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Serious Games design: reflections from an experience in the field of Intangible Cultural Heritage education

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Abstract: *This paper tackles the issue of Serious Games design by drawing on the experience conducted in the framework of the i-Treasures project, which deals with the preservation and transmission of Intangible Cultural Heritage (ICH). In i-Treasures a collection of Serious Games has been developed addressing four relevant ICH areas: singing, dancing, craftsmanship and music composition. So far one game for each of the four areas has been developed; the ultimate aim of the games is making learning and transmission of specific ICH expressions (namely Tsamiko dance, human beat box, pottery, contemporary music composition) more motivating, engaging and, ultimately, effective. Starting from the concept of pedagogy-driven game design, the main pedagogical choices adopted are outlined. Further considerations on the overall design process are also proposed by focusing, in particular, on the need for engaging in a collaborative work a variety of professionals (in the case partners of the project) with different expertise, skills and background.*

Keywords: *Technology Enhanced Learning, Serious Games, Game design, Gamification, Cooperative work, Collaborative research projects*

I. INTRODUCTION

Games are increasingly adopted to favour learning in a variety of different educational areas. This paper deals with their adoption in the area of Cultural Heritage Education [1], in particular in the field of Intangible Cultural Heritage (ICH) [2]. Actually, it focuses on the design of Serious Games (SGs) for supporting and enhancing learning and transmission of practical skills, such as those required to perform specific ICH expressions (e.g.: dances, handicraft).

In this area, the potential of SGs is relevant because the learning opportunities they offer are “situated”, that is the learner acts in a virtual context which closely resembles the one where the cultural expression is usually practiced [3]. Nevertheless, the SGs’ educational potential and actual effectiveness may vary appreciably as a consequence of the design choices made *a priori* before starting the implementation [4].

As to educational SGs, the design phase is essential to meet the user requirements, that concern both entertainment and educational aspects [5]; especially regarding the educational requirements, it is undeniable that the pedagogical choices play a major role [6] [7] and the adoption of appropriate learning design tools can be helpful for an effective design [8].

It is widely acknowledged that, presently, one of the biggest problems of SGs for education is the inadequate integration of educational and game design principles [9] [10]. Given the instructional goal, SG development should be strongly grounded on proper educational foundations. “To be effective, serious games must incorporate sound cognitive, learning, and pedagogical principles into their design and structure” [11].

Therefore, a new discipline, called “Game design” has started acquiring increasing popularity, and has stimulated the birth of specific training opportunities (university and master courses) which are usually highly interdisciplinary.

In this panorama, a variety of tools has also been developed aimed at supporting SGs design, with specific attention to those for education. Some examples are the tools produced within the GALA NoE (www.galanoe.eu) and available through the Serious Games Society, among which:

- The *Serious Games Reusability Point of Reference* (SGREF) which supports the identification of reusable SG assets and their reuse within SG communities and beyond. To facilitate reuse, SGREF manages collections of references to reusable SG assets and a repository with SG assets uploaded by users. The reference-based approach has been adopted to stimulate availability of resources, even if they are not open source (<http://www.sgref.com/>)
- The *Catalogue of web services for SGs*. A catalogue that provides links, descriptions and interfaces of web services (SOAP or RESTful) usable to develop Serious Games following the Service Oriented Architecture (SOA) paradigm. (<http://services.seriousgamessociety.org/>)
- The *SG Analysis Database* (SGA-DB) which is a structured, searchable and machine-readable knowledge environment for Serious Game studies. Four main knowledge areas are covered for each SG: description/classification, learning environment, analysis of game components (e.g., UI, rules, goals, entity manipulation, and assessment) & architecture, context & analysis. <http://studies.seriousgamessociety.org/>
- *Gleaner* which is a framework for working with learning analytics in SGs. <http://e-ucm.github.io/gleaner/>

The aim of this paper is to contribute to the debate around effective design of educational Serious Games and this is done by presenting the i-Treasures experience of game design.

The following sections of the paper deals with the experience of game design conducted in the framework of the project, which is related to learning and transmission of Intangible Cultural Heritage (ICH). After drawing a picture of the project and briefly outlining its scope, the process that led to the development of a set of Serious Games is described by focusing on both relevant theoretical and managerial aspects.

