example, while

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there was none in the United Kingdom till the mid 1980s, today there are more than twenty science and technology centres. Similarly, in the 1980s, on average one science centre per year was developed in India.

As can be seen from the statement of mission of individual institutions[1], one of the primary objectives of science museums/centres the world over is to develop positive attitudes toward science, with special mention of youngsters. In this paper, I aim to analyze the role of science centres in attitude development. I shall first examine whether, in theory, science centres have the potential of building positive attitudes toward science or not. In the second part, I shall review the studies conducted in science museums and centres on this subject.

In the following discussion, I shall mainly focus on hands-on and interactive settings but will often consciously use the word 'museum' (with a view to discuss the findings in the broader framework) in place of 'science centre'.

Attitude Development in Science Museums

At the outset, it appears essential to think about what constitutes a museum - a curator, an architect, a building or a few objects? If we pose a simple question to ourselves - can a museum run without a curator? The right answer would be, probably yes and sometime even runs better. For example, the science museum of Thessaloniki, Greece, has been organised and successfully operated not by curators, but by visitors and fans (Iatridis, 1995). Again, if we pose another question - can a museum run without visitors? Perhaps, the answer would be - no, never or who says? This question-answer session leads us to three essential building blocks of a museum, that is the museum (container), exhibits (content) and visitors (user).

In this paper, I shall take 'essential building block triangle' as a criterion in order to elaborate the impact of a museum visit on attitude development toward science (Figure 1). In other words, I shall discuss prominent features of museums, exhibits and visitors which may successfully nurture interest in the presented subject matter, and eventually build positive attitudes among visitors toward science museums.

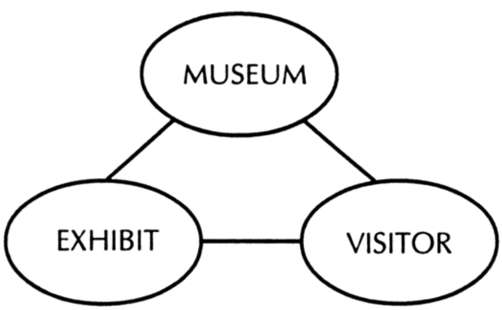

Fig 1. Essential Building blocks of a museum system

[1] The mission statement of Discovery Centre, Halifax, is: TO STIMULATE INTEREST, ENJOYMENT, AND UNDERSTANDING OF SCIENCE AND TECHNOLOGY THROUGH INNOVATIVE, EXCITING, HANDS-ON EXPERIENCES FOR ALL NOVA SCOTIANS.

Institutional Perspective

> We assembled on the spot, about ten in number, all strangers to me, perhaps to each other. We began to move pretty fast, when I asked with some surprise, whether there were none to inform us what the curiosities were as we went on? A tall genteel young man, *in person*, who seemed to be our conductor, replied with some warmth, 'What! would you have me tell you everything in the Museum? How is it possible? Besides, are not the names written upon many of them?' I was much too humbled by this reply to utter another word. The company seemed influenced; they made haste, and were silent (quoted in Hudson, 1975: 8).

The above is the museum experience of William Hutton, a bookseller from Birmingham, who visited the British Museum in 1784. Once upon a time, museums were indeed depressing, and sometimes even excruciatingly boring, environments. But since then, much has been changed. The present is an era of revival for museums as their aims and basic functions have either been changed or are in a transitional phase. For example, stress has now shifted from 'collection' to 'interpretation' and 'learning' or, in other words, from 'collection as a great achievement' to 'collection for a great achievement'.

Recognizing that most visitors do not come to museums to acquire specific knowledge, it has been, and is increasingly being, realised that learning is an informal, spontaneous and individual process in which experience itself is much more important for any significant learning to occur. Like previous times, visitors are no more 'unwanted intruders' in museums but they are 'guests' (in Experimentarium! the Danish Science Centre, Copenhagen, visitors are called 'guests'). Most of the museums have either created a visitor services or similar department or are thinking seriously in this direction. In the recent past, the majority of museum professionals have emphasised the importance of the museum as a whole in creating an environment that encourages active participation in a thoughtful and meaningful way. Ever increasingly thought is being given to each item on the learning environment inventory (Table 1).

