

Collaborative Learning & Serious Game Development

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Abstract - This paper presents the overall Learning, Training and Mentoring Framework as developed as part of the MASCA project. The key focus of the framework is on the establishment of a collaborative learning framework and an integrated learning package that focuses on supporting continuous performance improvement and learning (competency and capability at all levels) and ensuring that this overall learning is fully aligned to the strategic blueprint of the organization. One of the key outputs of the Learning, Training and Mentoring Framework was the development of a Serious Game called Skyboard. The development of Skyboard was based upon a training needs analysis and an iterative development and implementation approach at a large airfield. The research found that Skyboard was an effective means of enhancing communication, collaboration and decision making across intra-organizational agencies which had to collaborate in order to implement a cross-agency change initiative. This paper includes an overview of the supporting learning theory that has emerged from the MASCA project.

Keywords - MASCA, Collaborative Learning; Serious Games; Skyboard;

I. INTRODUCTION

Traditionally the concept of 'learning' has been related to formal education, whereas its use in the context of work is a relatively new phenomenon. Interest in workplace learning has expanded since the beginning of the 1990s, and currently the research in this area is both wide-ranging and interdisciplinary. The reason for this expansion is the unprecedented rapid change in society and working life that has taken place during the past few decades. The rapid development of information and communications technology, the growing production of knowledge in the economy, increasing internationalization and globalization as well as changes in occupational structures all have contributed to a challenging and continuously changing working environment

that requires personnel to be flexible and to quickly adapt to be able to operate in this environment. This work environment has made it necessary to find effective means of training that guarantee the preservation of high proficiency levels in employees. The contents and organisation of work have challenged not only educational institutions but also work organisations to develop new ways of ensuring that the level of competency and capability of the workforce meets these challenges (1). Thus, continuous and collaborative learning has become important both for individuals operating in the learning society and for organizations competing in international markets.

However many organizations are still focusing on the traditional approach to training. Figure 1 outlines 5 stages of work-place learning from stage 1 traditional classroom training right through to stage 5 more collaborative based training. The emerging evidence suggests that while many organizations are highlighting that they are not getting the value from stages 2-3, this is still where the majority of training activities are focused. Hart (2) found in her research that only 14% believe that the traditional approach to company training is an essential way for them to learn in the workplace.

For example in the Aviation sector, Human Factors training was mandated from a number of regulatory bodies (e.g., ICAO, EASA) which resulted in huge volume of Human Factors training offered to staff of Airlines, Aviation Maintenance Organisations, Airport Operators, Airport Handling Companies and Air Traffic Services. But 10 years on – does this approach to training (again primarily falling between stages 1-3 as identified in Figure 1) actually result in improved performance and enhanced capability in the workplace? Research from previous EU funded projects (3,4,5) highlighted that during the Human Factors training programmes, frustrations were often expressed by staff that

they were trying their best to apply the new learning but the system did not support them. Training was criticised by staff as being 'idealistic' and 'removed from the realities of the system'.

5 Stages of Workplace Learning (2010)

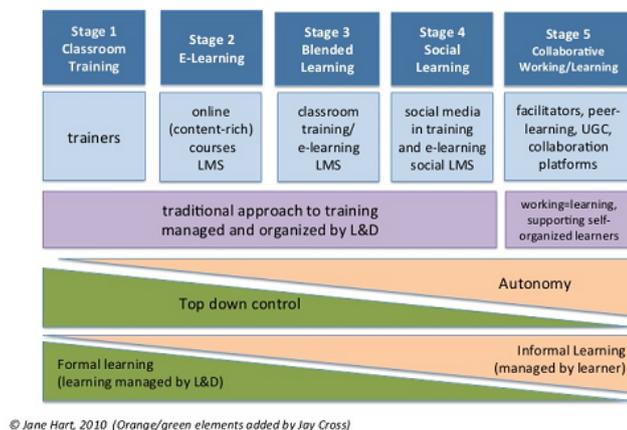


Figure 1. 5 Stages of Work-Place Learning

Return of Investment was also reported as having been difficult to demonstrate in terms of Human Factors training. Anecdotal evidence from aviation organizations suggests that they find formal training approaches "costly, repetitive, inconsistent and largely unmeasured" and they struggle to quantify the real value (increased safety and improved performance to ensure competitiveness) to their operations in the on-going investment in their training initiatives.