II. THE CONTEXT: THE i-TREASURES PROJECT

i-Treasures is an Integrated Project co-financed by EU under the ICT theme (Information and Communication Technologies) of the FP7 (7th Framework Program) started in 2013. It’s main objective is to sustain the passing down and transmission of ICH, defined as “the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage” [2]. Most of the cultural expressions defined as ICH so far have been learnt mainly by imitation, transmitted by looking at and listening to master performers and by practicing together with peers. i-Treasures is meant to make the most of cutting-edge technologies to renew the transmission modalities and ultimately make the passing down easier and more effective.

Actually, i-Treasures combines lots of different technologies like multisensory technology, singing voice synthesis and a 3D module for sensorimotor learning [12] to build a public and expandable platform aimed at enabling learning and transmission of the rare know-how behind four different ICH domain: rare traditional songs, rare dances, traditional craftsmanship and contemporary music composition.

The 3D sensorimotor learning module of the i-Treasures platform is endowed with game applications aimed to support learning and transmission of the considered ICHs.

Games have been built following a common structure, made of a sequence of training sessions followed by a final challenge. Each training session is structured as follows:

- an activity is shown (be it singing, dancing or pottery creation)
- the learner is required to reproduce it (appropriate sensors are used to track the learner's performance)
- the learner's performance is evaluated by comparing it with the expert's performance (who has been previously tracked again with the same sensors used with the learner).

So far, a standard "game framework" has been developed and one representative game for each ICH domain has been produced, namely Tsamiko for the dance, human beat box for singing, pottery for handicraft and modern music composition.



Fig. 1. Images from two of the four i-Treasures games.

III. DESIGNING THE i-TREASURES GAMES

The game development process required a precise design methodology, able to integrate different aspects and the related different competences; such an endeavour required a huge collaboration effort by the partners and experts involved in the project.

Figure 2 outlines the different steps undertaken to design the four i-Treasures games.

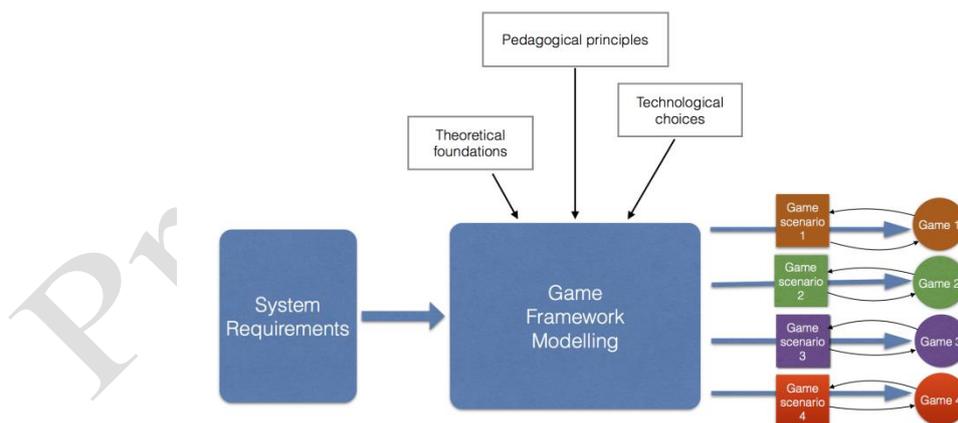


Fig. 2. Workflow of the i-Treasures games design phase.

The general system requirements elicitation constituted the basis for modelling and developing a general "game framework" for the single game instances [13]. Such modelling required further, in-depth attention to set the games within a solid, shared theoretical background and to adopt sound and effective pedagogical principles; both these aspects are detailed hereunder, while it is not matter of in-depth discussion here the wealth of technological choices that have been taken at this level.

Following the general modelling phase, specific requirements for each of the four games have been defined by experts in each specific field and the related game scenarios have been produced, so to guide the actual development. The specific game scenarios differ one from the other, due to the features/ constraints posed by each ICH domain and this is reflected in the game structure flow, presentation and interface [14].

