



UNIVERSITÉ DE GENÈVE

**FACULTÉ DE PSYCHOLOGIE ET DES
SCIENCES DE L'ÉDUCATION**
TECFA

EUN SCHOOLNET
Workpackage 12

**Analysis of the Virtual Library (3D):
Expert, Teacher and Student Evaluation**

Allison Piguet and Daniel Peraya

August 2000

Table of Contents

Overview of the Virtual Library Project	3
The Development of the Virtual Library as a Two-dimensional Environment (BDP)	3
The Transformation into a Three-dimensional Environment	4
Description of TECFA's 3D Virtual Library Environment	4
The Building	5
The Elevator	5
The Lobby	6
The Cinema	7
The Gallery	8
The Library	9
The Studio	9
Evaluation of the Virtual Library	10
Subjects	10
The Questionnaire	11
Distribution of the Questionnaire	11
Results	12
Participant Knowledge of the Technology	12
Efficiency	13
Quality of the 3D graphics	13
Navigation	14
Resources	15
Potential Usage for Students	16
General Appreciation	16
Discussion	17
Evaluation Method	17
The Dynamics between Participant Groups	18
Resources	19
Annex: Quantitative Evaluation Results	20

Overview of the Virtual Library Project

The Virtual Library is a workpackage that was commissioned within the European Schoolnet¹ framework in October 1998. This two year project aimed at contributing directly to the virtual school activities within the wider EUN initiative. The Virtual Library was envisioned with many different goals in mind. First of all, the Virtual Library would create a new model of an educational learning site, as well as an interactive environment on the Internet as a model for co-operation between schools. By developing the educational use of Internet resources, the Virtual Library would stimulate the organisation of a school network for the documentation and development of didactic research activities on-line. Additionally, the Virtual Library model would provide on-line resources for learning and make the resources produced by schools usable on-line, as well as encourage telematic communication and comparisons of the didactic experiences of schools from different countries.

In order to achieve these goals, the Virtual Library project called for the creation of two different interface design prototypes. The responsibility of the first model was designated to the BDP² (Biblioteca di Documentazione Pedagogica), in Florence. Their task consisted of the development of a two-dimensional Virtual Library. The second model of the Virtual Library, involved the transferability of the two-dimensional site into a three-dimensional environment. This task was allocated to TECFA³ (Technologies de Formation et Apprentissage), at the University of Geneva.

The Development of the Virtual Library as a Two-dimensional Environment (BDP)

According to the workpackage's demands, the BDP conceptualised the first Virtual Library⁴ environment, represented in a two-dimensional interface. This model contains two main interconnected elements, the Natural Park environment and a Virtual Library database.

The Natural Park (*Image 1*) environment presents thematic information, constructed with the aid of multimedia material (text, images films). Additionally, the environment provides a set of tests (multiple choice, yes/no questions) as well as on-line exercises and interactive games (memory, puzzles, building blocks, colouring pictures).



Image 1. A view of the natural park environment in the Virtual Library, developed by the BDP, displays thematic topics as well as laboratory activities for the students to use.

Secondly, the Virtual Library contains a database (*Image 2*). This database is a tool that allows students to search an archive of resources, placed by other European schools. Here, students are able to find texts, pictures, videos etc. and input reports of their own didactic experiences and material that they have produced. Inside the database students can also download a software (Tool-kit) that allows them to create hypertexts combining material available in the library with other objects created within their own research project.

¹ <http://www.en.eun.org/eun.org2/eun/en/index.html>

² <http://www.bdp.it>

³ <http://tecfa.unige.ch>

⁴ <http://dante.bdp.it/parco/index.htm>



Image 2. Inside of the Virtual Library is a database where students can perform queries about specific information. In addition, students can add their own experiences to the database.

The Transformation into a Three-dimensional Environment

The second call of action in the workpackage was the transformation of the BDP's 2-dimensional Virtual Library protocol into a three-dimensional environment. The rationale of implementing a 3-dimensional Virtual Library was to provide a type of interface that would provide the best optimal learning environment for its users, promoting active, engaging, and learner centered experiences (Scardamalia, et al, 1989). As a consequence, these specific types of environments have been found to support students' active mental engagement in the knowledge construction process. (Winn, 1995). Further, the perceived advantages of a 3-dimensional virtual environment as an instructional tool include the opportunity to change perspective at will (Dede, Salzman & Loftin, 1996) as well as accommodate an abstract concept representation (Winn, 1994).

With this idea in mind, TECFA began the conceptualisation of the new 3D Virtual Library environment. The fundamental idea was to attempt to model a real world situation using the power of Virtual Reality. This type of environment would work in real-time and allow users to navigate and interact with 3D images within a virtual-world. It was also an important aim for the 3D Virtual Library to be able to simulate the same actions that are encountered in a real-world library, as to mimic a real-world situation which is natural to the user (Houser, 1987). By doing this, the Virtual Library could function in such a way as to immerse the user into the virtual-world, giving them a sense of being embedded within the synthetic environment.

After this realisation, TECFA commenced the construction of the 3D Virtual Library environment. Here, the actual programming of the interface was initiated through the use of VRML (Virtual Reality Modeling Language). More specifically, VRML is a specification for displaying 3-dimensional objects on the World Wide Web. VRML produces a hyperspace (or a world), a 3-dimensional space that appears on the display screen.