There is also evidence to suggest that as much as 60 to 80 per cent of the 'learning' that occurs in today's workplaces arises from the more informal, tacit and social systems of knowledge exchange and from what actually happens in normal operational practice (3,5,6).

In order to successfully optimize the way this learning is developed and existing knowledge and experience is exploited, organizations need to facilitate the dynamic capabilities required for converting the knowledge available from the insights and competencies of people into appropriate structures, processes, products and systems that allow the value to be exploited. Therefore what is needed is a more flexible, operationally embedded deployment of on-going collaboration and learning opportunities within the air transport system- 'the right level of knowledge, to the right people at the right time'. Furthermore the knowledge and skill has to be based on a new understanding of how the complex system-of-systems of aviation works, how it should be managed, how it can be changed and how to design for learning and improved future system operations (7).

The overall objectives of this paper are to provide an overview of the MASCA Learning, Training and Mentoring (LTM) framework, focusing on the development, implementation and evaluation of a Serious Game to support

learning and collaboration in one organization's change management program.

II MASCA APPROACH TO COLLABORATIVE LEARNING

The overall MASCA work program has a primary focus on the transfer of change management capability into the organizations that are responsible for and involved in change. In order to effectively support the change initiatives a core component of the MASCA Change Management System is a framework for Learning, Training and Mentoring (LTM).

The key supporting infrastructure within the MASCA learning framework was the establishment of a collaborative and flexible (i.e., on-line) 'meeting place' to enable a community of users to collaborate in building and learning an archive of practical knowledge that could continually capture the overall learning processes, lessons learned, the requirements of key skills and knowledge into a flexible and interactive resource that could be utilised by all stakeholders. Figure 2 provides an overview of the key features of this integrated and collaborative learning community.



Figure 2. Overview of Key features of MASCA Learning Framework

This proposed approach to learning is multi-layered and multi-faceted. In its broadest sense it is a continuum of approaches in terms of time, place, pace, content and mode of learning applied in varying degrees. Its overarching purpose is to increase opportunities and options available to learners and give them greater control over their learning through an integrated package of learning modes and interactions. This includes the capacity for high level strategic competency and capability through participation in a Master's Program. One of the key outputs of the MASCA project was the development of a Master's Program 'Managing Risk and System Change' due to commence in September 2014. The framework also includes the design and delivery of highly participative

training programmes (both on-line and face-to-face). The training programs developed have provided practical tools & guides, personal development opportunities practices dealing with ‘real’ implementation issues & providing the participants knowledge, skills and attitudes to ‘practice’ in a safe environment.

As one of the key aspects of the framework focused on the establishment of a learning community the active use of social media (e.g., on-line discussion groups) and on-line collaborative learning tools (e.g., webinars) was also utilized as part of this overall learning framework. The development of a Serious Game was one of the innovative outputs of the project and the following section provides an overview of the development process, implementation and evaluation of the SKYBOARD Serious Game and how it supported the implementation of change in one organization.

III SERIOUS GAMES AS AN EFFECTIVE MEANS TO MEET LEARNING NEEDS

To support the MASCA learning and training framework, a serious game called Skyboard was developed within the MASCA programme. “Serious Games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement.” (8). They are games that aim to teach the players competencies that are important and relevant for their professional development. Serious Games are often used in parallel with other learning tools and environments, such as lectures, e-learning forums, and simulators.

The advantage of using serious games over other learning tools is that serious games enhance students’ motivation (9). In fact the games elicit them to play, and therefore learn, over and over again (9). A serious game is considered well-developed when the correct balance between entertainment and education is found. Therefore, the development of a serious game is a flexible process with many iterations and interactions between developers and potential users to ensure the correct balance and continuous and on-going learning.