3.1. Theoretical foundations

The i-Treasures games are deeply grounded on the concept of “experiential learning”: actually, learning is acquired by observing, reflecting, mentally representing and enacting movements and/or actions. This is in accordance with Kolb’s [15][16] definition of learning as “the process whereby knowledge is created through the transformation of experience” and acknowledges the results of a variety of research studies supporting that personal “experience” should be set as one of the main pillars of game-based learning [17][18].

In Kolb’s experiential model of learning, individuals are encouraged to reflect on the actions and consequences, so to foster understanding and reapplying this understanding to future actions. Kolb defines four possible learning styles: (i) Divergent (feel and watch), (ii) Assimilative (watch and think), (iii) Convergent (do and think) and (iv) Accommodative (do and feel). These Kolb’s styles are possibly interrelated depending on individual preferences, and may result in four different outcomes: Concrete Experience (feel), Reflective Observation (watch), Abstract Conceptualization (think) and Active Experimentation (do) (Fig.3).

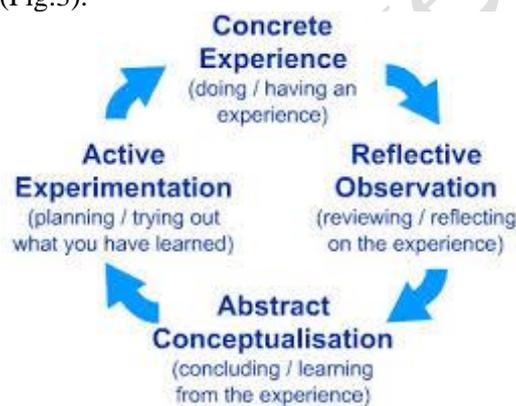


Fig. 3. Kolb’s experiential learning model (adapted from: <http://www.simplypsychology.org/learning-kolb.html>).

Kolb’s experiential learning model has been recently revisited in order to include new generation of Virtual Environments (VEs and SGs).

To conceptually support issues of game design using pedagogically driven approaches, the Four Dimensional Framework (4DF) [16] and the SG Exploratory Learning Model (ELM) [19] have been proposed. These models open the capability for learning through the experience of exploring SG/VE spaces. 4DF suggests to inform game design by referring to four dimensions, such as: learner profiling (e.g. ICT skills, gaming experience), selection of pedagogies used (e.g. associative, cognitive or situative), used representation (e.g. level of fidelity, interactivity and immersion) and context within which learning takes place (e.g. disciplinary context, place of learning).

Similarly, the ELM model (Fig. 4) extends from Kolb's experiential learning model to include the typical and popular characteristics of VEs and SGs, such as the 3D world settings and the social interactive learning aspects. Reflection is central throughout the learning process – and the role of meta-reflection is particularly important to support the main challenge. The challenge is to achieve learning transfer between virtual, abstract and lived contexts. The formation of abstract concepts can then be supported either within or outside of the learning session and these can then be tested in a range of different contexts (e.g. in the workplace, in other real contexts or through building upon sets of related learning experiences) building up a constructive understanding of the processes underway.

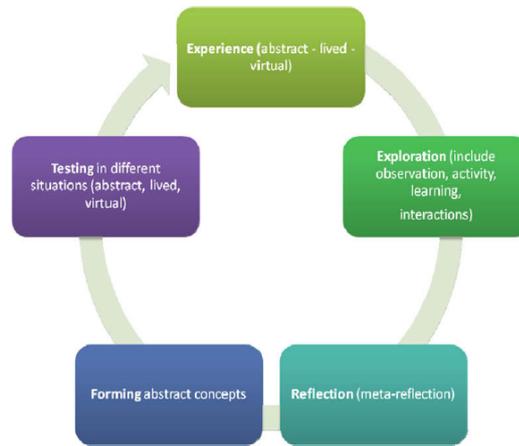


Fig. 4. The ELM model (adapted from:[19])

In accordance with these models a variety of educational experiments have been conducted, as for instance Arnab et al. [20], who explored the use of tactile interactions in a game-based learning environment implemented atop of a multimodal browser-based platform aimed at promoting “hands-on” engagement with a topic - the cultural heritage, in the implemented case.

In the i-Treasures games we have taken on board these models, thus basing the game design on practical skill, movements and gestures [21].

