An Agent Based Approach to designing Serious Game: the PNPV case study

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Abstract

Serious games are designed to train and educate learners, opening up new learning approaches like exploratory learning and situated cognition. Despite growing interest in these games, their design is still an artisan process. On the basis of experience in designing computer simulation, this paper proposes an agent-based approach to guide the design process of a serious game. The proposed methodology allows the designer to bring forward the assessment of educational effectiveness to the design phase and to strike the right equilibrium between educational effectiveness and entertainment, realism and complexity. To this end, an agent based approach is proposed because it provides the actors involved in designing the game with specific tools and guidelines for determining whether the proposed model is clear and comprehensible to the students. The design of the PNPVillage game is used as a case study. The PNPVillage game aims to introduce and foster an entrepreneurial mindset among young students. It was implemented within the framework of the European project "I can… I cannot… I go!" Rev.2

Keywords: *Serious Game Design, Agent Based Social Simulation, Entrepreneurship Education*

1. Introduction

Simulation is a representation of a real-world environment, system or process. Simulations are usually used for scientific or educational purposes, when the real system may not be observed directly for various reasons (e.g. inaccessibility, cost, danger, etc.) [1].
The effectiveness of simulation technology in education has been extensively demonstrated for teaching various topics as well as at different levels of education[2]. In the context of science education, Merchant et al. [3], through meta-analysis, highlight the role of simulation as a robust addition to the available traditional teaching methods. In fact, most of the studies report positive effects of the simulation approach where simulations were used to enhance traditional lessons. Kincaid & Westerlund [4] also report a positive effect of virtual reality technology-based instruction (i.e. games, simulation and virtual worlds) in K-12 and higher education, reporting a meta-analysis of 7.078 articles. Simulation helps students to see complex relationships, provides students with new methods of problem solving [4] and reduces the cost of errors for users [5].
The issue of differences between games and simulations has long been debated in the literature. According to De Freitas [6], simulations represent aspects of reality while games do not; conversely, in the case of serious games (SGs), resemblance to reality appears to be a key feature. In fact, although SGs are in general terms defined as "games designed for a primary goal different from pure entertainment" [7] [8], according to Watkins et al. [9] Gloria et al. [10] SGs "contextualize the player's experience in challenging, realistic environments, supporting situated cognition". From this point of view, SGs and simulation are closely related.

Although the term SG has been used since 1970 when Abt [11] first introduced it, and its meaning has changed very little, it is only in the last few years that attention to SGs has grown. Initiatives such as the network of excellence "European Project Games and Learning Alliance" (GaLA NoE) have been investigating some open research issues concerning SGs.
First of all, there is no shared consensus about their educational effectiveness; "the empirical evidence to support this assumption is still limited and contradictory, particularly regarding the effectiveness of games for concrete educational purposes" [12]. At the same time, analysis about the impact of serious games on student motivation has produced some contradictory results. The analysis conducted on the use of commercial games in education failed to detect a significant impact of these technologies on student motivation. In contrast, analysis conducted on games specifically designed for educational purposes highlights a significant increase in motivational aspects [12]. So, creating effective and attractive learning environments is essential for motivating learners, enabling them to embark on engaging and challenging educational paths [13].
The design of SGs is still an artisan process and no proper guidelines exist that are based on a validated methodological approach [14][15]; moreover, the design is often determined by the simulation goal, thus shifting the emphasis from the educational aspect to the realism of the simulated system. Several authors emphasize the need for a design approach that allows for verification of the educational effectiveness of the developed learning environment [1][16].
Moreover, understanding of social realities can benefit from the use of serious games. According to Gilbert [17] "human societies are complex …the result is that it becomes impossible to analyze a society as a whole by studying the individual within it, one at time…"; furthermore, in this context, ensuring that the simulation environment is totally realistic may no longer be a design goal per se. Instead, achieving the right balance between realism and learning effectiveness is an essential design criterion.
In this context, the main goal of SGs is to simulate the actors' decision-making processes and to demonstrate the consequences within social systems where the users have to cope with difficulties arising from the complex nature of these systems [18]. For this purpose, a methodology for designing and developing SGs based on recent developments in the social simulation research field is proposed.
This paper describes the agent-based simulation approach in social sciences, and starting from the principles of agent-based simulation design presents the methodology used to design the serious game PNPVillage. In particular, this work also aims to clarify under which conditions the agent-based approach could be an effective solution in serious game design.
In the following sections the new agent based methodology for designing and developing SGs is proposed and the experience of designing the PNPVillage is reported. PNPVillage is a serious game developed within the framework of the EU-funded project "I can ... I cannot ... I go!" Rev. 2 (PNPV project) that aims to create a training model and tools for the acquisition of knowledge and entrepreneurial skills.

