Virtual Science Centers: A New Genre of Learning in Web-based Promotion of Science Education

Leo Tan Wee Hin and R. Subramaniam
National Institute of Education
Nanyang Technological University
1 Nanyang Walk
Singapore 637616

Anil K Aggarwal
Merrick School of Business
University of Baltimore
Baltimore, MD 2120
USA

wlhltan@nie.edu.sg and subrar@nie.edu.sg
aagarwal@UBmail.ubalt.edu

1. Introduction

In recent years, the Internet has made a profound impact in the field of education. By providing a novel setting for the creation of new learning experiences, it is impinging on various aspects of traditional education structures, for example, distance learning, student assignments, on-line learning, group learning, e-experiments and e-universities.

The ubiquity of the personal computer, the nature of the client-server architecture on the Internet, the low cost of logging on to the Internet and the scope for simultaneous access are all factors that have helped to fuel the evolution of various genres of learning on the Internet platform. Most universities and schools, at least in the developed world, have a web presence, and their portals feature a wealth of information and other resources for learning.

One aspect of web-based education that has received little attention in the science literature is that of virtual science centers. It is the cyberspace analogue of traditional science centers, institutions which popularize science and technology to students and the public. Providing distributed learning beyond the confines of their traditional infrastructure, virtual science centers have engendered a unique genre of offerings that present tremendous potential for science learning.

The popularity of virtual science centers can be gauged from the fact that the website of the Association of Science-Technology Centers (ASTC) has links to over 200 science centers, museums and other non-formal institutions of learning. Visits to virtual science centers have been increasing over the past few years -- for example, The Exploratorium, which is considered to be the pioneer of the science center movement, attracted 132,585,374 visits from 1993 to 1998 [1]. Among ASTC members, 70% have websites: 34% of these sites are hosted by donors, 23% are hosted by web-hosting services, and 41% are hosted by the institutions themselves. During 1997, a total of 195.3 million hits were recorded by 77 science centers and museums. Though this figure does not capture the unique number of separate visitors, a point to note is that 38 of these institutions reported that the number of distinct hosts served in Dec 1997 alone was a staggering 896,362 [2].

Published studies on virtual science centers are rather sparse in the primary science literature. Commentaries on the web offerings of a few science centers have appeared in newsletters [2,3] as well as in conference proceedings [4]. Studies of museum portals have, however, been quite extensive [5-12].

The purpose of this paper is three-fold:
(a) to briefly review the science center movement and its migration onto the Internet platform,
(b) to survey the unique features of science centers on the web, and the technologies which make their range of offerings possible, and
(c) to comment on the unique issues facing virtual science centers, and suggest possible solutions in the light of our experiences.

Through this we wish to accord further recognition to an educational genre which has tremendous potential for science education.

Abstract

The opening of a virtual annexe by science centers has given rise to a new genre of learning in web-based education. Seeking to enhance the outreach effectiveness of non-formal science education initiatives among students and the public, these virtual science centers fulfill a useful role in promoting the public understanding of science. The types of content which can be hosted in these sites are discussed. A commentary is also presented on some of the unique issues encountered in this new learning environment, including some suggestions on possible solutions in the light of our experiences.
2. Review of science center movement and its migration onto the Internet platform

Science centers are non-formal educational institutions of relatively recent origins [13]. They have been established primarily for the purpose of popularizing science and technology to the public and students, thereby contributing to the enhancement of science literacy levels. Initially, the tasks were performed by science museums which were, and generally still continue to be, repositories of scientific artifacts. As the exhibits here represent treasures of historical value, opportunities to appreciate them in an interactive manner were understandably minimal.

Within the framework of a museum environment and as a sequel to their natural evolution, the concept of a science center began to germinate. Science centers were envisaged as vibrant institutions that can popularize science and technology in multi-dimensional ways among the public. The Exploratorium in San Francisco is to be credited for pioneering the science center movement in 1969 and of making a success of it for others to emulate [14, 15].

Over the years, the concept gained further recognition, and this has seen the proliferation of numerous science centers across the world. A large number of these science centers are in North America, and a significant number of them are in Europe. Some museums also started to function as science centers or with an interactive science annexe, for example, the Launch Pad in the Science Museum of London, and the Xperiment! in the Manchester Museum of Science and Technology. It took some time for science centers to be established in Asia, and in South East Asia, the Singapore Science Center has been the pioneer [16]. More recently, science centers have been established in Hong Kong, Malaysia and Indonesia.

