In recent years, several researchers have investigated virtual worlds as learning tools, showing that students’ perception of new technologies are positive (Bayle & Foucher, 2011; Dalgarno, 2002; Dalgarno, Lee, Carlson, Gregory, & Tynan, 2011; Iqbala, Kankaanrantaa, & Neittaanmäki, 2010; Peachey, Gillen, Livingstone, & Smith-Robbins, 2010; Wankel & Kingsley, 2009). Researchers mainly refer to educational environments where learners are actively engaged in the process of skill development (de Freitas & Neumann, 2009; Parsons, Leonard, & Mitchell, 2006; Adamo, Bertacchini, Bilotta, Pantano, & Tavernise, 2010) and to the involvement of young people, thanks to the offer of a new kind of experience that is instructive and engaging at the same time (Bilotta, Gabriele, Servidio, & Tavernise, 2009; Pantano & Tavernise, 2011; Pantano, Tavernise, & Viassone, 2010; Bertacchini, Bilotta, Pantano, & Tavernise, 2012).

However, a rapidly growing area of virtual worlds is related to cultural heritage education (Bertacchini, Feraco, Pantano, Reitano, & Tavernise, 2008; Febbraro, Naccarato, Pantano, Tavernise, & Vena, 2008). In fact, exploring archaeological sites from a distance, visiting historical cities that are ruined or that no longer exist, looking at monuments that are not static 2D images, and manipulating specific objects all enhance students’ ability to contextualize abstract knowledge (Bertacchini, Gabriele, & Tavernise, 2011; Chittaro & Ranon, 2007; Pantano & Tavernise, 2009; Bertacchini & Tavernise, 2012). As a result, a number of European projects dedicated to modelling historic cities in 3D have emerged to contribute to the field of cultural heritage education, and provide
the opportunity for students to engage in serious archaeological investigation. Among these, we can cite the international project Rome Reborn (Frischer, 2008), illustrating the urban development of ancient Rome from 1000 BC to AD 550, the *NUovo Museo Elettronico* [New Electronic Museum] (Nu.M.E) initiative (Bocchi, Bonfigli, Calori, Guidazzoli, & Petrone, 2001), a virtual reconstruction of the centre of Bologna, Italy and demonstrating its historical transformation from the twelfth to the twentieth century. However, these reconstructions are mainly virtual tourist sites rather than advanced tools for learning.

In this chapter, we present three virtual worlds endowed with educational paths related to cultural heritage. They have been developed under the “Connecting European Culture through New Technology—NetConnect” project, promoted by the European Commission’s Culture 2000 Programme (Bertacchini et al., 2008), and downloadable from the “3D Reconstructions” section in the portal of the NetConnect project. We describe the three immersive NetConnect virtual worlds, explaining how they offer asynchronous technology-enhanced constructivist learning (Gärdenfors & Johansson, 2005; Kafai, 2006; Kafai & Resnick, 1996) using personalized educational paths. After that, we present a case study of a distance education lesson taken by 50 students aged 15 to 18, assess learning achievements and student motivation, and also collect the participants’ opinions on positive and negative aspects of the experience. We end by proposing possible future developments for cultural heritage education.

**NetConnect Virtual Worlds**

The main aim of the NetConnect consortium has been to deploy emerging information technologies to make the rich material from archaeological sites accessible to learners, in order to promote understanding of the importance of cultural heritage among the younger generation. The project has mainly been focused on the design of three historic settlements that reached their zenith between the eighth and the fifth century BC: Biskupin in Poland, Glauberg in Germany, and Magno-Greek Lokroî in Italy. Using a technology-based approach, anything that was present in ancient daily life has been realized virtually on a computer screen through the interpretation of the remaining evidence studied by archaeologists: the city’s layout, specific buildings and squares, houses/huts, and the various objects in them. In this way, users have been able to explore lost locations, and to manipulate 3D objects that are now only fragmentary (or visible through in a museum window) in the physical world, following a
technology-enhanced constructivist approach (Bilotta, Gabriele, Servidio, & Tavernise, 2008).