2. Agent-based Serious Game design

The development of simulations that reproduce aspects of social behaviour can support the comprehension of social systems [19]. Axelrod [20] emphasizes the value of simulation as a research methodology, "a third way of doing science" that differs from both standard methods of doing science: induction and deduction. Computer simulation supports the understanding of complex social phenomena by means of what Epstein called a generative approach [21]. Prediction, performance, training, entertainment, education, proof and discovery are all potential applications of simulation in social science.
The typical phases involved in the definition of the simulation model are shown in the following figure (fig. 1).

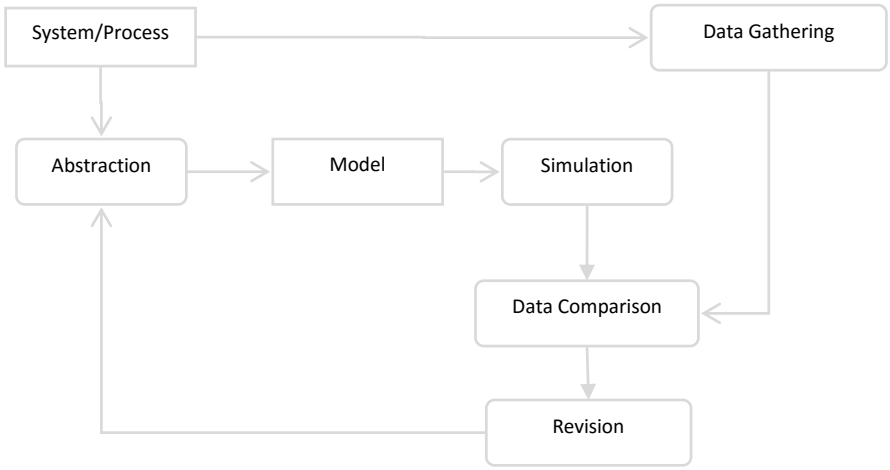

Figure 1. Simulation model definition and validation scheme [29]

The abstraction phase generates a simulation model consisting of a formal description of the system or process. The level of detail of such a formal description must be suitably defined so that only the subset of relevant aspects of the target system is reproduced. This process implies great simplification of the real world system to be analyzed and, therefore, it enhances the importance of correct model validation. Models must be kept as simple as possible, provided that they are able to show valid behaviour, i.e., coherent with the actual evolution of the system or process under analysis.

During the simulation phase, the model is executed and it generates a collection of simulated data that are to be compared with the real ones in order to adapt the model and make it closer to the target system.

In an educational context, the main use of simulation is to allow users to learn relationships and principles by themselves. For this to happen, simulation need not be sophisticated enough to suggest a complete real or imaginary world.

In the last few years the use of multi-agent based simulation (MABS) as an approach that provides useful and often essential insights into a large number of scientific and application sectors has grown continuously [15], [22], [23], [24], [25]. Although agent-based social simulation has been proposed since the seminal works of Schelling [26] [27], it has become more popular in recent decades with the development of artificial intelligence and computational theory. Numerous authors have recognized the effectiveness of MABS for the investigation of social and biological systems [28].

Starting from the advance in simulation design and exploiting the features of agent systems the following design process of a SG is proposed (Fig. 2).

Other models aimed to support the design of a Serious Game are available in the literature. For example Yusoff [30] defines the steps to be taken to design a serious game. Marfisi-Schottman et al., [14] proposed a step-by-step process for engineering design in Serious Games in which at each step specific experts are involved; moreover, a visual design tool is proposed. Also Marne et al., [16] suggest an approach, where they tried to relate the different phases of game design to "the right expert (s) for each design area."

The design process proposed in this work suggests practical quantitative tools to verify the effectiveness of the model from an educational point of view.

To understand how the educational objectives influence the process of abstraction it is necessary to highlight the characteristics of multi-agent models.

