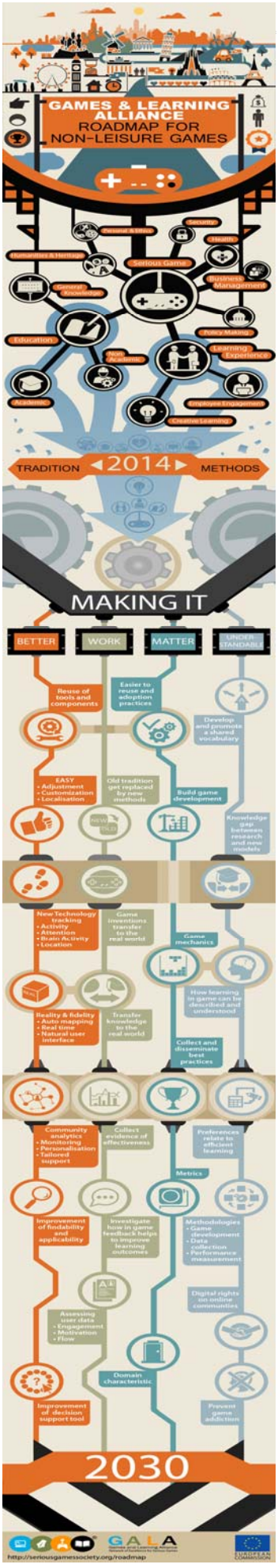
Roadmap on Serious Games in Companies



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1 INTRODUCTION

Serious games are games that educate, train and inform; and they have been shown to be successful as a learning method for conveying skills on complex tasks. It could therefore be expected that serious games would play an important role within corporate training, but this seems not to be the case. This document analyses the state of the art of serious games that are for use in companies. It then identifies gaps that need to be addressed by research.

There is a long tradition of the use of Serious Games for corporate training, going back to the 1950s (Cohen & Rhenman, 1961). Serious Games have proven to be an important tool in supporting training in industry (Michael & Chen, 2006). The evolution of Serious Games has continued and in the last 15 years there has been a significant growth of interest and research in the application of serious games. In particular there has been a digital turn (Aldrich 2005; Faria 2001; Gibson & Aldrich 2007), which has led to an upsurge in interest. Some recent examples are the use of Serious Games in the US Army - in 2002 they released the online, free-of-charge, America's Army (Alhadeff, 2007).

A review of serious games intended for use in companies was carried out (see Azadegan & Riedel, 2012; Riedel & Azadegan, 2014). This review produced a framework for classifying the ways that serious games can be used in companies. Further, the framework was validated by mapping circa 60 SGs onto it (Azadegan & Riedel, 2012). Serious Games can be used in companies in four main ways (See figure 1 below):

1) in corporate training,
2) in active company interventions/ strategic change,
3) through viral diffusion and
4) with Gamification

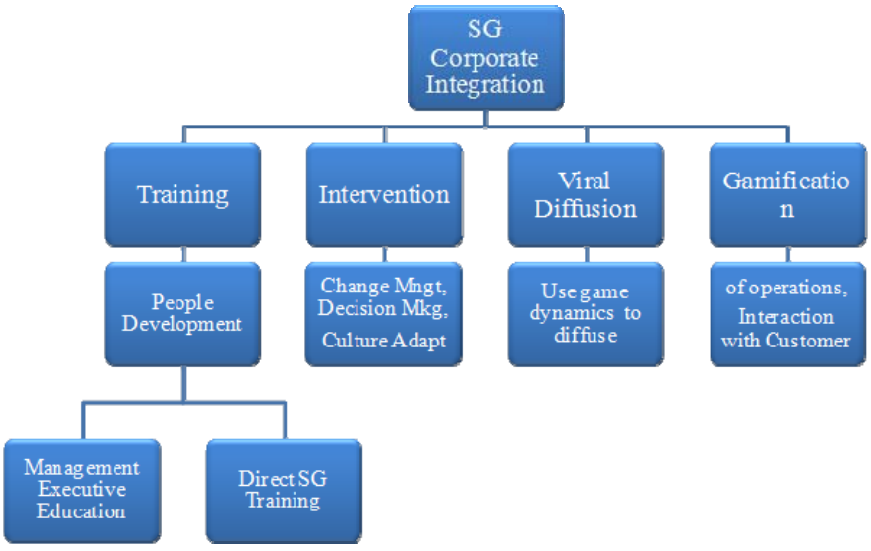


Figure 1: Classification Framework of Serious Games Use in Companies

Importantly the framework identifies that serious games can be used as organizational change interventions – to improve organizational processes (by modelling existing and improved processes), for cultural change/adaptation, and for strategy development. The classic example of a strategic intervention is the use

of Lego Serious Play – which can be used by companies to model their vision of possible future strategies. There has been a recent growth in the use of gamification within companies for both internal uses (eg. Gamifying corporate social network systems) and external uses (advertising/promotional purposes). Finally, serious games may be distributed through an organisation through a process of viral diffusion – as opposed to just being used on formal training programmes. This viral diffusion approach enables a rapid uptake of serious games in the company and encourages mass participation – thus achieving a low cost per participant.

1.1 Corporate SGs SoA overview

A mapping of the state of the art for SGs for business and industry was carried out (Riedel & Baalsrud Hauge, 2011; GALA D7.1). As a first step a classification scheme of applications of serious games for business and industry was devised. The classification scheme has got two dimensions – simulation level (individual, team, organisation, etc) and skills mediated (hard: product knowledge, etc; and soft skills: learning, creativity, etc.). The primary dimension of this classification scheme is that of the simulation level, see Table 1 below. The "simulation level" means the level, or amount, of the world that is simulated in the simulation or serious game. This is a hierarchy starting with the World/ God/ Universe – in which level whole worlds are simulated. The hierarchy then proceeds downwards from nation, industry, inter-organisational, business/ organisation, department/ organisation, group/ team, discipline and individual to games addressing the Operations/ Task level. The table below gives an overview of the results of the mapping: the areas of a business that serious games can be used in (simulation level), example applications, example SGs and the target users. This shows that many areas of business are addressed by serious games.