Description of TECFA's 3D Virtual Library Environment

The completion of TECFA's 3D Virtual Library favoured a virtual environment for interactive navigation applicable to all disciplinary areas. The 3-dimensional interface makes it possible for schools to directly explore the virtual 'world' and gain direct personal experience from it. With this type of innovative 3D setting, students are able to have an easy-to-use method of navigating, as well as accessing information resources. However, the environment does not support a multi-user platform, where users can manipulate objects and resources synchronously (same time). Instead, the environment offers a platform where students can work asynchronously (different time).

Simply, the 3D Virtual Library functions as a large database within a Virtual Library atmosphere. Students of various countries have the opportunity to add resources in the large data base, view resources posted by other people, as well as the means of a searching the database. The types of resources that can be found in the database include a variety of different multimedia formats such as video, sound, music, images, photographs, texts, HTML pages, and pdf documents.

More specifically, the interface resembles that of a real library building, only in a virtual setting. The Virtual Library is composed of 5 principal parts: The lobby, the cinema, the recording studio, the library, and the art gallery. Each of these five places in the Virtual Library provides the possibility for the user to access, add, search, and retrieve resources in the database. The following descriptions will illustrate each of the rooms as well as their specific functionality in relation to the overall purpose of Virtual Library.

Navigation around the Virtual Library is achieved through using a combination of three different methods. This first is by clicking on different objects inside of the environment. For example, clicking on the front door of the Virtual library building will lead to the interior of the building. Additionally, clicking on the registration desk will lead automatically to the registration form, etc. The second method of navigating in the environment done by manually dragging the mouse to advance the placement of location on the screen. And the third method is attained by simply clicking the hypertext building references (i.e. "search, gallery, etc.) in the left hand side of the menu bar.

The Building

The exterior of the building resembles a modern architectural design of a library (*Image 3*). This scene is the initial page that the user is introduced to when entering the Virtual Library site. The reference to the BDP is located on the exterior, therefore establishing a link between the database of previous Virtual Library to the new 3D prototype.



Image 3. This image illustrates the exterior of the Virtual Library. Access to the interior can be done through either using the "viewpoint" function on the interface or by dragging the mouse.

From the exterior view, the user has the possibility to quickly access several viewpoints. These viewpoints include the door, the arrival area, the center of the lobby, the elevator, the registration, and the search.

The Elevator

The elevator (*Image 4*) is located and accessed inside of the Virtual Library building. Its function is to transport the user to the different floors of the building. In total there are 5 different floors, or levels in the Virtual Library. They include:

- Ground floor = lobby /registration /search
- 1st floor = cinema
- 2nd floor = gallery
- 3rd floor = library
- 4th floor = studio



Image 4. View from the inside of the elevator. All of the 5 different floors can be accessed by simply pressing on the number value that corresponds with the desired floor destination.

Access to the elevator is located on each of the different floors. One click on the elevator will open the elevator doors and the user may enter inside. The view inside of the elevator displays the floor buttons that can be clicked on in order to be transported to a different floor.

The Lobby

The lobby, located on the ground floor of the Virtual Library, serves as the information and initiation center in the building. Most importantly, the lobby houses the registration and search facilities for the Virtual Library database.

To register as a user in the database, a secretary-type avatar is located behind the counter and motions towards the registration form (*Image 5*).



Image 5. View of the avatar behind the counter.

From here, the user has the opportunity to click on the registration form and fill out all of the necessary information in regards to his/her school and the type of resource that he/she wishes to add (*Image 6*). After clicking the "submit" button at the end of the form, all of the information is stored in the Virtual Library's database.

Image 6. With this registration form, the user can register his/herself as well as add resources .

One of the most important functions located inside of the lobby is the search feature (*ground floor*). The terminal which conducts all of the search functions in the database is discovered on the right side of the lobby. On the terminal display three different buttons can be found. Simply clicking the green button on the left hand side will perform the search (*Image 7*).

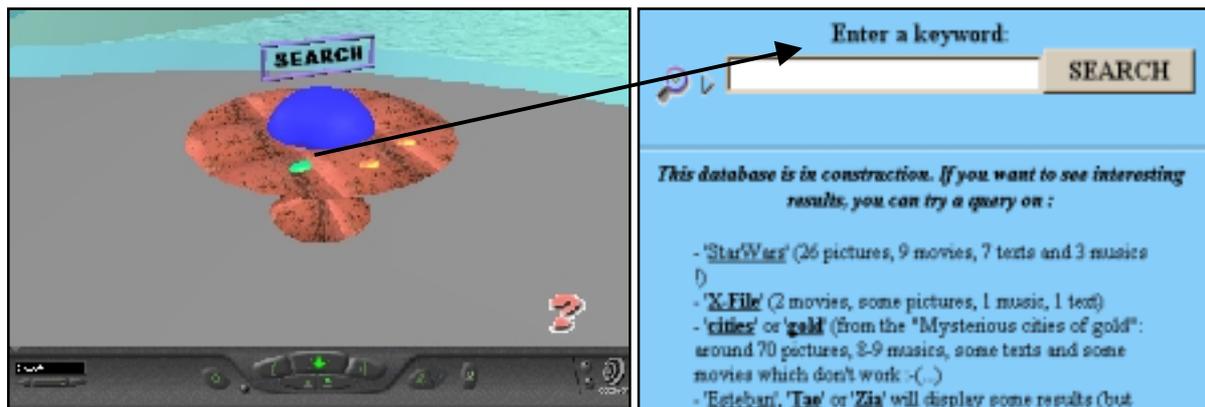


Image 7. The search terminal performs all of the queries to the Virtual Library database.