Multi-agent models consist of a community of agents situated in a simulated dynamic environment. The macro level outcomes of MABS are inherently dynamic because they derive from the evolution of agent interactions at the micro level; agents can intervene in composite ways, allowing researchers to study the complex emergent behaviour of a simulated system.

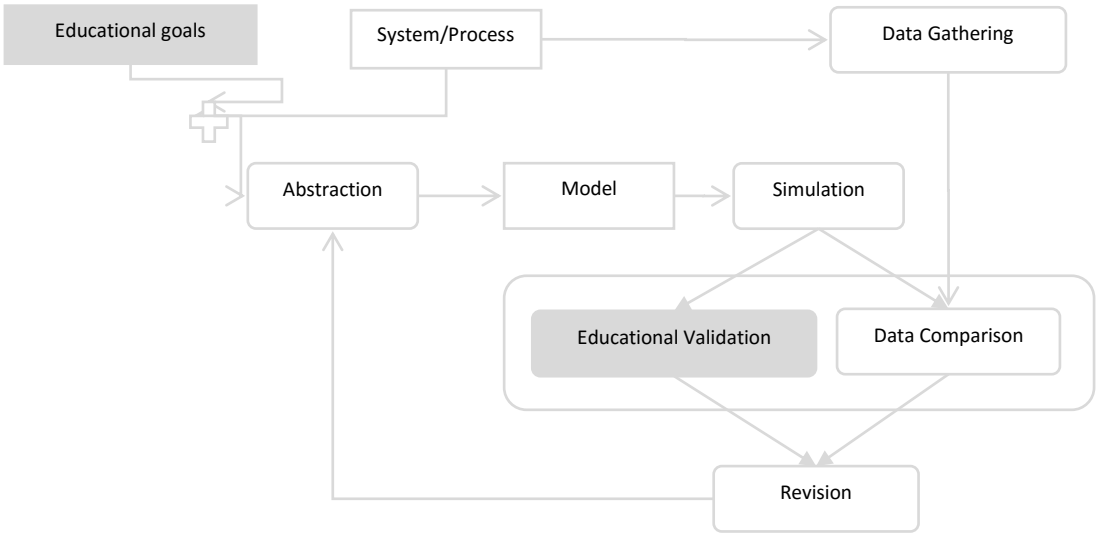

Figure 2. Serious game model definition and validation scheme

In other words, the system behaviour is not modelled at the macro level, but emerges from the composition of the behaviours of the single entities interacting with each other and with the environment (emergent behaviour).
Generally, the abstraction process of an ABSS involves the following steps:

- identifying the active entities (agents) of the system; agents are active since they are capable of perception, communication, and action;
- specifying the knowledge and behaviours of each agent; agents can correspond to both physical and logical elements, and can be permanent or transient;
- defining the subsets of system state variables to be included in the agents' private data; only the agents have responsibility for storing and updating these data. In a MABS model, the system state is thus distributed and mainly controlled by separate agents;
- modelling the environment; the environment model also denotes the relationships among system entities and anything else needed to simulate the influence of the world surrounding the system.

In the proposed model the educational objectives influence all of the four phases of the abstraction step; nevertheless, they have a decisive influence in the definition of the behaviours of each agent. The model of each agent could be made as complex as in the real world, but a complex model could be difficult for the students to understand.
From this point of view, the educational objectives are a discriminating element that allows the designer to select the behaviours that the instructor wants to highlight to the students. Moreover, focusing on the agent's behaviours the instructor could defines the assessment step in order to check if each behaviour could be understood by the students and also if the students could realize what are the factors that may affect it.
The “Educational Validation” phase has the objective of verifying the educational effectiveness of the model from different points of view:

- allowing learners to infer the simulation model and in particular the behaviour of individual agents in the system;
- validating the inferred behavioural model of each agent by means of a comparison with theoretically valid models;
- validating the emergent behaviour of the system by means of a comparison with theoretically valid models at the aggregate level.

The proposed process allows the designer to validate if the simulation is a realistic model and also to check it from an educational points of view; this leads to the creation of an educational environment where learners cope with a complex situation similar to real social systems and acquire specific knowledge of the behaviour of individual actors.
From a practical point of view, the phase of "Educational Validation" includes the preparation of game scenarios and a set of specific quests. The scenarios must be prepared in order to analyse the understanding of the agents’ behaviours, as well as the effects of different decision-making levers on these behaviours.