Though science centers are sometimes called museums or science museums, they differ from the latter significantly. Museums generally host art collections and other historical artifacts whilst science museums display a range of scientific artifacts. Generally, these exhibits do not allow for hands-on exploration. In contrast, in science centers, the emphasis is more on interactive exhibitry.

Science centers have now come to be regarded as not only part of a nation's scientific and educational infrastructure but also as important co-ordinates in the domain of the leisure industry.

With the entrenching of the Internet, science centers have been compelled to colonise the Web in their efforts to stay relevant, address new challenges and tap new opportunities for growth. In the early years, their offerings were more of a static nature. With advances in technology, a whole new genre of offerings have sprouted on the websites of science centres. Almost all science centers have now a web presence. These virtual science centers popularize science and technology through virtual science exhibitions and other educational programmes. In fact, the web provides yet another platform for science centers to engage the public as part of their extension education efforts in science literacy. Being natural nodal points in cyberspace for the public to seek information about science, the learning potential of offerings in the portals of virtual science centers have increased greatly over the years.

Virtual science centers are different from other websites in that they are dedicated sites for the promotion of non-formal science education. The type of content that science centers host in their webs mirrors the emphasis that they follow in the physical domain. That is, the content is geared towards popularizing science and technology among the online public, including students.

3. Examples of content suited for virtual science centers

The web architecture of a virtual science center is no different from that used to administer any corporate website. A high capacity server with appropriate software tools for the design and delivery of content is a fundamental pre-requisite.

We highlight in this section examples of content which capitalises on the unique potential of the Internet for the promotion of informal science education on the portals of science centres

3.1 Virtual Exhibits

Exhibits are the principal means by which science centers communicate their mission objectives on site. This emphasis is also continued in cyberspace, where the exhibits can be static or interactive. By way of example, we focus on one of the virtual exhibits in the virtual realm of the Singapore Science Center: ballistic simulator. We believe that this is a good example of what an interactive virtual exhibit should be like.

The ballistic simulator is an exhibit which illustrates how the dynamics of motion of an object along a trajectory can be affected by various factors. This web exhibit is a good exhibit because it evokes not only the physicality of a gallery exhibit but also harnesses the unique potential of the web to foster learning experiences. It is not easy to set up this exhibit in the exhibition gallery of a science center because of space constraints, logistics requirements, safety considerations and operational factors. The web offers the potential to scale it down to a dimension that offers interactivity whilst capturing the essence of the physicality.

More specifically, the online exhibit challenges the visitor to hit a target under a variety of conditions. To enhance the learning potential of the exhibit, a menu of
options are available in order to vary the parameter of interest -- muzzle angle, muzzle velocity, gravitational field strength, and wind speed. Selection and adjustment of the options can be done through a window on the screen with the use of a mouse. No input from the keyboard is required.

Once the relevant parameters are selected, clicking the start button evokes a mapping of the trajectory of the object under the chosen conditions on the screen. This feedback allows the visitor to see whether he has played the game correctly or, rather, how the chosen parameters have affected the dynamics of the object's motion.

The key features of this exhibit which make it to be a good example of an online interactive exhibit are:

(i) multiplicity of contexts for the user to connect with the exhibit in a seamless manner,
(ii) good instructional design
(iii) pro-active learning contexts
(iv) good balance between learning and leisure
(v) no text-heavy pages to interfere with the learning experience

Fostering a play element in the learning process makes the exhibit fun to interact with. Even a child who has little knowledge of the dynamics of the requisite physical processes at work is likely to be drawn by the play elements embedded in the exhibit design, with learning taking place, perhaps, in a subdued or subliminal manner. It is also likely to foster a desire in the child to know more about the workings of the exhibit or the concepts inherent therein.

Other virtual exhibits which have impressed us include:

(i) Cafe Wall Illusion, Shimmer, and Depth Spinner, in the website of the Exploratorium in San Francisco, USA
(ii) Mixing Colours, Computer Crayons, and Get the Drop on Pixels, in the website of the Ontario Science Centre in Canada
(iii) The Virtual Fish Tank and The Dance of Chance, in the website of the Boston Museum of Science in the USA

### 3.2 Science Net

Science Net is a unique feature of the website of the Singapore Science Center, and is not to be found in the portals of other science centres or science museums. It is a web-based platform for the public to obtain answers or explanations for any of their scientific queries. The database of questions and answers are organized according to the following schema:

- Computer Science
- Earth Science
- Engineering
- Life Sciences
- Space and Astronomy
- Others

Since its introduction in 1998, over 16,000 questions have been posted by the public, not only from Singapore but also from other countries, and answered by the organizers! This is testament to the popularity of the site.

