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PERFORMATIVE FRAMEWORK AND CASE STUDY FOR TECHNOLOGY-ENHANCED LEARNING COMMUNITIES

Moumoutzis N., Sifakis Y., Christodoulakis S., Paneva-Marinova D., Pavlova L. **Performative Framework and Case Study for Technology-Enhanced Learning Communities.**

Abstract. This paper employs the overarching concept of communities to express the social contexts within which human creativity is exercised and learning happens. With the advent of digital technologies, these social contexts, the communities we engage in, change radically. The new landscape brought about by digital technologies is characterized by new qualities, new opportunities for action, new community affordances. The term onlife is adopted from the Onlife Manifesto and used to distinguish the new kind of communities brought about by the modern digital technologies, the onlife communities. Design principles are presented to foster such communities and support their members. These principles constitute a framework that emphasizes the concept of performativity, i.e. knowledge is based on human performance and actions done within certain social contexts, rather than development of conceptual representations. To demonstrate the use of the framework and the corresponding principles, the paper presents how they can be used to analyze, evaluate and reframe a concrete system addressing creativity and learning in the field of cultural heritage (history teaching and learning). One of the most significant results is the adoption of principles that facilitate students' engagement in rich learning experiences moving from the role of end-user towards the role of expert-user with the support of so called maieuta-designers. The result of this process is the use of the studied software not only to consume ready-made content but the creation of new, student generated content, offering new learning opportunities to the students. As the evaluation shows, these new learning opportunities enable students to develop a deeper understanding of the topics studied.

Keywords: Learning Communities, Performativity, Creativity, Evaluation.

1. Introduction. With the proliferation of modern computing technologies and the wide use of social networks to promote new personal learning opportunities, many people worldwide are engaged in technology-enhanced learning communities to pursue a personalized approach to technology use and learning while at the same time collaborate with other people pursuing common goals [1]. Official educational systems try to take advantage of these new opportunities and transcend traditional ways of teaching towards new approaches that put learners at the center of learning process and enable them to become creators of new content using appropriate tools and exploiting plenty of materials available online. This new way of learning is ideal for addressing any kind of learning theme ranging from official school curriculum subjects to life-long learning settings, especially when it comes to the need to continuously update and extend the knowledge of professionals and teachers in related disciplines [2].

Recognizing and promoting technology-enhanced learning within the above overall framework, there is a clear need to design and develop appropriate learning tools and platforms and use them within adequate learning and training frameworks. They offer diverse learning modes that are informed by modern pedagogical approaches that promote personalization and rich interactions and give opportunities for knowledge construction in a personally meaningful manner.

An overarching approach that can effectively address all these distinct learning settings can be based on the notion of community. A community is essentially a group of people who share an interest or have a common goal. The group can evolve naturally because of the members' common interest in a particular domain or area, or it can be created specifically with the goal of gaining knowledge related to the interests of its members. This knowledge development aspect can be effectively supported by an appropriate framework that provides an effective connection between learning and certain skills that can be demonstrated via specific performed tasks of the learner.

It is through the process of sharing information and experiences with the group that the members learn from each other, and have an opportunity to develop themselves. Communities can exist online, such as within discussion boards and newsgroups, or in real life, such as in a lunch room at work, at the institution or elsewhere in any social setting.

The goal of the work reported in this paper and its scientific novelty, following the discussion above, is to provide a comprehensive approach to technology-enhanced learning that is based on the concept of community as a central notion for enabling learning and creativity. The approach is informed by current trends in re-conceptualizing and rethinking about our societies facing the so called “hyperconnected era” [3]. This is reflected in the term “onlife”, which has been employed in The Onlife Manifesto [3]. This term stresses the fact that the deployment of information and communication technologies and their uptake by society radically affect the human condition, modifying our relationships to ourselves, to others and to the world. Consequently, the term onlife communities is employed to signify a social context that emerges from these developments.

To elaborate a framework for the establishment and support of onlife communities, valuable lessons can be drawn from work reported in [4, 5]. In particular, that work criticizes the so called engineering mythology that is based on a set of certain assumptions. These assumptions are related to the fact that digital systems consist of parts that interact according to certain patterns that are defined and understood at design time. Designers seek to discover these patterns, or even invent them, with the aim to achieve a certain way of operation of the system under consideration. On the other hand, users are expected to interact with the final system in certain ways following certain rules that are effectively imposed by the internal logic of the system.

Following the engineering mythology in technological projects there are cases when the emergence of certain patterns in end-user usage of the systems or desirable features that go beyond initial assumptions during to address these emergent patterns, an alternative mythology has been proposed that goes beyond the legitimacy of design as a process done by computing experts with the participation of representatives of end-users in order to guide the development of digital systems [4]. This alternative mythology points to the fact that digital systems can be realized by the composition of elementary components with limited initial design and be put to work by end-users, facilitated by computing experts that play the role of catalysts of change and evolution of those systems towards directions not initially fore-seen [4].

Elaborating on this alternative design approach, this paper presents PerFECt, a Performative Framework to Establish and Sustain Onlife Communities, i.e. communities of creators using digital tools in a certain domain, emphasizing creativity and learning. This framework is then employed to analyze and evaluate the use of ViSTPro, a spatiotemporal process visualization platform. Spatiotemporal processes are a generic model for representing various types of content knowledge [6, 7, 8]. Such processes are difficult for learners to conceptualize with traditional teaching and learning approaches due to their complexity and inherent dynamic nature [9]. Consequently, a generic approach on dynamic spatiotemporal process modeling could be used in supporting many educational domains, promoting an active inquiry-based style to learning [9].

The ViSTPro platform presents features that can be analyzed via the PerFECt framework concepts: it fosters active explorations of spatiotemporal processes as rich scenarios prepared by educators and offered to learners through a web-based player. Playing a scenario involves graphic representation of formations, movements, and interactions on Google Maps. This way, learners interact with graphical entities in an intuitive manner. In contrast, traditional ways of learning depend upon a painful and difficult process to develop abstract mental images with no real-world direct mapping. Additionally, the platform enables learners to make questions and receive personalized explanations. Therefore, learners can watch the representation of the processes' evolution in space and time, and actively intervene. Furthermore, ViSTPro can offer new learning opportunities to leaners if they are enabled to use the functionality initially offered to teachers (scenario authoring). This means, the students can be supported to act as creators of their own scenarios, thus becoming expert users, in the terminology of the PerFECt framework. This is an option that clearly demonstrates the applicability of the concepts of the framework to foster learning communities and facilitating a transformation process for end-users to become expert users.

The rest of the paper is organized as follows: Section 2 presents the details of the PerFECt framework along with links to the related literature that provides important concepts used in the framework. Section 3 presents the core features of the ViSTPro platform and links ViSTPro to the PerFECt framework by presenting its use in order to interpret how users apply or could apply ViSTPro. Section 4 presents experimental evaluation results on the usage of ViSTPro in the domain of learning communities (learning his-tory) that confirm the hypotheses drawn from applying the PerFECt framework. Section 5 concludes and presents directions for future work.

