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## The use of visual semantic web for designing virtual expeditions

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**Abstract:** The current paper demonstrates application of visual semantic web for designing virtual expeditions in the framework of cultural heritage preservation. The objective of our project was twofold:

- 1 to design an interactive platform based on the virtual expedition (VE) methodology, and
- 2 to assess its usability and impact on users' critical thinking and open-mindedness.

Based on the VE methodology, a flash mockup on the life story of two women scientists and their cultural heritage was developed and tested among 107 university students. Findings indicated increase in students' disposition towards open-mindedness, especially related to gender equity. Findings also indicated positive views related to operative, cognitive, and affective aspects of the platform's usability. Students were highly motivated to explore the VE platform and were inclined to discuss issues related to the preservation of their own cultural heritage.

**Keywords:** cultural heritage; learning; preservation; open-mindedness; semantic web; system design; virtual expeditions.

**Reference** to this paper should be made as follows: Barak, M., Kozyrev, S. and Dori, D. (2012) 'The use of visual semantic web for designing virtual expeditions', *Int. J. Learning Technology*, Vol. 7, No. 3, pp.297–313.

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## 1 Introduction

The Semantic Web is an evolving extension of the World Wide Web in which web content can be expressed not only in natural language, but also in a format that can be read and used by software agents, permitting them to find, share, and integrate information more easily (Dori, 2002). One of the promising areas for implementing the Semantic Web is cultural heritage preservation. In the current study, the advantages of the Semantic Web were used for designing ‘virtual expeditions’ (VE) – an interactive platform for the creation and explorations of cultural heritage items.

Every society, cultural group, or even a private person, has assets, artefacts and resources that should be preserved and presented to the world. It is important to present cultural heritage items not in isolation but with the connections between them. Indeed, presenting cultural heritage in a way that attracts the potential audience and promotes tolerance and open-mindedness, is becoming ever more important in our modern, rapidly-changing society (Barak et al., 2009). An effective way to use modern technologies for these purposes is a viable option. In line with this train of thought, the design and implementation of a new platform and the assessment of its usability were the foci of this study. The design of such a platform requires appropriate methodology that would apply pertinent theories of learning and thinking.

Our project set forth the vision of promoting open-mindedness by presenting unique learning experiences. As the world progresses, more and more people are required to make rational decisions based on evaluative or critical thinking (Barak et al., 2007). One aspect of critical thinking is open-mindedness. A person who wishes to think critically about something like politics or religion should be open-minded to different views and cultures. To meet this challenge, the design of the VE methodology was

based on two learning theories: the constructivist theory (von Glaserfeld, 1987) and Mayer's (2002) cognitive theory. The VE platform was designed to allow users to participate in an educational quest towards open-mindedness and pluralistic views.

The objective of this study was twofold: to design a platform which is based on the VE methodology, and to assess its usability and impact on users' disposition towards open-mindedness. Based on the VE methodology, a flash mockup was developed and tested with university students as subjects.

In this study, we characterise three different methodologies: the VE methodology – a framework for the design of an interactive platform for the preservation of cultural heritage (described in Chapter 3); OPM – object process methodology that allowed us to graphically describe the VE platform to our IT people via the OPCAT – Object-Process CASE Tool (described in Chapter 4); and the evaluation research methodology – the framework for the evaluation research (described in Chapter 5).

## **2 Literature review**

### *2.1 Semantic web and education*

Semantic Web is a mesh of information linked up in a way that is easily processed by machines on a global scale (Berners-Lee et al., 2001). Potentially, Semantic Web is an efficient way of representing data on the World Wide Web, or as a globally linked database (Baker, 2006). Although the future of Semantic Web technologies appears to be bright, there are debates about the likely direction it should follow and its characteristics. One of the main problems of the Semantic Web is the relatively small number of communities and organisations that are using it. To achieve the goals of the Semantic Web there is a need for its implementation in new projects and in new areas. One of the promising areas for applications of the Semantic Web is education in the context of cultural heritage preservation.

For the past decade, new models of education have been evolving in response to the new opportunities that are becoming available by web-based technologies (Dori and Belcher, 2005; Barak et al., 2009). Among its many applications, the web serves as a tool for designing new learning environments and generating e-learning and distance-learning communities (Barak, 2012; Gorissen et al., 2012; Naeve et al., 2005).