IV METHODOLOGY

The development process of serious games is iterative in nature and visualised in Figure 3.

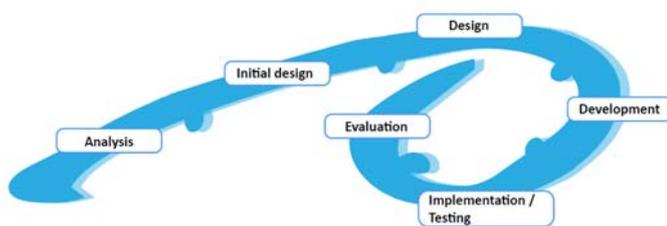


Figure 3. Development process of MASCA game

The development process starts with gathering information necessary for the initial design. Most of this information results from a training needs analysis (TNA), such as demographics of the target population, the available training time and the competencies that need to be trained. The rest of the required information comes from the user requirements analysis. This information answers questions regarding four entities: the knowledge domain, the game principles, the simulation model and the didactical principles. The target audience of Skyboard consists of people working at airports in middle or higher management. These are the people who have to make decisions for their company with regard to dealing with events in their operations, such as lost passengers, de-icing and closed runways.

Based upon the TNA a competency profile was developed, with the key competencies including creating a common understanding of the mutual benefits of implementing A-CDM, communication, joint decision making and information sharing. For the complete profile of Skyboard the reader is referred to Zon and colleagues (10). The competency profile forms the basis for the learning elements of the game, while the game dynamics form the framework and the basis for the ‘fun’ elements of the game. They comprise the way how players interact with the game. Examples of game mechanics are the pieces that chess players use to express their moves on the board to the other player, or rolling a dice to determine the likelihood that something happens during game play. Learning elements from the competency profile and ‘fun’ elements from the game dynamics are necessary to create an effective serious game.

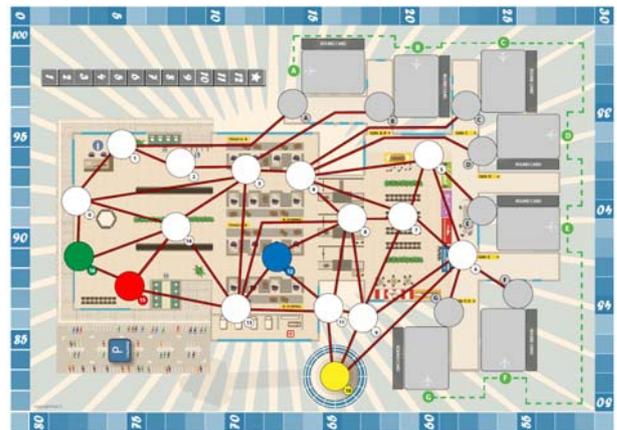


Figure 4. The Skyboard Game

Competencies and game dynamics are selected and deselected in this phase of game development to create the best fit between the two. Some game mechanics cover multiple competencies and some none. Competencies that are similar or fit into the same mechanics can be chunked, but care needs to be taken to ensure that players will be rewarded for demonstrating the behaviour that matches with the competency profile and ‘punishes’ non-compliant behaviour.

After this important analysis and initial design phases, the iterative phase starts. Part of this phase is aimed at balancing

and test-playing the game with prototypes. Balancing is necessary to ensure that each player has an equal chance of winning. In serious games design it also entails ensuring that appropriate use of the to-be-trained competencies is more rewarding. An automated procedure based upon a computer model of the game was developed for parts of the balancing work. This procedure was alternated with test playing with real players to compare computer models with the creative and erratic behaviour of real human players.

V PLAYING SKYBOARD

Skyboard is a board game that is played by 4 persons. Each represents a stakeholder in the A-CDM process: ATC, Airline, Ground Handling and Airport Operations.

The players aim to get all aircraft to depart on time. However, during the game several bottlenecks occur at random, such as missing passengers, snow on the runways, etc. These bottlenecks make it difficult to adhere to the schedule and forces players to decide which aircraft should be services first or maybe be cancelled.