Table 1: Overview SoA corporate serious games

SG Level	Application	Example SGs	Target users
Inter-organisational	Supply chain management	Seconds, STP-VP	Engineers, managers
Strategy	Strategy problems and strategic change	Lego Serious Play	Senior managers, functional managers
Organisation	• Behaviour change: *- gamification of corporate knowledge sharing* *- (customer) social networking platforms* *- energy saving* • Communication: *SGs as a novel means* Marketing/ Brand awareness	 Deloitte, Joiz EMC Ramp SAP Vampire Hunt Siemens' Plantville	All employees The public, potential customers
Department/ organisation	Change management Cultural change Cultural Awareness	EIS, Wallbreakers Lego Serious Play Afghanistan	Managers, Departmental managers
Team	Business simulations/games (hundreds of examples – focused on finance)	TopSim	Executive education

	Collaboration	TeamUp	Managers
	Negotiation	Eagle Racing	Managers
	Teamwork	Cosiga, Beware	Employees
Discipline	Call centre training		Employees
	Accountancy	Income-outcome	Managers
	Supply Chain Mngt	beer game	Engineers, Junior managers
	Production planning	Shortfall	
	Induction (on-boarding)		Employees
	Compliance/legal: Health and safety, diversity, money laundering, bribery, etc.		
Individual	Soft skills training: *communication,* *negotiation,* *decision making,* *psychological profiles,* *thinking styles,* *creativity* *healthy lifestyle*	*Mindbloom's Life Game, NEXTJUMP*	Employees, managers
Operations/ Task based	Training for assembly operations, Aircraft maintenance	Vistra	Employees – technicians; Employees Technicians
	Customer service	ABC Bank	Bank employees
	Pressure sores reduction	STP	Nurses and caring professionals
	Sepsis improvement	Sepsis 6	

From this overview we can derive a basic classification of the serious games in use: whether they address strategic or operational issues and whether they are digital or not. Although digital games have made good progress the since the late 1990s, non-digital games (either based on boards or cards, or using other physical artefacts – such as plastic bricks) are still very much used. It was stated by one the leading German business games designer at ISAGA 2014 (TopSim) that board games have a key advantage – they display a continual overview of the company finances and it is easy to visualise the flow of cash (this is something rather hidden in computer-based finance games/simulations). This highlights the fact that digital and non-digital games have their specific advantages and therefore, there is no definitive reason why digital games should dominate. It is a question of who is the target audience and what pedagogical lessons are to be delivered. For example, front line healthcare workers, such as nurses typically do not have access to computers in their normal working time and so non-digital games could be more effective in delivering and refreshing knowledge.

1.2 Basic classification of corporate SGs

Table 2 shows the different types of SG applications within the corporate sector. It makes a distinction between SGs which are used for strategic purposes and SGs used for operational purposes. Typically, SGs used for strategic purposes need to address unique situations in a company and therefore they need to be highly adaptable to that situation. Therefore, non-digital games are more suitable as the facilitator can carry out this adaptation. Digital SGs have the significant advantage that they can deliver the same content to large numbers of participants and therefore their cost per participant is low.

Table 2: Basic classification of corporate SG

Strategic SGs	Non-digital	One-off, complex, adapted to organisation and purpose, low participant numbers, human interaction, use of facilitator; analysis, creativity	High cost per participant
Operational SGs	Digital	Addressing common tasks/activities at operational level, procedural knowledge, multiple participants and large numbers, cost effectiveness, facilitator not needed, low human interaction	Low cost per participant

A typical example of an SG used to address strategic issues within a company is the well known LEGO Serious Play (see Figure 2). This SG is the most flexible and adaptable SG available. It can be used for developing new strategies for companies and also for developing cultural awareness between for example two newly merged companies. LEGO serious play does rely heavily on the facilitator and this is what creates its flexibility.

Figure 2: Lego Serious Play in Action

1.3 Game type/technology:

Table 3: Game type and technology within corporate training

Non-digital	Physical games: Board games, Lego/ bricks.
Digital	Computer-based, web-based, 2D/3D graphics, VR

Physical, non-digital, SGs are either based on boards with 'counters' or player pieces (eg. most non-digital business simulation games), cards (again some business games use these – for announcing unexpected events), or some form of bricks or parts (these are typically used in production/operational games).

As 3D and VR technologies develop and in particular become cheaper they become natural technologies to use where high-fidelity to the real-world and it operations are requirements of the pedagogical situation. This would include most manufacturing operations, where realistic visuals of the workpiece and machines are required for training purposes. This would also be the case in surgery where 3D-VR can be used to increase the time surgeons can spend learning their profession and also practising new procedures. However, in most companies 2D graphics are all that is required: see for example Figure 3 – the ABC Bank customer service game and Figure 4 the Afghanistan pre-deployment military game.

Figure 3: Call Centre SG

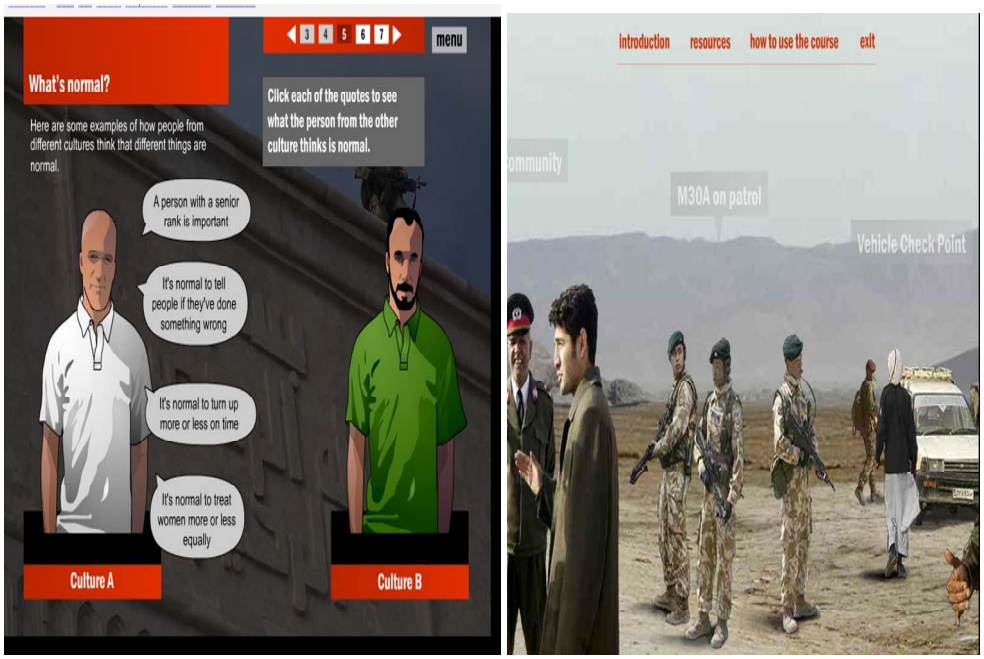


Figure 4: Afghanistan Pre-deployment SG

2 SGs in companies – Roadmap Topics

The main topics for the roadmap were derived after several group discussions among the Gala members active in corporate SGs, in consultation with industrial members of the advisory board, in collaboration with SIG3.1 (Business & Management) and SIG 3.2 (Engineering & Manufacture) and ad-hoc discussions with industry contacts. The main challenge is the adoption and use of SGs in companies. Companies are still not aware of the benefits of SGs. The surge of interest in digital serious games has helped to raise awareness; however, more needs to be done. This roadmap identifies the key challenges and sets out a time-plan for how they can be met by the serious games community.

