SCIENAR Virtual Community: A Useful Tool to Promote the Synergies Among Artists and Scientists

I. Alfano, M. Carini, L. Gabriele, and G. Naccarato

University of Calabria, Arcavacata di Rende (CS), Italy

Abstract—**This paper describes a Virtual Community (VC) developed within the framework of the European project SCIENAR (Scientific Scenarios and Art). The SCIENAR project explores the connections between Art and Science and the use of new media and Information Communication Technologies (ICTs) for the exploration and representation of these relationships in an innovative and productive way. The main objective of the Virtual Community described herein is to strengthen the role of the "artistic-scientific" community in the production of new science and new art. This objective can be achieved by promoting synergies and collaborations between the different protagonists involved in the large field of research of Art and Science.**

Index Terms—**Computer mediated communication, cognitive psychology, online scientific communities, psychology, science and art communication, science and art visualization, virtual communities.**

I. INTRODUCTION

Speaking about Art and Science many connections can be highlighted, although they are apparently very different and often opposite.

Primarily, it is very important the support provided by sciences to arts: over the centuries they offer the means in interpreting and representing the nature and the world. For example, let us consider Ancient Greeks who believed that the Golden Mean governed the universe harmony and represented the perfection. For this reason they used this ratio in designing and producing their artefacts, like the temples devoted to the divinity [1]. In the field of visual arts, the technical perspective represents the best demonstration of how sciences can improve the representation processes. The plane representation of three-dimensional objects was an issue discussed since ancient times, and for this reason artists found different solutions based on empiricism. Only during the Renaissance there was a change towards the elaboration of precise rules for the representation of reality: Leon Battista Alberti (1404-1472) in his *De Pictura*, was the first who wrote about perspective and presented a true perspective representation model [2], extending the ideas of his predecessor Brunelleschi (1377-1446). Later, Piero della Francesca (1416-1492), in his *De perspectiva pingendi*, investigated in deep this argument using mathematical and geometrical subjects.

Moreover there is a deep analogy between the working processes of scientists and artists: both are human activities and essentially constitute a way of observing and interpreting the perceived world in order to facilitate a comprehension of some unknown fragments of reality [3-4].

But the most obvious connection between science and art is probably the fact that they are two activities dealing with the representation of the world: while art is inspired by nature in its forms, science uses art in order to facilitate understanding of certain concepts, sometimes very complex.

Today, while scientists and researchers find often in the art field an ideal place to better communicate their achievements, more and more artists draw inspiration from science by exploring different disciplines, for instance, biology [5].

Moreover, many artists produce their artworks physically, while others accomplish them in a digital way or model their sculptures on a computer before creating them in a wide variety of materials such as metal, glass, etc. For example, Benjamin Storch usually combines his skills in sculpture with his knowledge of mathematical plotting and CAD applications and represents them in two or three dimensions, ranging from computer graphics to geometrical sculptures. He works with metal sheets to create dynamic surfaces, arising from mathematical formula or from the principles of anticlastic form. According to Storch, mathematical language is a helpful means to understand some of the phenomena around us and he represents this concept into his artworks: "Space Knot", that is an artwork that represents a geometrical shape, previously modeled using CAD tools, shaped with a ribbon and characterized by varying of width and curvature; "Seahorse", instead, is a copper sculpture, inspired by natural forms as the tail of this marine animal [6].

The same Storch, in collaboration with the mathematicians Bernd Krauskopf and Hinke Osinga, made a band of the 'Lorenz Manifold' as a sculptural form in metal. The researchers Krauskopf and Osinga developed computer models, through which Storch worked to create his elegant steel sculpture, using a special hammering technique [7].