NetConnect virtual worlds show what daily life was like in the relevant historical age or period. Thus, by discovering the different elements of a specific cultural heritage in an ordinary day of the past, a learner can have unique and personalized experiences by engaging in activities and tasks that coincide with his or her own interests (Naccarato, Pantano, & Tavernise, 2011). In particular, the user can choose from among the following educational paths: (1) a visit to the virtual world to follow a list of points of interest; (2) a personal exploration, done by walking across the town and looking at a map; and (3) access to different kinds of content (videos, texts, pictures) present in the multimedia sections for each ancient city.

In each NetConnect virtual world the user can look at a menu that offers the opportunity to choose selected places to visit from a list of points of interest at the various historical sites (Figure 10.1). This path leads to a multimedia section and then directly to the selected point of the site. The user can choose to explore the city as he or she would in real life, walking in the streets, courtesy of a map on the right side of the desktop; large arrows over the important points of interest can help him or her to find the way to them.

Figure 10.1 The list of historical sites in NetConnect virtual worlds: Lokroi, Biskupin, and Glauberg. Courtesy of the NetConnect project.
The user can also go inside some structures (Figure 10.2), indicated by a brilliant light. For example, in Lokroi users can visit the temple, the Sacellum, and the Stoà, but cannot enter the two houses, indicated by a red light.

Multimedia sections are available for each historical site, and users can choose to examine material in four subsections: Video, Pictures, Text, and Extra. Users can watch a video about a specific place in the city they have selected, read the text that accompanies the video or additional documents, or view the reconstructed object in its original state (Figure 10.3).

At some points of interest in the virtual world it is possible for the user to virtually manipulate cultural artifacts (Figure 10.4). By doing this, the user can understand the function of an object, its specific dimensional and typological characteristics, and its place in the city/house and time period in which it was used. These objects are reconstructed in 3D based on real tools from the collections of major museums (Chowaniec & Tavernise, 2012).

The user can also take the virtual tour using the “I-vision” camera view: in this mode, the user’s avatar is not shown in the virtual world. During virtual visits users can meet both non-interactive avatars (Figure 10.5) and domestic animals; using the categories suggested by Yu, Brown, and Billett (2007), we classify
Figure 10.3 Screenshots of the multimedia sections in Lokroi virtual world: Videos, Pictures, Extra. Courtesy of the NetConnect project.

Figure 10.4 Objects that the user can manipulate in the NetConnect virtual worlds of Lokroi, Biskupin, and Glauberg. Courtesy of the NetConnect project.
these characters as “atmosphere agents.” Avatars dress in the exact reproduction of clothing typical of the time period and engage in activities derived from historical sources, allowing users to gain knowledge about this cultural heritage. For example, in Lokroi the clothes and activities of avatars are mainly inspired by imagery found on vases and pinakes (painted scenic panels made out of terracotta and dated to the period between 490 and 460 BC) (Bilotta, Bertacchini, Laria, Pantano, & Tavernise, 2011). An example of a pinake and how it helped inform the design is displayed in Figure 10.5.

The atmosphere agents are inserted in a virtual world containing many other models and objects, and thus they have been designed using a small quantity of polygons. They have less than 2000 polygons and details have been added to create textures at a resolution of 1024x1024 pixels applied to the mesh with UV maps (Bilotta et al., 2011). The designers developed the 3D environment using the Unity platform, and the user can move through it in a way that is very similar to moving about in videogames, using the mouse and keyboard, or a joystick. Moreover, the virtual worlds can be accessed using a Wii™ wireless controller and console, which can provide an appealing experience for young users (Pantano & Tavernise, 2011).

The Case Study

In this study funded by the NetConnect project, secondary school students from three different European cities (Warsaw, Frankfurt, and Rome), studied the topic
“Magno-Greek colonialism in Italy” using the virtual world Lokroì. Here we examine the results from one of the network nodes (Rome).