The analysis of the results of the individual quest could be qualitative or quantitative if specific success indexes for the game are defined.
The analysis allows the designer to check the knowledge gained by the participants on specific scenarios relating to individual agent's behaviours, and in general provides a check of the correctness of the simulation model.
In summary, the agent based approach improves the educational effectiveness of the simulation by means of a simplified model which measure comprehension students' .
Finally, the instructor can increase the complexity of the model gradually during the educational path; this allows the student to approach the understanding of the simulated system and its dynamics incrementally enabling what de Freitas [6] defines as 'exploratory learning', i.e. "as a learning approach whereby learning takes place through exploring environments, and real lived experiences".

3. The PNP Village

In this paragraph a structured description of the PNPVillage serious game is provided.

- **General**

PNPVillage is a web-based game [31] for acquiring, improving and testing the skills of students in the management of a tourist resort. It has been designed and developed according to the following general aims:

- to create a simulated environment resembling the real world as closely as possible, allowing students to understand the elements of complex situations;
- to promote self-monitoring, by means of indexes that summarize market trends and aid/facilitate interpretation;
- to encourage cooperative and competitive strategies among students;
- to promote entrepreneurial skills and a business mindset.

- **Learning Environment**

PNPVillage is a multiplayer game and consists of 7 levels. In the early levels, students play in a simple environment to acquire basic skills and knowledge, later the environment becomes gradually more complex to transfer advanced business concepts.
Students work in groups to stimulate collaborative and cooperative learning, moreover each group competes in a single simulated market to stimulate competitiveness.
A Non-player character (NPC) and attractive game graphics (Fig. 3) are developed to engage students in an enjoyable learning environment. The NPC leads students through the game levels and provides advice and tips to help them if they encounter difficulties.

- **Architecture**

In PNPVillage, students compete in a simulated tourist market. The ACE theory has guided the implementation of the tourism market simulation. ACE is a specialized area of economics that studies economics models as evolving systems of autonomous interacting agents [32] [33].
The simulation engine exploits a multi agent system solution to represent the complexity of the market as interaction of simple agents' behaviour.
From a pedagogical point of view, a blended learning path that exploits learning by doing, discovery learning and cooperative learning technique was designed.

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Figure 3. PNPVillage's user interface.

- **Context**

The PNPVillage is a game intended for VET students, moreover it can be used by young adults that want to explore the world of "doing business".
In PNPVillage teachers assume the role of 'facilitators of learning', guiding students and reflecting with them on the learning process.

4. Design PNPVillage

In this paragraph the application of the proposed model to the design of the PNPVillage is described.

4.1. Educational Goal

The PNPVillage learning goal is to improve students' awareness and abilities in the management of a tourist village.
The game focuses attention on these issues:

- marketing policies: market segmentation and market dynamics;
- financial and organizational management;
- social responsibility.

PNPVillage is divided into 7 levels. At each level, the students will acquire new entrepreneurial concepts related to the management of the village through the activation of specific decision-making levers.
The number and complexity of the concepts and their related levers will increase during the game.
Decision-making levers can be divided into strategic and operating levers.
The strategic levers represent the management goals in terms of marketing strategy over a long period, while the operating levers represent operative choices.
At each level, players will have to manage the village for a whole virtual year, which has been divided into four quarters. In this way, students can analyse the results of their decisions after each quarter, and apply the necessary changes to their management strategy.
The decision-making levers introduced at each level of the game are listed below.

- Level 1: the student has to choose the marketing strategy, the market segment, the name and the slogan of the village. Finally, the student will be able to build his own village inserting accommodation units and sea services.

- Level 2: the student can select the most appropriate communication tools for the chosen market segment pursuing an effective advertising policy.
- Level 3: the student can change selling prices of his tourist packages.
- Level 4: the student can recruit/release the reception staff.
- Level 5: the student can create a catering service in the village and recruit/dismiss its staff.
- Level 6: the student has to face corporate social responsibility issues. He can also decide to create green areas, to eliminate architectural barriers as well as to make his employees follow training courses.
- Level 7: the student can build sports facilities in the village and recruit/dismiss its staff.