Other sculptures were firstly physically accomplished and then modeled in a digital three-dimensional way. This is the case of the handworks of the sculptor John Robinson (1935-2007). In the early 1970s this sculptor began the "Universe Series" of Symbolic Sculpture, a series of over one hundred works, including sculptures in bronze, wood, stainless steel, and marble. In this collection the artist represented symbolically the earth, animals, man and woman, birth, religion, civilization, and death. Each work is a visual interpretation of the artist's feelings and each one is created in a form found in nature such as spiral,

ovoid, circle, and cone. In his artworks he matched scientific and mathematical principles with artistic aesthetic. For example, the artist saw the sculpture's Immortality "...not only as a continuous journey through generations, but also the scroll on which all of life's experience is recorded". This sculpture is represented by a Möbius Band in the shape of a trefoil knot. The same sculpture was later digitally modeled and animated by the same Robinson in collaboration with the mathematician Nicholas Mee.

While many artists use concepts and mathematical forms to represent their feelings in accomplishing their artworks, others use art to better communicate scientific concepts.

The German painter and sculptor Julian Voss-Andreae, drawing inspiration from his background in physics, made a steel sculpture named "Quantum Man". This sculpture represents the image of a walking man seen as a quantum object. This sculpture, symbolizing the dual nature of matter (wave–particle duality, a central concept of quantum mechanics), being seen from the front shows its solid steel consistence, but being seen from the side, it almost disappears, because of the light that shines through the spaces between the slabs.

Evgeniy Meshkov, instead, in his "Composition No 3" assembles five intersecting dodecahedra, formed by sixty identical pieces, cut from sheets of mirror-plastic, with twelve spheres. The resulting product from this assembly suggests a complex molecule [6].

In both just described processes of communication, artists and scientists found a strong support in the use of ICTs. In fact, these last ones have given to artists the opportunity to renew and revitalize their creativity by producing digital artistic products such as 2D and 3D images [8, 9, 10] and music [11, 12, 13, 14, 15]. Rizzuti et al [16] used chaotic systems to generate sounds and music. Besides being a valuable tool in the artistic composition, the same technologies have also become a milestone of modern education [17], especially for the visualization and teaching of scientific concepts, for which visualizing ideas represent a crucial problem [18].

In his research, Shaffer [19] exploring the role for arts' learning, made possible by recent technological advances, he presented through a qualitative study a successful intervention, in which students learned mathematics through design activities. Norton and Cooper [20] reported the results regarding a project intended to trial the use of design practice as a tool for integrating the teaching of mathematics and technology.

In this work we present SCIENAR Virtual Community (VC), which aims to reinforce the synergies and collaborations, already existing among the different protagonists involved in the broader research field of art and science. It also means to harmonize and improve the dissemination of knowledge in this area as well as of the best examples regarding the use of new technologies in producing art, communicating and teaching sciences.

In the following section, we give a brief description of SCIENAR Project. In the section III we underline the importance of a virtual community as a virtual place capable to make easier the creation of a network and to engage the collaboration and the cohesion among the members. Then, in the section IV we present the structure of SCIENAR virtual community and some tools, virtual labs and resources that the community offers to the users to improve and to stimulate the creative process in producing new art and science. In the last section, conclusion and suggestion for follow-up work are reported.

II.   THE SCIENAR PROJECT: SCIENTIFIC SCENARIOS AND ART

The European project SCIENAR– Scientific Scenarios and Art (http://www.scienar.eu/main) takes into account the connection, existing between Science and Art from the times of Greek Culture until present time, and it uses the innovative possibilities that new media and ICTs offer for a better visualization and communication.

The central idea consists in developing and building three emblematic scenarios, closely related to three different historical ages, in which the interaction between Mathematics & Art is deep.

In particular the scenarios refer to:

- The birth of Mathematics in the Antiquity - *Arithmetic and Geometry*. In this period Platonic Solids and The Golden Mean are the prototype of beauty and harmony and the underlying Geometry is Euclidean Geometry, which describes the "ordinary space";
- Development of Mathematics from Renaissance to '900: *Perspective and Symmetry*. During Renaissance artists can represent the space as it appears by means of Perspective, while its construction are dominated by symmetry.
- Mathematics in the XX Century: *Curvature, Motion, Relativity and Chaos*. The modern art represent the World as it is perceived by human mind. In Mathematics, together with Riemannian Geometry, we have the dissolution of an absolute space in favor of many private ones.