Obviously the application domain of SGs within companies was the most important topic, followed by evaluating the effectiveness of SGs, game analytics, data and privacy issues, and game mechanics and learning. We also identified technical topics as being important: development of mobile SGs/learning, emerging interaction devices (Occulus rift, z-space, Microsoft Kinnect, etc) and interoperability. After careful consideration and consultation with the GALA technical committees, it was decided these topics would be better covered in those technical roadmap sections (eg. HCI, SG programming, etc.

The following main topics were identified for the corporate training roadmap:-

1. Corporate SG Applications
2. Evidence of SG Outcomes in companies: learning & commercial outcomes
3. Game analytics & data and privacy issues
4. Game mechanics and learning
5. SG development from 'art' to science
6. Development of remote/mobile SG learning

2.1 Topic 1: Corporate SG Applications

This section analyses the applications for which serious games are used in companies. It gives an overview of the state of the art of existing games, identifies the gap between the vision and the SoA and proposes research challenges to be addressed by researchers (internal and external to GALA, those working on SG evaluation methods, game analytics and game mechanics.

2.1.1 State of the Art

The table below presents a Classification of the types of applications addressed by SGs in companies (corporate training, change management, and gamification). It identifies the main learning outcomes addressed in each of these areas. In corporate training SGs can target Hard Skills (eg. product and job knowledge – this could be how to assemble a component on an assembly line, or the product features that a sales person needs to know). Or SGs could target Soft Skills, such as communication and negotiation skills. The third area for training is in legal and regulation compliance (eg. health and safety). SGs can also be used in companies to change individuals and the organisation – this can be to change the culture within an organisation, change individual behaviour, to change (improve) organisational processes, or for change management (overcoming resistance to change, etc). Finally a fast emerging and growing area in companies is that of gamification. Here companies are using gamification to engage and motivate participation both of their (internal) employees and externally with their customers.

Table 4: Classification of Corporate Applications of SGs

Application Area	Topics Addressed		Examples
Training	Hard-Skills	Product knowledge Procedural knowledge Job knowledge Decision making Financial Awareness Business Simulation SGs	Assembly, Maintenance; Call centre Customer service IT systems Project Management
	Soft-Skills	Interpersonal communication Team working Negotiation Decision-making Problem solving - multicultural working - multilingual working	TeamUp EIS Eagle Racing Beware Afghanistan Cosiga
	Compliance	Health & Safety Diversity Legal compliance On-boarding	
Change	Culture Behaviour Process improvement	Company merger Energy saving Factory and office work	LSP Online platforms OFFSIM

	Change management	New technology, re-organisation , etc	EIS, Wall Breakers
Gamification	External Use	Advertising Customer behaviour Smart Branding	Plantville
	Internal Use	Awareness campaigns Online platform participation Process improvement	Nutrition Joiz

It has to be said that there is a preponderance of quantitative business games (or simulations) on the market. Most of these target the financial operations of a hypothetical company (these include such accounting topics as capital investment, cash flow, debts, inventory costs, etc). It's now time to better understand what companies need and how to make improved SGs that deliver effective and cost-effective results.

The key points of the SoA are:-

- Serious games are context dependent and require subject knowledge for their development
- They are active learning methods and promote hard and soft skill development
- They are multidisciplinary and multi-person games – which should be ideal for industrial purposes
- They can be complex and based on simulations of real-life systems and processes
- They need facilitation by human facilitators in order to get the best learning out of them, although they can be used stand-alone.

Most real life skills are complex, i.e. they involve both technical and social aspects, which often lead to an increased complexity of the training. Consequently, a new approach is required to combine the best practices of human and computer managed training tools, for example serious games.

Table 5: Corporate SGs Application: SoA

	Corporate SG Applications
Relevance/priority (on a 1-5 scale)	4 (high)
SoA/ SG Current Status description	1) Team player games. This is a feature already implemented in many games, but it is foreseen to become more and more important in order to build or increase team cooperation, spirit and communication among employees. Individualism is one of the utmost characteristics of our society, but in most cases it is against the productivity objectives of a company. However, despite the fact that many games state that they address team working skills we do not fully understand how team playing and group dynamics impact on game results and whether

	developing team working skills in the game transfers to everyday working. Research is needed to identify the effectiveness of SGs for developing team working skills and whether they are transferred to everyday work. 2) Developing understanding of how SGs can better mediate team-working skills, decision-making and soft skills in general. Virtually all SGs targeted at the corporate sector say that their games improve team-building, decision-making and soft-skills. However, the scientific evidence for this is lacking. In particular we need to know how team-based SGs can effectively build team-working skills – should this be through context specific games (which are typically custom-built, complex and take a long time to develop)? Or should it be through abstract, reduced games, such as TeamUp! (Mayer, et al. 2013), which provides the necessary scaffolding to develop team collaboration and decision-making without huge complexity and development effort. They also have the advantage that they can be used in many industrial sectors and types of company and therefore will more easily return their development cost. The issue to be addressed by research is then, whether they are effective at building team-working skills in different industrial contexts.

2.1.2 Vision and Gap

This table summarises the gap between the vision and the state of the art for SG applications in companies. With the increased availability of Tablets and Smartphones there is a need to have SGs which run on these platforms (this could also help to overcome some of the corporate IT security concerns).

Table 6: Corporate SG Applications – Vision & Gap

	Corporate SG Applications
Vision 2020	Development of more effective team player games - Transfer of SGs to mobile platforms (tablet and smartphone) for easily reaching trainees everywhere - Scalability, in order to train increasing numbers of employees at the same time
Gap Analysis	Although much is claimed for SGs that they develop team-working, decision-making and soft-skills there is no rigorous evidence for this. There is therefore a need to understand how team playing and group dynamics impact on SG results; and how SGs can improve the decision-making skills of participants and mediate soft-skills effectively.

2.1.3 Research Challenges

Having looked at where and for what SGs are used in companies we have identified a key need to carry out research on team-based SGs: to understand how they work (that is deliver team working skills to participants) and whether these skills can be transferred to participants' everyday work. There is a lack of understanding of how team dynamics impact upon the outcomes of an SG. There is also a need to develop serious games for service based organisations – there are many for manufacturing companies and for supply chain management but not so many for mediating service processes.