For the upcoming i-Treasures games we would like to pose emphasis also on other aspects such as for example sequencing of learning experiences, meta-reflection, peer assessment and group work, that are interesting and innovative aspects of SGs.

3.2. Pedagogical aspects

As said above, a variety of pedagogical aspects were taken into account during the design of the i-Treasures games. Figure 5 summarizes the main areas considered.

At the core there are the educational objectives to be met, which represent the focus of the endeavour and the ultimate aim to be pursued. These were carefully defined and guided the whole implementation endeavour, which, nevertheless, consider also: the desired nature of the game (e.g.: collaborative, individual...), the exact contents to be proposed, the game structure to be followed, the interaction modalities and, in particular, the methods for feedback provision and for supporting the play out of the situation, the methodology for carrying out a thorough and effective evaluation and to make it visible and comprehensible to both students and educators.

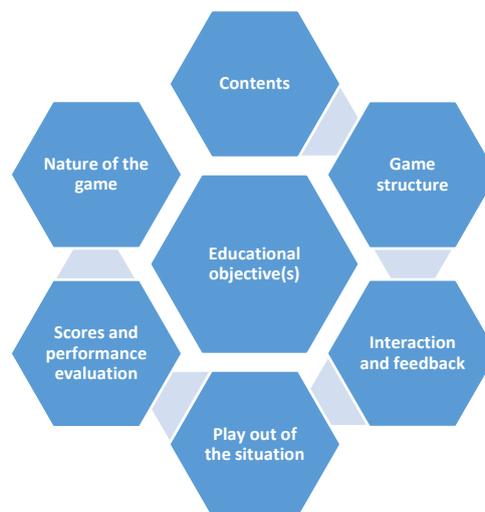


Fig 5. Pedagogical areas/ aspects considered during the game-design

As to each one of the specific aspects mentioned above, details were made available by pedagogy and content experts to professionals in charge of the game implementation.

In the following, based on the i-Treasures experience, examples are provided of what it is needed in the specific areas.

As to the **educational objective(s)**, a comprehensive but detailed list should be produced and expressed by paying attention to its homogeneous formulation and to defining their internal sequence and the rationale why each of them needs to be pursued.

A detailed list of the **contents** to the educational objectives should also be produced, by providing details of what has to be taught (e.g. specific tasks and subtasks). Each content should be associated to a specific task with a specific level of difficulty and a list produce of the foreseen levels should be produce also defining the possible scenes, in case that multiple scenes are foreseen for each task.

The definition of contents is directly linked to the overall delineation of the **game structure** which basically refers to: 1) the game internal organization: (e.g.: scenes / levels, progression modality) and the optimal sequence of game actions (e.g.: Player identification, avatar choice/construction (if needed, possibility to set personal parameters and to test the system on specific users' behaviour).

Particular importance should also be given to properly and accurately defining the **play out of the situation**; the educational strategy suited to each task (e.g. drill & practice or experiential learning or ...) and the modality it is implemented should be defined as well as the exact sequence of actions (from scenes to levels) and the possible deviations from the standard (if any); if specific hardware complements should be adopted (e.g. in i-Treasures, the sensors), their role should be made explicit.

Interaction & feedback provision should be a priori defined [22] by highlighting: 1) the form of the feedback (oral/visual/ written/iconic etc..), 2) the preference/need for formative or feedback (or both), 3) the most suitable feedback provision modality (upon requestor confirmation/automatic) and type (oral/ visual etc...), 4) the eventual need for adapting/customizing the feedback provision to the personal needs/characteristics of each player (e.g. oral or written form) and should also be as much as possible customized on the basis of players' performance.

Together with the feedback provision attention should be devoted to a priori defining the methodology **for scores attribution and performance evaluation**; this means paying attention to their computation as well as to how the results should be made visible and comprehensible by the final users (students and educators). As to computation among other things one should consider, for example, whether the score obtained should be based on performance in each task, sub task or overall exercise, whether the number of attempts made in each task should affect or not the score. Alternative options could be, for instance, that scores computation is not machine-lead but based on a sort of self-assessment or self-monitoring", which also goes in the direction of sustaining metacognitive support to learning. As to the score visualization, it should be taken into account that the visualization modality (and timing) may highly affect the users' perception of own performance and if the system should visualize differently the scores obtained for the benefit of player and the educator (for the educator a more complete report is needed)

Another aspect that can highly affect the game design is the **nature** itself of the game to be implemented; of course, it should be decided a priori before starting the game design and implementation and is, to some extent, linked to the formulation of the educational objectives, can, nevertheless. Different constraints can be found, for example, if the game is meant to be as a team or individual game and if it is set to collaborative or competitive one.