It is obviously not possible for a single institution to take on the mammoth task of answering all the questions posed because of the diversity of expertise and number of personnel that would be needed for such an exercise. To address this challenge, the two premier universities in Singapore, the National University of Singapore and the Nanyang Technological University, were also inducted as co-organizers of this section. The two universities provide resource personnel who help to answer questions closest to their field of specialization. Some questions have two answers -- this is more a consequence of some interesting or tricky questions being directed simultaneously to two experts. Besides minimizing the response time of getting at least one explanation for the question, the strategy also offers the public the benefit of obtaining alternative perspectives. Often, it may not be that easy to answer a question -- such questions are then posted on the website itself, soliciting for answers. Hyperlinks are sometimes provided for in a number of answers; this is not to be viewed as a quick-fix solution for answers that are brief but more as an extension of the textual narrative and also as a recognition that there needs to be a limit on the length of each answer. In particular, the use of hyperlinks encourages visitors to continue their learning experience, an important consideration in their extension education.

To make it easy for the global public to pose questions, user-friendly features are incorporated into the site. They need to key in brief details of their personal particulars before entering the question/s. This helps to capture a profile of the visitors as well as to personalise the question in that the person who posed the question is acknowledged next to the question in the database. A click-button sends the question to the Science Net coordinator, who then re-routes it to the relevant expert in the resource panel.

To ensure that the public do not pose questions that have already been answered, a search protocol is available. This allows the public to enter key words describing a concept in order to facilitate checking. Based on analyses of the server log files, about 35% of the questions posed by the public have been found to be previously answered. For such cases, an email response is sent, directing them to the relevant section of the Science Net -- a time consuming exercise.

The aesthetics and dynamics of the site have been preserved by the use of a simple layout, presence of a design motif without flamboyant elements on the answers.
If a photon travels through a wall of glass, is it the same photon passing in? How does a photon travel?

**Answer:**

Photon is the elementary particle or ‘package’ (quantum) of energy in which light and other forms of electromagnetic radiation are emitted. The photon has both particle and wave properties. It has no charge, and it is considered massless but possesses momentum and energy. When light shines through a wall of glass, photons of certain frequencies might be absorbed. Electrons in glass have a natural vibration frequency in the ultraviolet (UV) range. When UV light shines on glass, resonance occurs as waves build and maintain a large amplitude of vibration between the electron and the atomic nucleus. The energy the atom receives may be passed on to neighbouring atoms by collisions, or it may be re-emitted. Resonating atoms in the glass can hold onto the energy of the UV light for a short while (about 100 millionth of a second). During this time, the atom makes about 1 million vibrations, collides with neighbouring atoms and gives up its energy as heat.

At lower frequencies, like those of visible light, electrons in the glass are forced into vibration, but at less amplitude. The atom or molecule holds the energy for less time, with less chance of collision with neighbouring atoms and molecules, and less energy is transformed to heat. The energy of vibrating electrons is re-emitted as light. Hence, glass is said to be transparent to the frequencies of visible light. The frequency of the re-emitted light that is passed from molecule to molecule is identical to the frequency of the light that produced the vibration in the first place. The main difference is a slight time delay between absorption and re-emission. It is this time delay that results in a lower average speed of light through a transparent material. Light travels at different average speeds through different materials.

Access to the Science Net is free and is available globally. The rich repository of information available in the site draws visitors from across the world. It is the public's participation that has helped to generate a vast database of intellectual resources in a public domain.

The strategy of the public posing questions for which they seek answers or explanations constitutes an important aspect of furthering the public understanding of science. Often, questions are posed by the public because they have doubts about a topic or a concept which they seek to address in their learning attempts. No institutional mechanisms are currently available to service such learning needs of the public -- the Science Net comes closest to this model, and is a key feature of the web-based learning environment at the Singapore Science Center.

### 3.3 Ancillary science-based educational resources

To enhance the potential of the science portal, substantial text-based resources are featured in the webs of most science centers. These textual resources encompass various aspects of science and technology, especially those of a contemporary and thought-provoking nature. The principal advantage of hosting textual resources is that these can be easily digitized.