Although web-based technologies are considered to be commonly used for educational purposes, many of them focus merely on knowledge transfer. In contrast, the virtual expedition (VE) platform is designed to enhance higher-order thinking in the form of Critical reading and thinking while integrating semantically-based cultural objects of varying complexity. In this context, the Semantic Web technologies provide the technological basis for the design and development of the VE platform and the conceptualisation of its architecture. In order to provide a technological design for the VE platform, there is a need to define VE processes and relevant entities with an appropriate modelling tool. In the current study, the object-process methodology (OPM) was used to build the VE platform conceptual and technological model.

OPM is a holistic approach for the development of systems that integrates the object-oriented and process-oriented paradigms into a single frame of reference. Due to its structure-behaviour integration, OPM provides a solid basis for modelling complex

systems in general and those documented through the Semantic Web in particular (Dori, 2002). The VE platform is a good example for a complex system, designed as a digital story-telling tool, enabling collaborative writing, and the sharing of multimedia (photos, images, and video).

## *2.2 Digital story-telling and the promotion of open-mindedness*

In order to ensure that the VE will not become just another collection of resources in the form of digitised photo album, content contributors were encouraged to introduce their cultural heritage items in a framework of an interesting narrated story. But what makes a story interesting? An interesting story has a strong coherence and a consistency of a plot. The story should evoke emotions; it should be exciting, disturbing, funny or unexpected (Turner, 1994). Technology-enabled stories should assign an active role to the user and allow the creation of belief and reflective thinking. They should invoke emotional responses from the users, and users should be able to identify with the characters in the story (Murray, 1997). Many cultural heritage resources (objects, customs, historical figures, etc.) have a story to go with them, and good record keeping is the key for their preservation. It is important that artefacts are presented in the context of interesting historical events and with relation to people who owned them, and not just as a collection of lifeless things. Well-designed stories may generate or sustain a sense of identity and belonging to a certain community.

Stories can affect readers both emotionally and intellectually at the same time, and good stories can raise questions and get people thinking (Begiebing et al., 2004). Being exposed to the stories of different and diverse cultures might promote a better understanding of their beliefs and customs. Based on this assumption, stories might have a positive influence on users in terms of enhancing their pluralistic views and critical thinking. One aspect of critical thinking is open-mindedness. A person who wishes to think critically about something like politics or religion should be open-minded to different views and cultures. This requires being open to the possibility that not only others may be right, but also that you may be wrong. Rokeach (1960) defined open-mindedness as the extent to which the person can obtain, evaluate, and act on relevant information received from the outside, on its own intrinsic merits, and not being deviated by irrelevant factors in the situation arising from within the person or from the outside. Open-mindedness requires that the individual be prepared to entertain the thought that he might be wrong, and must be willing to revise his ideas in light of new information (Hare, 1979).

Jonassen et al. (1998) made a connection between open-mindedness and technology progress. They introduced the concept of Mindtools as computer applications that, when used by learners to represent what they know, necessarily engage them in critical thinking about the content they are studying. The VE platform is an example of a Mindtool; it does not only present cultural heritage items and their stories, but it requires users to participate in an educational experience. Our supposition was that this educational experience might lead to a positive change in users' opinions, resulting in a more pluralistic view of the world.

### 3 VE methodology and platform

The VE methodology is a framework for the design of an interactive platform for the preservation of cultural heritage. The VE platform is envisioned as a thematically-organised succession of cultural heritage items in the form of web-based resources. Since stories can affect readers both emotionally and intellectually, the VE methodology was conceptualised as an educational instrument, designed not only for cultural heritage preservation, but also for long-term educational impact.

The underlying concept of the VE methodology is that educational impact does not happen as a result of merely viewing a sequence of individual resources, but rather requires conceptually driven structuring of the resources into a meaningful whole. VE are therefore based on five conceptual pillars:

- *Multimedia*: The use of diverse media types (text, photo, audio, video, graphic, and animation) for the presentation of cultural heritage items.
- *Coherence*: Cultural heritage items are fully and coherently integrated to produce a seamless VE.
- *Non-linearity*: The users are able to choose the order in which to explore the cultural heritage items.
- *Interactivity*: The users can actively engage with the platform by carrying out such activities as answering questions, receiving feedback, and communicate with the VE author.
- *Hypertext*: There are links to other relevant websites and VEs within the story text.

The VE methodology envisioned each VE as a story that is divided into short cultural heritage items which together generates a complete story. Each heritage item consists of one resource (such as a picture, audio, or a video file) and a short textual paragraph, presenting information as a narrated story.