Table 1. Details of Learning Environment Inventory (LEI) in a science centre.

Item	Description
Accessibility	Location (City Centre - high rating), transportation facility, parking and similar facilities, provisions of equal opportunities for special needs publics
Transitional Areas	Information desk, cloak room, baby changing facility, toilets, drinking water, cafe, museum shop, relaxing area, public telephone booth, children play area and first aid facility
Orientation	In person briefing of facilities, slide shows, introduction panels, museum guide book, pamphlets, sign boards, touch screens and audio guides
Circulation Choices	The provision of multi-entry and exit points, free standing exhibit units in the hall, provision of demonstration islands, small theatres, cave and dome inside the hall
Total Stimulus Control	General lighting, interior plants, thermal control, humidity control and odour control
Exhibit Editing	Colour scheme, exhibit lighting, human factors, labels (type-size, length, contrast and style, and content)

Exhibit Stimulus Rating	Cleanliness, protection, maintenance, replacement of consumable items and lost components, front staff and their professionalism
Total Integration	Indelible museum experience - no physical or psychological problem; exhibit - convey the feeling and knowledge that it is worth exploring; over-all time needed - manageable; space and time - enjoyable

To some extent, powerful drives, such as the need for personal affiliation, can mitigate many of the physical barriers. However, where the desire to learn is a less than powerful drive (an all-too-common-situation), a little inconvenience may have a marked effect. This 'long overlooked or ignored' factor has now been, or is increasingly being, identified by museum professionals as an important one:

> We believe we should be delivering quality to them (visitors), not just in terms of the content of our public galleries but also in the way in which the place is run, its cleanliness, the public facilities for it, and so on. So, we have refashioned the museum over the last three years to include high quality retailing (Neil Cossons in a interview with Januarius, 1990).

The desire to make visitors feel psychologically and physically at ease and to make the museum more attractive, both inside and out, forms undoubtedly the underlying purpose of this revival and it has largely been possible through the co-operation between museum professionals, architects, political leaders, industrial houses, and local communities. As a result today, most museums follow an holistic approach. They want the building to also convey the message in conformance with exhibits. For example, the Centre for Understanding the Environment, Horniman Museum, London, has desired that the building's design itself should speak out about environmental matters:

> It will be built from sustainable timber, insulated with recycled newspaper, finished with non-organic toxic paint, and topped with a living grass and wild-flower roof. Hollow timber beams and columns will create a natural passive ventilation system, reed beds will recycle waste water and solar panels will generate electricity (*Museums Journal*, November 1994: 8).

There is evidence that many non-users, including those who had formed their negative image about museums long ago, perhaps in their childhood, and have not attended museums since then, still hold the conventional image - museums as glorious depository of a nation's heritage (Prince and Schadla-Hall, 1985; *Museum Development*, March 1991: 25). But, the scenario is gradually emerging as a promising one. Dr Michael Gore, who visited the Exploratorium in 1975 with his family, and on his return developed his own science centre called *Questacon* in Australia, gave a very interesting account to this effect. He revealed that:

> He had to drag his family in and then, three hours later, drag them out (Duensing, 1987).

There can be seen an unprecedented increase in attendance and change in visitors' behaviour after opening up a gallery based on the science centre approach in an old museum accused of inertia by the general public. For example, following the opening of its prestigious art and (Earth) science extension in October 1993, the National Museum of Wales, Cardiff, witnessed a leap of 36 per cent in visitor numbers (*Museums Journal*, May 1994: 25).

A further example to this effect is an ambitious exhibit, entitled *Caltex Volcanoes and Giants*, at Auckland Museum, New Zealand. In order to achieve its goals of attracting a large audience and of generating a significant exhibition income, the exhibit makes an exemplary and realistic use of display techniques and resources such as constructed environments, sound, life-size animal re-constructions and animations, interactive computers, video clips and big-screen video projectors. Following the opening of the exhibit on 6 May 1994, the museum attracted 153,000 people in the subsequent three weeks; visitation was up 100,000 on the 1993 figure for the corresponding period (Prickett, 1994).