2. The PerFECt Framework and Background Work. As exposed in [5, 10], end-users of digital systems are increasingly more required to act as active contributors at use time, thus becoming "producers" of contents and functionalities. The term expert-user is to signify a person that is an expert in a particular domain with main goal to develop the capabilities of available software tools. An expert-user subsumes all those roles denoting people in charge of carrying out creative/authoring activities without being a professional software developer. Usually, the role of end-user and that of an expert-user is played by different people that may also belong to different communities. Furthermore, [5, 10] suggest the role of meta-designer to describe professionals who create the socio-technical conditions for empowering expert-users to engage in continuous system development. Meta-designers create open systems at design time that can evolve by their users acting as co-designers. Yet another important role is that of maieuta-designer who is mainly oriented at organizational and social issues, rather than technical ones, for supporting the task of the expert-users: ensuring the socio-technical prerequisites that are necessary for enabling expert-users working out new solutions by using the available technological means. This task undertaken by expert-users addresses as many end-users as possible in the process of continuous refinement of the available technology, thus promoting and strengthening participation, as the ultimate goal of maieuta-designers. The word "maieuta" is used in direct analogy to the well know learning method employed by Socrates, the philosopher. It signifies the facilitation of people to address challenges by enabling them to develop knowledge and self-confidence and ultimately transform themselves from passive consumers of technology to active creators, i.e. moving from the role of end-user towards the role of expert-user.

Starting from the above conceptualization of user roles of meta-designers, maieuta-designers, end-users and expert-users, the PerFECt framework seeks to adapt these concepts within the so called hyper connected context that is framed by modern digital technologies. This is captured in the term onlife that is borrowed from the Onlife Manifesto [3] to describe the type of communities that this framework is trying to describe and establish. The Onlife Manifesto is the result of work within the Onlife Initiative that started as a project envisioned and implemented directly by the European Commission's Information Society Directorate-General in 2012. The project was intended to explore the extent to which the digital transition impacts societal expectations towards policy making. The project outcome was the Onlife Manifesto [3]. The baseline of this text is that advent of digital technologies in all aspects of life has fundamental consequences in the human condition. It affects our reference frameworks, in a number of different domains including:

- our self-conception (who we are);
- our mutual interactions (how we socialize);
- our conception of reality (our metaphysics);
- our interactions with reality (our agency).

The members of the Onlife Initiative decided to adopt the neologism "onlife" to refer to the new experience of a hyperconnected reality within which it is no longer sensible to ask whether one may be online or offline. Within this new reality that is brought about by digital technologies and their ever-increasing pervasiveness four important transformations are happening:

- the blurring of the distinction between reality and virtuality;
- the blurring of the distinctions between human, machine and nature;
- the reversal from information scarcity to information abundance;
- the shift from the primacy of entities to the primacy of interactions

Following these developments, the PerFECt framework suggests the term onlife community to signify aggregations that emerge in hyperconnected spaces when humans engage with other humans as well as with machines and natural entities in mindful interactions with sufficient human feeling to form webs of personal relationships. Furthermore, by adopting the four user roles of end-user, expert-user, meta-designer and maieuta-designer it seeks to provide a certain structure to onlife communities and provide a mechanism to enable rich learning experiences.

To further analyze how these user roles are understood in their dynamics, it is important to note that they interact with each other and with digital artifacts and digital tools to form a co-evolution phenomenon. The meta-designer is focused on designing and providing the most effective tools that may sustain the co-evolution between end-users and expert-users. The maieuta-designer facilitates the migration from the role of end-user to the role of expert-user to empower end-users to appropriate and contribute to the use of available digital tools. In cases when an end-user is not interested or fails to evolve into the role of expert-user, the maieuta-designer may facilitate participation in system evolution by systematizing the reporting of shortcomings and system faults as identified by the end-user and proposing solutions that are handled by expert-users.

Consequently, the above four roles give rise to two co-evolution processes: The first one refers to the use of software targeted to the end-user where there is continuous (cyclical) interaction between the end-user and the system. This is depicted in Figure 1 (left) with three homocentric cycles of arrows that represent the action-interpretation cycle at the lower level, the task-object cycle at the middle level and community-technology cycle at the upper level. In an analogous way, there is a second cyclical process depicted in Figure 1 (right) that refers to the use of software components as building blocks of the system in continuous evolution from the perspective of expert-users. This process corresponds to yet another three homocentric cycles of the same nature: action-interpretation, task-object, and community-technology layers.

The inner interaction cycle in each co-evolution process refers to actions (triggered by the corresponding user or software) that are interpreted by the other party (software or user respectively). The task-object cycle in the middle refers to the co-evolution of the user task and the corresponding artifact within the boundaries of the system. Finally, an outer community-technology cycle captures the idea that the overall environment within which a user is working (community), co-evolves with the technology that supports the operation of the environment.

Before describing in more detail the two co-evolution processes, one pertaining to end-users and the other to expert-users, we need to present the concept of universality. This concept refers to blends of machines and physical objects that generalize the notion of software or tool within a hyperconnected landscape. Universality addresses the issue of causality in digital representations, as Brenda Laurel puts it in her seminal book “Computers as Theatre”: “The fact that people seek to understand causality in representational worlds provides the basis for Aristotle’s definition of universality. In the colloquial view, an action is universal if everybody can understand it, regardless of cultural and other differences among individuals. This would seem to limit the set of universal actions to things that everyone on the planet does: eat, sleep, love, etc. Aristotle posits that any action can be “universalized” simply by revealing its cause; that is, under-standing the cause is sufficient for understanding the action, even if it is something alien to one’s culture, back-ground, or personal ‘reality’.” [11]. Consequently, a Universal Object is an artifact that presents itself in a way that is meaningful and understandable through casual relationships that enable the user of such an object to effectively manipulate it and understand it, i.e. link it to casual interpretations. A Universal Object can be acted upon to produce certain effects because its casual interpretation enables the user to know what will happen if certain manipulations are made. Furthermore, its response to certain manipulations is predictable and thus can be used to produce the desired effects within the context used. The essence of digital technologies is, in this respect, to transform plain objects into Universal Objects.

Universal Objects are considered a core element of the PerFECt framework and their use by end-users in combination with their development (as Universalizing Assemblies) by expert-users constitute the two aforementioned co-evolution phenomena in three co-eccentric cycles built around them to describe the relationship between end-users/expert-users and the end-tasks/expert-tasks that they engage in. This phenomenon has been first described in [12] and has been linked to an approach to effectively address end-user needs during system design and evolution. End-user needs evolve as the end-users use a specific technology meaning that the system developers need to support the evolution of the systems as well as to adapt and address the evolving end-user needs. In a similar way, expert-users' needs evolve as well.