Cultural heritage items are not automatically presented to the user. They are hidden until the user acts to reveal one by clicking on an active area or button. Users may choose a virtual story that evokes their interest and motivation. They explore and learn about people, customs, symbols, and artefacts by clicking on active buttons, presenting cultural heritage items, at their own pace and as often as they wish.

Exploring an existing virtual story is one usage facet, creating ones own story, is another. Indeed, the VE methodology was designed to allow users to create and record their own virtual stories. The creation of a VE consists of three main stages:

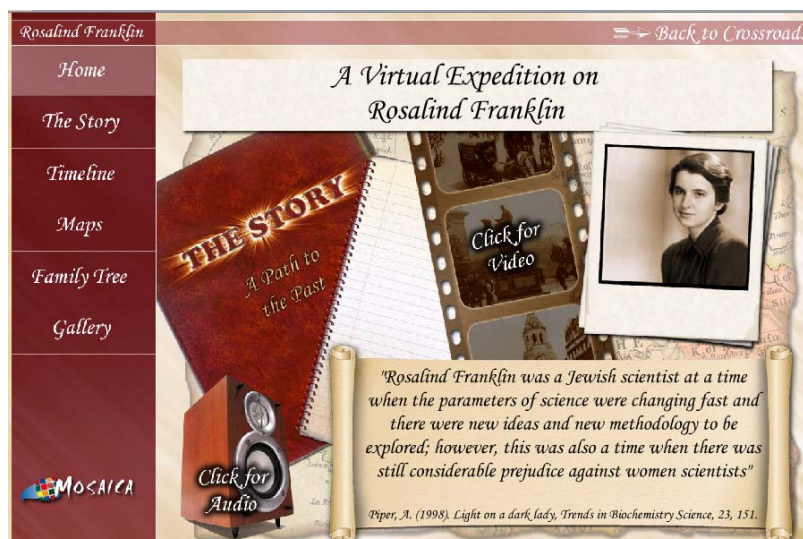
- a Designing the story and preparing the resources – Users select a historical event or theme, a place, a person, or an artefact. Then they select relevant resources, such as websites, pictures, documents, or video clips (all resources should have an internet address). Users break the story down to a sequence of heritage items, each tagged as follows: title – a short description of the event, the person or the object; description – a detailed description of the event or the resource; media resource – a photo, video, audio, or text document; place and date – where and when the event took place; hyperlinks – links to a relevant website, another VE, or another template within the same VE.

- b Uploading the resources using a Semantic Annotator – Users catalogue their heritage items by providing metadata information. The metadata should include target audience, resource type, language, owner, and copyrights. The users enter the semantic layer and select the relevant instance for annotation. During the requirements definition it was decided to implement the platform’s semantic layer in the form of unifying framework allowing the ontology-based representation of cultural objects and resources. Finally, the users are asked to view the annotated resource and approve or modify it.
- c Operating the VE platform creation mode – Users can operate the VE creation mode by clicking on the ‘Editing’ control to allow the creation of a VE.

The VE was designed to allow users to choose one or more of the following story-telling templates:

- *The story*: A simple text control with an option to add pages. Each page is designed as a text box with an option to add multi-media files, similar to a digital museum exhibition, thematically and logically organised to create a feeling of a storybook with flipping pages.
- *Timeline*: A table with configurable number of columns. One row holds the year, the second holds a short title, and the third holds a small picture. Clicking on the picture (formatted as a hotspot) opens a related cultural heritage item that provides detailed information.
- *Maps*: A display of a single graphical file with the ability to mark visible hotspots on it. The hotspots are bullets in multiple colours. Clicking on each of the bullets, displays a cultural heritage item with additional information related to the story and the place marked on the map.
- *Family tree*: A family tree consisting of textboxes and connecting lines. The size of the family tree can vary. A certain number of preset options and a number of line types accordingly to family relations (full, dotted, double, etc.) are available. Clicking on a certain textbox with a name displays a cultural heritage item.
- *Gallery*: A set of pre-defined graphical templates (e.g., room in a house, street, synagogue, and cemetery) each with a preset location of hotspots – graphical files displayed (a picture on the wall, a book on a table, a building in a street, etc.). Clicking on a certain graphical display, presents a cultural heritage item.