Furthermore, this project aims to: enhance the exchange of information and expertise related to the topic of SCIENAR, facilitating thus relations among institutions of the sector in order to obtain an efficient network through which experts can really cooperate and to facilitate creative exchanges; to offer support for improving cooperation among scientific (universities and other centres of scientific research), artistic (centres working in innovative Art methods), technological (centres working mainly in computer science and innovative technologies) and cultural worlds (cultural associations, museum, etc.); to gather cultural and artistic contributions from institutions dealing with such kind of interdisciplinary studies and to spread their results at an European level, contributing to the dissemination of innovative approaches and research results, works, artistic forms among a wide audience.

The idea to implement a Virtual Community (VC) is stemming from the idea that lies at the basis of SCIENAR project. Due to our intention, this VC is capable:

- to create a much larger network of interactions between artists, scientist and cultural worlds;
- to generate cultural cooperation at different levels, from the local to the European one as whole;
- to promote the use of new media, which improve and enhance both collaboration and realization of new art and new science.

III. VIRTUAL COMMUNITY AS A VIRTUAL PLACE ABLE TO PROMOTE AGGREGATION

According to Abraham Maslow [21], any community arises from primary human need to join and feel aggregated with other people, to provide common Physiological and Safety Needs, which are the most basic of human needs. Maslow [21] sets at the third level of the homonymous Pyramid, the social needs of belonging, which includes the desire to have friends, to be part of a group, to be accepted by the others, to receive friendships and affection.

VCs do not represent an evolution of traditional communities, even being inspired from these last. They promote a new type of interaction among groups, integrating the opportunities offered by modern computer technologies and the Web, with the occasion to share and to be part of a social space [22, 23, 24].

VCs have not intrinsic qualities capable to improve living standards as the traditional ones; they are set in a network architecture disguised as social realities capable to stimulate feelings of belonging.

Hence, a VC begins and develops over a network; it requires a group of people taking advantage of common services and sharing views and ideas about particular issues or needs in network sharing of common interests [25, 26, 27].

Furthermore, we can affirm that a social network is a social structure made by people as friends, family, and others, with whom one can split social relationships, interests, friendship, commerce, etc [28].

The space on which a VC born is virtual and is the web [29, 30, 31]. As each successful partnership, a virtual community should foresees: shared goals and values; joined individual skills towards the benefit of whole group; mutual respect and confidence; the creation and manipulation of shared spaces; communication; clear positions of responsibility; online interaction; constant check on the quality of offered services/information [32-33-34]. Both user-navigator and user that supplies contents can participate to it in an active or passive way. In an active way, proposing and offering contents and products according the aims of the Virtual Community and in a passive way, using information already shared in the VC.

The user, who participates in the VCs, has a twice advantage to get in touch with other people having the same interest, and to access to a range of services, contents and offers proposed in the Virtual Community.

The characteristics and level of involvement/ engagement of users influence the mechanisms of growth of a VC. Three levels of involvement exists:

Level I - a community of discussion (forum or mailing list), it foresees a minimum engagement for user since it is based on the conversation;

Level II - a more complex and evolved kind of Virtual Community, since it requires participants to bring values, knowledge, scientific contributions, expertise, active and frequent engagement;

Level III - a community of business, which provides a strong involvement of the participants in order to generate business matching. Moreover, three key elements play a crucial role in creating and developing a successful virtual community:

- Contents;
- Collaboration;
- Exchange.

All relationships, both friendly and commercial, or artistic or scientific ones, begin from "content", sharing users' personal information, affiliations, needs and aspirations. In order to form a successful virtual community, the contents need to engage the "collaboration", signing up for its development the participants' input and the free flow of knowledge (information, programs and services) [35, 36].

Many collaborative applications can significantly enhance the "connecting" of all participants into the present activities of the virtual community. A noteworthy value can be activated across all community of participants through the integration of collaborative applications of Discussions, Communications and Email Lists.