Visitors coming to the webs of science centers are not only looking for opportunities to savour the various core offerings but are also looking for other interesting resources that may appeal to their learning fancy. By presenting a taxonomy of various resources, these initiatives help to extend the educational potential of the virtual science center further. Examples of such resources include school science projects such as, for example, different ways of taking off a T-shirt; a guide to common vegetables; basic principles of remote sensing; optical litter; and the chemicals we eat and drink. On the website of the Exploratorium, a range of science activities as well as webcasts of images from the Hubble Space telescope are featured.

The featuring of interesting school science projects is an extremely effective way to incorporate value-added content on the website since the students do the bulk of the work.

### 4. Design elements in the fabrication of virtual exhibits

The virtual science center movement, though a relatively new concept in the field of science education, has undergone significant maturing over the past few years. New technologies and tools have greatly facilitated the induction of creative elements in the process of
interpretation of various concepts through cyberspace exhibitry and other means.

In science centers, learning takes place predominantly through interaction with exhibits. A range of scientific concepts can be addressed via interactive exhibitry. When these concepts need to be transplanted into the virtual realm, they should not just be cyberspace equivalents but should aim to exploit the unique features of the web, which is an entirely new media, in order to foster learning.

Some of the issues which science centers face in the fabrication of online exhibits are explored here.

4.1 **Choice of exhibit**

The choice of exhibit which can be put up in cyberspace is dictated mainly by curatorial considerations and the emphasis which science centers wish to foster. It can develop along two axes: static and interactive, with the former being less bandwidth-intensive and less expensive to set up.

4.2 **Software tools**

Where curatorial choice leads to consensus in the treatment of an exhibit idea, the design elements which need to be used to present the exhibit idea become important. This is the stage where creative inputs from a variety of sources are harnessed: curators, designers, educationists, and software specialists. The team has to contend with not only a consideration of the traditional elements of conventional exhibitry but also of how to configure it for the digital realm.

Several technological tools are now available to aid in the fabrication and enjoyment of online exhibits. A number of these tools are available as plug-ins to complement the user's browser software, and some can be downloaded for free. A discussion on some of the important tools used for art museum exhibits in cyberspace has been presented in the museum literature [17-19], and these are generally valid for virtual science exhibits as well. A review of the more important tools is presented here.

4.2.1 **Shockwave Flash** This tool allows for the creation of ‘flash’ pieces that are of near theatrical integrity but are less bandwidth-intensive. They thus allow for quicker downloading. It is possible to interface streaming audio with Shockwave Flash and, in conjunction with Java Script, initiate a flash in any part of the webpage.

4.2.2 **Shockwave for Director** In the same class as Shockwave Flash, these are larger files which are ideal candidates for fabricating puzzles and independent games.

Both Shockwave Flash and Shockwave for Director are static files. Once they are embedded in an online activity, it is difficult to upgrade the activity without extensive re-writing of the software.

4.2.3 **Java Script** This is the most important tool available for the cyber curator. It integrates the various components of a web page so that it functions harmoniously, and it also allows other tools to be combined in creative and innovative ways.

4.2.4 **Embedded Audio, MIDI and Beatnik** Sound effects triggered in the background of an online activity in the form of sample loops, MIDI or Beatnik files allow for the creation of an appropriate mood setting. For narration, Real Audio is good but for interaction-triggered sound, WAV files are the choice.

4.2.5 **Real Media, Windows Media and Quick Time** These are tools for transmitting streaming video. Streaming feed is possible even on a narrowband platform because there is no necessity to download entire files in order to appreciate it. Of course, on a broadband platform, the quality of the user experience is distinctly superior on account of the greater throughput of data and picture frames per second.

4.2.6 **Dynamic HTML** This tool permits manipulation of any aspect of an HTML document in real time. Other capabilities include creation of layers that appear, disappear or move upon user interaction.

4.2.7 **Java** This is a versatile programming language that allows ‘dreams to be turned into reality’ on the web. It is only limited by the experience of the programmer.

4.2.8 **QuickTime VR and Photovista** These tools allow for an object to be rotated around its axis and be viewed in 3-D. It also permits the viewer to be placed in the centre of a virtual sphere and turn in any direction. Thus, these tools are useful for examining small objects or to relish the grandeur of the interior of an object. Being rather bandwidth-intensive, they have to be used rather judiciously.