Each template includes a collection of diverse heritage items, based on the five conceptual pillars, mentioned above: multimedia, coherence, non-linearity, interactivity and hypertext. To facilitate this, each template includes a menu bar that consists of the following options: connections to external links, connections to other related virtual stories, search, play video, and play music. An example of the ‘Home screen’ of the VE on Rosalind Franklin, is presented in Figure 1.

**Figure 1** VE on Rosalind Franklin (see online version for colours)

#### 4 The VE platform design

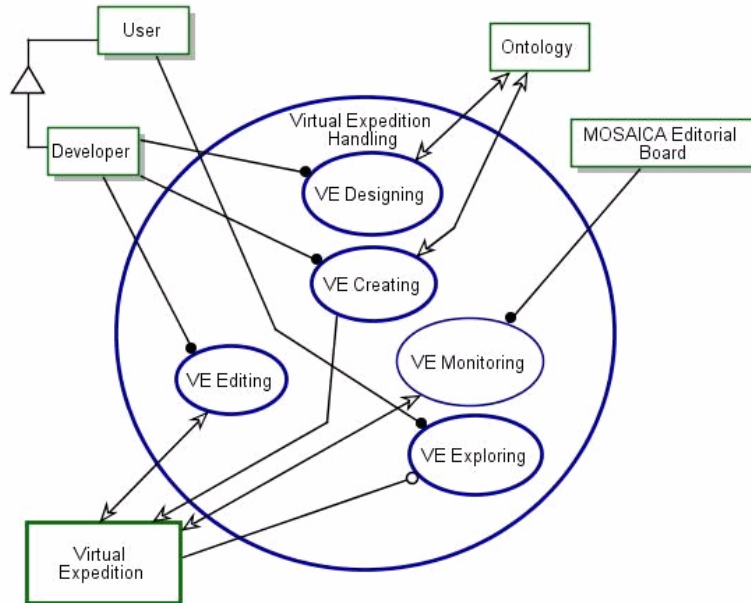
The VE platform model was developed with Visual Semantic Web (ViSWeb) as an OPM-based layer on top of XML/RDF/OWL to express knowledge visually and in natural language. The use of technologies like ViSWeb can significantly reduce difficulties many humans have with applying man-machine knowledge representation dichotomy (Dori, 2002, 2004). The OPM principle is based on the use of both graphic and the textual representations that are strictly equivalent. OPM assigns special graphical symbols for a selected set of relations (similar to UML class diagrams, only for a larger set of relations). The elements of the OPM ontology are entities and links. Entities, the basic building blocks of any system modelled in OPM, are of two types: objects and processes. Objects are things that exist, while processes are things that transform objects. Links can be structural or procedural. Structural links express static, time-independent relations between pairs of entities. Procedural links connect entities (objects, processes, and states) to describe the behaviour of a system.

In the current study we used OPCAT (Dori et al., 2003) an OPM-based CASE tool, to support the VE platform development lifecycle, starting from requirement analysis through system design and implementation. OPCAT automatic ensured that the specification designed by the system architects and endorsed by the domain experts is indeed reflected without any translational gap in the actual system.

OPCAT presented the processes and objects described in the VE methodology in two semantically equivalent forms: as the set of interrelated object-process diagrams (OPDs) showing portions of the system at various levels of detail, and as equivalent object-process language (OPL) sentences. As noted, OPL is a constrained subset of English oriented toward humans as well as machines. The system model specified several detail levels each being an in-zoomed elaboration of its ancestor, enabling one to see the

picture of the system as a whole or the details of a specific fragment of the system (Figure 2).

**Figure 2** VE handling (see online version for colours)



In Figure 2, the basic processes of VE handling are specified. These include VE designing, creating, monitoring, editing, and exploring. The editorial board is responsible of monitoring the VE contents by providing administration authority to groups of users such as: museums, heritage centres, municipalities, and schools. Simple users can only explore VEs created by others. However, users with ‘developer’ authority are allowed to design, create, and edit their own VEs.

One of the most interesting processes from the listed above is VE Creating (Figure 3).