The search functions as a basic query and display of the database. The first step to search the database is to type a keyword in the provided text field. After clicking the button "search," the results of the search will be displayed below. Afterwards, these results can later be retrieved in the corresponding floors of the Virtual Library.

The Cinema

The cinema is located on the 1st floor of the Virtual Library and serves the viewing theatre for all movie/film resources. The scenario of the cinema functions to that of a real movie theatre where a film is loaded in the projection room (*Image 8*) and then viewed in the theatre by the audience.



Image 8. View from the projection room. To enter the theatre, it is necessary to click on the projection window.

In the Virtual Library, all previous films that were queried in the previous search can now be retrieved here (*Image 9*). In order to view the film, a series of tasks must be performed. First the user must enter the theatre, sit down in the seats, turn out the lights on the console display, and then click on the "play" button. To exit the cinema the user must click on the green exit sign, bringing him/her back to the elevator.

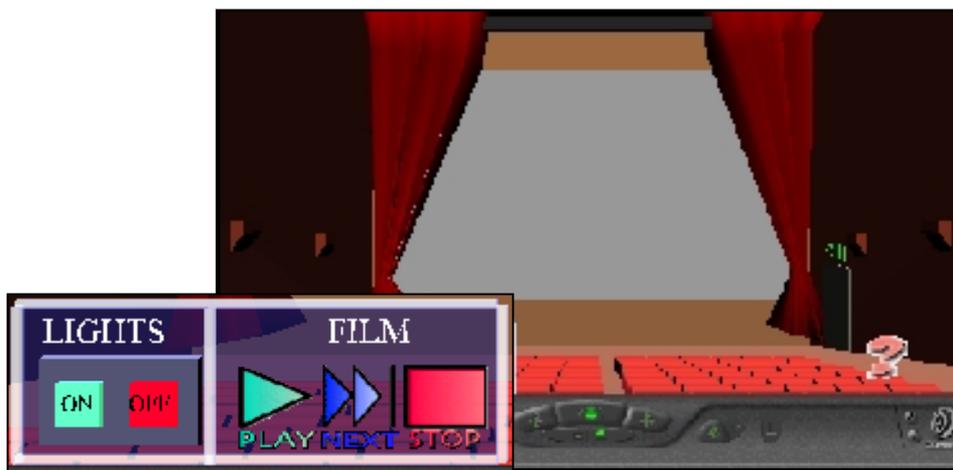


Image 9. A view from a seated user inside of the theatre.

The Gallery

The gallery, located on the 2nd floor, is a place where images can be displayed such as in an exhibition (*Image 10*). Therefore, numerous images can be viewed at the same time. Again, only images that were performed in an earlier search can be retrieved here.



Image 10. The gallery displays the retrieved images from the search like than of a museum.

The Library

On the 3rd floor, the library can be found where all of the texts, documents, and HTML pages can be retrieved. After a search is performed, an arrangement of books is displayed on the center table. As a consequence, each different book is cleverly titled with the corresponding search (Image 11). To view the resource, it is necessary to click on the appropriate book.



Image 11. A stack of books appears on the table of the library after a search for texts, documents, and HTML pages has been performed. Each book is titled according to the search display.

The Studio

The studio is located on the 4th floor of the Virtual Library. It functions as a sound studio in order to retrieve audio resources (Image 12). Such as in the cinema, retrieving an audio resource is done by clicking the "play" button the console. In addition, there are four different viewpoints of the musicians located on the interface console.



Image 12. A "large view" viewpoint of the sound studio. All music formats can be retrieved and listen to here by using the functions on the console panel.

Evaluation of the Virtual Library

An evaluation of the both the 2-dimensional and 3-dimensional Virtual Libraries was requisitioned within the EUN Workpackage 12 guidelines. More specifically, the evaluation would serve as a type of pedagogical usability measure for both of the environments. Therefore, the first evaluation (for the BDP's 2D Virtual Library) was devised by the Greek partners at the Lambrakis Research Foundation (LRF)⁵. This specific evaluation directive called for a total of 10 participants, 5 experts and 5 teachers.

A couple of months later, the construction of the Virtual Library was completed, TECFA was responsible for the creation of the second evaluation for the 3-dimensional environment. Its purpose was to gather a set of predictive evaluations that could be analysed in order to predict the pedagogical effectiveness and transferability of the 3D Virtual Library protocol. Although quite similar to the first evaluation, one major difference exists...the addition of a student participant group. This group was added to the evaluation directive in order to fulfil a more complete pedagogical realm, by comprising expert, teacher, and student assessment of the environment.

The following results detail the evaluation activities of the 3D Virtual Library:

Subjects

The subjects chosen for the evaluation of the Virtual Library consisted of a small sample (Figure 1) of experts (5), teachers (5), and university level students (5).