The game can be played in two different modes. In the A-CDM mode players are rewarded and elicited to collaborate and play as they would in an airport where all stakeholders are fully operating according to the A-CDM principles. In the non-A-CDM mode players are encouraged to work as they normally do without a strong necessity to collaborate or work according to A-CDM principles. Based upon the scores that players will accomplish when playing the game and based upon the feedback that players will receive from the trainer the difference between A-CDM and non-A-CDM will become unmistakably clear to all players.

The game board can be seen as a shared Situational Awareness between the players. The board presents a bird's eye view over the airport. All aircraft standing at the gate, all bottlenecks that need to be solved and the status of every player can be seen. All players are able to see for themselves what the situation at the airport is, where help is needed, where deviations from the planning are taking place. They can decide for themselves whether they should take action and support the other stakeholders or not based upon this knowledge.

The game can be played without an instructor present. However, a well-trained instructor will enhance training effectiveness. The instructor's task is to observe players during the game to identify behavioural markers that are related to the selected competencies. Upon identifying one of these behaviours, the instructor interrupts the game and discusses the behaviour with the players. This way, the players are given the chance to practice the correct behaviours during the same game in a safe learning environment.

VI EVALUATIONS FROM DEVELOPMENT WORK-SHOPS

The test sessions during the first development cycles took place within the development team, with gaming and training experts at the Dutch National Aerospace Laboratory – NLR

and with training experts at Trinity College Dublin. Three more elaborate test sessions /workshops were held at the airport with representatives of the target group.

Each of the large sessions was preceded by a presentation of the role of the game in the process of introduction of A-CDM and test play to familiarise the players with the new game. Instructors were present during the test sessions, but their primary role was to guide players through the game rules and to gather information on improvements. Therefore, feedback on the competencies was not provided by the instructors during gameplay.

Before and after playing the game, players were asked to fill out a questionnaire aimed at identifying their attitudes towards CDM and serious games in general and towards Skyboard specifically. The following paragraphs present these test sessions and the results they have generated.

A final validation test has recently been undertaken to identify if players learn the competencies the game aims for, if players enjoy playing the game. The results of this validation will be published shortly.

A. First Test Session

The first of these sessions was intended to test the concept of Serious Games and to generate ideas for further development. An early prototype of the game was played and commented on by airport staff. This session focused on game dynamics and on how representatives of the target group considered serious games.

The trainees were very enthusiastic about using a Serious Game to aid the introduction of A-CDM. They were positive about physically meeting other representatives of airport stakeholders, instead of only talking on the phone or emailing. However, the game dynamics were not good enough yet. The game did invite trainees to discuss A-CDM related issues with other trainees, but it did not immediately invite to cooperate. Therefore, the game development after this session focused on developing game dynamics that force trainees to cooperate. A game dynamic that changed after this session was, for example, the introduction of barriers that make it harder for players to achieve their goals.

B. Second Test Session

The target group of the second session consisted of change managers from the same airport. The goals of this session were to verify how the trainees appreciated the improvements that were made to the game and to explore what the trainees learned by playing the game.

This session started with exploring the attitudes of participants towards the introduction of A-CDM. Even though the expectation was that some participants would still be a little unsure of the implementation of A-CDM at the airport all participants indicated that they were looking forward to it. Their expectations for CDM were that it contributes to a better

coordination and better predictability of arrival and departure times.

The second research question pertained to the belief of participants that Serious Games can effectively contribute to learning. Trainees were asked to rate several learning environments on their suitability for training skills. After playing the game, the trainees were more convinced of the effectiveness of serious games compared to their initial attitude towards serious games before playing the game (the belief that serious games can be used for training skills and attitudes increased significantly after playing the game, $p < 0,05$).

Thirdly, trainees were asked which learning goals they thought the game would achieve. Most of them indicated that the main learning goal is in the area of collaboration.

A final research question was to find out how much players enjoyed playing Skyboard. This is an important question, because students (as stated above) who enjoy a learning experience are more motivated to perform their best and will therefore learn more from their experience. The participants indicated that they enjoyed playing the game. **Figure 4** shows the attitudes of players regarding Skyboard. Players were satisfied with most aspects of the game, but somewhat less positive on learning how to play the complex game.