Table 7: Research Challenges for Corporate SG Applications

	Corporate SG Applications	Until when	Priority
	Development of more team player games. This may be implemented :	2017	4
	- within a classroom, so that a trainer may be present, may interact with the trainees, and in some cases may be one of the players him/ herself, typically in a supervisor or team-leader role.	2016	4
	- in a distributed, or remote way, e.g., through the web or on smartphones. In this case standardization becomes a crucial issue.	2017	3
	Understand how team playing and group dynamics impact on game results	2018	4
	Understand if team-based SGs improve decision-making skills of participants	2018	3
	Understand if team-based SGs mediate soft-skills effectively	2019	2
	SGs for service based organisations are needed	2018	3

The diagram below shows the timeline for corporate SG applications. The research activities are divided into different categories (see colour code key to the right of the table): research and development, demonstration (of prototypes, early systems), regulatory and standards (development and compliance with), and market introduction. Research and development cover basic and plied research and prototype development. Demonstration includes piloting in end-user organisations and showcase applications/ integrations with corporate systems. Regulatory and standards includes the development of standards, the development and compliance with regulations and laws (eg. data protection, health and safety, etc). It also includes codes of practice and best practice. Finally market introduction means the selling on the open market of SGs. This implies that they are commercially ready – ie. robust and reliable, have facilitator training, and are promoted through marketing campaigns.

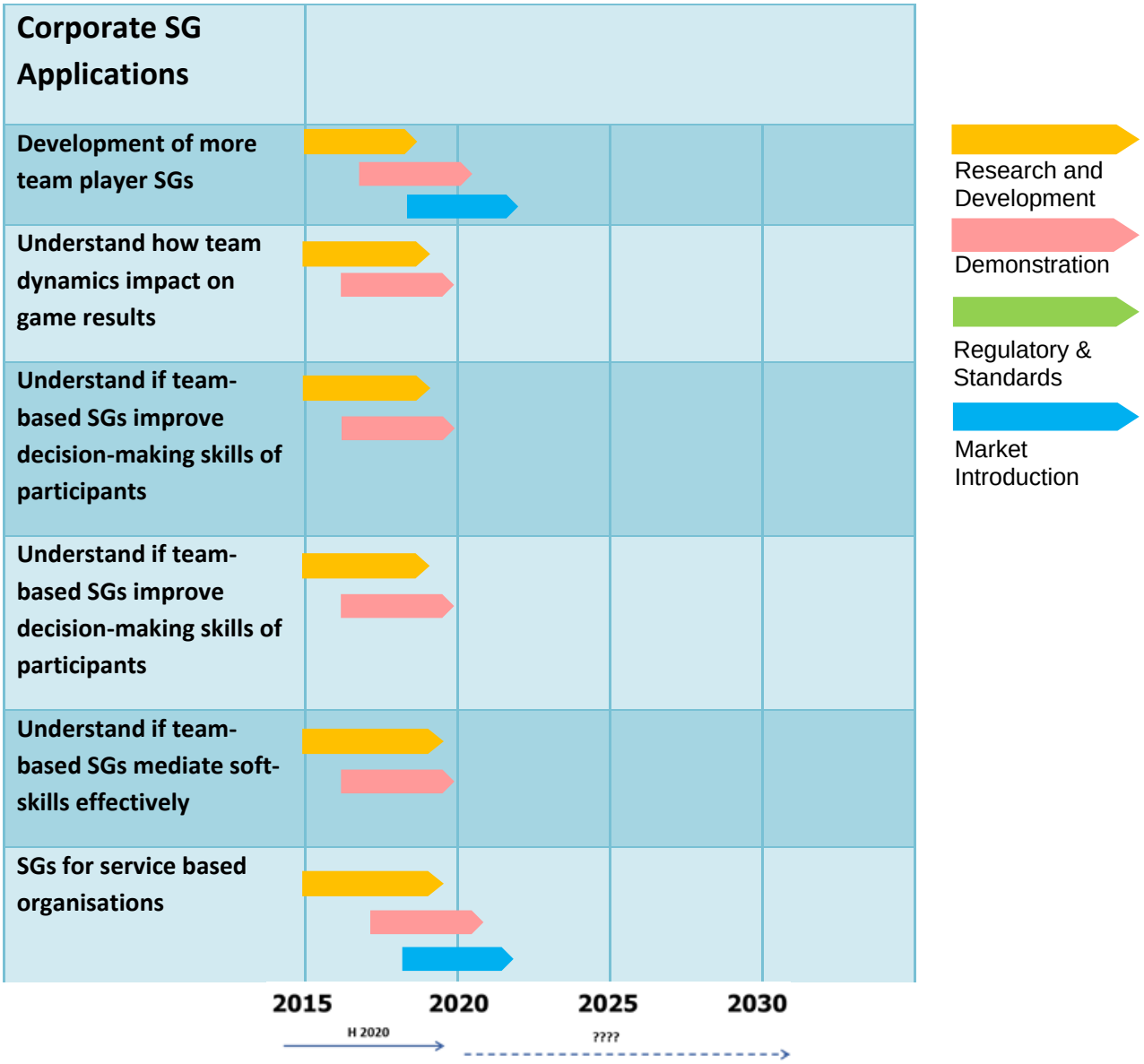


Figure 5: Corporate SG Applications Timeline

Most of the research identified for SG applications is basic research on the impact of SGs on team dynamics, decision-making and soft-skills. This research can be carried out without the development of new SGs – although this may be useful or needed, depending upon the specific research questions to be addressed and the SGs to be used in the experiments. There is a need to carry out research to understand whether SGs are effective team building tools (as their developers and vendors claim); and to understand whether these games produce any commercial benefits for the companies using them. These two questions do not have any hard evidence to back them up. There is also a need to develop effective measures for soft-skills and commercial outcomes and these are included in the next topic. The experiments and the development of the measures need to proceed in parallel.

There is a clear near for the development of more SGs for service organisations as this domain is not well covered by existing SGs – which have had a tendency to be based on manufacturing industries. However, the development of SGs for new applications in companies should be strongly led by the market. This requires

SG developers and researchers to understand the market needs of companies before embarking on the development of new games. Something to absolutely deprioritise is the development of yet another business simulation/ game. There are hundreds of these available – as any brief Google search will reveal. For some examples see: TopSim (Marga Games), and Profitability.

2.2 Topic 2: Evidence of SG Outcomes in Companies

This is one of the most important topics. There is desperate need for evidence of the effectiveness of SGs in companies and in particular of the commercial outcomes. Virtually all the rigorous studies of SG effectiveness have been conducted in an educational context with either school pupils or higher education students. We simply do not know if the positive results for learning effectiveness in the educational context apply to SGs in companies. We also do not know if SGs can produce positive commercial outcomes (improved productivity, increased revenue) for companies and if they justify their cost.