We measured what 50 students aged 15 to 18 learned in a 12-hour laboratory course using quantitative pre-entry and post-entry questionnaires, then used 24 items from the Intrinsic Motivation Inventory (IMI), measured on a 7-point Likert scale, to assess students’ motivation. Finally, we collected the students’ opinions on positive and negative aspects of the experience. All the questionnaires were administered online and student participation was mandatory, as they were given extra credits for school.

The method, including both quantitative and qualitative approaches using pre- and post-entry questionnaires to measure knowledge gained, and interviews, has already been utilized by Liu, Horton, Olmanson, and Toprac (2011) and O’Tuathail (2011). In this study, we chose the knowledge and motivation tests to investigate the effect of a virtual world on students’ learning and motivation, and the relationship between students’ motivation and their learning. The IMI has already been utilized in a number of studies related to intrinsic motivation and self-regulation (e.g., Ryan, 1982; Ryan, Connell, & Plant, 1990; Ryan, Koestner, & Deci, 1991; Ryan, Mims, & Koestner, 1983), and includes four subscales connected to our interests for this study: interest/enjoyment, perceived competence, effort/importance, and value/usefulness. We also added questions on motivational characteristics in virtual worlds because of the positive aspects of qualitative research highlighted by Iqbal et al. (2010) and Thompson (2011), and for the purpose of triangulation (Creswell, 2009).

**Quantitative Analysis**

We designed a questionnaire in order to collect some personal data (age, sex, grade level), and to assess each student’s level of Magno-Greek history knowledge upon entering the virtual world. Fifteen multiple-choice questions were administered online before students navigated in the virtual world and after the visit; they were not identical but very similar, in order to prevent the students from learning from the initial questionnaire. One point was attributed for each correct answer and zero for each incorrect one, for a maximum of 15 points.

Each question had three choices. Examples of the questions are as follows:

(i) What was the ancient Magno-Greek city called?
   (a) agora
   (b) polis
   (b) chora
(2) When was Lokroii funded?
   (a) IV cent. BC
   (b) VIII cent. BC
   (b) VIII cent. AD

(3) Lokroii was surrounded by . . .
   (a) walls
   (b) a fence
   (b) the sea

**Motivation**

Twenty-four items from the IMI, measured on a 7-point Likert scale (1 being not at all true and 7 being very true), were used to assess the students’ motivation. This instrument assesses participants’ interest/enjoyment, perceived competence, effort, value/usefulness, pressure and tension felt, and perceived choice, thus yielding six subscale scores. The IMI has been reported as reliable and valid by McAuley, Duncan, and Tammen (1987).

In this study we selected, four subscales because of their connection to the research; the same subscales have been chosen in similar studies, such as Liu et al. (2011). Cronbach’s alpha values were computed for this sample: interest/enjoyment (seven items $\alpha = .87$), perceived competence (five items $\alpha = .81$), effort/importance (five items $\alpha = .85$), and value/usefulness (seven items $\alpha = .77$). The IMI as a whole had an alpha value of .82.

At the end of the IMI, we added two open questions: “Please indicate the positive aspects of your experience” and “Please indicate the negative aspects of your experience.” We requested this description of the activities in the students’ own words in order to enrich the study with the nuances of personal opinions.

**Results**

For the knowledge questionnaire, a Wilcoxon signed-rank test showed that the scores after the visit to the virtual world were significantly higher than the scores of the pre-test ($Z = -2.054, p < .001$). The mean score on the pre-test was 1.36 out of 15 ($SD = 1.08$) and on the post-test was 13.38 out of 15 ($SD = 1.18$). Gender differences were also examined, since literature indicates a male bias toward computer-based learning (Mitra, LaFrance, & McCullough, 2001; Mitra, Lenzmeier et al., 2001). However, the correct responses in the knowledge test increased significantly from pre-test to post-test for both male and female students. Table 10.1 shows students’ mean scores and standard deviation.
Table 10.1 Knowledge Questionnaire: Students’ Mean Scores and Standard Deviation

<table>
<thead>
<tr>
<th>Knowledge questionnaire</th>
<th>N</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M (0–15)</td>
<td>SD</td>
</tr>
<tr>
<td>Boys</td>
<td>25</td>
<td>1.28</td>
<td>1.24</td>
</tr>
<tr>
<td>Girls</td>
<td>25</td>
<td>1.44</td>
<td>0.91</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>1.36</td>
<td>1.08</td>
</tr>
</tbody>
</table>

For motivation, we ran a multiple regression analysis to investigate the relationship between the scores obtained in the post-test knowledge questionnaire and the IMI compared to those for the pre-test, showing a significant $R^2$ of 0.65, $F(2, 28) = 22.5, p < .01$. The motivation test scores, obtained after the virtual world activities, can be considered a predictor for knowledge post-test scores.