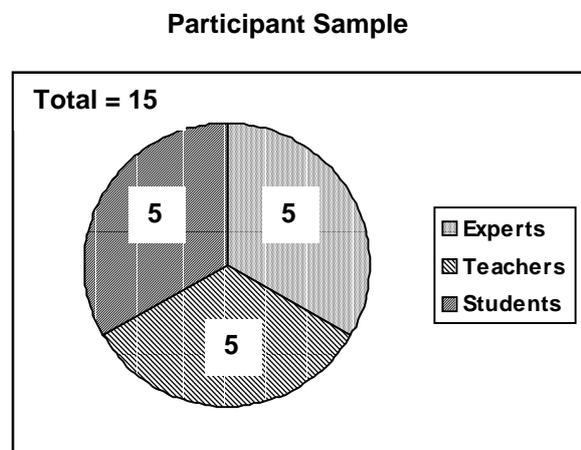


Figure 1. The distribution of Experts, Teachers, and Students in the participant sample.

⁵ <http://www.lrf.gr/>

More specifically, this particular sample was chosen on the basis of two important factors: 1) moderately prior experience in using and navigating in 3-dimensional, virtual environments, and 2) general knowledge of Information Communication Technology (ICT). In total, 15 participants were gathered for the evaluation. The following domains demonstrate some of the various participant affiliations:

1. **TECFA**⁶. TECFA is an academic unit that offers a Masters degree program in the field of educational technology. It belongs to the Faculty of Psychology and Educational Sciences at the University of Geneva.
2. **LME**⁷. LME is an educational unit in the Faculty of Psychology and Educational Sciences at the University of Geneva. It offers undergraduate courses in the domain of elementary education.
3. **CPTIC**⁸. The Pedagogical Centre for ICT (CPTIC) of the Department for Public Education of Geneva (DIP) is operated by teachers, professors and specialists.
4. **LEARNETT**⁹. Lean-Nett is a European project that allows students from different European universities to initiate the use of ICT (Information and Communication Technologies) through different projects.
5. **ENIS**¹⁰. European Network of Innovative Schools established the EUN.

The Questionnaire

The questionnaire was conceived by TECFA and was targeted for three different groups of users: experts, teachers, and students. More specifically, the questionnaire focused on evaluating and gathering information on the usability, pedagogical effectiveness and transferability of the three-dimensional Virtual Library.

In total, a five-point, fifty-one item scale was implied in the questionnaire that represented a set of user attitude statements, ranging from "poor" to "excellent." This choice of implementing a five-point scale greatly increased the possibility of obtaining results based on a middle scaling. This is due to the occurrence that when there are only a few scale steps to choose from, the selection is often in the middle or "average" category. In addition, several text areas were presented after each set of question, thereby prompting user comments.

The content of the questionnaire consisted of several categories. These sections contained the following elements: participant identification, efficiency, quality of the 3D graphics, navigation, resources, potential usage for students, and general appreciation of the site.

Distribution of the Questionnaire

Distribution of the questionnaire took place within a three week time frame. The selected 15 participants were contacted either by e-mail or personally to ask for their participation in the evaluation. After their agreement, the questionnaire was issued after a short demonstration of the environment was explained by the site's creator (Karine Delhom). Following, the participants were asked to perform a hands-on activity that would allow them to perform a given series of tasks. The first task consisted of exploring the Virtual Library by navigating around the environment. The second, third, and fourth tasks included the addition, search, and retrieval of a resource in Virtual Library. After completion of these series of steps, the participants were asked to complete the Web-based evaluation by themselves.

⁶ <http://tecfa.unige.ch>

⁷ <http://tecfa.unige.ch/tecfa/teaching/LME/lme-overview.html>

⁸ <http://wwwedu.ge.ch/cptic>

⁹ <http://tecfa.unige.ch/proj/learnett/>

¹⁰ <http://www.en.eun.org/enis/set-enis.html>

Results

When all of the evaluations were collected, both quantitative results were gathered from the evaluation questionnaire and further detailed. The quantitative data included the experts' responses to the evaluation scale for each section in the questionnaire. Therefore, the following quantitative data charts demonstrate the mean number from the total responses to each category of questions. The mean numbers are correlated directly to the attitude scale in the questionnaire. Therefore 1 = very poor, 2 = poor, 3 = average, 4 = good 5 = excellent. These ratings were important in order to further analyse and explain the results of the conclusive mean values.

Participant Knowledge of the Technology

During the course of the evaluation procedure, the experts were asked to quantify their previous knowledge of navigating in 3-dimensional environments. The following graphic demonstrates the responses given by each participant, according to their group affiliation (*Figure 2*).

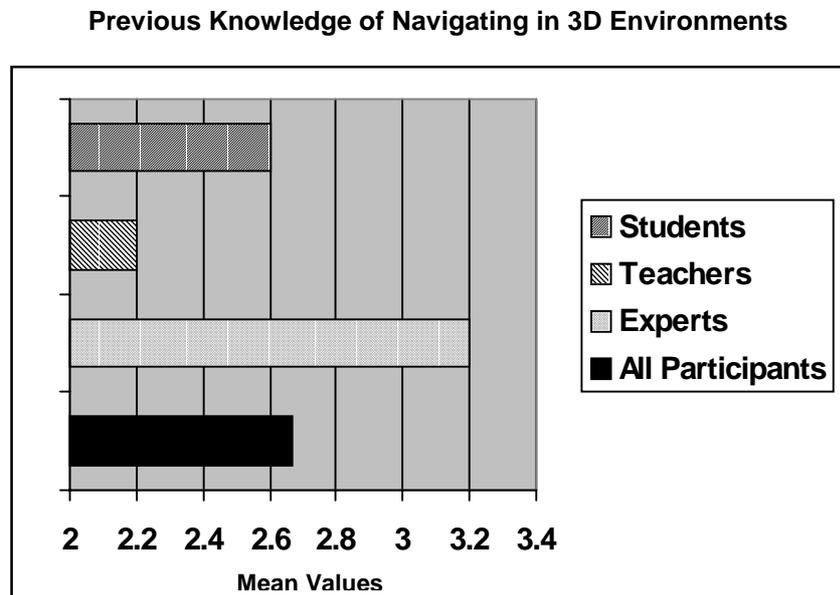


Figure 2. The expert group had the most previous knowledge of navigating in 3D environments, while the teacher group had the least experience.