In PNPVillage several tools have been included that allow students to implement the marketing strategy of choice and position their product on the market. These tools enable students to define: pricing policies, communication campaigns and advertising. PNPVillage also includes a series of levers that allow students to cope with the main aspects of managing a resort, such as the management of tourism infrastructure, accommodation services and staff.

4.2. Abstraction

The definition of the model started with the analysis and identification of all the actors and their interactions. This process is the result of synergistic activity between the domain expert and the multi-agent systems specialist.
The first step was to choose the structure of the market. In this case, the educational goal and the simulation goal overlapped. In fact, in order to promote competitive dynamics, all the villages operate in a single simulated market. In this way, the result obtained by a single village does not depend just on its own choices but also on those made by all the others. Each village competes in an environment very similar to the real world, where the success or failure of a business is determined not only by personal ability and by entrepreneurial skills, but also by the behaviour of its competitors.
The model consists of four main groups of agents:

- Customers.
- Advertising campaign agents.
- Villages.
- Advertising brokers.

A detailed description of the *Customer agent* is given below. For a complete description of the simulation model we refer to Allegra et al. [31].

4.2.1 Customer agent

The customer agent is the key element of the simulation model. It is an autonomous agent that operates in the market in order to select the products that best fit their preferences. The purchasing process is carried out through a series of steps that allow the agent to gain an overview of the market (through marketing policies promoted by individual villages), to find out about the villages and their offers and to select the offer that best suits its preferences and finally to decide whether or not to purchase the product.
All these steps are guided by the preferences of the agent and by the choices made by each village that operates in the market.
The market has been segmented into 5 types of customers in order to simplify understanding of the market and to foster training in the marketing policies needed to meet customer preferences. Each type of customer is characterized by different preferences and by a different purchasing propensity, resulting in a different way of evaluating the various offers.
The segments into which the market has been divided are:

- VIP, customers with a high disposable income looking for high quality services as well as relaxation and well-being;
- Business, customers with a high disposable income who are looking for accommodation with a wide assortment of services;
- Young people, customers aged between 18 and 25 years with a low disposable income who are looking for sport and entertainment services;
- Middle Family, customers with a low disposable income who are looking for children's entertainment services

- Working Family, customers with a low disposable income who are looking for inexpensive services.

After the single *customer* has entered the market, he "chooses" his preferred type of accommodation; then, he analyses the market to verify the availability of a holiday package which meets his preferences.
The *customer* does not have a thorough knowledge of the market, but is informed only about the *villages* that have adopted an adequate marketing policy. The two key elements for a village to have a good marketing policy are 1) to select the *advertising campaign agents* and the respective advertising channel most suitable for the targeted customer type and 2) to invest an adequate amount of capital compared to its competitors.
Then the agent sends a request to every village he knows about, or conversely sends a call for proposal to those villages that have been able to contact him using the appropriate marketing levers.
The villages respond automatically by providing a set of parameters that are used by the customer for a comparative evaluation of the offers. The evaluation performed by the agent is a quality cost analysis; the evaluation of the quality is closely related to preferences that characterize the type of customer.
As the levels of the game progress the number of parameters used by the customer become more and more complex; at the same time the levers that the individual villages can use to influence the customer's choice become even more complex.

4.3. Data Comparison

The experience of the domain expert is the main element used to revise the model, including how well it corresponds to reality. Starting from the trend in the tourism market in the last few years and taking into account all the strategic and operational levers available to the players, the domain expert provided the data used to perform the data comparison.
In particular, the expert provided a set of case studies that were used as a benchmark. Each case study was characterized by:

- a definition of the market, i.e. the number of customers in the market and the percentage distribution of each type of customer;
- the number of competing villages;
- configuration of the villages, i.e. the composition and choices made by the village in terms of housing, services and staff;
- the expected outcome in terms of annual profit for each village.

At this stage the parameters of the simulation model were tuned in order to achieve the benchmark defined by the above case studies using the technique of sensitivity analysis.
These data were used to verify the correctness of the model and possibly vary the characteristic behaviours of the agents in the revision phase.