IV. COLLABORATIVE DESIGN ISSUES

The i-Treasures experience has confirmed that designing an educational game is a very complex task, often involving different people and various competences.

In the i-Treasures context this difficulty emerged as being particularly relevant, as each game, in order to be designed and developed, required inputs from a variety of professionals with different background and expertise: experts of the cultural expression at hand, the technical people experts of

the sensors to be used, the technical people who developed the game, the educational technologists and methodologists, who provided advice about the educational aspects of the game, etc.

Starting from the definition of the learning objectives and of the contents to be addressed in the games, down to the definition of the game dynamics and of the interface, the whole game design process was the result of a collaborative process. This required managing a complex interaction among many people and taking into account a wealth of variables, some of them predictable, others completely unforeseen.

Important factors, such as the multi-disciplinary structure of the research team, the multi-modality of the sensor data, big divergences in the single ICH considered (e.g.: singing vs. dancing), played a key role in the overall process. However, most of the issues were solved by blending technical research and educational targets under a game design pipeline.

One of the most important lessons learnt from the experience and from the collaborative process enacted, was the need for high flexibility of the games and for a continuous monitoring and recursive process of adaptation and modification of the outputs. Thus, in i-Treasures an iterative approach was followed, where feedback was obtained by the involved professionals during intermediate development steps; updates of the design schema were consequently produced reflecting the contributions. This was managed through recursive and multimodal interactions among all the people involved.

IV. CONCLUSIVE REMARKS

The aim of this paper is to contribute to the debate around effective design of educational Serious Games and this is done by presenting the i-Treasures experience of game design.

In i-Treasures the game development process required a precise design methodology, able to integrate different aspects and different competences; such an endeavour required a huge collaboration effort by the partners and experts involved in the project.

While outlining some key aspects of the methodology adopted in the i-Treasures project to design the educational games, we have pointed out what are the main theoretical models and pedagogical principles that should guide the design of any game.

Future research directions include: sequencing of learning experiences, meta-reflection, peer assessment and group work that are interesting and innovative aspects of SGs.

References

- [1] Ott, M., Pozzi, F., 2008. ICT and Cultural Heritage Education: Which Added Value? In Lytras et al (Eds). *Emerging Technologies and Information Systems for the Knowledge Society. Lecture Notes in Computer Science*, 5288 (pp.131-138). Springer Berlin Heidelberg..
- [2] UNESCO Culture Sector, 2003. *Convention for the Safeguarding of the Intangible Cultural Heritage*. Unesco. Retrieved February 2, 2015, from <http://www.unesco.org/culture/ich/en/convention>
- [3] Van Eck, R., 2006. Digital game-based learning: It's not just the digital natives who are restless. *Educause review*, 41(2), 16.
- [4] Squire, K., 2005. *Game-Based Learning: Present and Future State of the Field*. University of Wisconsin-Madison Academic ADL Co-Lab. Retrieved February 2, 2015, from http://cecs5580.pbworks.com/f/10%20Game-Based_Learning.pdf
- [5] Bellotti, F., Ott, M., Arnab, S., Berta, R., De Freitas, S., Kiili, K., De Gloria, A., 2011. Designing Serious Games for education: from Pedagogical principles to Game Mechanisms. In *Proceedings of the 5th European Conference on Games Based Learning*. University of Athens, Greece (pp. 26–34). Academic Conferences and Publishing International.
- [6] de Freitas, S., Ott, M., Popescu, M., Stanescu, I., 2013. New Pedagogical Approaches in Game Enhanced Learning: Curriculum Integration (p. 310). Idea Group Inc (IGI). Retrieved from <http://books.google.com/books?hl=en&lr=&id=SyGqHbFCLD8C&pgis=1>