As a result of revival, visitors can be observed now exploring things enthusiastically in new museums. They easily become absorbed in the environment. A large proportion of visitors leave the museum with a commitment to return in the near future. At the same time, a considerably large account of return visits paid to these museums confirms that visitors, in general, find the course of their visits meaningful and satisfying.

The overall perception of a visit is an extremely important factor in attitude development. Robert M. Hazen, a research scientist at the Carnegie Institution of Washington's Geophysical Laboratory, observes that 'museums can have tremendous influence. We have an opportunity here to change our national attitudes toward science' (Lantos, 1994).

Objectives of Exhibits

The exhibit is the heart of the museum, and learning from exhibits is known to be one of the prominent motivations for a visit to museums. The exhibits here are usually built upon certain objectives. According to Shettel (1968), the underlying purpose of scientific and technical exhibits is generally the same - to impart knowledge about various technical subjects, and/or to change the attitude of the viewer in a favourable direction toward science, its practitioners, and its institutions. The objectives of scientific and technical exhibits are mostly found to be educational, lately much to do with the public understanding of science and its processes. In general, these educational objectives can be crudely conceived in terms of cognitive, affective and psychomotor areas. By means of exhibits, science centres first aim to kindle in visitors' heart the wonder and loving sympathy for their content and ultimately for science, and thereafter they hope for facts to multiply in the memories of visitors:

> They expect most visitors to browse, directing their attention where they will. Through such episodic encounters with engaging material, science centres *hope to lure, stimulate, and invite* visitors to discover something new - just one thing - about the structure of the physical world' (my italics) (Grinell,1992: 13).

In exhibition halls, hands-on exhibits are changing in quality (from push button type to ones rich in varied psychomotor skills) as well as in quantity. Contemporary learning and teaching theories are increasingly being integrated with the process of exhibit development. New technologies are being employed in the exhibits to provide visitors links that would presumably facilitate learning. The interactive exhibits have been found to be the most popular ones among visitors (Thier and Linn, 1976; Alt 1983). Though interactive exhibits have been discovered to be successful in conveying information effectively (Zelig and Pfirman, 1993), most researchers believe that individual, or a group of, exhibits may not contribute immediately and directly to the deeper understanding but their indirect effect in affective domain must not be underestimated (Wellington, 1989).

Learning theorists have long championed the idea that situational stimuli - events in the environment - directly influence our attitudes and behaviour. Roberts (1990) asserts that the nature of exhibits- multi-sensory, three dimensional, and interactive - should appeal strongly to the part of the brain that concerns with space, image and affect. True, visitors may in due course forget the detail of what exactly was displayed and encountered with, but they are unlikely to forget the enthusiasm such exhibits can generate.

Reids goes further in suggesting in his Ph.D. thesis that it is the achievement of interactivity, rather than the exact format, whether it be simulation, group discussion, or role playing, which is central to attitude development (quoted in Byrne and Johnstone, 1988). In a very extensive review of the literature, Bredmemeier and Greenblatt (1981) conclude that under certain circumstances and for some students simulation-gaming can be more effective than traditional methods of instruction in facilitating positive attitude changes.

In conclusion, all the above arguments and evidence suggest that the hands-on approach to exhibits provides a nutritious substance for attitude development toward science.