The results concerning previous knowledge of navigating in 3D environments varied between the three participant groups. As stated earlier, the mean values correlate with user attitude statements. With this in mind, the experts expressed themselves as having the most knowledge out of all of the other groups. This is supported by the fact that they were chosen as "experts" in the domain and were expected to have a higher competence in this area. Modestly, they rated themselves as having very average knowledge of 3D navigation. Concerning the other groups, the students possessed slightly less knowledge than that of the experts, having a lower than average level. Finally, the teachers had the least experience with 3D navigation, rating themselves as having little knowledge.

Efficiency

The category of efficiency was devised in the evaluation of the Virtual Library and was intended to measure the ability of each participant's perceived use the system in respect to their productivity in completing the various tasks. Some of the questions in this category included the following: 1) finishing tasks using the environment, both quickly and effectively, 2) feeling at ease using the environment, and 3) ease of use.

The results for each participant group according to their responses for the efficiency are displayed in *Figure 3*.

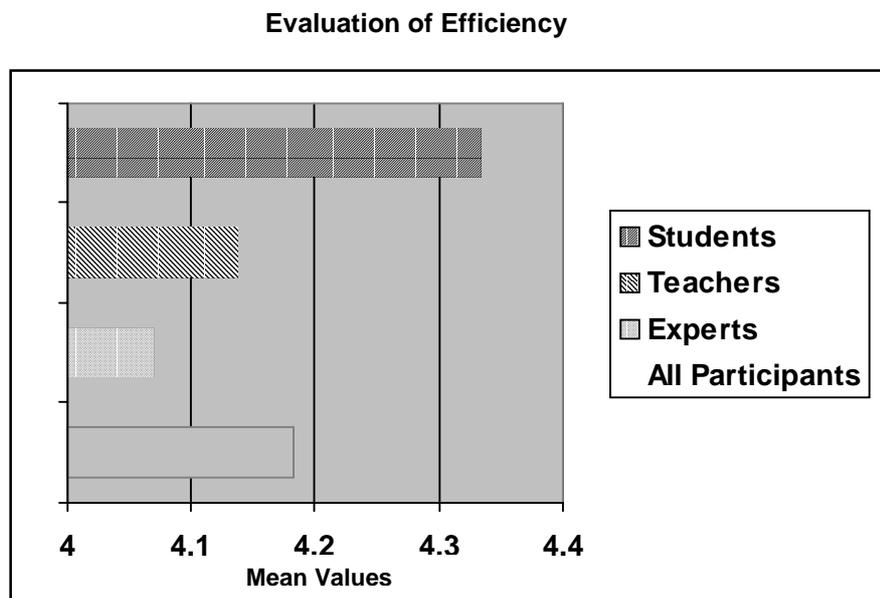


Figure 3. Clearly each participant group had its own distinct mean value in terms of efficiency. However they all regarded the Virtual Library efficiency as "good."

Overall, all of the participant groups rated the Virtual Library as being "good," in terms of efficiency. However, some clear distinctions can be made between the mean values for each group. It is obvious to note that the students perceived the efficiency rating higher than the teachers, and even higher so than the experts.

Quality of the 3D graphics

The next evaluation category dealt with perception of the quality of the 3-dimensional graphics presented within the Virtual Library. This category concerned issues such as: 1) the satisfaction of the interface, 2) the accuracy of 3D representation in the environment, 3) the possession of specific navigational scenarios, 4) the organisation, representation and reality of the virtual space, and 5) the choice of graphics, colours, objects for the environment.

The final quantitative results for the quality of the 3D graphics are exposed in *Figure 4*.

Evaluation of 3D Quality and Graphics

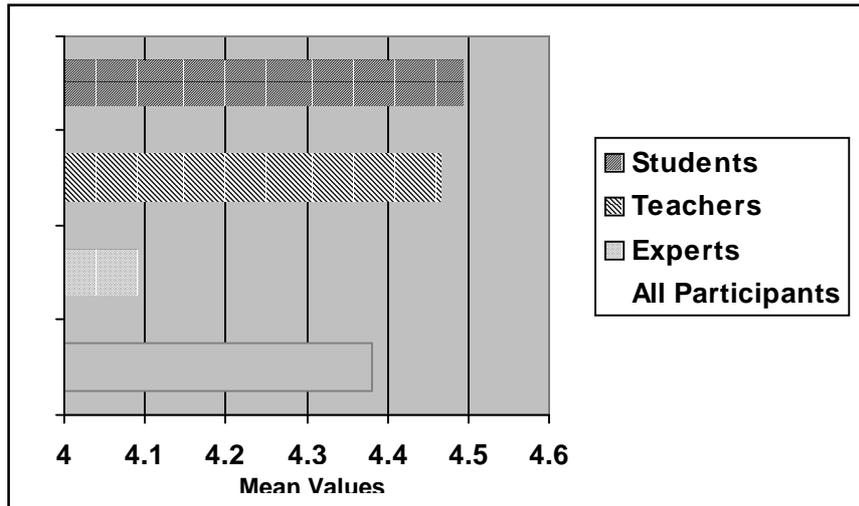


Figure 4. All of the mean values between 4.10 - 4.50, suggest each group rated the quality of the 3D Graphics as being good.