Finally, any exchange of value among participants includes: exchanging profile information; sharing general information; registering for an event; a clear and shared sense of belonging; broad communication and engagement (expanding participation); resources (tools); openness, curiosity, imagination; a will to succeed and the grace to compromise; an interplay of design and practice (pilot, learn and adapt).

IV. SCIENAR VIRTUAL COMMUNITY: STRUCTURE, FUNCTIONALITIES AND RESOURCES

The SCIENAR VC (http://www.scienar.eu/network/) was created with the open source Joomla! (www.joomla.org). It is a Content Management System (CMS) used to organize and to facilitate a collaborative creation of Internet sites. The choice of using this software is not accidental, because it is one of the best tools capable to manage contents. Moreover, in virtue of its stability, prerogatives and functionality, this software has in short time conquered an incredible number of users that utilize it both for amateur purposes as well as for business purposes.

A preliminary activity of the installation of Joomla! consisted in register the associated domain name with a server space, according to the characteristics necessary to the proper functioning of the software. LAMP is the acronym of the used web environment and takes its name from the initials of software components, according to which it has been conducted; Linux is the operating system; Apache is the Web server; MySQL is the database management system (or the database server); PHP is the programming language.

The basic version of the software doesn't contain modules, able to handle the most of the features that are present on the site and, for this reason, our development team has created new modules that allow a high level of interactivity of the virtual community.

The site provides three typologies of users:

- Administrator;
- User;
- Visitor.

The administrator can access to all the features of the platform (including those that take part in the back-end) in order to manage the CMS system.

The user can enter all the features provided by front-end and is enabled to contribute to the production of contents.

The visitor can access to the published contents and functionalities those don't require the identification of users through credentials of access (username and password).

Through a user account, the system provides contents and customizable features.

The Fig.1 represents the Homepage of the SCIENAR VC.

The layout of the site is organized in three columns: the left and the right ones contain the modules, which give an access to the interactive capabilities, while the central column represents the contents.

The contents, which describe the scenarios, are organized into categories, any of which can contain one or more relative sub-categories.

The "leaf nodes" of the database, made by records cards, are produced by a particular group of authorized users, called Scientific Committee. This one consists of a set of experts in various disciplines such as Mathematics, Physic, Art, Archaeology, Digital Technologies, etc., belonging to different research institutes and universities of world.

The main task of the Scientific Committee is to ensure the accuracy, quality and exactness of contents published on the platform. Moreover, all members are registered users, with username and password, and they are authorized to perform different functions within the VC. In the platform different kinds of files can be add: audio files, videos, pictures or texts; each of them must meet sizes and dimensions specified by the administrator and they have to be linked to the keywords that describes the three scenarios.

Regarding the texts, the registered user can access to the "Template for data cards". This latter are predefined templates that support users in the inserting phase of the different kinds of topics (see Fig. 2).

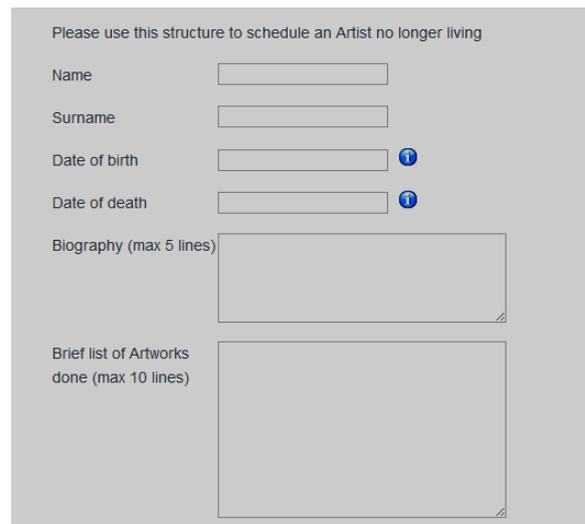Figure 1.   Homepage of the SCIENAR Virtual Community

Figure 2.   A screenshot of the artists card

When the user wishes to include information about a specific artist, he can use the template "Living Artist" or "No Longer Living Artist". In addition to personal data, this template requires a brief biography, a list of carried out artworks, an indication of related links and Art Galleries that exhibit or exhibited artist's collections.