Visitors' Perspective

Learning is strongly influenced by personal world views, knowledge, attitudes and aspirations, and social interactions. Active involvement of students rests at the heart of effective science learning. Recent research points to the dominance of information processing actions in the museum environment. In a large metropolitan museum of natural history that provides ready access to novel information through its traditional displays and interactive exhibits, Hike (1989) reveals that 86 per cent of all events undertaken by visitors concern the exhibits themselves. McManus (1989), in her study of detailed discourse analysis of the recorded conversations of visitors, finds how close and personal visitors' talk is, but at the same time mediated by the labels on exhibits. Several other studies made on young visitors (Gottfried, 1980; Herbert, 1981; Alt, 1983, Carlisle, 1985; Tuckey, 1992) also reach the conclusion that children on a field trip to a science centre, at first, exhibit diverse exploratory behaviour and gradually become orderly, attentive and interested in exhibits. On the basis of these many studies, it appears reasonable to conclude that visitors through their active involvement fulfil a necessary, though it alone may not be a sufficient, condition of learning.

During the visit, visitors see a number of miscellaneous, unique and splendid things, and participate in a number of activities in a short span of time. They often see or do something which rubs-off and sticks and 'sparks-off' something in their mind which may resurface later (Wellington, 1989). Indeed, there are many, varied and scattered views about what actually visitors take away with them. Stevenson (1991) collected diversely scattered 'professional views' about visitors' assets and summarised them in six categories:

1. a set of experiences (or memories).
2. a set of effects.
3. a set of explanations.

4. a set of applications.
5. more understanding in a general sense.
6. a change in attitudes.

To make Stevenson's list further useful, on the basis of my behavioural studies (Kaushik, 1996) I suggest to include two more categories:

7. a set of brain-storming questions (or mysteries).
8. a set of misconceptions.

For category 6, Stevenson says that it is generally hoped that a visitor may feel positively disposed after a visit to a science centre. In their independent studies, both, Stronck and Birney, conclude that highly structured organised school visits appear to result in greater cognitive learning and less structured visits result in producing more positive attitude (Stronck, 1983; Birney quoted in Falk and Dierking, 1992: 50).

Attitude Change: Theory and Practice

From the above discussion, it is clear that all the three essential and mutually enlightening building blocks of a museum system, that is the museum (container), exhibits (content) and visitors, strive for the same goal - development of new attitudes and consolidation of the existing attitudes. Hence, theoretically, it can now be assumed that science museums have great potential for attitude development.

To answer the question whether science centres have been, and are, successful in the process of attitude development toward science, we have largely some anecdotal evidence. In general, exceptional and illuminating experiences act as a catalyst in the process of human development. For example, the sight of a huge electric arc as a child determined Sir Bernard Lovell's career as a scientist (described in his book *Astronomer by Chance*). Those scientists who had some contact with science museums as children usually maintain that the museums played a vital role in developing their interest in the pursuit of science (Oppenheimer, 1968; Tressel, 1992). Besides, we have also got some evidence from the general population. For example, Frank Oppenheimer talks about a woman who reported that visiting Exploratorium gave her confidence she needed to rewire a lamp. Similarly, a woman rectified a lock in her sister's house a week after visiting Launch Pad (Tulley and Lucas, 1991). Anecdotal evidence is important for the individual concerned, but as individual statements they have limited applications. It is, therefore, always desirable to establish some generalised results.

A number of quantitative research studies have already been undertaken on the aspect of attitude change as a result of exposure in museum settings. "Do attitudes change after exposure to the U.S. Science Pavilion?" was one of the main queries of the study conducted in the US Science Pavilion at the Seattle World's Fair, 1962 (Taylor, *et al.*, 1963). During their literature survey, the authors went through several constructed scales but noted that they were exploring no more than the strength of pro-or-con feelings about science (Taylor, *et al.*, 1963: 19). On the basis of literature survey and free-response interviewing, Taylor and his colleagues selected four main attitude variables: stereotypes of scientists, stereotypes of science, the meaning of scientific endeavour, and the potentials of science. They prepared an attitude questionnaire consisted of 45 items, taking 15-20 minutes to complete.

Interviews were conducted at six different locations and it was intended to find out the attitude change occurring in response to different activities or displays: that is, in response to the *House of Science* film in Hall I, to the *Development of Science* exhibit in Hall II, to the simulated trip through space in Hall III, and so on. The majority of significant attitude changes occurred in response to the film showed in Hall I. The slight observed changes that took place after exposure to Hall II (*Development of Science*) were speculated to have occurred not as a result of the exhibits placed there but as spill overs from the changes induced by the *House of Science* film. In sum, portions of the pavilion produced changes in attitude, but the changes were of slight magnitude.