- [7] Bellotti, F., Berta, R., De Gloria, A., Lavagnino, E., Dagnino, F., Ott, M., Romero, M., et al., 2012. Designing a Course for Stimulating Entrepreneurship in Higher Education through Serious Games. *Procedia Computer Science*, 15, 174–186. doi:10.1016/j.procs.2012.10.069.
- [8] Persico, D., Pozzi, F., Anastopoulou, S., Conole, G., Craft, B., Dimitriadis, Y., Hernández-Leo, D., et al., 2013. Learning design Rashomon I – supporting the design of one lesson through different approaches. *Research in Learning Technology*, 21. doi:10.3402/rlt.v21i0.20224.
- [9] Kiili, K., 2007. Foundation for problem-based gaming. *British Journal of Educational Technology*, 38(3), 394–404. doi:10.1111/j.1467-8535.2007.00704.x
- [10] de Freitas, S., Earp, J., Ott, M., Kiili, K., Ney, M., Popescu, M., Romero, M., et al., 2012. Hot Issues in Game Enhanced Learning: The GEL Viewpoint. *Procedia Computer Science*, 15, 25–31. doi:10.1016/j.procs.2012.10.054.
- [11] Greitzer, F. L., Kuchar, O. A., & Huston, K. (2007). Cognitive science implications for enhancing training effectiveness in a serious gaming context. *Journal on Educational Resources in Computing*, 7(3), 2:1–2:16. doi:10.1145/1281320.1281322
- [12] Manitsaris, S., Glushkova, A., Bevilacqua, F., Moutarde, F., 2014. Capture, Modeling, and Recognition of Expert Technical Gestures in Wheel-Throwing Art of Pottery. *Journal on Computing and Cultural Heritage*, 7(2), 1–15. doi:10.1145/2627729
- [13] Pozzi, F., Antonaci, A., Dagnino, F.M., Ott, M., Tavella, M., 2014. A Participatory Approach to Define User Requirements of a Platform for Intangible Cultural Heritage Education. In *Proceedings of the 9th International Conference on Computer Vision Theory and Applications (VISAPP2014)* (pp.782-788), Lisbon, Portugal, 5-8 January 2014.
- [14] Yilmaz, E., Dagnino, F.M., Ott, M., Pozzi, F., Dimitropoulos K. et al., 2015. Novel Game-like Applications based on 3-D visualization and sensorimotor learning for Learning forms of Intangible Cultural Heritage. In *Proceedings of the 10th International Conference on Computer Vision Theory and Applications (VISAPP2015)*, Berlin, Germany 11-14 March 2015.
- [15] Kolb, D. A., 1984. *Experiential learning: Experience as the source of learning and development*. Englewood..
- [16] Kolb, A. Y., Kolb, D. A., 2005. Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. *Academy of Management Learning & Education*, 4(2), 193–212. doi:10.5465/AMLE.2005.17268566.
- [17] De Freitas, S., Oliver, M., 2006. How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & Education*, 46(3), 249–264. doi:10.1016/j.compedu.2005.11.007
- [18] Kiili, K., 2005. Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, 8(1), 13–24. doi:10.1016/j.iheduc.2004.12.001
- [19] de Freitas, S., Neumann, T., 2009. The use of “exploratory learning” for supporting immersive learning in virtual environments. *Computers & Education*, 52(2), 343–352. doi:10.1016/j.compedu.2008.09.010
- [20] Arnab, S., Petridis, P., Dunwell, I., De Freitas, S., 2011. Tactile interaction in an ancient world on a web browser. *International Journal of Computer Information Systems and Industrial Management Applications*, 3, 687 – 695.
- [21] Dagnino, F.M., Ott, M., Pozzi, F., Yilmaz, E., Tsalakanidou, F., Dimitropoulos, K., Grammalidis, N., 2015. Serious Games to support learning of rare ‘intangible’ cultural expressions. in *Proceedings of the 9th International Technology, Education and Development Conference (INTED 2015)*. Madrid, Spain, March, 2-4, 2015
- [22] Bottino, R. M., Ott, M., & Benigno, V. (2009). Digital mind games: experience-based reflections on design and interface features supporting the development of reasoning skills. In *Proceedings of the 3rd European Conference on Games Based Learning*.Graz, Austria. Academic Conferences and Publishing International.