Similar to the previous category of efficiency, all of the participants assessed the quality of 3D graphics as good. However, this rating of "good" can be analysed further when taking a closer look at the different mean values for each group. Here, a better distinction can be made between the different user groups and their perception of "good." Again, the students were generally more impressed by the quality of the 3D graphics, as their high mean values show. The teachers were also enthusiastic, but just fell short of the students' mean averages. However, the experts' opinions were lower than that of the other two groups. They rated the quality of the 3D graphics quite marginally, just above the "good" attribution limit.

Navigation

This category concerned issues such as: The third category that was evaluated was the navigational aspects explored in the environment. These aspects consisted of four sub-categories and include: 1) control of direction, 2) freedom of exploration, 3) facility for error recovery, 4) analysis of scenarios in accordance to navigation techniques.

Concerning the evaluation of navigation within the Virtual Library, the following graphic (Figure 5) represents the final results from each participant group.

Evaluation of Navigation

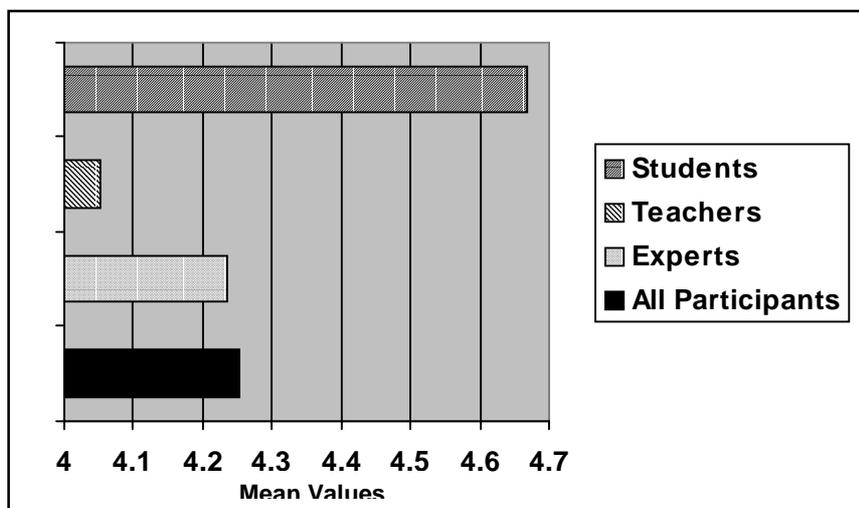


Figure 5. The three participant groups all agreed that aspects of navigation in the Virtual Library were evaluated as "good."

Clearly the results from the category of navigation have many similarities to those from the previous categories (efficiency and quality of 3D graphics). The first similarity that can be observed is that an overall evaluation of "good" resulted in all of the mean values for the three participant groups. When looking in more detail at the mean values, the second likeness points to the consistently higher results performed by the students. Once again, the students attributed a higher rating of "good" to the aspects of navigation involved in the 3D virtual library, in fact, almost reaching a nearby "excellent" mean value.

However, one difference is noticed in respect to the lower teacher evaluation vs. the expert rating. As seen in the results from the other two previous categories, the teacher results were consistently higher when those of the expert results. This occurrence of a lower teacher evaluation can possibly be explained in terms of the results demonstrated in understanding of their competence level of previous knowledge of navigating in 3D environments. As explained earlier in the participant knowledge of technology, the teachers had the least knowledge in 3D navigation in comparison to the two other participant groups. Therefore, the teachers' lower evaluation for the category of navigation can be explained in terms of their lower previous knowledge of 3D navigation.

Resources

The fourth category in the evaluation involved the various resources found in the Virtual Library. This category of resources involved the following topics: 1) on-line help, 2) facility of finding resources, 3) facility selecting resources and 4) facility depositing resources.

The results for the category involving resources in the Virtual Library are explained in *Figure 6*.