In the late 1960s, Harris Shettel evaluated an ambitious American exhibit *The Vision of Man* at the National Museum of History and Technology. The exhibit was designed to impart knowledge about the role of the federal government in science and technology and to develop a favourable attitude in young visitors toward this role. Three indices - a maximum, a minimum and a control - of effectiveness measure were established in order to determine changes occurring in three areas - knowledge, interests and attitudes. The results in the areas of interest and attitudes were found to be difficult to interpret. While the findings in interest area were found unstable, the problem with attitude data was of no difference at all. The findings here tend to show that attitudes do not seem to be influenced in response to short term exposure to an exhibit and, therefore, are found to be inconsistent with Shettel's own studies for the *Atoms in Action* exhibit (Shettel, 1973). In *Atoms in Action*, Shettel surveyed exhibit viewers and non-exhibit viewers and found that most viewers showed positive changes in attitude to the peaceful use of nuclear energy.

Borun (1977) used three sub-scales - that is, interest in science, science is good or bad and perception of impact of science - in order to measure attitudes toward science, technology and society. In her study, high pre-visit attitude became low post-visit attitude indicating that the museum experiences failed to sustain the initial level of attitude. The major weakness of this study seems to be that the author did not attempt to define her concept of attitude and its underlying structure.

In 1981, Bob Peart (1984) conducted an evaluation of exhibits (using the post-test only control group design) in the *Living Land-Living Sea* gallery of the British Columbia Provincial Museum. A questionnaire was developed to measure knowledge gain and attitude change about the seabird colonies. No significant change in attitude was found among the control and five experimental groups (1. a word exhibit, comprised of a label only, 2. a picture exhibit, also including the label, 3. an object exhibit, without the label, 4. a standard exhibit, with objects and the label, 5. a sound exhibit, with objects, the label and sound) pooled as one. Seventy-one per cent of the control group visitors were voted in favour of leaving seabird colonies undisturbed. For the experimental group, the corresponding figure was 78 per cent.

In 1984, Finson and Enochs (1987) conducted a study to determine if a visitation to the Kansas Cosmosphere and Discovery Center in Hutchinson can affect attitudes toward science-technology-society (STS). A previously developed Scientific Attitude Inventory (SAI), composed of 60 items in a statement format with a five-point Likert-type scale for responses, was employed (with slight modification) for this purpose. The items were divided into sub-scales focusing on intellectual and emotional attitudes. The authors found the building of more positive attitudes toward STS of students who visited the museum (Finson and Enochs, 1987).

In a recent survey study of teachers' reaction on the role of interactive science centres in fostering positive attitude toward science (Tuckey, 1992), respondents were asked to react to the statement, "My pupils have shown a more positive attitude towards science as a result of their visit to Satrosphere." By using this type of statement, we may perhaps not reach the right conclusion because: first, the term 'attitude' may have different meanings to different teachers; second, teachers instead of paying critical attention to the question may respond in socially accepted terms; and third, it is an indirect study in the sense that teachers estimate the attitudes of their students and so may draw their conclusion on the basis of some bright students. The response to the above statement seems obvious (in positive terms) and so actually is the case. Sixty-eight per cent of the respondents agree strongly with the statement. In her conclusion, Tuckey (1992) also admits that changes in attitude are notoriously difficult to measure and further tries to supplement the findings by statements from children.

Discussion

All the above discussed studies seem to bring no consensus over the issue of changes in attitudes toward subject matter as a result of a science museum visitation. The researchers reported all possibilities - an increase, a decrease and no change in post-visit attitudes. In general, researchers also did not attempt to define the concept of attitude. The attitude measurement is a notoriously difficult task mainly because attitude is not a 'predefined' nor a 'stable' concept, recognised through the emergence of a shared world-view. Conceptually, attitudes are explored and defined from affective, cognitive, behavioural, biological, social and cultural perspectives. In these circumstances, in order to measure attitude changes, it becomes essential to explore and learn the way attitudes toward science are organised.