2.2.1 State of the Art

Table 8: State of the Art for Evidence of SG Outcomes

	Evidence of SG Outcomes in Companies
Relevance/priority (on a 1-5 scale)	5 (very high)
SoA/ SG Current Status description	A systematic literature review of studies of effectiveness of SGs used in companies was undertaken (see Gala Deliverable D7.3; Riedel, et al 2014). It was found that most 'business games' were developed and targeted at higher education. Only six studies were found, four studies used executive education students (Ben-Zvi, 2007; Trifschmann, 1976; Wolfe, 1975; Wolfe & Luethge, 2003), one study used a combination of both students and company employees (Cook, 1967) and only one study was carried out with engineers and project managers in a company in Italy (Pourabdollahian et al, 2012). The levels of analysis/operation in the games included the individual, team and firm levels. A number of methodological weaknesses were found as well: performance measures were poor (either proxy or derived from in-game indicators); weak performance measures (eg. use of engagement); no specific learning outcome measures were used (neither subjective nor objective). For example, the performance measures used in Wolfe and Luethge (2003) seem to be weakly formulated. They used in-game indicators, i.e. the return on equity and assets and earnings to evaluate participants' game performance. The use of in-game measures is problematic because we need to be sure that the game generates the correct measures – that is the fidelity and validity of the game's algorithms needs to be high. Other methodological problems were present in the studies too, in Trifschmann's (1976) research, no sample size was reported and it is thus difficult to evaluate the validity of study.

	It is difficult to develop appropriate measures for the learning outcomes, especially for measuring soft skills outcomes (for example, interpersonal skills, leadership and negotiation). Management and HR researchers need to develop validated measures for these so that they can be applied in a standard way to evaluate serious games. There are several reasons for this situation: confidentiality, opportunity (time, access), it is hard to measure some outcomes (especially soft-skills). In summary, although serious games have been used for the purpose of training for a long time, limited empirical evidence has been found for the effectiveness of serious games in companies. Serious games have two main effects in companies – learning outcomes and commercial outcomes. Future research is desperately needed to evaluate the effectiveness of serious games in companies. Development of more appropriate evaluation methods is also important in order to more accurately assess the effectiveness of using games in companies. Measures of the learning effects need to be developed, drawing on the many evaluation studies conducted in the educational context. Secondly, measures of the commercial impacts of serious games need to be developed – only if we can show that companies can gain commercial benefits will they be convinced to invest in serious games. A further recommendation is that serious games developers and evaluation researchers need to build strong relationships, so that the developed games can be evaluated with rigor and at low cost.

2.2.2 Vision and Gap

Table 9: Vision and Gap for achieving evidence of SG outcomes in companies

Topic	Evidence of SG Outcomes in Companies
Vision 2020	The vision for the evaluation of SGs in companies is that we have the evidence to prove that SGs deliver learning and commercial outcomes. This will remove the doubts in the minds of potential buyers and accelerate the adoption and use of SGs. In order to generate this evidence we need rigorous, cost effective and easy to use evaluation methods and measures. The benefits of serious games can also be demonstrated through the use of in-game learning analytics – these however are not necessarily specific to companies.
Gap Analysis	The analysis of the state of the art for evaluation of SGs in companies showed a number of critical gaps. First there is a dearth of academic/ research studies of the evaluation of SGs in companies. Second, the few studies that exist suffer from a lack of rigor, methodological weaknesses and poor measures/metrics. Lack of people trained in evaluation; In the case of soft skills there is even more difficult o measure game

	effectiveness (for example: self control under very stressful conditions is measured by sensors of sweat, eye movement, face expressions, etc., which are often invasive and that may perturb the game conditions). Finally, there is a lack of research studies of commercial outcomes of SGs. This is probably due to commercial confidentiality reasons. Therefore, challenges were formulated to address these gaps, in studies, methods and measures. Also the role of learning analytics was identified.

2.2.3 Research Challenges

The following table lists the research challenges for achieving evidence of the effectiveness of SGs in companies. There is a need to develop methodologies to evaluate the effectiveness and commercial outcomes of SGs. Second, there is a need to develop validated and standardised measures for both these issues. If these standardised measures are used then the performance of different games can be compared and lessons learnt for developing better games derived.

Table 10: 2.2.3 Research Challenges for evidence of the effectiveness of SGs in companies

	Evidence of SG Outcomes in Companies	Until when	Priority
	Development of effective and easy to use SG evaluation methodologies for use in companies [TC2.6, WP7]	2017	5
	Development of appropriate performance measures for SG learning outcomes in companies [TC2.6, WP7]	2016	5
	Development of appropriate measures for SG commercial outcomes in companies [TC2.6, WP7] - to some extent these depend on the SG application	2017	5
	Develop strategic partnerships for evaluation with SG developer companies	2015	5
	- Publish scientific articles on commercial outcomes evaluation (to achieve credibility with potential collaborator developer companies)	2014	5
	Include SG evaluation as a core topic in serious games courses, especially Masters courses	2015	5
	Develop methodologies & studies for evaluating the long-term benefits of SGs	2017	5
	Develop methodologies & studies for evaluating the transfer of learning from SGs to daily job/work	2018	5

Develop methodologies & studies for evaluating soft-skills	2016	5

The diagram below shows the timeline for evidence of the effectiveness of SGs in companies.