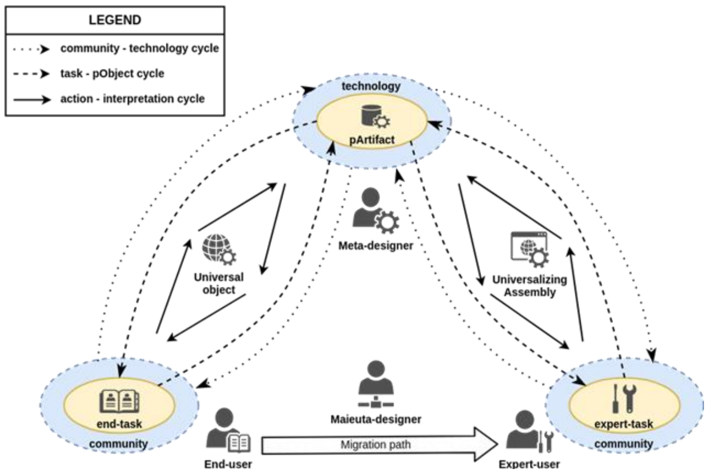

Fig. 1. Main components of the PerFECt framework

Let us see in more detail the co-evolution phenomenon around Universal Objects as depicted in the left part of Figure 1:

1. At the higher level, there is the community-technology of co-evolution cycle meaning. Relationship of people and technology is dynamic and evolves people working with a certain technology to learn how to do

certain things. As a result of this evolution their expectations and conceptualizations with respect to available technology change and give rise to evolution of the technology itself that triggers further evolution of the community of end-users. This higher level of co-evolution cycle entails the motives of people, i.e. their needs and how they satisfy their needs via their activities. By offering new interaction possibilities, technologies employed change end-user habits and this means that the social and work organization evolves with the use of certain technologies.

2. At a lower level, there is the task-artifact co-evolution cycle that refers to the tasks that end-users are able to do with a specific version of a system and the corresponding artifacts that they manipulate or use during their work. Consequently, at this level, end-users articulate their behavior towards certain goals that form a cause-effect chain in order to pursue the motives of the upper level. Furthermore, the use of certain artifacts to support end-users' tasks suggest in many cases new possible tasks and these new tasks mean that new artifacts should be created.
3. At the lowest level there is an interaction cycle during which end-users are expected to do certain operations to effectively use the available technological features. Such interactions call for a certain interpretation of their actions in order to be able to effectively use the available features. This lowest level cycle could thus be conceptualized by successive materialization and interpretation, representing meaningful actions that support and trigger the upper levels of the co-evolution phenomenon.

At the center of the three end-user cycles (left part of Fig. 1) the PerFECt framework suggests the concept of Universal Object, a concept that generalizes the concept of software and it is based on the concept of universality as already presented. Such Universal Objects, can be the result of the work of expert-users, as will be described next, to address the evolving needs of end-users within the wider context provided by the PerFECt framework.

The co-evolution cycles that address the expert-user role (right part of Fig. 1) are structured around the concept of Universalizing Assembly. This is a complementary concept to the concept of Universal Object. A Universalizing Assembly is essentially a synthesis of performative artifacts (pArti-facts) that enables the creation of Universal Objects supporting the task of end-users. Consequently, the task of expert-users is to enable this universalization of plain objects by exploiting the available tools in the form of performative artifacts (pArtifacts) to account for the incorporation of the idea of performativity in digital technologies.

Performativity underlines the relationship between humans and the artifacts they create that is triggered by social interaction and continuously recreates the bonds that keep the society as a whole. [13] offers an interesting concept to capture this idea and link to purposeful and mindful use of physical objects: the concept of performative object, which is a special type of design object to facilitate mindful awareness of the physical and symbolic social actions and their consequences. Considering that performative objects are design objects, the framework presented here uses the term performative artifacts in a broader sense: all artifacts involve a certain level of performativity that is usually captured by their affordances i.e. clues about how an object should be used, typically provided by the object itself or its context. However, this latter term, does not explicitly refer to mindful-ness as a target during the design process. In this respect, the term performative artifact, is used here to capture the idea of intentional design for social interaction, to create and sustain social bonds and call for symbolic social actions that recreate the social contexts within which we live in. To conclude, the three levels of the co-evolution cycles in the case of the expert-users, are the following:

1. At the higher level, the community-technology co-evolution cycle captures the dynamics of the relationship of people and technology using pArtifacts to enable the universalization of certain objects. As expert-users evolve and learn how to do certain things (i.e. providing tools in the form of Universal Objects to end-users) their expectations and conceptualizations with respect to the available technology change and give rise to evolution of the technology it-self that triggers further evolution of the community as a whole.
2. At a lower level, there is the task-artifact co-evolution cycle that refers to the tasks that expert-users are able to do with a specific version of a system and the corresponding pArtifacts that they use to create/extend the Universalizing Assemblies that constitute the target of their work. It is important to note that expert-users pro-vide the ground for end-users to work within a cause-effect framework (this is captured by the idea of universalization). The evolution of expert-users is related to the evolution of end-users as well taking into account that the role of expert-users is to support the evolving needs of end-users. To this end, there is a critical contribution of maieuta-designers that facilitate the articulation of end-user needs and their effective communication to the expert-users.
3. At the lowest level there is an interaction cycle during which ex-pert-users are expected to do certain operations when they are engaged in the use of the technological features offered by meta-designers. Such interactions call for a certain interpretations so that expert-users are

able to use the underlying technologies in an effective way. At this level, the interaction between the expert-users and the underlying technologies are taken without direct reference to their social context as successive rounds of materialization and interpretation of certain actions that support and trigger the upper levels of the co-evolution phenomenon.

To summarize, an onlife community within the PerFECt framework captures the structure that is imposed by four user roles of the framework: end-user, expert-user, maieuta-designer and meta-designer along with the artifacts, tools and even underlying physical objects to account for situations where technologies are embedded into an underlying reality. In other words, the adoption of the concept of community emphasizes the fact that all these user roles, through their interactions within the two co-evolution processes, create a bigger aggregation of humans. They engage with other humans as well as with machines and natural entities in mindful interactions, thus creating the social contexts described as onlife communities to account for hyper-connectivity as well.

3. A Case Study: ViSTPro. As a concrete case of study, the framework presented in the previous section can be put in action to enable a deeper understanding of how modern digital technologies can foster social interaction and promote creativity and learning. This section presents ViSTPro and how it enables the formation of onlife communities within the domain of cultural heritage and, in particular, history learning.

ViSTPro has been developed by the authors of this paper as a generic tool to enable the visualization of spatiotemporal processes. Such processes are a generic model for representing various types of content knowledge ranging from historical developments (e.g. representations of battles and other historical events) to physical processes like the ones studied in geosciences, life sciences etc. [6, 7, 8]. Such processes are difficult for learners to conceptualize with traditional teaching and learning approaches due to their complexity and inherent dynamic nature [9]. Consequently, a generic approach on dynamic spatiotemporal process modeling could be used in supporting many educational domains, promoting an active inquiry-based style to learning.