Finally, the user has to insert the keywords, linking the artist to a scenario, in order to index all the information and to allow a fast research. The template data cards for artworks foresees the inclusion of artwork's title, author, description and a representative image of the artwork, artwork's category (painting, sculpture, music...), the technique used or, in case of virtual artworks, the software used for develop the artwork, the current location of the artwork and any related links. Also in this case, the user that inserts contents has to specify the keywords necessary to index the artwork and to indicate the best scenario (or scenarios).

Regarding the inclusion of texts that describe Topics, the user must provide a description of them, he has to indicate the artists/scientists who works in the topic, useful links, a list of keywords and the related scenario (or scenarios).

After the compilation of the template data cards, the user sends it to the administrator of the VC by means an on-line submission.

The administrator will send the file to a member of the Scientific Committee with expertise in the related topic. This latter will check the quality of contents and he can accept or reject the cards.

The Scientific Committee members have the username and the password in order to access (this is a category of the particular enabled users mentioned above) to:

- Personal page that contains the following fields, editable at any time (Name, Surname, E-mail, Username, Profession, Affiliation, Useful links, Curriculum Vitae, Photo).

- Publish scientific contents.

- Access to resources area - the enabled users are redirect to the page that provides them the ability to download and/or upload documents, audio and video files.

- Access to a Chat, exchanging instant messages in multi-user mode directly on the virtual web TV screen.

Visitors can access to the contents of the platform without login. This users' group is enabled to read the contents published by the Scientific Committee and to visit the different sections of the platform, among which the three scenarios: Arithmetic and Geometry, Perspective and Symmetry, Curvature, Motion, Relativity and Chaos, each of which contains specific topics linked to the context. For example, in the scenario "Curvature, Motion, Relativity and Chaos", relative to mathematics of the XX century, visitors can find descriptions of topics such as: Fractal Theory of Strings and Superstrings, Generative Art, etc.

Each scenario, and the various topics contained therein, can be: inspiration source for artist and/or scientist for further artworks' creation, and useful for knowledge diffusion and dissemination of innovative approaches and results.

Moreover, visitors can access to the following sections:

- Project - this link redirects to the official website of the SCIENAR project where it is possible to find information on the aims of the project, the consortium, events and publications produced under the same project.
- Artists – this section shows a list of artists, representative of the three scenarios, inserted in the database. These artists' cards contain a brief biography of each artist, some useful links, and artworks connected to the scenario.
- Galleries – this is a collection of art galleries in which users can search and view the galleries that take care of exhibitions and events related to the theme of science and art.
- Artworks – this section includes a series of artworks linked to the scenarios. In this way, each artist can make visible and accessible all his works, and at the same time, visualizes artworks of other artists, stimulating thus the creativity and the invention of new artifacts (see Fig. 3).
- Cross Paths – there is a series of results obtained with cross-searches on specific topics, thanks to indexing processes by the keywords.
- Virtual Labs – this section is characterized by the organization of interactive laboratories aimed, mainly, to a better understanding of science, to create new ways to communicate information to the public and to improve teaching scientific and artistic concepts. Furthermore, it is encouraged and promoted the use and application of new technologies for the exploration of new areas of research, and for the creation of artistic products / scientific innovations. In particular, the laboratories aim to:
  o visualize science, to better communicate it;
  o visualize science, to better teach it;
  o use digital technologies as a mean to explore the interplay between Science & Art; as a tool to produce new art or/and new science.
    For each laboratory and purpose are presented exemplifying multimedia applications.

- Tools – here the user can access to a range of digital tools (software), views different examples of their application and get suggestions for developing new ideas and creation of new artworks.