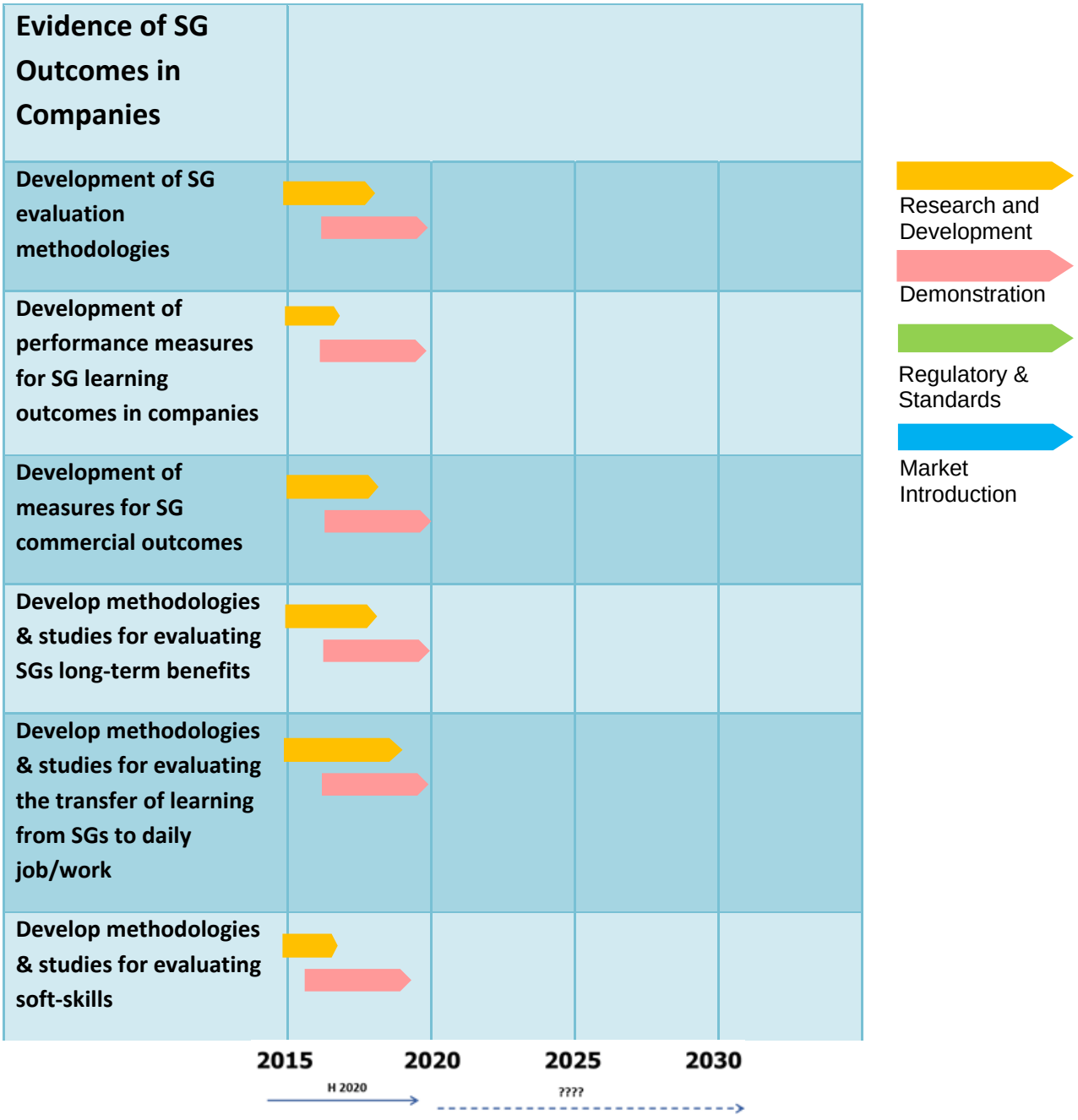


Figure 6: Evidence of SG Outcomes in Companies Timeline

Most of the research identified for Evidence of SG Outcomes in Companies is basic research. It consists of the development of methodologies and accompanying measures. This type of research can be completed in one to two years – it consists of the design of experiments and analysis techniques. The development of measures requires literature review, collation of existing constructs from the literature, refinement of constructs, experiments to collect data based on the constructs, statistical analysis (including reliability analysis) and it concludes in a set of validated constructs for measuring the concepts (learning, commercial outcomes, etc). This work is required for the research identified in the SG Applications topic on studying the

impact of SGs on team dynamics, decision-making and soft-skills. All of this research is high priority and should be carried out as soon as possible.

2.3 Topic 3: Game Analytics and Data Issues

This topic concerns the use of analytics in games to determine the progress of the participants and to use that to adapt the game to their rate of progress (slowing down for slow learners and speeding up for faster learners). A side effect of this is the need to collect sensitive personal information on the participants (how well they are doing in the SGs, how fast they are progressing, whether they have completed tasks or not and the final SGs outcome). This information needs to be treated with care, especially in a commercial environment, and processed according to the laws of data protection and privacy.

2.3.1 State of the art

Table 11: State of the Art: Game Analytics and Data Issues

	Game Analytics and Data Issues
Relevance/priority (on a 1-5 scale)	5 (very high)
SoA/ SG Current Status description	The use of in-game analytics and the collection of data for different purposes is a promising future direction. It does raise a number of issues: what type of data is collected and for what purpose; what feedback is given to the user on their performance; if the users know they are being monitored this could potentially undermine the effectiveness of the game (as people become less playful and more concerned about avoiding mistakes); how this data is used; and data privacy.

2.3.2 Vision and Gap

Table 12: Vision and Gap: Game Analytics and Data Issues

	Game Analytics and Data Issues
Vision 2020	Game analytics is the collection and analysis of in-game data deriving from participants' interaction in the game. Effective game analytics which can provide accurate assessments of the users progress in a game; that can provide a summation of the users learning from a game. Game analytics which respective privacy and that do not create self-conscious participants who try to avoid mistakes. There is potential to use game analytics data for performance assessment of employees.
Gap Analysis	Effective game analytics for assessing different types of learning; for assessing different types of learning content; for assessing different types of learning style.

2.3.3 Research Challenges

The research challenges for game analytics are for assessing different types of learning; for assessing different types of learning content; and for assessing different types of learning style. For data and privacy challenges there is a need to know what information can be collected and what is permitted to be done with it. There is also a need to inform the user that information is being collected, for what purpose and what will happen to the data after the game.

Table 13: 2.3.3 Research Challenges: Game Analytics and Data Issues

	Game Analytics and Data Issues	Until when	Priority
	Effective game analytics for assessing different types of learning; for assessing different types of learning content; for assessing different types of learning style [TC2.6]	2018	5
	Effective game analytics that can provide a summation of the users learning from a game.	2018	5
	Privacy and Data:		
	What types of data can be collected respecting users' privacy	2016	5
	What types of data can be collected and stored respecting users' privacy	2016	5
	What types of data and data collection methods do not respect privacy	2016	5
	How communicate to the user what data is being collected and how it will be used	2016	5

The diagram below shows the timeline for Game Analytics and Data Issues.