To address this need, interactive digital maps could be employed, on top of which appropriate active objects are overlaid representing real-world phenomena or events. This way, open exploration environments could be assembled and offered to learners as intuitive dynamic spatiotemporal models [9]. The learner has the opportunity to create symbolic formations, move them, and determine their interaction with other entities. In other words, a "visual narrative" is developed, in such a setting, for the evolution of spatiotemporal processes trough the animation of imported, process-type specific, graphical symbols superimposed on maps. Learners are familiar with this kind of animations because they regularly use digital applications with similar features [14]. The transfer of this positive experience in a learning context brings pleasure and offers more opportunities for learner engagement.

To effectively support this type of learning and engage learners, careful design should be employed. ViSTPro employs the concept of scenario for modeling complex spatiotemporal processes [15]. This concept suggests the visual representation of the evolution of spatiotemporal processes. Exploitations and semantic maps play an important role in this representation. ViSTPro distinguishes scenario authoring from scenario playback. During scenario authoring ViSTPro helps and guides the scenario author through-out the process. The scenario author initially selects a name and describes the new scenario. At the same time, active components of the scenario are determined.

A scenario contains groupings, types of entities and specific entities. For example, in the case of a historical battle a grouping may represent the troops that participate in the battle, types of entities may relate to the infantry or cavalry and certain types of entities can represent leading figures of the battle. The user selects the characteristic color of each troop and the representation of each entity type and also can import additional icons. Specific types of entities are represented with a larger size in order to differentiate from other types of entities. In addition, the representation of the different states of the types of entities providing multiple views for each of them (e.g. killed, on-fire, etc.) can be supported, while the user can create custom states. These elements are contained in optional map legends to facilitate the explanatory power of the presentation.

The second stage of the authoring process is the structuring of the scenario. The structural elements of a scenario include activities, sub-activities and events. Activities correspond to main units of action. Each activity is connected with a title, a description, and may include other activities or elementary unities of action (sub-activities) where the action unfolds and the movements, actions and interactions of the active components are visually described. For each subactivity several properties are available such as its name, description, start- and end-time, photos, recorded narration and related activities and other sub-activities of the scenario. Sub-activities may include events that represent a milestone or a particular incident. An event is identified by its title, description, timestamp and possibly its correlation with some type of entities, its state and a semantic object. Each scenario is thus modeled as a hierarchical structure of activities, sub-activities and events.

Another important scenario element is the set of formations that will be visualized. A formation is a set of entities handled as a whole. ViSTPro offers the necessary tools for the design of formations through predefined geometrical shapes (square, rectangle, circle, polygon, etc.), varying sizes, orientations, etc. After formation definition, entity types can be specified along with their size, location and density, in order to be included in the corresponding formations. Furthermore, the existence and position of one or more specific types of entities can be indicated.

The handling of a specific formation is possible through sub-activities. When a sub-activity is created, the scenario author chooses which formations will appear, defines the initial and final position and specifies the path that will be followed during scenario playback. Furthermore, there is a set of actions available for each formation. These actions are related to their behavior and interaction during playback.

The representation of actions is displayed by means of suitable graphical elements, such as icons and arrows. A formation may change its state as it moves or performs an action or interacts with other formations during scenario playback. For this reason, during scenario authoring, it is possible to redefine the state of a formation by defining its size, shape and density of varying types of entities, while their state can be modified.

Another important modeling primitive is graphics. A set of graphical elements are available such as lines, arrows, and other predefined elements, which are overlaid on the map during scenario authoring, and they play a crucial role in the playback of a scenario. Semantic content is provided via title and description, and can also determine characteristics such as color, size and orientation. During scenario playback the graphics can remain stationary or move. They can also change their shape in a manner similar to the state change of formations.

Process visualization addresses important elements such as human-made objects and significant locations of the surroundings. The presentation and provision of relevant information regarding these objects are done through semantic maps. Semantic maps are collections of important locations and objects of a region, which are represented on a map. The creation of a semantic map gives the possibility to create semantic objects each one described by its name, description, and one or more images. Thus, during scenario playback, it is possible to interact with the objects of a semantic map and examine their semantic content. Semantic maps are customizable by selecting certain objects and creating a new semantic map containing them. The new semantic map can be saved with a new name for future use. An original or customized semantic map can be used in one or more scenarios in the way described above.

During scenario playback individual learning needs are addressed through the provision of explanations for better understanding the evolution of the processes represented in each scenario. ViSTPro handles the movement of formations, involved in each sub-activity from an initial to a final position and provides an intuitive representation of state changes by changing the size, shape and density and status of the types of entities employing appropriate interpolations. Furthermore, during scenario playback each sub-activity title and description is presented possibly enriched with sound recorded narration. The playback can be paused to give time for examination of photos, related information that may have been registered in the sub-activity or even the physical surroundings. Events are depicted through entitled panels on the map, with location and time properly indicated. If an event is associated with a specific type of entities and/or a specific semantic object, those entities and/or objects are shown emphasized. Event-related additional information and pictures can be examined if scenario playback is paused.

During the playback of a scenario its hierarchical structure is provided. Through this structure one can switch to another scenario that describes in more detail the currently presented sub-activity. Finally, it is possible to speed up or slow down playback in order to adjust the speed to learner needs.

For more details regarding the design of the ViSTPro and its comparison with similar software targeting spatiotemporal process visualization, see [15]. The objective here is to present how ViSTPro use in specific learning settings can be guided by the PerFECt framework. In other words, to present a comprehensive case study that demonstrates how to employ the concepts and user roles of the PerFECt framework presented in Section 2. Analyze the use of software platforms such as ViSTPro so that they can be put within a wider context that accounts for the rich social interactions that could be promoted towards the establishment of onlife communities. In particular, ViSTPro can be considered as a representative tool on how a learning community can be established (in the field of cultural heritage in general and history learning in particular) that brings together:

- software developers supporting the software and providing further enhancements to address the needs of the users,
- teachers that prepare animations of historical events, i.e. scenarios representing the corresponding spatiotemporal processes in ViSTPro along with semantic maps and digital materials explaining the details of the animated events, and
- students that use the scenarios prepared by teachers to learn about the animated historical events in a personalized manner.

Employing the user roles described by the PerFECt framework, the above categories of participants in a ViSTPro-based learning community can be presented as follows:

Software developers that support ViSTPro and implement further enhancements to address the needs of teachers and students are the meta-designers of the PerFECt framework. As meta-designers, they are expected to be offered an open system that can evolve by its users as co-designers. To enable this, ViSTPro offers several capabilities to use various media types, thus offering the capability to integrate digital materials coming from a diverse range of sources. Furthermore, it offers a flexible authoring environment as a means to support expert-users that wish to develop new scenarios, thus animating new historical events or providing alternative visualization for events that have been already described with existing scenarios. Finally, ViSTPro is also open with respect to creating semantic maps, i.e. providing semantic information about human-made objects and physical formations on top of Google maps. Semantic maps can be used within scenario playback to provide important semantic information that allow for deeper understanding of the animated events.