4.2.9 **Live Picture Viewer** This tool permits a live peep into an institution.

4.2.10 **Quick Cam** This permits a streaming video feed, and thus allows the visitor to enjoy live telepresence in an institution.

The foregoing assortment of tools allow for the creation of virtual exhibits that foster innovative learning experiences as well as learning interfaces that are not possible in the physical exhibit. They have to be used...
judiciously and not as gimmicks. If they are not embedded in context, they may appear invasive and thus detract the user from the learning experience. It is important to bear in mind that there is a difference between real world manipulation of exhibits and cyberspace manipulation of exhibits. The former fosters experiential learning via a range of senses whilst in the latter, there would necessarily be impoverishment of the experiential factor on some counts; for example, the digital realm currently has limitations in the savouring of tactile and aural feedback.

Even trivial issues such as information overlay need to be carefully addressed in the design brief so as to minimize cognitive overload and visual fatigue. Judicious use of graphics and eschewing of flamboyant design elements are essential, for otherwise access can be sluggish, thus detracting the user from the learning experience. High quality graphics, whilst embellishing a site, contributes to problems when featured on navigation pages. Also, multimedia files for downloading need to be placed in the lowest hierarchy on the web page. Generally speaking, images of about 2 Mb or more would cause slow downloads on a narrowband platform [5].

With the proper design elements, cyber-curated exhibits would be able to confer a new dimension in the learning of science through the creation of compelling experiences. This ensures that online exhibits do not degenerate to the extent of being surrogate equivalents of gallery exhibits. Indeed, replicating the actual experience of a gallery exhibit is not desirable, for then it affects gate traffic at the institution!

4.3 Pedagogical Issues

The effectiveness of knowledge transfer through the use of online exhibits, though influenced by the richness of the experiential environment, is, to a significant extent, dependent on the educational elements embedded in the exhibit. A learning experience bordering on constructivism is possible with creative exhibit design. Good instructional design and pro-active learning contexts contribute towards sound pedagogical practice. It needs no reiterating that the educational aspects have to be pitched at a level that the public can resonate with rather than at a level for those honed in the catechism of a domain specialty!

A delicate balance between leisure and learning is also essential.

4.4 User Interface

User-friendliness of an online exhibit is the prime determinant in ensuring the quality of the learning experience. In this respect, exhibits designed from the viewpoint of the user need to meet several criteria.

The focus of the learning experience has to be achieved through the use of instructional contexts that admit of guided exploration. Recognising that the primary mode of interaction is via the mouse and that the spatial dimensions of the clickable areas on the screen is often small, dexterity in visual-motor co-ordination has to be taken into consideration and be catered for. The navigability of the site must be streamlined to ensure that usability is enhanced, thus the necessary tools must be made available to the user to get the desired information and so ensure that the learning experience is not distracted by extraneous considerations which could cause him to defocus. A common strategy is menu options, which allow for directedness of the learning experience.

The concatenation of curatorial choice, design elements, pedagogical aspects and user interfaces will ensure that virtual exhibits, whilst not engendering the physicality of gallery exhibits, do distil the salient aspects of the floor experience.

5. Unique issues facing virtual science centers

A discussion of some of the other issues facing virtual science centers is presented in this section.

5.1 Educational potential of virtual field trips

Field trips to science centers are now recognised as constituting valuable out-of-school experiences to students. For the public, this becomes part of their extension education in keeping abreast of contemporary developments in science and technology.

The educational potential of virtual field trips to the portals of science centres, though backed by anecdotal evidence [3] has, however, attracted little attention from researchers. In a typical school group visit to a science center, there is enough time to savour a good number and variety of exhibits in an interactive manner; the communal dynamics of the visit is an experience that cannot be replicated in cyberspace. A virtual field trip, in contrast, is an individual experience, and the number and type of exhibits that can be relished in the same time frame are far less.

Clearly, there needs to be further research on the potential of virtual field trips. Virtual trips are a relatively new phenomenon, and more time is needed to underscore their utility. A survey of current practice obtained from anecdotal evidence suggests that virtual trips can be an educationally enriching experience provided that the offers on site are tailored more to capitalise on the potential of the web and are carefully structured for visits by students of the desired level. The potential of virtual visits in overcoming constraints such as distance, time and cost is, however, a strong factor in its favour.
the focus of field trips to science centers is normally controlled by the teacher, the directedness of virtual trips is often set by students, even though the broad terms of reference are set by the teacher; to what extent this interferes with the learning experience is not clear, and has to be addressed by research.