Currently is available the link to webMathematica (TM) that allow to dynamically create graphics objects, working on codes that model some physical processes (http://www.wolfram.com/products/webmathematica/index.html).

There is also ImaginationTOOLS (TM), a musical software that uses mathematical models to create sound and music (http://www.imaginationtools.it/). It presents a 3D graphical interface and it has been developed in order to help musicians to approach themselves to the sound synthesis [8].

Is also available PD (aka Pure Data), a real-time graphical programming environment for audio, video, and graphical processing (http://puredata.info/).

- Latest News - this section is dedicated to the collection of the latest news concerning national and international events as well as publications related to science and art fields, and to the project SCIENAR (conferences, seminars, workshops, but also exhibitions of art and multimedia installations).
- Web links – visualize new web links.
- Web TV and Chat – the enabled users can watch movies proposed by the Scientific Committee (see Fig. 4).
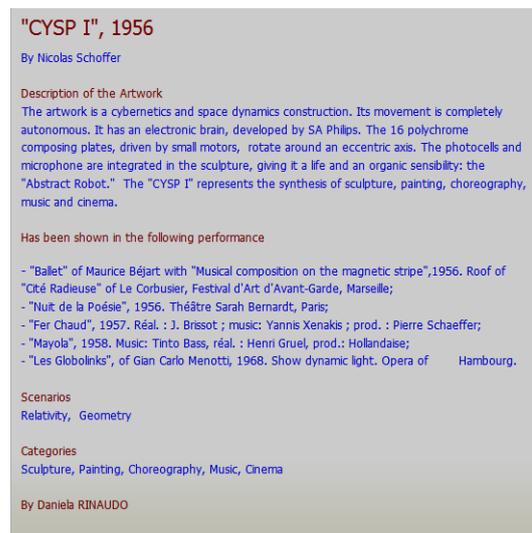

Figure 3.   A screenshot of an Artworks card upload on the SCIENAR Virtual Community

Figure 4.   A screenshot of the virtual web TV service

V. CONCLUSION AND FUTURE WORKS

This paper has presented SCIENAR Virtual Community, a network that aims to strengthen the synergies and collaborations, already existing among the different protagonists involved in the broader research field of art and science. It also means to harmonize and improve the dissemination of knowledge in this area as well as of the best examples regarding the use of new technologies in producing art, communicating and teaching sciences. The current prototype provides a simple and efficient interface to navigate through networks of scientists and artists, allowing users to discover in an easy way many examples of the strictly connection that exist between Art and Science. Additionally, our visualization procedure also emphasizes the main connection between artists and scenarios, allowing the user also to check what are the most distinctive attributes of artists and of their artworks.

In the last phases of the project we have planned to improve the fruition of the Community through usability test of the three scenarios and to enhance SCIENAR Virtual Community aggregation with a more intensive promotion and exploitation of the results.

REFERENCES

[1] A. Stakhov, "The golden section, secrets of the Egyptian civilization and harmony mathematics", *Chaos, Solitons and Fractals*, vol. 30, pp. 490-505, 2006. doi:10.1016/j.chaos.2005.11.022

[2] K. Andersen, The Geometry of an Art: The History of the Mathematical Theory of Perspective from Alberti to Monge. New York: Springer, 2007.

[3] G. Careri, "Discovering by Perceiving in art and in Science," *Leonardo*, vol. 27(3), pp. 181-182, 1994. doi:10.2307/1576048

[4] P. Campbell, "Seeing and seeing: visual perception in art and science," *Physics Education*, vol. 39(6), 2004. doi:10.1088/0031-9120/39/6/001

[5] J. Voss-Andreae, "Protein Sculptures: Life's Building Blocks Inspire Art," *Leonardo*, vol.38(1), pp. 41-45, 2005. doi:10.1162/leon.2005.38.1.41

[6] C.H. Sèquin, "Art Exhibition at Bridges Donostia 2007," *Journal of Mathematics and the Arts,* vol. 1(4), pp. 247–261, 2007. doi:10.1080/17513470701792490