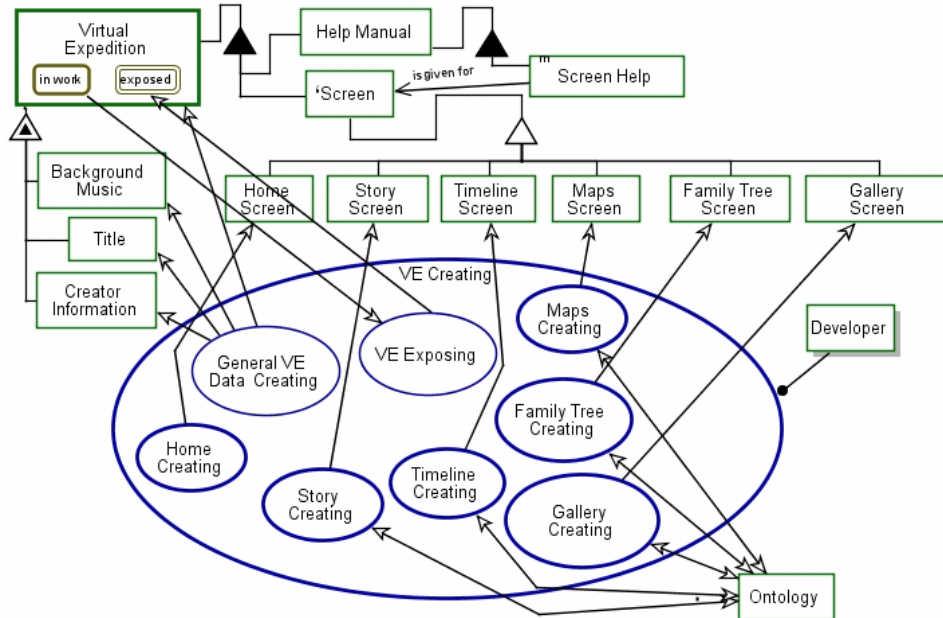
Figure 3 displays the design of the VE creating process for each one of its screens (Home, Story, Maps, Family Tree, Timeline, and Gallery). These screens correspond to the templates described in the ‘VE Platform and Methodology’ section. VE can be in work (while editing) or exposed (presented to viewers on the web). Each VE exhibits a title, a background and the creator’s information. It can also exhibit background music. It also consists of a Help manual. VE creating is designed in a way that users can edit each screen by changing the title and adding various heritage items. In the ‘creation’ mode, users can reuse a variety of heritage items that other users uploaded and tagged, in order to create their own VE. All processes described in the VE creating are related to Ontology – a hierarchical, rigorous, and exhaustive organisation of knowledge domain that contains all the relevant entities and their relations.

The OPM supported the hierarchy structure of VE methodology. It was instrumental in specifying the system structure and behaviour, and to demonstrate that the system design meets the requirements of the VE methodology, i.e., the functionality required from the VE platform. The use of OPCAT for modelling, triggered changes and enabled



iterative modifications of both VE platform design and VE methodology. Each new idea resulted in a change in OPCAT model or in the textual methodology in a circular process.

**Figure 3** VE creating (see online version for colours)



## 5 Evaluation study

The objective of the evaluation study was twofold: to assess the VE platform usability and to examine its impact on users' disposition towards open-mindedness. Based on the VE methodology and platform design, a flash mockup was developed presenting the stories of two Jewish women and their cultural heritage. One presented the life story of Rosalind Ellis Franklin, a prominent chemist who passed away at early age (Figure 1). The other presented the life story of Rita Levi-Montalcini, a Nobel Prize winner in medical research. Each virtual story presented their family, childhood, difficulties, achievements, and contribution to society. The exploration took place in groups of two. Students talked with each other during the exploration process. The flash mockup was developed as an initial stage, allowing users to explore the stories while using different screens (Story, Maps, Family Tree, Timeline, and Gallery). The VE creation mode will be developed in the second stage of our study.

The user population included 107 undergraduate students from three higher education institutions in Israel. The students' age ranged from 18 to 25, about half were female (54%), more than half of the general population were Jewish (64%) others were Muslims (all women except one male). The research was based on the mixed methods research model, which incorporates both quantitative and qualitative methodologies in the analysis and interpretation of data (Leech and Onwuegbuzie, 2009).

The students answered two questionnaires, before (pre) and after (post) using the VE platform. The pre-questionnaire consisted of 20 items on a 1-to-5 Likert type scale (1: strongly disagree and 5: strongly agree) indicating their level of disposition toward open-mindedness. The 20 items were divided into five sub-categories:

- a acceptance of different opinions
- b acceptance of non-prejudice views
- c acceptance of non-judgemental views
- d acceptance of strangers and other cultures
- e gender equity.