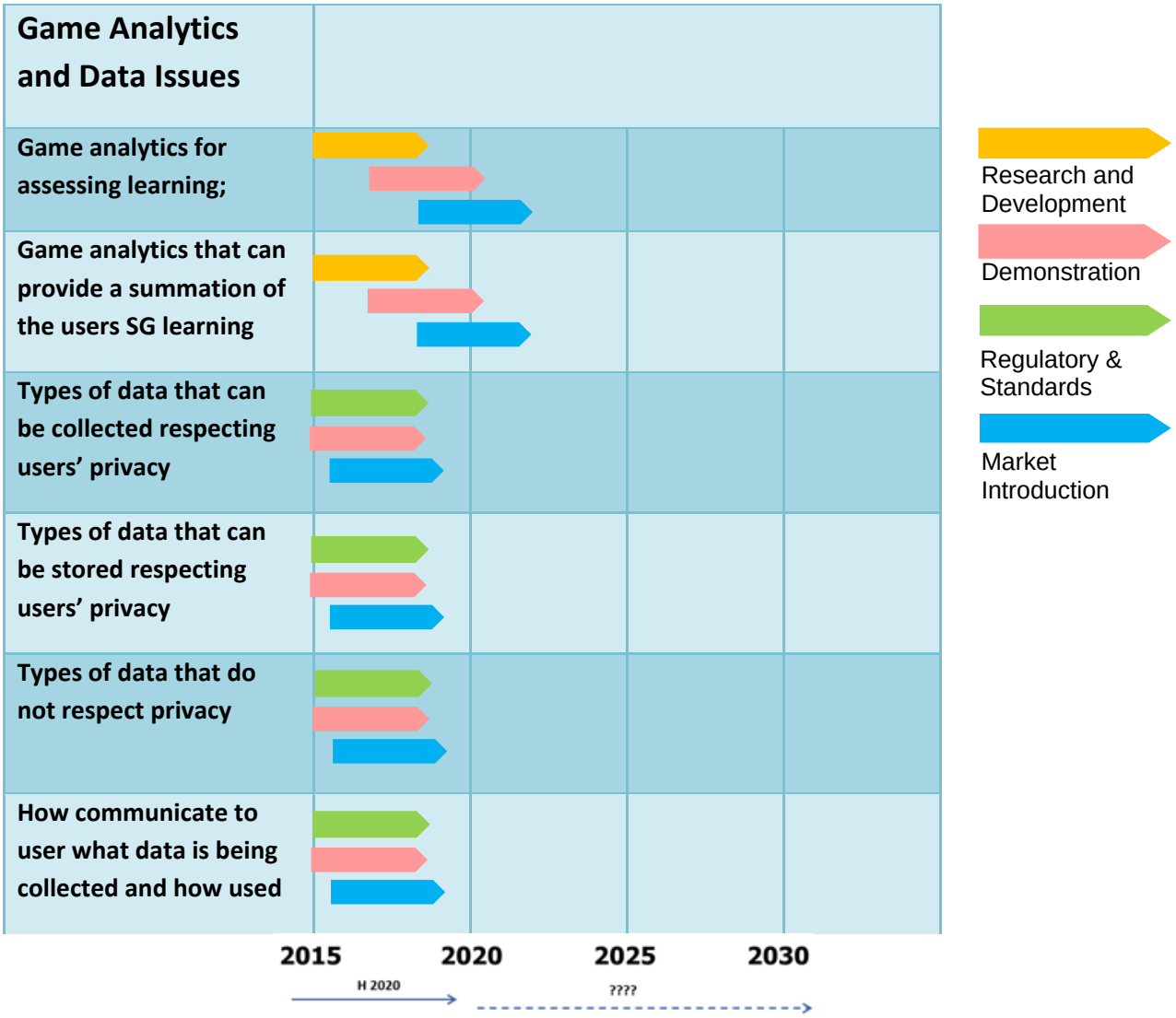


Figure 7: Game Analytics and Data Issues Timeline

The first two topics, concerning game analytics, are research and development oriented. The emphasis of this R&D should be on developing game analytics for use in companies and of course it should be carried out in collaboration with the research on game analytics in general. The remaining challenges concern the legal and regulatory aspects of data privacy. These do not need research as such; rather guidance and demonstrators of best practice can be produced. Further, best practice in communicating the data collection and the use it will be put to can be produced. For example, if data gathered during a gaming session will be stored after the game is over and used for league tables or benchmarking purposes then the user needs to be informed in an appropriate manner.

2.4 Topic 4: Game Mechanics and Learning

For the topic of game mechanics and learning there is a huge amount of research to be done. We do not know the effectiveness of different game mechanics; and especially not whether they will work well in a corporate context. Are scores, badges, etc. effective as reward mechanisms in companies?

Table 14: Game Mechanics and Learning SoA

	Game Mechanics and Learning
Relevance/priority (on a 1-5 scale)	5 (very high)
SoA/ SG Current Status description	The relationship between game mechanics and learning is still poorly understood. There is no standard way of describing game mechanics; this hinders the research into their impact on learning.

2.4.1 Vision and Gap

Table 15: Vision and Gap: Game Mechanics and Learning

	Game Mechanics and Learning
Vision 2020	We need to be able to pick the appropriate game mechanics for delivering effective learning with different learning contents and styles.
Gap Analysis	We need to build a knowledge base on game mechanics and their learning effects – this should be contextualised depending on learning content, learning style, etc.

2.4.2 Research Challenges

One of the main challenges of game mechanics is to find a standardised way to describe them. Design patterns seem a fruitful way to describe game mechanics. Once a standard way of describing game mechanics has been agreed upon it can be used to build a knowledge base of all the known game mechanics. The learning effectiveness of these different game mechanics can then be investigated.

Table 16: Research Challenges for Game Mechanics and Learning

	Game Mechanics and Learning	Until when	Priority
	Develop a formalisation of game mechanics	2017	5
	Build a knowledge base of game mechanics	2019	5
	Study the learning effectiveness of different game mechanics with different learning contents and styles	2020	5

	Research is needed on the relationship between individual learning and organisational learning – how does this occur and how can it be encouraged	2020	5

The diagram below shows the timeline for Game Mechanics and Learning. The first challenge is to develop a formalisation (standard description) of game mechanics. Once a formalism has been developed it can be used to build a knowledge base of game mechanics. The emphasis should be on developing game mechanics for use in companies and it should also be carried out in collaboration with the research on game mechanics in general. A loner term research is needed to study the effectiveness of individual game mechanics; and in the corporate context we need to know the impact on organisational learning. It may be that game mechanics could be a very effective method for promoting organisational learning – this is something very difficult for traditional training methods (lectures, exercise, workshops, etc) to achieve. Therefore research which shows that SGs can uniquely deliver organisational learning would be helpful in promoting SG adoption in companies.