Currently, there is no global indexing of the taxonomy of learning resources available on the webs of science centers in order to help promote structured and focused visits.

5.2 Cost of digital exhibits and other online programmes

The cost of development of digital exhibits is rather high, not surprisingly since they involve expertise from across disciplines: curators, designers, educationists and software specialists. In contrast, a gallery exhibit can be developed at rather modest cost using in-house expertise and resources in the workshop.

Generally, science centers do face a financial crunch in present times even though most may not want to admit to it. This means that they would have to balance their priorities on whether they need to populate their websites with virtual exhibits, which virtual visitors can access free of charge, or use the same funds for conventional exhibits, which attract paying visitors.

Sustaining a web presence is not inexpensive. A fulltime web master is indispensable for ensuring that the site remains dynamic and does not get dated. Even more expensive is the cost of fabricating digital exhibits and other online programmes. New models of partnerships will have to be explored in order to support such initiatives. There are a number of ways of overcoming these constraints. For example, in supporting the Science Net at the Singapore Science Center, the two premier universities in Singapore were also inducted as co-organizers for this section; this allows reliance to be also placed on a large pool of university staff from various disciplines in order to help answer the questions posed by the public. This has proved to be a useful strategy in obtaining premium grade service at essentially zero cost! On the websites of the Boston Museum of Science and the Tech Museum of Innovation in San Jose in California, for example, partnerships with software vendors have been harnessed for the purpose of hosting content. For software expertise in developing digital exhibits and other online programmes, use of university and polytechnic students majoring in computer science can also be a helpful option. Short periods of internships can be traded for credits towards project modules in their course of study. Licensing of content to multimedia developers is another option. Science and technology centres networks should also not be overlooked, for the pooling of expertise, resources and funds opens up more opportunities for collaboration.

5.3 Server architecture

The anatomy of the server architecture is a key determinant in determining the volume of virtual visitors that a science centre portal can service simultaneously as well as the amount of resources that it can host. For the website to be touted as a key destination in the virtual realm, the server capacity has to be high. Difficulties in accessing the site or in interacting with the web offerings can sometimes be traced to the inadequacy of the server capacity, though other factors can also be responsible.

The dynamics of server architecture is basically a factor under the ambit of the institution. Technological advances and economies of scale are fuelling an increase in server capacity with a concomitant decrease in price. Upgrades of server hardware or use of higher capacity server software programs will have thus to be looked into on a regular basis. Of interest to note is that the educational content in the portals of science centers, being significant investments in terms of time, funds and resources, are seldom deleted: they are merely archived, thus adding to the volume of content hosted by the server.

5.4 Choice of user connection

The quality of the user experience is dictated by the immediacy of access -- that is, the choice of network connection, whether narrowband via 56K modem, or broadband via cable modem, integrated services digital network or digital subscriber lines.

On a narrowband connection, pages generally take a longer time to load while plug-ins to complement browser capabilities take an even longer time to download.

The educational potential of virtual science centers can be harnessed to good advantage through the use of a broadband connection, the popularity of which is not yet widespread. In Singapore, broadband penetration rates are high, so slow access is seldom a problem for local access [20, 21]

What is not commonly realized is that broadband is an entirely new platform, which has to be relished using a taxonomy of offerings geared at a higher hierarchical level. As it is, the content in the websites of science centers is seldom designed to tap the unique potential of broadband.

Though a broadband connection would be helpful in savouring bandwidth-intensive fare on the webs of science centers, quite a number of fare can be relished using a 56K connection. Generally, a broadband connection permits faster access and speedier downloads, and in this respect enriches the learning experience of surfers. Currently, migration of content onto the broadband platform is constrained by the lack of a critical mass of users. Uptake of broadband is, however, on the increase.
5.5 Evaluation of virtual exhibits and other online programmes

Assessment tools for the evaluation of exhibits in the galleries of science centers are well established in the literature [22]. The issue of assessment of virtual exhibits has, however, not been settled as it has attracted little attention from researchers. One complication is that a single evaluation tool cannot be applied across a spectrum of exhibits because of the diversity in the range of offerings.