The disposition toward open-mindedness questionnaire derived from the California Critical Thinking Disposition Inventory (CCTDI), developed by Facione et al. (1996). The questionnaires' internal consistency, measured by Cronbach's alpha, was 0.72

After exploring both virtual stories, in a period of several weeks, the students responded to the post-questionnaire which included two parts. The first part consisted of the same 20 items, indicating their disposition toward open-mindedness, as in the pre-questionnaire. The second part consisted of a usability questionnaire, stating their opinions about the VE platform. The usability questionnaire included 12 items on a 1 to 5 Likert type scale (1 – strongly disagree and 5 – strongly agree), divided into three categories: affective, cognitive, and operative, all relating to the VE platform usage. The usability questionnaire was based on a similar questionnaire developed by Barak and Rafaeli (2004), and its internal consistency, measured by Cronbach's alpha, was 0.87.

### 5.1 Students disposition toward open-mindedness

Students' responses to the pre- and post-questionnaires indicated a positive increase in their disposition towards open-mindedness. For each of the 20 items, the post mean was higher than the pre mean, indicating that the cultural heritage stories presented via VE platform had a positive effect on users' dispositions towards open-mindedness. A paired t-test indicated that the positive increase was statistically significant in all subcategories (Table 1).

**Table 1** Paired t-test comparison for the dispositions toward open-mindedness in the pre- and post-questionnaires and subcategories

	N	Pre		Post		Net gain	t	p <
		Mean	SD	Mean	SD			
Total questionnaire	107	3.42	0.55	3.79	0.49	0.37	8.60	0.01
Acceptance of different opinions	107	3.61	0.81	3.99	0.76	0.38	5.80	0.01
Non-prejudice views	107	3.00	0.76	3.28	0.81	0.28	4.05	0.01
Non-judgemental views	106	3.28	0.77	3.71	0.69	0.43	5.62	0.01
Acceptance of strangers	106	3.56	0.77	3.90	0.70	0.34	5.01	0.01
Gender equity	107	3.41	0.73	3.81	0.69	0.40	5.77	0.01

The results indicate that the highest difference between pre and post results was observed for *Non-judgemental views* category (Net gain = 0.43) and *Gender equity* category (Net gain = 0.40). The highest difference between pre and post results was observed for item: *Men and women are equally logical* (Mean difference = 0.63). This result can be explained by the fact that the VE focused on the cultural heritage stories of two Jewish women: Rosalind Franklin and Rita Levi-Montalcini, who, in spite of gender inequality and discrimination, were able to make significant contributions to science and society.

In order to examine the influence of each independent variable, namely, students' pre-dispositions toward open-mindedness, their religious background, and gender, a stepwise multiple regression analysis was performed. The above variables were defined as independent variables while the results of the post questionnaire were defined as a dependent variable (Table 2).

**Table 2** Regression procedure for the open-mindedness post questionnaire results

<i>Variable</i>	<i>Explanation %</i>	<i>Beta</i>	<i>p &lt;</i>
Pre questionnaire open-mindedness	38.80	0.65	0.01
Students' gender	4.00	0.20	0.01
Students' religious background	-	-	NS*

Note: \*NS – non-significant.

Table 2 shows that students' pre-dispositions toward open-mindedness (Beta = 0.65,  $p < 0.01$ ) and students' gender (Beta = 0.2,  $p < 0.01$ ) are the two variables that had a statistically significant influence on students' final dispositions toward open-mindedness (the post-questionnaire results). The students' pre-dispositions explain almost 40% of their final dispositions toward open-mindedness, their gender explains only 4% of the results, and their religion does not influence the results. No interactions between variables were found.

The statistical analysis indicates that the more open-minded a person is, it is more likely that s/he will be influenced by the VE platform. The results also indicate that the exploration of the VE platform has a potential to promote open-mindedness among people regardless their religious background.

## 5.2 Usability evaluation findings

The means and standard deviations of the usability questionnaire items, divided by three aspects: affective, cognitive and operative are presented in Table 3.

The highest mean score, observed in Table 3, was for the item 'VE usage is a good way to present old documents and pictures' (Mean = 4.57, SD = 0.79), meaning that the VE platform, in the eyes of its users, is well designed for cultural heritage preservation.

For statistical analysis, the means of the negative items (marked\*) were normalised by using a recoding procedure. The affective, cognitive and operative aspects' total mean scores (after recoding negative items) were relative high (Mean = 4.12, SD = 0.75; Mean = 3.68, SD = 0.86; Mean = 4.24, SD = 0.76; respectively). Overall, the students asserted positive views related to the VE platform usage (Mean = 4.02, SD = 0.79).