4.4. Educational validation and revision

The educational validation phase involved a group of researchers and teachers. The aim of this phase was to verify educational validity of the simulation model. For this purpose, a set of activities was presented to the testers in the form of game *quests*. Each quest had a different goal in order to verify specific operating levers.
Two main indexes were defined and used to verify the quest goal: the Visibility index (VisIndex) and the Value for Money index (VfM).
The game levers have different influences on the VisIndex and VfM indexes, depending on the type of customer.
The VisIndex measures a village's market visibility, in relation to a particular market segment. The level of a village's visibility will be calculated as a function of the investments in communication made by all the villages, for each communication channel.
The VfM is a parameter expressing the quality of the operational choices made by a single village in relation to the different types of customers. From the customer's point of view, it is the main element for evaluating and comparing the offers made by the various villages. For the complete description of the algorithms we refer to Allegra et al. [31].
Figure 4 provides some examples of quests:

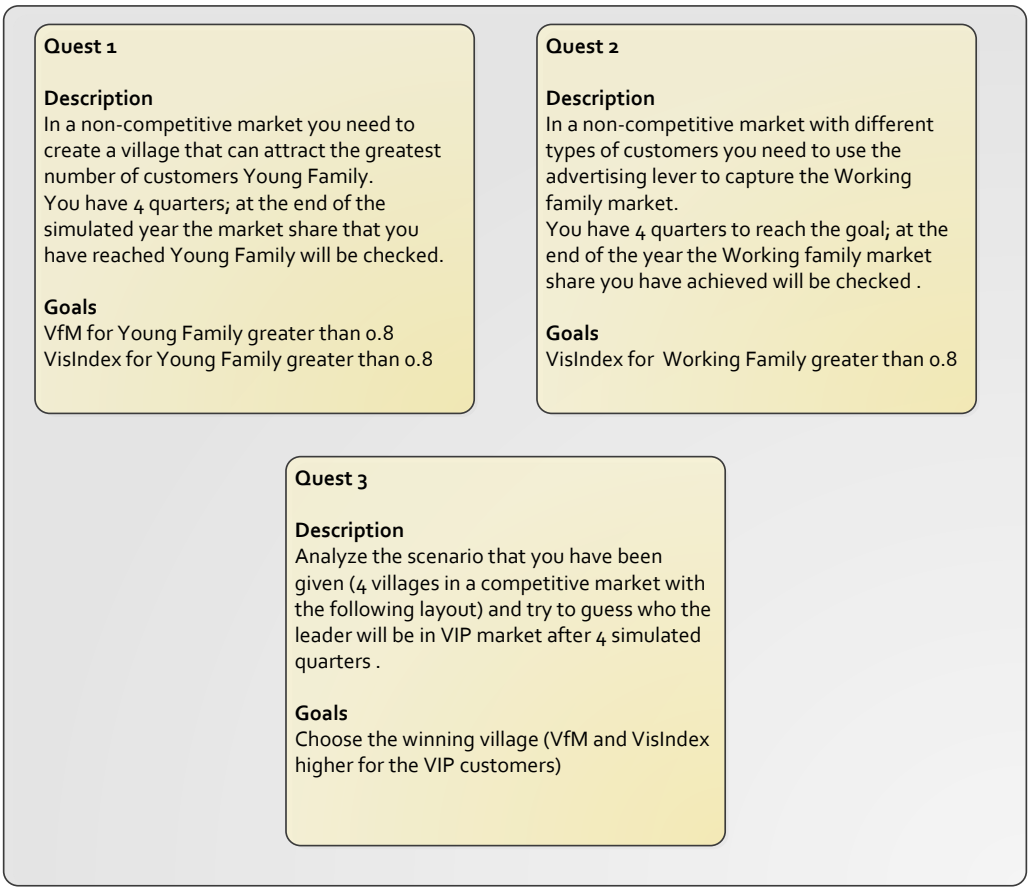

Figure 4. PNPVillage's quest examples

A set of more than 40 quests was defined. The educational validation was carried out through gaming sessions attended by 15 researchers and teachers selected from those who had not participated in the design and implementation of the game.
At the beginning of the game session, a quest was randomly assigned to each participant (normally 4 participants per session were involved); moreover, all the learning resources explaining the use of the decision levers and the description of the market were provided to the participants.
The participants expressed initial difficulty in distinguishing between the behaviours of two types of customer: Working Family and Middle Family. Consequently, a clearer distinction was made between the behaviours of these types of customers by tuning the parameters appropriately; moreover, a more detailed description of these customers was provided.
Qualitative analysis of the educational validation step highlighted a progressive improvement in solving the quests and a general improvement in the model in terms of clarity and transparency for the users.