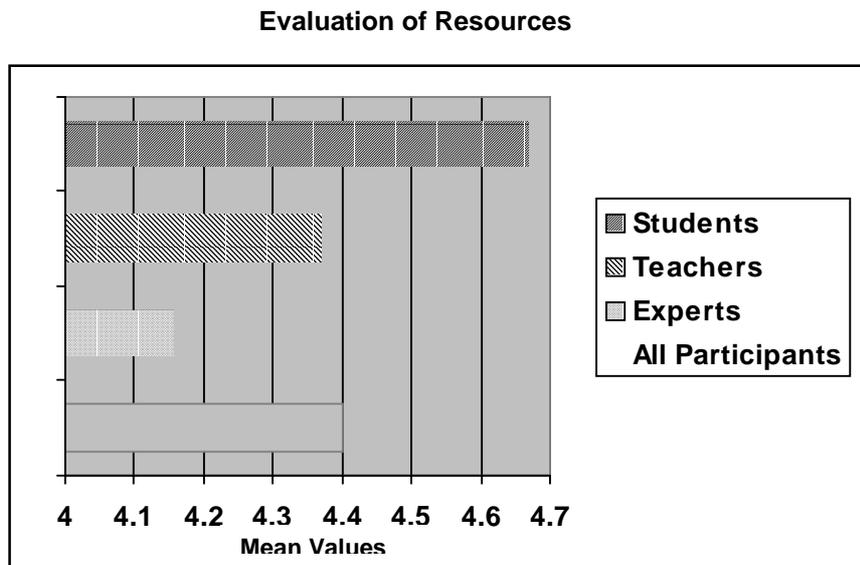


Figure 6. Similar to the previous results of the other categories, the evaluation of resources obtained an evaluation of "good" by the three participant groups.

Concurring with the previous results, again, the overall evaluation of "good" was attributed to the fourth category involving the resources in the Virtual Library. Also, a common pattern can be observed between the all of the results. Concerning the category of resources, the students again offered the highest evaluation, followed by the teachers, and then experts.

Potential Usage for Students

The potential usage for students was the fifth category that was evaluated concerning the Virtual Library. Furthermore, this category was comprised of the following sub-topics surrounding the issue: 1) The pedagogical interest for students, 2) The pedagogical usefulness for students, and 3) The willingness to use the Virtual library with or for students.

The results for the category involving the potential usage for students are summarised in *Figure 7*.

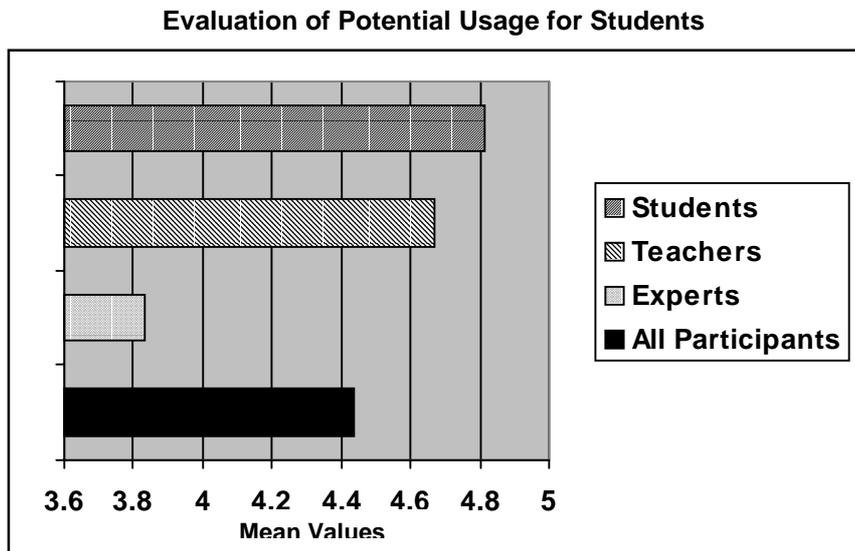


Figure 7. All of the mean values for the three participant groups ranged between 3.83 - 4.81, thereby suggesting a conflict between average and good, concerning the potentiality of use for students.

Again, the results for the fifth category demonstrated the reoccurring event of higher student evaluation vs. teacher evaluation, not to mention the expert evaluation as having the lowest mean of all. However, the graphic in this case is quite different in terms of the overall evaluation connected to each participant group. For this category of evaluating the Virtual Library's potential usage for students, the experts assessed it as average. On the other hand, the teachers' and students' evaluation outcome conflicted with this average quality, giving a much higher rating of good it potentiality.

General Appreciation

Following the evaluation of the previous five categories, a general appreciation category was found at the end of the questionnaire. This category was implemented in order to test the reliability of the other five categories by simply comparing the previous mean values to the generalised mean value.

Figure 8 charts the results of the general appreciation evaluation for the experts, teachers, and students.

Evaluation of General Appreciation

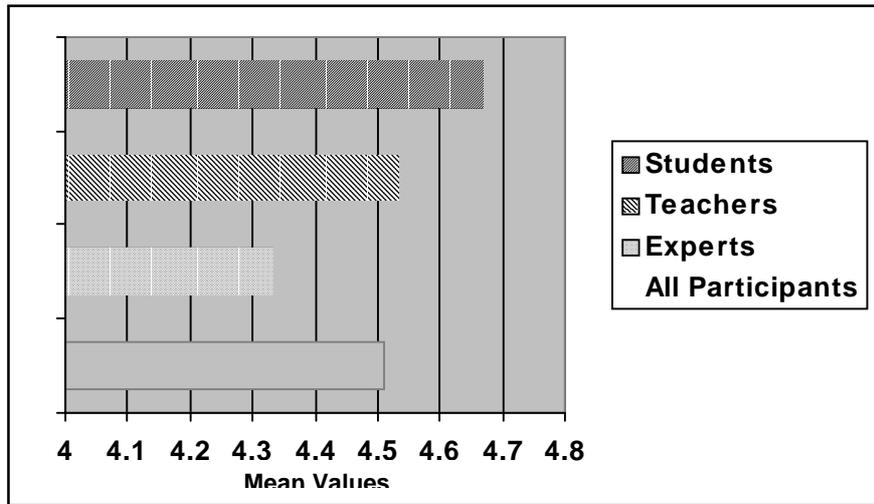


Figure 8. The three participant groups overall agreed that their general appreciation the Virtual Library was assessed as "good."