The subscale “Interest/Enjoyment” emerged as the strongest predictor, while we also noted a significant relationship between knowledge scores and the subscale “Perceived competence.”

For qualitative analysis, at the end of the motivation test the students answered two open-ended questions about what they thought were the positive and negative aspects of their experience. Their answers were excitedly positive, mostly commenting on the use of the computer and the feeling of play. Furthermore, the majority of the students expressed the wish to use the same kind of tool to study other subjects. They expressed no negative comments; only one student commented that the test after the lesson was boring additional work.

Discussion

The pre-test results have highlighted that, even though Greek history is a topic covered by the Italian secondary school curriculum, Magno-Greek colonialism in southern regions is a very specific subject almost unknown among students. However, the rise of correct answers in the post-knowledge test suggests that the developed virtual world can be an effective support in the study of an unfamiliar subject. Moreover, from the students’ point of view, the use of virtual worlds and, in general, of computers, has a positive effect on motivation and the feeling of enjoyment. Outcomes confirm those obtained by Verhagen, Felder, van den Hooft, Meents, and Merikivi (2012) concerning the role of extrinsic and intrinsic motivation as behavioural determinants. As for the
qualitative analysis, all the students interviewed in the research by Iqbala et al. (2010), like the participants in the present study, emphasized the opinion that education was more interesting as a result of immersion in virtual worlds. They saw the value in exploiting opportunities for bringing together education and virtual worlds, acknowledging, for example, the potential to use virtual worlds to practice for exams.

Properties highlighted in other studies as being highly motivating for young users are present in NetConnect virtual worlds, especially the possibility of exploring new places (Tychsen, Hitchens, & Brolund, 2008), and users’ freedom to do things following their own interests. Competition and challenges, intrinsic properties of games, were shown to be not quite as essential and powerful in virtual worlds. Finally, since the majority of virtual worlds connected to cultural heritage learning are simple 3D reconstructions of archaeological sites and due to the fact that precise statistical data on learning have scarcely been collected, we cannot provide an adequate comparison to other studies here. Moreover, the data we examined are incomplete with respect to more complex research involving three network nodes (Warsaw, Frankfurt, and Rome). All the results coming from distance learning experiences will need to be analyzed. Furthermore, data collected in secondary schools should be compared with additional data collected in primary school studies, as well as in courses with a synchronous version and the presence of multiple users.

Future Directions and Conclusion

Our research has demonstrated that the use of 3D technologies such as virtual worlds can support and enhance the learning of history by secondary school students, as a result of the global desire to create various archaeological cultural heritage sites, and the motivating opportunity to play with the virtual artifacts as in a videogame. In fact, in NetConnect virtual worlds, users can choose what to explore and access using personalized paths of learning. We collected both quantitative and qualitative data, measuring: (1) students’ understanding of learning concepts linked to Magno-Greek history with 15 closed-ended questions using a pre- and post-lesson questionnaire; (2) students’ motivation to use the virtual world, by a 1–7 Likert-type questionnaire adapted from the Intrinsic Motivation Inventory (IMI); and (3) students’ opinions on positive and negative aspects of the learning experience. The results show that NetConnect scenarios present an advanced learning opportunity to cover the topic of cultural heritage, because learners are not only allowed to look back into time and witness history but they also have access to an effective hands-on approach.
that encourages a deep understanding of all the elements of cultural and artistic heritage. While sweeping generalizations cannot be made, the evidence does speak to the efficacy of the approach in addressing both the cognitive and affective aspects of learning.

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