To examine the differences in users' opinions about the usability of the VE platform, three population groups were compared: Jewish male students ( $N = 49$ ), Jewish female students ( $N = 20$ ) and non-Jewish female students ( $N = 37$ ). There was only one

non-Jewish male student in our user population. A One Way ANOVA test showed no statistically significant difference between groups. Meaning that all students, regardless their gender and religion asserted positive opinions towards the usability of the VE platform.

**Table 3** Means and standard deviations for the usability questionnaire items

<i>Aspect</i>	<i>Item</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>
Affective	Exploring the VEs was challenging and exciting.	107	3.78	1.06
	VE usage is annoying and irritating.	107	0.62*	0.98
	The exploration of VEs gave me motivation to use such kind of programmes in the future.	106	4.18	1.12
	The exploration of VEs was not so interesting.	107	0.84*	0.93
Cognitive	Exploring the VEs improved my understanding of the Jewish cultural heritage.	107	3.49	1.15
	Exploring the VEs encourages thoughts about Jews and their contribution to society, culture and science.	107	3.64	1.38
	Exploring the VEs enhanced my open-mindedness towards a multicultural society.	105	3.68	1.17
	VE usage did not contribute to my understanding of Judaism.	107	1.06*	1.16
Operative	I encountered technology problems while exploring the VEs.	106	1.06*	1.34
	The VE interface is friendly and comfortable for use.	99	4.36	0.78
	The move from one VE screen to another was quick and reliable.	106	4.12	1.15
	VE usage is a good way to present old documents and pictures.	107	4.57	0.79

Note: \*Means of the negative items.

In addition to the questionnaire, and in order to gain better understanding of the students' opinions about the VE platform, interviews were conducted as they explored the virtual stories. Students' remarks and comments were documented and analysed, resulting with three arguments:

- a the virtual stories appear to evoke students' interest in the content presented
- b the cultural heritage items that are hidden until user acts to reveal, appear to encourage a feeling of knowledge exploration and learning
- c the exploration of the virtual stories appears to encourage discussions among students about their own cultural heritage and cultural heritage preservation.

Students' assertions that support the first and second arguments are presented in the following.

*Argument 1 The virtual stories appear to evoke students' interest in the content presented*

Supporting assertions:

- The virtual stories bring a new and interesting approach for receiving information. The integration of different templates that focus on the same topic was very interesting to me and helped me get the whole picture.
- The VE exploration was so interesting that I intend to continue with it even after class is over.
- I liked the way VEs present new material. It caused me to explore the VE screens very thoroughly, trying not to miss any active button and reading the text carefully.
- I think there is lack of computer programs that are oriented to culture heritage preservation that are friendly to the end user... the VE platform seem to be a wonderful instrument for teaching and learning in schools and universities about cultural heritage.

*Argument 2 The cultural heritage items that are hidden until user acts to reveal, appear to encourage a feeling of knowledge exploration and learning*

Supporting assertions:

- Searching for the cultural heritage items is a challenge during the exploration process; it makes the learning process more interesting.
- The usage of active buttons and pop-up boxes for presenting cultural heritage is good because it allows dividing a complex topic into simple parts, resulting in better learning and understanding.
- I liked the fact that the virtual stories present the information in small chunks. It helped me focus on one concrete idea each time and prevented the mix-up of different concepts.
- The approach of using cultural heritage items is innovative and important for learning, but I think that their number should be greater and their search should be more sophisticated in order to make the exploration interesting for adults.

*Argument 3 The exploration of the virtual stories appears to encourage discussions among students about their own cultural heritage and cultural heritage preservation*

Supporting example: ST1 is a Muslim student and ST2, ST3 and ST4 are Jewish students.

ST1 I like the way the virtual expedition presents the life of Rosalind Franklin. It presents the material in several ways like maps or family tree and makes the exploration interesting. It allows us to learn in an easy way about people who lived many years

ago. I think it's very important, because this makes it possible to store information about our own ancestors.

ST2 In our culture we don't pay enough attention to this issue. I don't know anything about my ancestors who lived generations ago.

ST1 In our culture we do preserve information about previous generations as part of our family tradition. But we usually tell these stories out loud. We do not use technological innovations for that... Virtual Expeditions can help store information, it seems really friendly and comfortable to use!