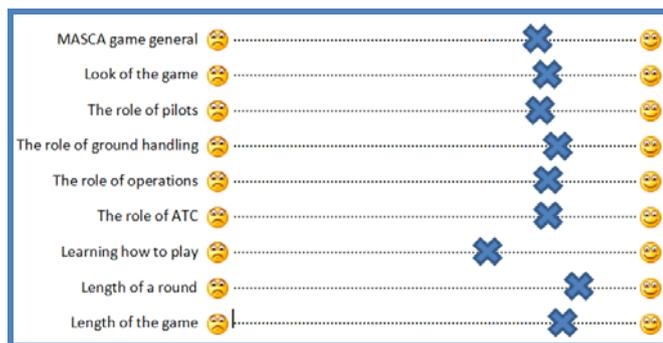


Figure 4 Target Group Attitudes towards Skyboard

C. Third Test Session

The third session was performed with the same target group as the second session and it mostly studied the same questions, but it was performed with other stakeholders from the airport. An additional goal of this session was to study if the game required further improvements or if it was ready for finalisation and validation.

The results are mostly comparable to the second test session. All participants looked forward to having A-CDM introduced at their airport. They expect better predictability and more accurate information on arrival and departure times. The participants' beliefs towards the effectiveness did not change after playing Skyboard, but were quite positive (7 positive against 1 negative) beforehand. The learning goals that they expected were a better understanding of A-CDM and were in the area of cooperation.

An important finding from this session was that there were no significant differences in the appreciation of Skyboard ($F = .192$; $p = .977$). Thus, the participants in the final test session were comparably satisfied with the game, indicating that further improvements on game dynamics were no longer necessary and the game was ready for validation.

VII CONCLUSIONS

While the fun element is a key aspect of the Serious Game development, this study and other studies have shown that Serious Games do play a role in fostering the development and improvement of various soft skills, like communication, collaboration or negotiation and to enhance overall collaborative learning (11,12). The key benefits of introducing the Serious Game to support the implementation of A-CDM in this case included the opportunity for the key stakeholders to spend significant time with each other, getting to know each other in a fairly relaxed and 'fun' environment and getting a better understanding of each other's roles and the challenges they were facing with the implementation of A-CDM. A second benefit of the game was that it raised more awareness and initiated a more in-depth discussion of the implementation of A-CDM and what it meant for each of the stakeholders. The next phase of the overall approach within the airport is to more fully embed the Serious Game into a more specific training program for the key operational staff. Collaborative learning is an approach based on the idea that learning is largely a social behaviour involving groups of learners working together as a team to find a solution and work together in implementing that solution. Collaboration is broadly defined as an interaction among two or more individuals and can encompass a variety of behaviours including communication, information sharing, co-operation, co-ordination, problem solving and negotiation in order to create an overall common and compatible operational picture. One of the most important elements of learning which is absent from traditional approaches to training and learning is the process of social interaction in order to establish an understanding of this common and compatible process and the content of knowledge, competency and capability to achieve the overall strategic plan for change. This level of understanding and learning is vital for the success in implementing A-CDM and ensure on-going learning.

The underlying theoretical principles of the MASCA Learning Model is based on an on-going and collaborative learning process, with each phase involving preparation and guidance, collaborative learning, consolidation of that learning and practically focused next steps that can be deployed to enable overall change management. Figure 5 describes a 5 stage approach to the overall MASCA learning process.

Stage 1: Understand the present - Collaborative learning to build a common operational picture amongst diverse stakeholders in the operation begins with understanding their present working situation (the 'local rationality' of each stakeholder group) and making tacit knowledge explicit thus ensuring a full understanding of both formal and informal

ways of working. This forms the basis for the current ‘as-is’ process or processes. The primary learning mode is assimilation of that newly explicit information..