Looking at the results displayed in the graph, there is a clear and rather consistent trend that once again transpired concerning the overall appreciation of the Virtual Library. Like other previous occurrences, there was a high student evaluation vs. teacher evaluation, followed by the expert evaluation as being the lowest. In addition, the overall mean values rather consistently concur to an overall "good" assessment of the Virtual Library.

Since these results harmonise with the former evaluations from the other categories, it can be considered that the results gathered from the entire evaluation are quite reliable.

Discussion

Evaluation Method

The method to evaluate the Virtual Library was far from perfection. There were several issues that contributed to the failure of conducting a thorough analysis for this study. The first weak point of the study was the number of participants involved in the evaluation. Although a moderate 15 participants were active in the study, the fact that they were divided into different participant groups impaired the final results. There would have, no doubt, been stronger, and more precise evidence of solid mean values if more than 5 participants per group were involved in the evaluation. Fewer participants normally leads to constraints in data analysis.

As a consequence, weak conclusive mean data was gathered. This was due to the observance of marginal differences between mean values, therefore producing difficulties in clearly distinguishing attitudes among the participant groups. Distinctions of the mean values could be visible only when the data chart was magnified to show these slight variances.

The last and most evident weakness in the study was the absence of qualitative results. Although the questionnaire prompted space for user comments and reflection for each category, participants failed, and simply refused to answer. Sadly, as a result, no qualitative results were even collected. Combined with previous experiences, it is believed that by simply allowing a free space for a participant to write an explanation is a completely ineffective means of collecting qualitative data. It would be best for future studies, to collect all qualitative results through conducting personal one-to-one interviews with each of participants.

It is with no contest that obtaining qualitative results would have only strengthened the already established quantitative results. It was with great interest to explore the true reason why participants evaluated each category in such a manner.

The Dynamics between Participant Groups

Revisiting the already established conclusions for each of the evaluation categories, one basis can be established in this study. It is with clear evidence to consider that the Virtual Library was experienced, assessed, and accepted differently among the three different participant groups in this study. Certain tendencies for each participant group could be observed. The students were the leaders in viewing the Virtual Library on an overall positive scale. Second, the teachers were next in line, however establishing their views just under that of the students. And finally, the experts were more prudent with their assessment of the Virtual Library, having a lower place on the positive scale.

The question now remains as to why the dynamics between these three participant groups occurred. Since qualitative results are absent from the study, only hypothetical explanations can be offered. For example, it could possibly be hypothesised that students, in general, are rather over-enthusiastic to emerge themselves in 3-dimensional environments. This could be due to vast phenomenon and familiarisation of 3D games that exist on the market today, targeted especially for the younger generation. As far as teachers are concerned, it appears that their approach to 3D environments varies according to their experience and familiarity in using them. Another hypothesis could be proposed to suggest that experts generally are more cautious when assessing the pedagogical value of a 3D environment. This could be due to a scepticism that exists between the debate of play vs. learning in a 3D environment.

All of these avenues concerning the dynamics between participant groups could offer further exploration for future evaluations and studies.

Resources

- Dede, C., Salzman, M., Loftin, R.B. (1996). *The development of a virtual world for learning Newtonian mechanics*. Originally published in the Proceedings of the Multimedia, Hypermedia, and Virtual Reality conference, MHVR '94. Berlin: Springer-Verlag.
- Houser, N. (1987). Towards a Piercarian semiotic theory of learning, *American Journal of Semiotics*, 5, 251-274.
- Loftin, R.B., Kenney, P.J. (1995). Training the Hubble space telescope flight team. *IEEE Computer Graphics and Applications*, 15(5), 31-38.
- Scardamalia, M. Bereiter, C., McLean. R.S., Swallow, J. Woodruff, E. (1989). Computer-supported intentional learning environments. *Journal of Educational Computing Research*, 5(1), 51-68.
- Winn, W. (1994). It's virtually educational, *Information Week*, March 28, 1994, p36.
- Winn, W. (1995). Virtual Reality Roving Van Project. *T.H.E. Journal*, 5(12).

Annex: Quantitative Evaluation Results

CATEGORY	GROUP	MEAN
Efficiency	All Participants	4.182
Efficiency	Experts	4.069
Efficiency	Teachers	4.138
Efficiency	Students	4.333
Quality of the 3D Graphics	All Participants	4.380
Quality of the 3D Graphics	Experts	4.091
Quality of the 3D Graphics	Teachers	4.466
Quality of the 3D Graphics	Students	4.492
Navigation	All Participants	4.253
Navigation	Experts	4.236
Navigation	Teachers	4.051
Navigation	Students	4.667
Resources	All Participants	4.400
Resources	Experts	4.158
Resources	Teachers	4.368
Resources	Students	4.667
Potential Usage for Students	All Participants	4.436
Potential Usage for Students	Experts	3.833
Potential Usage for Students	Teachers	4.667
Potential Usage for Students	Students	4.812
General Appreciation	All Participants	4.511
General Appreciation	Experts	4.333
General Appreciation	Teachers	4.533
General Appreciation	Students	4.667