ST3 VE exploration caused me to think about the reasons for preserving our culture and history. It is especially important nowadays, when some people are trying to distort parts of our history.

ST4 You are right but I'm rather confused by the fact that VE platform allows each user to add comments. It will make it possible to give wrong interpretation to historical events.

ST3 I'm not sure. As for me, it's more important just to start talking about these events in order not to forget them... Each person has a right to express his opinion.

The students made several important remarks regarding ways to improve the VE platform. First, they noted some technical problems. Some of the links didn't open and there were several editing mistakes in the text. Second, some of the students proposed to change the order of the VE templates so that the story template, which is the most informative and most general one, would be the last. The students preferred to explore the timeline, maps and other templates, and get the whole picture only in the end. However, other students were satisfied with the fact that the story template is the first one. These students preferred to get the general picture at the beginning and only then learning the details described in the other templates.

Students referred to the issue of making the VE exploration interesting to users. They suggested improving the platform interface by using different colours, and defining the supervising institution that will be responsible for the revision of the published contents.

## **6 Summary**

The VE, based on the ViSWeb approach, were designed to provide the students with an opportunity not only to actively explore the virtual stories but also to create their own. Indeed, technologies should not support learning by attempting to instruct the learners. Rather, they should become knowledge construction tools that students learn with, not from Barak et al. (2009) and Jonassen et al. (1998). Accordingly, the VE were designed as knowledge construction tools for learning through exploration and creation of virtual stories. Each virtual story is created by the users themselves so that during its creation users learn about a certain topic or theme that is gradually discovered as the user continues to construct their story. This gradualness is achieved by recognising that meaningful usage of cultural heritage items requires structuring of individual resources into a meaningful whole.

The VE platform design supports this concept, presenting stories as a collection of cultural heritage items. The power of storytelling lies in persuasion as a means of

preservation of cultural heritage, of education or even of entertainment. In order to instil moral values, storytelling can affect listeners both emotionally and intellectually at the same time (Barak et al., 2009; Begiebing et al., 2004). The VE platform demonstrated ability to enhance users' disposition toward open-mindedness and to reduce differences in disposition between people from different cultures and gender. One of the possible explanations of the positive feedback received from students is the non-standard VE platform design. Based on the ViSWeb principles (Dori, 2004), the VE platform design integrated structure and behaviour in a single model, making it simple and amenable to straightforward implementation. Moreover, the current Semantic Web man-machine knowledge representation dichotomy is overcome by using OPL, a formal subset of English, for both human comprehension and a future basis for automation. Our statistical analysis of the VE platform usability indicated positive views related to the platform's operative, cognitive, and affective facets. The results indicated that the students perceived the exploration of VE as friendly, attractive, and enjoyable. Men and women, Jewish and Muslims alike, felt they had gained new knowledge, and indicated they would recommend it to others.

While the study shows positive results related to the design and the usability of the VE platform, our study has several limitations. One limitation is that the VE exploration was performed using flash mockup and not the actual platform. This approach has both advantages and disadvantages. On one hand, web application analysis, design, and development can be complex without an appropriate implementation model. Therefore, effective communication with prospective end user is essential, and this is effectively achieved using prototyping (Snyder, 2003) to enhance this feedback. On the other hand, a mockup is only a portion of the product and it is isolated in time.

The narrated stories that were used for testing the VE platform should be carefully considered while analysing the results. In the current study, we focused on the stories of women scientists and their cultural heritage. Both stories implicitly related to the same open-mindedness category (i.e., gender equity). Other stories that focus on topics such as Jewish, Muslims, and Christens' holidays or other religious themes need to be designed, developed, and tested to refine our conclusions and prove external validity.

The contribution of this study is twofold. First, it presents a system design based on the VE methodology, an innovative methodology for the creation and exploration of cultural heritage items. Second, it demonstrates how Semantic Web technologies can be utilised for educational projects such as the VE platform.

The VE platform is in its infant stages and further development and study needs to be carried out following three tracks: system design, pedagogy, and methodology. The success of the VE platform depends on deeper understanding of the processes and motivations of humans to share information. What are the system-based incentives for people to preserve cultural heritage and create their own virtual stories? How can the design of the VE platform improve the users' willingness to contribute content? Whether and to what extent can the use of the VE platform enhance other users' pluralistic views and open-mindedness?

We believe that the study of these important questions will promote the growing body of knowledge on web-based environments for learning, knowledge sharing, and cultural heritage preservation.

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