Hit counts are commonly used to tout the popularity of a site. However, these hit counts give only general feedback. Questions such as the effectiveness of online exhibits in conveying the educational message, the quality of the learning experience, the length of the dwell time and the type of domain from which surfers came (edu, org, com, etc) are not apparent from hit counts. Also, it makes no distinction between new and repeat visitors.

Though there are a number of drawbacks involved in the use of hit counts, the point is that they are still important. Hit counts indicate that the site is drawing traffic, an important consideration for administrators and stakeholders. Also, they are politically less sensitive to present than other statistics.

Rigorous analyses of server log files can, however, reveal more useful information: for example, the number of pages accessed by a visitor, which is an indication of the quality of the visitorship; the demographic profile of the visitors, which is an indication of the outreach effectiveness across various segments of the population; the domain from which surfers accessed the web page, which is an indication of the institutional profile of surfers; the activity level by top entry page, which is an indication of whether the surfer has assigned value to the website by bookmarking it; percentage views, which is an indication of activity level in the various sections; and referrer log data, which is an indication of whether the site has been accessed via a hyperlink.

It is important to bear in mind that these tools should not be used in isolation, and that cognizance is borne of some of its limitations. For example, it is not possible to obtain the number of separate visitors accessing the virtual science center by an examination of the number of unique Internet Protocol (IP) addresses captured by the server. This is because corporate networks and large Internet Service Providers using a proxy server will always register a single IP address on server log files, even though they service a large number of clients. In the absence of real data on the number of separate visitors to a website, the number of unique IP addresses captured by the server log file is still the nearest indicator of such visitations. Also, surfers accessing the site by dial-up access will be assigned a floating IP address which may not always be the same for subsequent visits, thus causing a spurious increase in the number of domains served.

One useful determinant would be to determine to what extent an exhibit has been configured for the web. This, however, would require user studies of a structured nature, involving possibly online feedback from surfers as well.

7. Future trends

Predicting the future lies less in looking at a crystal ball and more by looking at an organization through a wide-angled lens [23]. The Internet will become even more pervasive in the years to come, and this will see the migration of more content onto the webs of science centers. With enabling technologies becoming more powerful, virtual science centers will evolve in size and complexity.

The following are possible scenarios for the future:

• With the ubiquity of the personal computer and increase in content hosted by virtual science centers, field trips to virtual science centers are likely to become more popular among school groups. Such virtual trails will open up another dimension in the learning of science. Needless to say, careful planning by the teacher as well as the need to ensure greater access to personal computers for students is necessary.

• Virtual science centers will become strategic nodal points for the collection of more science learning resources. There would thus be greater migration of content from general science portals to virtual science centres, leading these websites to be rich repositories of science resources.

• There will be greater collaboration between science centers on the web, and this will lead to rationalization in their range of offerings. Since a virtual exhibit in one science centre can be accessed by people in other countries, there is little justification for ‘re-inventing the wheel’ when a hyperlink is all that is needed to host a virtual exhibit.

• The cost of virtual reality, videoconferencing, broadband, and other enabling technologies will come down further, thus offering scope for positioning 3-D and other high-end exhibits on the webs of science centres.

• Credits for the public understanding of science are likely to be obtained from the portals of science centres. This would be a new challenge for science centers to address as part of their contribution towards nation building efforts. Via this technological intervention strategy, they can further galvanise public opinion to the
tremendous potential of science and technology for promoting socio-economic development.

- There will be co-operative endeavours between schools and science centers to create online exhibitions and other programmes on the web. The prestige of showcasing school-based endeavours on the website of a prestigious institution such as a science center is a potent factor which science centres can leverage on in order to enhance the dynamism of their website offerings. Of course, this is a result of the pervasiveness of information technology in the school curricula.

- Communities of interest will evolve in a country through moderated chat fora on various issues of interest in science and technology, for example, ethical issues in cloning, promotion of alternative forms of energy, etc. Such feedback would be useful for policy makers. The perspectives would also help to sensitize the online public to contemporary issues in science and technology.

- Technologies and tools will mature further to create an information architecture around which an entire virtual exhibition on a science theme can be built on the webs of science centers.

8. Conclusion

The virtual science center movement is a new genre in the taxonomy of web-based learning environments. By providing a novel platform for the promotion of non-formal science education, it offers science centers a unique opportunity to entrench their role as purveyors of scientific knowledge in this networked world -- not capitalizing strategically on this opportunity would mean the risk of being left behind in the technological avalanche fuelled by the Internet!

9. References