5. Conclusions

The paper describes an advanced methodology that uses a multi-agent system model to design a serious game.
The proposed approach aims to bring forward the assessment of the educational effectiveness of a SG to the design phase. To this end, an agent based approach is proposed because it gives specific tools and guidelines to actors involved in the design of the game in order to determine whether the proposed model is clear and comprehensible to the students.
The *educational goals* and *validation* phases of the design process play an important role in the methodology, permitting designers to control and verify all the components of the model and, using feedback, to review it in terms of realism and educational effectiveness.
The methodology has been tested on the design process of PNPVillage. The game has been integrated into curricular activities for students aged 16 to 18 attending secondary schools in four different European countries.

Further analysis is needed to obtain a complete validation of the effectiveness of the PNPVillage game, to improve both students' knowledge and entrepreneurial skills.

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References

[1] Rieber, L. P. (1996). "Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games." Educational Technology Research and Development, 44(2), 43–58. doi:10.1007/BF02300540
[2] Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012). "The learning effects of computer simulations in science education.", Computers & Education, 58(1), 136–153. doi:10.1016/j.compedu.2011.07.017.
[3] Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). "Effectiveness of virtual reality-based instruction on students’ learning outcomes in K-12 and higher education: A meta-analysis.", Computers & Education, 70, 29–40. doi:10.1016/j.compedu.2013.07.033
[4] Kincaid, J. P., & Westerlund, K. K. (2009). "Simulation in education and training.", Proceedings of the 2009 Winter Simulation Conference (WSC), 273–280. doi:10.1109/WSC.2009.5429337
[5] Garris, R., Ahlers, R., & Driskell, J. E. (2002). "Games, Motivation, and Learning: A Research and Practice Model.", Simulation & Gaming, 33(4), 441–467. doi:10.1177/1046878102238607
[6] De Freitas, S. I. (2006). "Using games and simulations for supporting learning. Learning, Media and Technology", 31(4), 343–358. doi:10.1080/17439880601021967
[7] Charsky, D. (2010). "From Edutainment to Serious Games: A Change in the Use of Game Characteristics.", Games and Culture, 5(2), 177–198. doi:10.1177/1555412009354727
[8] Prensky, M. (2003). "Digital game-based learning." Computers in Entertainment. (1) 1, p. 1-4. doi:10.1145/950566.950596
[9] Watkins, R., Leigh, D., Foshay, R., & Kaufman, R. (1998). "Kirkpatrick plus: Evaluation and continuous improvement with a community focus." … Technology Research and …. Retrieved from http://link.springer.com/article/10.1007/BF02299676
[10] De Gloria, A., Bellotti, F., Berta, R., & Lavagnino, E. (2014). "Serious Games for education and training". International Journal of Serious Game, 1(1).
[11] Abt, C. C. (1970). "Serious Games.", Viking Press.
[12] Papastergiou, M. (2009). "Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation." Computers & Education, 52(1), 1–12. doi:10.1016/j.compedu.2008.06.004
[13] Kriz, W. C., 2003. "Creating Effective Learning Environments and Learning Organizations through Gaming Simulation Design." Simul. Gaming, 34(4), 495–511. doi:10.1177/1046878103258201.
[14] Marfisi-Schottman, I., George, S., Frank, T.-B., 2010. "Tools and Methods for Efficiently Designing Serious Games." Proceedings of ECGBL 2010 The 4th European Conference on Games Based Learning. p. 226-234., Danish School of Education Aarhus University, Copenhagen, Denmark.
[15] Conte, R., Gilbert, N., & Sichman, J., 1998. "MAS and social simulation: A suitable commitment.", In J. Sichman, R. Conte, & N. Gilbert (Eds.), Proceedings 1st. international workshop on multi-agent based simulation (Vol. 1534, p. 1-9). Berlin: Springer.
[16] Marne, B., Wisdom, J., Huynh-Kim-Bang, B., & Labat, J.-M., 2012. "The Six Facets of Serious Game Design: A Methodology Enhanced by Our Design Pattern Library." In A. Ravenscroft, S. Lindstaedt, C. Kloos, & D. Hernández-Leo (Eds.), 21st Century Learning for