In some cases, the researchers attempted to measure attitudes by means of a single question. A single item, at its best, can tell the opinion, feeling or interest of the respondents about a particular object or event. In this context, the researchers appear to follow the assumption that opinions are verbalised expressions of attitudes. But, in real life situations, attitude matters are much more complex than these have been considered.

> ...in private, a person says all sorts of things, slurs friends, uses coarse language, acts silly, tells dirty jokes, repeats himself, makes a companion laugh by shocking him with outrageous talk, floats heretical ideas he'd never admit in public, and so forth ... that we act differently in private from the way we do in public is everyone's most conspicuous experience, it is the very ground of the life of the individual (Kundera, 1995).

This obvious fact has often been ignored by the researchers. Indeed, attitudes are nearer to pre-dispositions than opinions; they are inside and unobservable.

Some researchers also seem to assume that attitudes are organised around beliefs. Beliefs can be crudely divided into three categories: descriptive or factual (for example, science is power); inferential; and informational. In most of the cases, the researchers have employed factual statements to measure attitudes. Unfortunately, such statements have low evaluative or discriminatory power. For example, who would like to disagree with the statement that, "Science is a process of generating knowledge." Factual statements are therefore to be tested for their evaluative character before including in the final tests.

Social factor is one of the key influences which makes the problem of attitude measurement much more intricate. While responding to a question, we are generally tempted to think in socially accepted norms. Most of us would tempt to say that conservation, environment and animal rights are good and that pollution, nuclear accidents and misuse of resources are bad. These feelings are less likely to be changed as a result of a science museum or centre visit. It is quite possible that Bob Peart (1984) did not observe any appreciable change in attitudes for this reason. To disturb seabird colonies appears to be unethical.

There is a substantial technology and associated mystique about attitude measurement. Central to this is a belief that it is not possible to evaluate something like attitude on the basis of a single statement. Through the use of a set of questions, or by getting an individual's expressed reaction to several statements, a sample of respondents' opinion should be obtained. And from this sample of opinions may be inferred or estimated people's attitudes - what they really think. Unfortunately, most of the researchers who used several items in their questionnaires appear either to have forced uni-dimensionality on the scale or to have chosen sub-scales (representing underlying attitude structure) arbitrarily or without due forethought.

In general, the researchers also did not pay due attention to the reliability and validity of their scales or questionnaires. The reliability is concerned with whether an instrument - regardless of what it truly measures - yields scores that are consistently repeatable. The question of validity refers to the issue of how we can be sure that a measure really does reflect the concept to which it is supposed to be referring. Evidently, the attitude measurement appears an useless exercise if we proceed without paying proper attention to the issues pertaining to the validity and reliability of the scale.

Conclusion

The potential of science centres in developing positive attitudes toward science seems to be far-reaching, but there appears to exist limitations or discrepancies in the research design which have so far been employed to explore the subject area. Although some correlation can be envisaged between attitudes toward science and museum visits, positive attitude changes have not been convincingly confirmed. What is needed first and foremost is the construction of the attitude concept after taking into account of its affective, cognitive, behavioural, biological, social, cultural and religious associations. Uni-dimensionality should not be unilaterally enforced on the attitude concept. In order to infer and examine the underlying structure of attitude, multi-factor analysis can also be employed.

Much additional research has yet to be done on appropriate research tools. This can be done either by refining existing attitude scales or developing new valid and trustworthy scales for measuring attitude changes in response to a science museum visit. While conceptualising questionnaires, factual and socially accepted statements should be avoided. It is, therefore, recommended that future studies include the gathering of qualitative data to define attitude concept, developing instruments that could meaningfully represent to those concepts, and convincingly confirm the relationship between attitudes toward science and science museum visitations. The task is original and challenging, yet achievable.

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