Stage 2: Envisage the future - The models of the as-is process(es) then provide a framework for sharing and exchanging information, enabling an understanding of each other’s local rationalities. This provides the basis for a collaborative process of thinking of potential transformations of the as-is process into a future process – envisaging the future - leading to a model of the future process. The main learning mode here is integration of different models, making explicit the principles that enable the design of a future process.

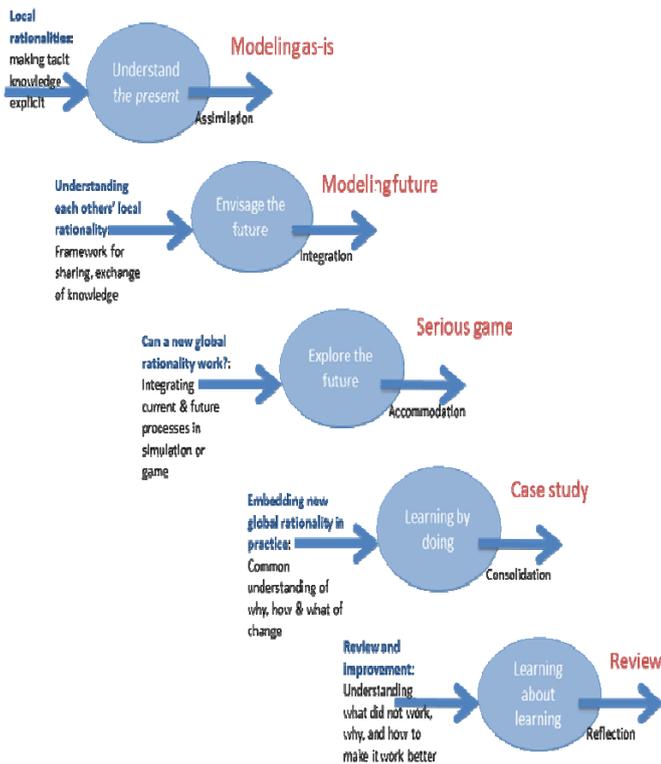


Figure 5. The MASCA Learning Process

Stage 3: Explore the future - The functional adequacy of the future process model then needs to be tested in some kind of exploration. This can be a simulation or game (in this case it was the SKYBOARD serious game). This can be more or less formally constructed, depending on requirements and opportunities. The basic question is – can the new global rationality work? The main learning mode here is accommodation – the adjustment of understanding to the ways in which the future might work. The more active and engaging this exploration as in a serious game, the more it provides the opportunity to develop tacit knowledge generated through the actions and interactions of the game.

Stage 4: Learning by doing - The fourth stage of the learning model comprises the embedding of this new understanding (common operational picture or global rationality) in normal

everyday practice, initially in a pilot trial or case study. This seeks to prioritize learning-by-doing to deepen and broaden practical understanding of the how, why and what of the changed reality. The primary learning mode is consolidation of all the learning of the previous stages into a new practice, based on shared understanding, intensifying the development of rich layers of tacit knowledge about how the system now works.

Stage 5: Learning about learning - The fifth stage involves reflection about how the change initiative worked (or not), generating a new improvement cycle. This provides a feedback loop to the plan and an opportunity for wide participation in learning. Middle management is critical in feed forward and feedback. This stage may provide direct opportunities for a higher level of collaboration or participation in the change, including locally-generated change initiatives. This stage is also critical at the strategic level and longer-term trajectory of capability building within the organisations. Thus internal change managers and other specialists within the organization need a process for their own competency development through advanced learning, for example in a Master’s program.

It is becoming apparent that we are at the beginning of a fundamental shift in the way that both learning and working is happening in organisations. Therefore the establishment of a collaborative learning process and integrated learning package needs to focus on supporting continuous performance improvement and learning (competency and capability at all levels) and to ensure this overall learning is fully aligned to the overall strategic blueprint of the organization.

A key aspect of this framework is that it requires persuading organizations to this new way of learning. This means recognizing it is no longer just about using traditional “command and control” approaches (that are employed in most training solutions to try and force people to learn), but will also involve encouraging and supporting people to engage in new collaborative activities to support one another as they work by helping them to “connect and collaborate”..

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