Scenario authors (e.g. teachers, but also historians or even students that wish to engage in activities to apply their historical knowledge in developing ViSTPro scenarios). They create scenarios in ViSTPro what the PerFECt framework describes as expert-users that address the needs of end-users using the open system capabilities offered by meta-designers to develop new components in the form of universalizing assemblies of digital objects that can then be used by end-users in their learning tasks. This is indeed what teachers are expected to do with ViSTPro: using its features to develop scenarios for spatiotemporal processes that represent important historical events. These scenarios capture knowledge about the corresponding historical events along with pedagogical content knowledge so that effective scaffolding can take place that will enable students to develop their historical knowledge within a rich learning environment supporting social interactions and use of digital tools to make complex historical events more understandable.

Students that use ViSTPro to see the animations of the scenarios (using its playback features) are what the PerFECt framework calls end-users. They essentially use the creations of expert-users in the form of Universal Objects, i.e. digital artifacts that represent and present causality within and across historical events to make the historical knowledge more understandable and justifiable.

Apart from the above-mentioned roles, which are directly related to ViSTPro as a tool supporting authoring and playback of spatiotemporal processes, the PerFECt framework introduces yet another (fourth) user role: maieuta-designers. This is an important role that has a critical contribution in framing and supporting an onlife community. In particular, as already discussed, maieuta-designers are addressing the social conditions for supporting the task of expert-users and the transition from the end-user role to the role of expert-user. This transition and support of expert-users' tasks are essentially a learning process that takes place within a social context (i.e. the community of users). In the case of ViSTPro, the need for maieuta-designers emerges very naturally from the use of the tool in actual learning situations when students are enabled to develop their own scenarios (i.e. go beyond the end-user role toward the expert-user role) and thus learn deeper about the historical events they study. These enhanced learning results are documented by the actual evaluation following a controlled experiment approach in actual school settings presented in the next section.

Furthermore, teachers also express their belief that students can learn better when they are engaged in expert-user role tasks, thus creating their own portfolio of digital artifacts that can help them express their creativity and offer insights and motivation to find more information about the studied historical events using digital resources. Consequently, this approach is directly related to inquiry-based learning approaches and, more importantly, to constructionism: the learning theory that claims learners study better when they construct things [16].

4. Evaluation results. Teaching spatiotemporal processes, as it is the case for history courses in school, can be quite difficult and challenging if traditional approaches are employed. This is due to the fact that teaching of these subjects forces the student to develop complex cognitive structures. The task of correlating spatiotemporal information presented linearly when using traditional means is left to the student to handle without any significant help. E.g., the description of a battle in a history textbook presents the related events in a certain sequence although, in many cases, these events may happen in parallel and trigger other events in complex causal relationships. Consequently, traditional teaching results at construction of a vague cognitive structure, thus, complicating absorbing the knowledge of complex spatiotemporal processes. Using ViSTPro in teaching and learning of such processes can offer significant advantages and the purpose.

At accounting for the above issues, the purpose of ViSTPro evaluation was to study the performance of the system to facilitate understanding of spatiotemporal processes for students. Specifically, the evaluation addressed the system's use by teachers and students in teaching and learning of historical events matching the complex spatiotemporal processes. The aim was to investigate whether ViSTPro promotes the effective learning at that also offering engagement and opportunities for creative expression. Thus, the investigation addressed both the use of ready-made scenarios and the creation of new scenarios by the students to demonstrate their knowledge and exercise their creativity. Furthermore, the evaluation aimed at studying the usability of ViSTPro and the emotional response of students when using it. Students evaluated the usability of the platform in terms of using the existing scenarios and interacting with them, as well as after experiencing the process of creating their own scenarios. The emotions evoked by the use of the system were also explored, as they shape the users' experience and influence upon the users' attitude towards ViSTPro.

The evaluation of ViSTPro was carried out in lower secondary schools (students aged 12-13) within an important topic of the history course: "The Battle of Marathon". In Greece the students of the 1st grade of high school study this important historical event. The experiment involved two classes of students, one serving as the control group and the other as the experimental group. Both classes were uniform in terms of the students' general performance. The first class (control group) consisted of 22 students (13 boys and 9 girls). The second class (experimental group) consisted of 17 students (12 boys and 5 girls). The students were clearly explained the purpose of the experiment and asked to answer anonymously through the used questionnaires.

The teachers who participated in the experiment also were clearly informed about the experiment purpose. The history teacher of the experimental group was trained to use ViSTPro in order to use it during the experimentation. The experimental group was also supported by the computer science teacher of the school since the experimental use of ViSTPro was exercised in the school computer lab. Both teachers and students out of the experimental group created their accounts in ViSTPro, thus, initiating a community that used the tool to share scenarios and learn through them as well as by creating new scenarios and sharing them with the other members of the community. The control group was offered a traditional teaching of the selected topic without any digital tool.

The experimental process was split in two stages. The purpose of the first stage was to study the effect of using ViSTPro when the teaching is performed based on ready-made scenarios. The experimental group was taught the selected topic using ViSTPro. The teaching was structured with due account for the functionality of the platform so that the features were used appropriately. Specifically, the teacher presented the battle and interacted with the presented scenario, activating and interrupting playback, and utilizing system explanations. The students played an active role throughout the learning. Then, each student had an opportunity to interact with the scenario individually through a separate computer. The students in the control group were taught the same unit traditionally, covering the same body of knowledge and covering the same aspects of the selected topic. At the end of the first stage, students from both the control and the experimental group were asked to answer content questions, while those in the experimental group filled out additional questionnaires to give feedback on the usability of the platform, their emotional response to its use and a final one addressing the creativity aspects of using ViSTPro.

The second stage of the experimental process aimed at studying the effect of ViSTPro upon learning when students undertake the role of scenario creators. Therefore, only the students of the experimental group were engaged in this stage. The students constructed their own scenarios to represent the "Battle of Marathon". The construction of the students' scenarios additionally required six (6) teaching hours. Initially the students created their accounts in ViSTPro and were informed by their computer science teacher about the script creation process. The second lesson dealt with scenario creation, specification of groupings, and the creation of the necessary types of entities. The remaining teaching hours were used by the students to represent the battle stages. After accomplishing this process, the students again answered content questions on the selected topic and filled out the questionnaires on the usability and emotional response.

The content questionnaire used both for the control and the experimental group to measure their performance after the teaching of the selected topic totally consisted of 27 content questions: 20 multiple choice questions, 2 questions to arrange the facts in correct chronological order, 1 matching question and 4 free text questions. The completion time for the content questionnaire comprised 40 minutes.

The questions were categorized following the classification of Bloom's educational objectives [17]. The corresponding types of questions were:

- Knowledge (8 questions) – recalling specific facts and data.
- Comprehension (5 questions) – understanding what is taught without necessarily connecting with other materials or seeing full implications.
- Application (5 questions) – generalizing and using abstract information in specific situations.
- Analysis (4 questions in total) – splitting a problem/issue into subdivisions and detecting relations between them.
- Synthesis (3 questions) – assembling parts to form a whole.

– Evaluation (2 questions) – using criteria to make judgments.