[7] R. W. Hall, "The mathematical art exhibition at BRIDGES: mathematical connections in art, music and science, Leeuwarden, the Netherlands, July 2008" *Journal of Mathematics and the Arts*, vol. 2(4), pp. 197–204, 2008. doi:10.1080/17513470802651355

[8] E. Bilotta, G. Di Blasi, P.S. Pantano and F. Stranges, "A Gallery of Chua Attractors. Part VI," *International Journal of Bifurcation and Chaos*, vol. 17(6), pp. 1801-1910, 2007. doi:10.1142/S0218127407018105

[9] E. Bilotta and P.S. Pantano, *A Gallery of Chua Attractors*. World Scientific Publishing Co Pte Ltd, 2008. doi:10.1142/9789812790637

[10] F. Bertacchini, E. Bilotta, E. L. Bossio, P. Pantano and S. Vena, " Learning Chaos in an Interactive Virtual Museum," in VIWO 2009 WORKSHOP (ICWL 2009) Proceedings, in press (International Conference on Web-based Learning 2009).

[11] J. Pressing, "Nonlinear Maps as Generators of Musical Design," *Computer Music Journal*, vol. 12(2), pp. 35-45, 1988. doi:10.2307/3679940

[12] R. Bidlack, "Chaotic systems as Simple (but Complex) Compositional Algorithms," *Computer Music Journal*, vol. 16(3), pp. 33-47, 1992. doi:10.2307/3680849

[13] J. Harley, "Generative Processes in Algorithmic Composition: Chaos and Music," *Leonardo*, vol. 28(3), pp. 221-224, 1995. doi:10.2307/1576078

[14] E. R. Miranda, *Composing music with computers.* Oxford: Focal Press, 2001.

[15] E. Cupellini, C. Rizzuti, E. Bilotta, P. S. Pantano, M. Wozniewsky and J. Cooperstock, "Exploring Musical Mappings And Generating Accompaniment With Chaotic Systems," in "ICMC2008" Proceedings, pp. 467-474, 2008 (International Computer Music Conference, 2008).

[16] C. Rizzuti, E. Bilotta and P. Pantano, "A GA-Based Control Strategy to Create Music with a Chaotic System," in *EvoWorkshops Proceedings*, pp. 585-590, M. Giacobini, Eds. Springer Verlag: Heidelberg, 2009.

[17] N. Radclyffe-Thomas, "White Heat or Blue Screen? Digital Technology in Art and Design Education," *International Journal of Art and Design Education*, vol. 27(2), pp. 158-167, 2008. doi:10.1111/j.1476-8070.2008.00571.x

[18] E. Bilotta, P. Pantano and F. Stranges, "Computer Graphics meets Chaos and Hyperchaos. Some key problems," *Computer & Graphics*, vol. 30(3), pp. 359-367, 2006. doi:10.1016/j.cag.2006.02.003

[19] D. Shaffer, "Learning Mathematics Through Design: The Anatomy of Escher's World," *Journal of Mathematical Behavior*, vol. 16(2), pp. 95-112, 1997. doi:10.1016/S0732-3123(97)90019-5

[20] S. Norton, T. S. Cooper, "Teaching Mathematics and Technology through Design Practice," in MERGA Proceedings, pp. 377-384, 2008 (MERGA, 31st Annual Conference of the Mathematics Education Research Group of Australasia, 2008).

[21] A. H. Maslow, *Motivazione e personalità*. Roma, IT: Armando, 1982.

[22] C. Romm, N. Pliskin and R. Clarke, "Virtual Communities and Society: Toward an Integrative Three Phase Model," *International Journal of Information Management*, Vol. 17(4), pp. 261-270, 1997. doi:10.1016/S0268-4012(97)00004-2

[23] J. Hummel and U. Lechner, "Social Profiles of Virtual Communities," in HICSS'02 Proceedings, vol.7, pp. 172b (35th Hawaii International Conference on System Sciences, 2002).