21st Century Skills SE - 17 (Vol. 7563, pp. 208–221). Springer Berlin Heidelberg. doi:10.1007/978-3-642-33263-0_17.
[17] Gilbert, N. (2004). "Agent-based social simulation: dealing with complexity. The Complex Systems Network of Excellence", 9, 1–14. doi:10.4114/ia.v9i25.771
[18] Westera, W., Nadolski, R. J., Hummel, H. G. K., & Wopereis, I. G. J. H., 2008. "Serious games for higher education: a framework for reducing design complexity.", Journal of Computer Assisted Learning, 24(5), 420–432. doi:10.1111/j.1365-2729.2008.00279.x.
[19] Cannon, H. M. & Friesen, D. P., 2010. "The simplicity paradox: Another look at complexity in Design of simulations and experiential learning.", Developments in Simulation and Experiential Learning, Vol. 37, Reprinted in the Bernie Keys Library [Available from http://ABSEL.org].
[20] Axelrod, R. (1997). "Advancing the art of simulation in the social sciences.", Complexity, 3, 16–22. doi:10.1002/(SICI)1099-0526(199711/12)3:2<16::AID-CPLX4>3.0.CO;2-K
[21] Epstein, J. M. (2007). "Generative Social Science.", (Princeton University Press, Ed.).
[22] Verlag.Salamon, T. (2011). "Design of Agent-Based Model: Developing Computer Simulations for a Better Understanding of Social Processes". Repin, Czech Republic: Bruckner Publishing.
[23] Drogoul A., Vanbergue D., Meurisse T., 2003. "Multi-agent Based Simulation: Where Are the Agents?" In Multi-Agent-Based Simulation II, Lecture Notes in Computer Science Volume 2581, 2003, pp 1-15.
[24] Gentile, M., Paolucci, M., & Sacile, R., 2004. "Agent-Based Simulation. Agent-Based Manufacturing and Control Systems.", CRC Press, pp. 119–151. doi:doi:10.1201/9780203492666.ch4.
[25] Epstein, J. M. (1999). "Agent-based computational models and generative social science. Complexity", 4(5), 41–60. doi:10.1002/(SICI)1099-0526(199905/06)4:5<41::AID-CPLX9>3.0.CO;2-F
[26] Schelling, T. (1971). "Dynamic models of segregation†. Journal of Mathematical Sociology". Retrieved from http://www.tandfonline.com/doi/abs/10.1080/0022250X.1971.9989794
[27] Schelling, T. C. (1978). Micromotives and Macrobehavior. Public Policy, 252. doi:10.2307/2989930
[28] Lopez-Paredes, a., Edmonds, B., & Klugl, F. (2012). "Special Issue: Agent Based Simulation of Complex Social Systems." Simulation, 88(1), 4–6. doi:10.1177/0037549711433392
[29] Gentile, M., Paolucci, M., & Sacile, R., 2004. "Agent-Based Simulation. Agent-Based Manufacturing and Control Systems," CRC Press, pp. 119–151. doi:10.1201/9780203492666.ch4.
[30] Yusoff, A., Crowder, R., Gilbert, L., Wills, G. (2009), "A Conceptual Framework for Serious Games". In: Proceedings of the 2009 Ninth IEEE International Conference on Advanced Learning Technologies, pp. 21–23. IEEE Computer Society, Riga.
[31] Allegra M., La Guardia D., Ottaviano S., Dal Grande V., Gentile M., 2013 in press. "A Serious Game to Promote and Facilitate Entrepreneurship Education for Young Students." The 2013 International Conference on Education and Educational Technologies July 16-19, 2013, Rhodes (Rodos) Island, Greece.
[32] Tesfatsion L., Judd K. L., 2006. "Handbook of Computational Economics," Handbook of Computational Economics, Elsevier, 1, 2, 2.
[33] Faria, A. J., 2001. "The Changing Nature of Business Simulation/ Gaming Research: A Brief History. Simulation & Gaming", 32(1), 97–110. Retrieved from http://sag.sagepub.com/cgi/content/long/32/1/97.
[34] Gentile M., La Guardia D., Dal Grande V., Ottaviano S., Allegra M., 2013 in press. "An Agent Based Methodology to Design Serious Game in Social Field", in International Conference “The Games and Learning Alliance Conference” (GALA), 23/25 October 2013, Paris.