The results drawn from the content questionnaires are shown below.

Table 1 compares the results of the control group and the experimental group at the first stage of the evaluation. Table 2 presents the results of the experimental group comparing between the first and the second stage of the evaluation. The grading of the student test used was based on a 100 scale.

Table 1. Results of the first stage of evaluation

	Experimental Group			Control Group		
	Mean	Stand. Error	95% T. Confid. Interval	Mean	Stand. Error	95% T. Confid. Interval
Knowledge	94.85	3.23	6.84	42.05	4.39	9.14
Comprehension	95.19	2.35	4.99	40.91	4.00	8.32
Application	77.78	5.87	12.45	26.26	4.11	8.54
Analysis	80.88	3.41	7.23	42.05	4.76	9.91
Synthesis	69.12	4.17	8.83	16.48	3.33	6.92
Evaluation	55.29	7.77	16.47	20.00	5.74	11.93

The results of the first evaluation stage (Table 1 and Figures 2, 3) clearly show the higher performance of the experimental group that used ViSTPro for all six categories of questions. It is worth noting that most of the averages of the experimental group exceeded 80/100, while those of the control group are under 50/100. The lower grades in the categories "Synthesis" and "Evaluation" are justified by the complexity of questions in these categories, in relation to the students' intellectual maturity. Nevertheless, the performance of the students of the experimental group is much higher disregarding the categories.

Figures 2 and 3 present the box plots of the performance of two groups so that the results can be seen in finer detail. The mean and median value of each question category is represented by dashed and bold lines respectively. The minimum and maximum performance scores of each category are also presented. The box plots confirm the results shown in Table 1: The performance of the students of the experimental group is much higher in all cases while the performance of the students in the control group is much lower. In addition, the last two categories of questions that are more demanding, demonstrate the importance of using ViSTPro in learning: The performance of the students in the experimental group in most cases exceeds 50/100 with respect to these two categories ("Synthesis" and "Evaluation"). There exist few exceptions of very low scores, which could be considered as outliers and are presented as small circles on the graph. Therefore, it can be safely concluded that the ViSTPro use facilitates learning and helps students to reach in-depth understanding and achievement of demanding learning objectives.

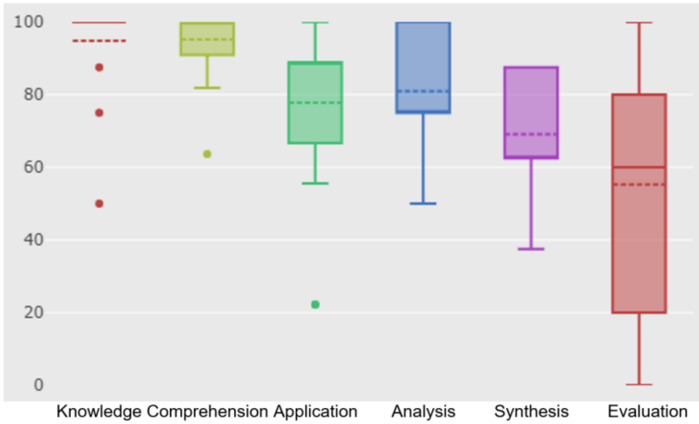

Fig. 2. Box plot of student performance (experimental group – first stage)

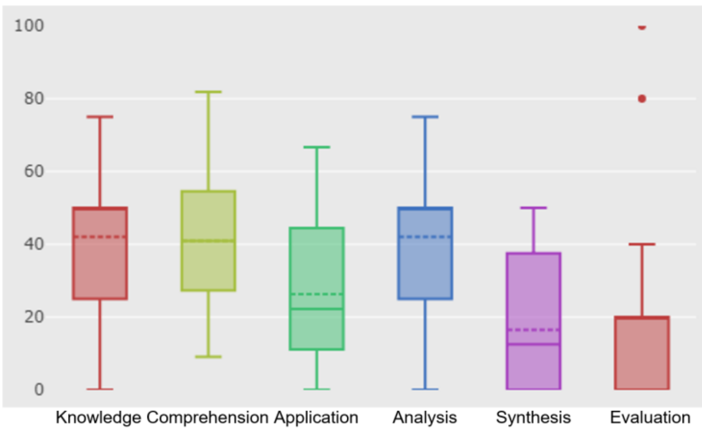

Fig. 3. Box plot of student performance (control group – first stage)

The experimental data out of the second stage of the evaluation present a further improvement in the performance of the students of the experimental group when they have used ViSTPro to create their own scenarios for the Battle of Marathon. Obviously, the improvement magnitude is small, since the students already had, from the first stage, a rather high performance. However, the creation of scenarios by the students bore a qualitative improvement that concerned both the learning process and the acceptance of the platform as students realized its potential to enhance their learning.

The students got excited, gave better structured answers and got acquainted with the technology. Table 2, below, summarizes the results and Figure 4 presents the corresponding box plot.

Table 2. Results of the first and second evaluation stages for the experimental group

	First Stage			Second Stage		
	Mean	Stand. Error	95% T. Confid. Interval	Mean	Stand. Error	95% T. Confid. Interval
Knowledge	94.85	3.23	6.84	97.79	2.21	4.68
Comprehension	95.19	2.35	4.99	95.19	2.71	5.75
Application	77.78	5.87	12.45	87.58	5.46	11.58
Analysis	80.88	3.41	7.23	80.88	4.03	8.54
Synthesis	69.12	4.17	8.83	70.59	4.54	9.62
Evaluation	55.29	7.77	16.47	72.94	6.85	14.52

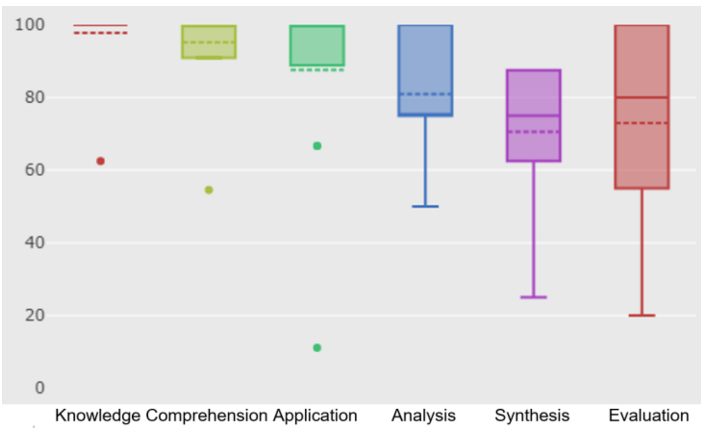

Fig. 4. Box plot of student performance (experimental group – second stage)

Beyond the learning effectiveness of ViSTPro presented above, another important aspect of the evaluation was the usability of ViSTPro. This part of the evaluation was made using the System Usability Scale (SUS) questionnaire [18]. SUS is a general-purpose questionnaire and can be used in evaluating the usability of different systems, equipment and products. It consists of 10 questions (statements) graded by the respondents on a 5-point scale which is numbered from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). The final score measures the usability of the system under evaluation.