[24] D. Memmi, "The nature of virtual communities," *AI & Society*, 20(3), pp. 288–300, 2006. doi:10.1007/s00146-005-0020-7

[25] J. Füller, M. Bartl, H. Ernst and H. Mühlbacher, "Community based innovation: How to integrate members of virtual communities into new product development," *Electronic Commerce Research*, vol. 6, pp. 57–73, 2006. doi:10.1007/s10660-006-5988-7

[26] M. Hsu, T. L. Ju, C. Yen, and C. Chang, "Knowledge sharing behavior in virtual communities: The relationship between trust, self-efficacy, and outcome expectations," *International Journal of Human-Computer Studies*, 65(2), 153–169, 2007. doi:10.1016/j.ijhcs.2006.09.003

[27] H. Lin, "Determinants of successful virtual communities: Contributions from system characteristics and social factors," *Information & Management*, vol. 45, pp. 522–527, 2008. doi:10.1016/j.im.2008.08.002

[28] B. Kloos, "Community Science: Creating an Alternative Place to Stand?," *American Journal of Community Psychology*, vol. 35(3-4), pp. 259-267, 2005. doi:10.1007/s10464-005-3405-3

[29] C.M. Johnson, "A survey of current research on online communities of practice," *Internet and Higher Education*, vol. 4, 45–60, 2001. doi:10.1016/S1096-7516(01)00047-1

[30] M. C. Bickle., J. McKenna, S. T. Meyer and G. C. Mabry, "Creating a virtual community to enhance member services: credit unions and e-commerce," *Telematics and Informatics*, vol. 21, pp. 157–165, 2004. doi:10.1016/S0736-5853(03)00054-6

[31] C. Bouras, E. Giannaka, A. Panagopoulos and T. Tsiatsos, "A platform for virtual collaboration spaces and educational communities: the case of EVE," *Multimedia Systems*, vol. 11(3), pp. 290–303, 2006. doi:10.1007/s00530-005-0005-x

[32] F. Lin, S. Lin and T. Huang, "Knowledge sharing and creation in a teachers' professional virtual community," *Computers & Education*, vol. 50, pp. 742–756, 2008. doi:10.1016/j.compedu.2006.07.009

[33] G. Dõgan, M. A. L. M. van Assena, A. van de Rijt, V. Buskensc, "The stability of exchange networks," *Social Networks*, 31(2), pp. 118–125, 2009. doi:10.1016/j.socnet.2008.12.001

[34] R. Toivonena, L. Kovanena, M. Kivelaa, J. Onnelab, J. Saramakia and K. Kaskia, "A comparative study of social network models: Network evolution models and nodal attribute models," *Social Networks*, vol. 31, pp. 240–254, 2009. doi:10.1016/j.socnet.2009.06.004

[35] H. Rheingold, The Virtual Community: Homesteading on the Electronic Frontier. London: MIT Press, 2000.

[36] A. Hemetsberger, "Fostering cooperation on the Internet, social exchange processes in innovative virtual consumer communities", 2001, Working Paper, Leopold-Franzens- Universität Innsbruck.

AUTHORS

I. Alfano (iole.alfano@unical.it) is PhD student in "Psychology of Programming and Artificial Intelligence" at the Department of Linguistic, University of Calabria, Via P. Bucci 17/b, Arcavacata di Rende, CS, Italy.

M. Carini (carini@unical.it) is researcher at the Department of Mathematics, University of Calabria, Via P. Bucci 17/b, Arcavacata di Rende, CS, Italy.

L. Gabriele (lgabriele@unical.it) is fellowship at the Department of Mathematics, University of Calabria, Via P. Bucci 17/b, Arcavacata di Rende, CS, Italy.

G. Naccarato (naccaratogiuseppe@gmail.com) is PhD student in "Psychology of Programming and Artificial Intelligence" at the Department of Linguistic, University of Calabria, Via P. Bucci 17/b, Arcavacata di Rende, CS, Italy.