The usability evaluation was done by the students of the experimental group at both the first and the second stage of the evaluation. At the first stage the final value of the SUS questionnaire was equal to 75.88, a value that characterizes the system as acceptable to good. At the second stage, the students rated the system with a final SUS value of 78.53. This shows that the demanding process of creating scenarios was followed without any significant difficulties and proves for the case as well the usability of the system. Besides that, the second stage showed that the students dealt with the system with pleasure, enthusiasm and good mood. Especially for the aspect of learnability (measuring how easily the users can learn a system), whose value is derived from two particular questions of SUS, the results are very important. The students graded the learnability of ViSTPro at the first stage by 78.68 and at the second stage by 83.82.

The diagram in Figure 5 shows the SUS score during the first stage (blue line) and the second stage (green line) of the evaluation on top of the benchmark graph used to interpret SUS scores as described in [18].

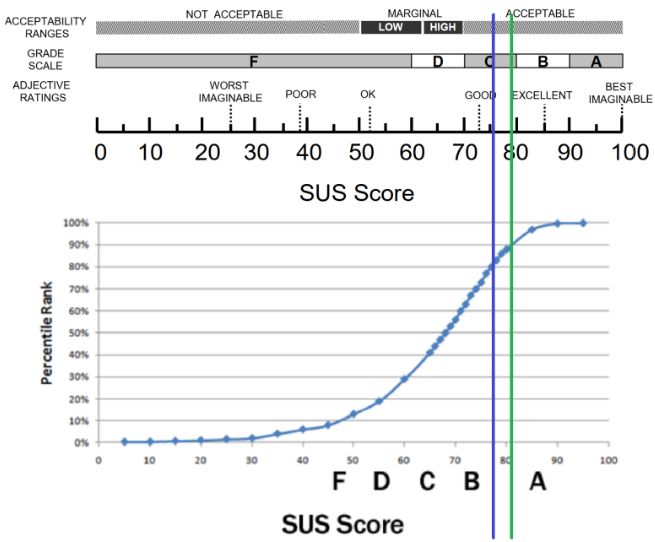

Fig. 5. SUS score during the first stage (blue line) and the second stage (green line) of the evaluation

In close relation to the usability, the emotional response of students towards ViSTPro was also evaluated. The methodology adopted for the evaluation of the emotional response uses emoticon cards [19]. These cards contain sixteen faces, male and female, depicting distinct emotions. These figures are grouped in pairs, each representing a combination of two emotional states. Therefore, the cards can be divided into eight sectors: Calm-Pleasant, Calm-Neutral, Calm-Unpleasant, Average-Unpleasant, Excited-Unpleasant, Excited-Neutral, Excited-Pleasant, and Average-Pleasant. The scores that fall into the pleasant sectors are interpreted as positive.

The following two figures (Fig. 6, 7) depict the results of this part of the evaluation. Both figures refer to the participants of the experimental group, during the evaluation first and second stages respectively.

The majority of choices in both cases is on the right side of the chart what means that the students found it pleasant to engage with ViSTPro. It should be noted that the results improved significantly at the second stage of the experiment, where the number of students that were excited using the system doubled. This result is in harmony with usability evaluation results and demonstrates that while the simple use of the system (first stage) provides for excellent learning opportunities, students find the creation of scenarios (second stage) more exciting. Therefore, using ViSTPro by students for the scenarios creating is an effective learning tool that is highly acceptable by them, promotes their creativity and ensures their active participation in the learning process.

Regarding creativity, the corresponding evaluation tool used was a short questionnaire based on the analysis presented in [20]. In particular, in the above work the authors suggest the use of a series of questions and metrics that examine whether the system under consideration helps to develop creativity. In resonance with their suggestions, the questionnaires used had the following questions:

- Q1: Would you use ViSTPro for personal reasons?
- Q2: Would you use ViSTPro to share a scenario with your friends?
- Q3: Would you use ViSTPro to spread a message to many people you do not know (e.g., online)?
- Q4: Would you use ViSTPro to share something you learned with your classmates?
- Q5: Would you like to watch scenarios made with ViSTPro?
- Q6: Do you think that ViSTPro could be used for educational purposes?

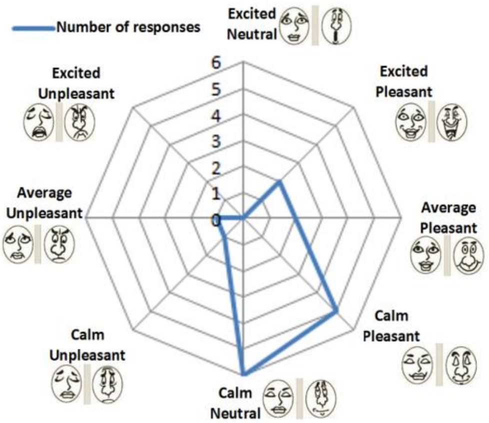

Fig. 6. Emotional response results (first stage)

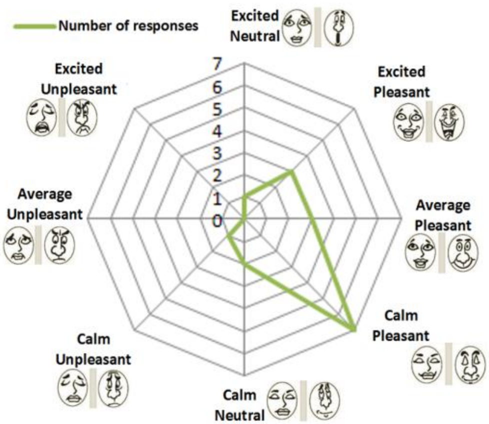

Fig. 7. Emotional response results (second stage)

Figure 8 shows the box plot results for the questions above. Students would use the system for the reasons they were asked, as the average of positive answers is over 3.7 in all cases. The median value exceeds (except for one question) the average and consistently has the value 4. The acceptance of the system by the students as an educational tool is impressive, since the average of the grades is equal to 4.2 and the median with 5. Therefore, students would use ViSTPro for personal purposes, to communicate their social environment and to follow scenarios and consider it a tool with significant educational value.

To summarize the results presented, using ViSTPro in teaching and learning with respect to traditional approaches has a significant positive impact. This is documented by the learning outcomes observed between the control group and the experimental group during the first stage of the evaluation. Apart from this, the results of the second stage of the evaluation that refer to students undertaking the role of scenario authors, demonstrate how the concepts of the PerFECt framework can be put in action and foster interactions to promote creativity and engagement in learning. In particular, the second stage of the evaluation addresses all three co-evolution processes depicted in Figure 1 that are in the core of the PerFECt framework. The action-interpretation cycles, referring to the way end-users and expert-users interact with the underlying system, are captured by the usability evaluation done using the SUS questionnaire. The task-oriented cycles are captured by the emotional response evaluation. Finally, the community-technology cycles, are captured by the creativity questionnaire and the content questionnaire evaluating the learning effectiveness of ViSTPro.

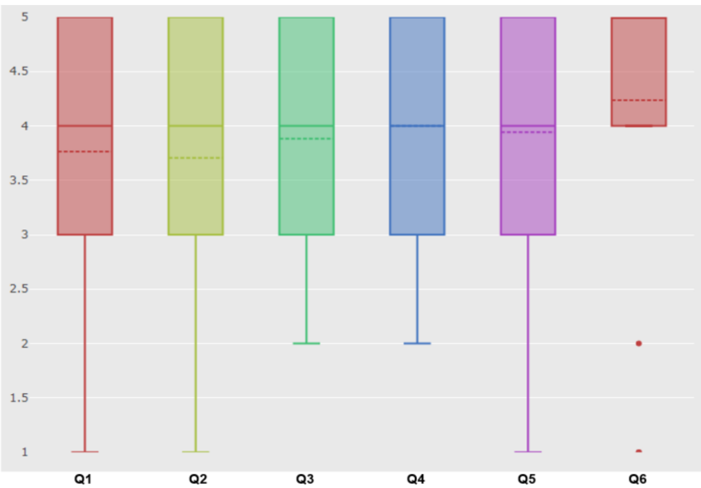

Fig. 8. Box plot with result for creativity evaluation

In all cases, the positive effects of the students undertaking the role of expert-users (i.e. scenario creators) are clearly shown. To enable this positive effect, the presence of maieuta-designers that will facilitate students in their transition from end-users to expert-users is extremely important. Moreover, it is important to underline that ViSTPro effectively supports the formation of a community of users by providing all the necessary features to create and manage user accounts, create and share scenarios and semantic maps.

6. Conclusion. The PerFECt framework presented in this paper addresses issues related to the establishment and support of onlife communities as rich socio-technical contexts where learning can be promoted, and engaging learning experiences can take place. This framework can be used to inform the design and use of educational digital platforms and tools.

As a concrete example of such a tool and its use, this paper presents ViSTPro, a digital platform that enables the specification of scenarios used to animate spatiotemporal processes. ViSTPro puts heavy emphasis in the hierarchical structure of spatiotemporal processes and enables gradual study from higher level abstractions to more specific detailed representations. Thus, a learner may initially see a simplified version of process evolution and then go into more details. The movements, actions and interactions of the formations are graphically represented on maps and those belonging to subactivities are presented synchronized based on a common timeline. This way the learner becomes familiar with complex spatiotemporal processes and acquires a complete picture of their development in time.

To demonstrate the flexibility of the ViSTPro and its capability to provide insightful visualizations, a pilot application has been elaborated focusing on the Battle of Marathon, pertaining to the corresponding chapter in the History course of the first grade of Greek Gymnasium (grade K-7). Based on this application, a controlled experiment was designed to evaluate the learning effectiveness of history teaching by ViSTPro. The evaluation also addressed ViSTPro usability, emotional response of users and creativity support. The results clearly demonstrate that using ViSTPro, history teaching becomes more engaging, and the learning outcomes are much better. An important part of the evaluation was to offer students the possibility to create their own scenarios for the taught topic. This additional task resonates with the PerFECt framework concept of facilitating the migration from end-user to expert-user role. The participating students were thus engaged in more deep study of the subject. An improvement of their performance was observed as well as higher scores in usability evaluation of ViSTPro and their students' emotional response to it. Furthermore, the students were extremely enthusiastic about the use of the tool and reported that it was much more interesting and engaging for them to create their own version of the scenario to study the Battle of Marathon instead of just watching the playback of a readymade scenario.

Future work will further employ the PerFECt framework to facilitate the use of ViSTPro in other learning domains to support users with alternative objectives and address new needs beyond history learning within school curriculum. Such objectives could be related to the study of local history by members of local communities that gradually evolve to expert-users and develop their own scenarios to represent the current state of knowledge regarding certain events of the local history. In such scenarios, the supported features of ViSTPro can be put under new light to account for supporting new semantics thus opening up new capabilities for the users.

Future work will further explore the use of the PerFECt framework to better understand how other software applications and systems promoting creativity and learning could be enhanced and repurposed to promote rich social interactions. Such a platform that will be analyzed and enhanced in the proposed manner is eShadow [21]. eShadow promotes an innovative digital storytelling approach inspired by traditional shadow theatre and it also provides extensions addressing other storytelling traditions such as digital marionettes. The analysis of eShadow using the PerFECt framework will identify interesting workflows that address the transition of its users from the end-user role to the expert-user role, how related external tools can promote this transition and facilitate the development of digital media authoring skills. Yet another domain that will be addressed refers to learning personalization [22, 23] addressing issues related to the use of digital tools to offer learning opportunities tailored to personal needs and expectations by individual users. Finally, a very interesting domain to analyze using the lens of the PerFECt framework is serious games [24-26] taking into account its importance in developing student creativity, learning engagement and collaboration within communities.

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ПЕРФОРМАТИВНАЯ ПЛАТФОРМА И ЕЕ ПРИМЕНЕНИЕ ДЛЯ ВЫСОКОТЕХНОЛОГИЧНОГО ОБРАЗОВАТЕЛЬНОГО СООБЩЕСТВА

Мамуцис Н., Сифакис С., Христодулакис С., Панева-Маринова Д., Павлова Л. **Перформативная платформа и ее применение для высокотехнологичного образовательного сообщества.**

Аннотация. В этой статье используется всеохватывающая концепция сообществ для выражения социальных контекстов, в которых осуществляется человеческое творчество и происходит обучение. С появлением цифровых технологий эти социальные контексты, сообщества, в которых мы задействованы, радикально меняются. Новый ландшафт, созданный цифровыми технологиями, характеризуется новыми качествами, новыми возможностями для действий сообществ. Термин onlife заимствован из Манифеста Onlife и используется для обозначения сообществ нового типа, созданных современными цифровыми технологиями - сообществ onlife.

Представлены принципы проектирования, направленные на развитие таких сообществ и поддержку их членов. Эти принципы составляют основу, которая подчеркивает концепцию перформативности, то есть то, что знания основаны на деятельности человека и действиях, выполняемых в определенных социальных контекстах, а не на развитии концептуальных представлений. Чтобы продемонстрировать использование структуры и соответствующих принципов, в статье представлено, как их можно использовать для анализа, оценки и переформулирования конкретной системы, относя ее к творчеству и обучению в области культурного наследия (преподавание и изучение истории).

Одним из наиболее значительных результатов является принятие принципов, которые облегчают вовлечение студентов в учебный процесс, переходя от роли конечного пользователя к роли эксперта-пользователя при поддержке так называемых maieuta-дизайнеров. Результатом этого процесса является использование изученного программного обеспечения не только для потребления готового контента, но и для создания нового, сгенерированного студентами контента, предлагающего студентам новые возможности для обучения. Как показывает оценка, эти новые возможности обучения позволяют студентам развивать более глубокое понимание изучаемых тем.

Ключевые слова: учебные сообщества, перформативность, творчество, оценивание.

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