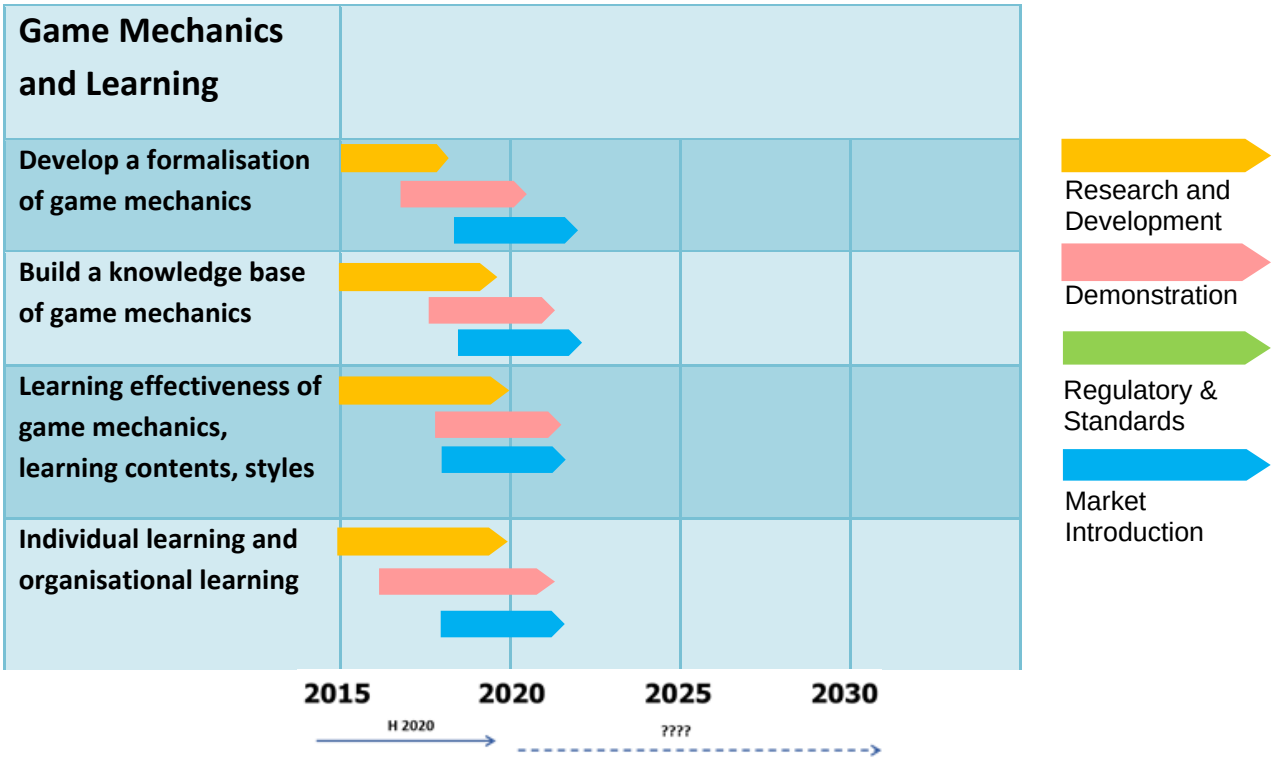


Figure 8: Game Mechanics and Learning Timeline

2.5 Topic 5: SG Development from Art to Science

This topic is very important. Currently SGs are one-off products that are developed from scratch for each specific application. This means they are costly to develop. There is a need to reduce this cost and speed development time. Also there is a need for a way to reuse game components and assets developed for previous games. So tools for SG design and development are desperately needed.

2.5.1 State of the Art

Table 17: State of the Art: SG Development from Art to Science

	SG Development from Art to Science
Relevance/priority (on a 1-5 scale)	5 (very high)
SoA/ SG Current Status description	The understanding of how to implement effective game mechanics is still quite poor. Game development is still practised as an 'art' rather than a science. This slows development and keeps costs high. Developing software tools and design approaches (eg. those based on design patterns) is needed to professionalise and introduce more rational approaches to SG development.

2.5.2 Vision and Gap

Table 18: Vision and Gap: SG Development from Art to Science

	SG Development from Art to Science
Vision 2020	We need to have more structured and formal SG design and development approaches that are productive and cost effective. There is a need for visualisation tools to enable SG stakeholders to 'see' the game being developed and help them provide guidance on the development. SGs should use low barrier interaction devices (eg. repurposed entertainment game interface devices).
Gap Analysis	Lack of tools and design/ development approaches for SGs. The awareness and use of structured design approaches is still pretty low (for example use of design patterns is low, partly because it is a new emerging approach for software development. Research is needed to develop a design patterns approach for serious games). There is a need for common and standard interoperability and semantics. Consumer entertainment games now have a lot of cool and high tech sensors, eg. Wii, Kinect, etc; however, serious games are generally lacking these interaction devices.

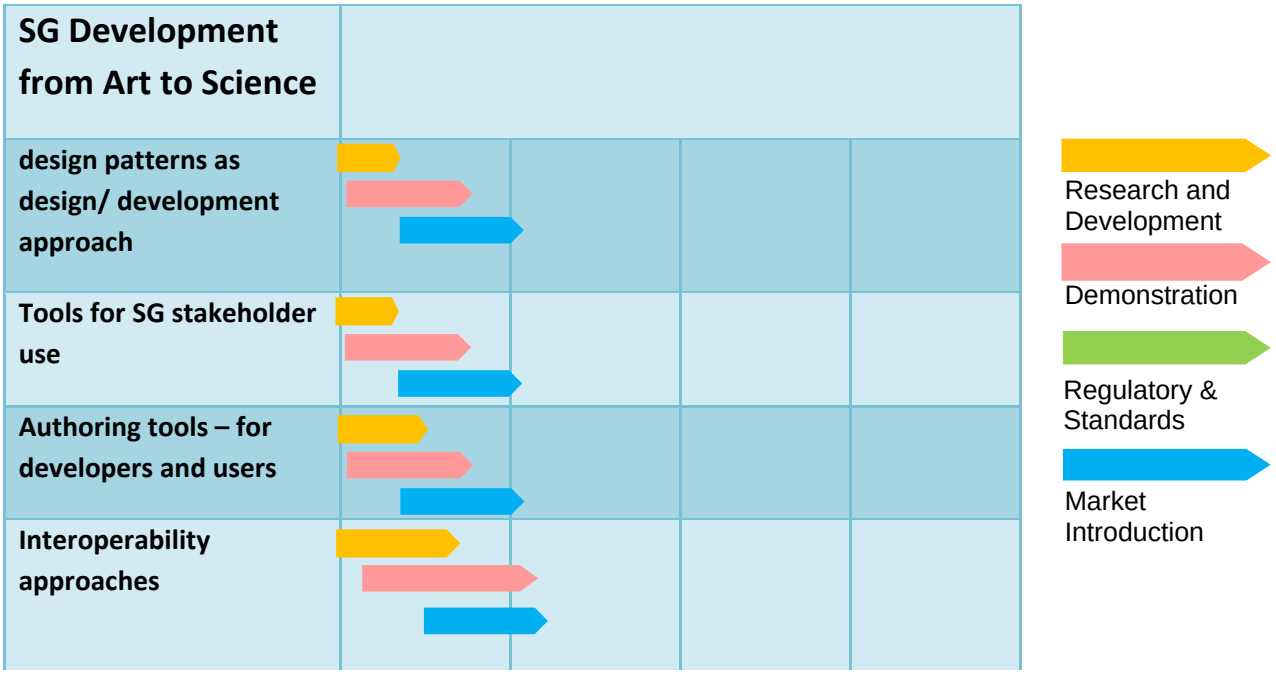
2.5.3 Research Challenges

Here we identify the research challenges to turn SG game development from an art into a science.

Table 19: Research Challenges: SG Development from Art to Science

	SG Development from Art to Science	Until when	Priority
	Research on design patterns as design/ development approach	2016	5
	Develop tools for SG stakeholder use: eg. visualisation tools to enable SG stakeholders to 'see' the game being developed and help them provide guidance on the development.	2016	5
	Research on authoring tools – for developers and users, balancing the complexity of the interface and the power of the tool	2017	5
	Develop interoperability approaches between data/content sources and delivery applications	2018	5
	Develop standard semantic models	2019	5
	Research on using low barrier interaction devices (eg. repurposed entertainment game interface devices – Oculus Rift, Kinnect, Wii controllers, Leap Motion, Z-Spacer, Razer Hydra, etc).	2016	5
	For new sensors to have high level APIs and not to have to code at the driver level.	2016	5

The diagram below shows the timeline for SG Development from Art to Science.



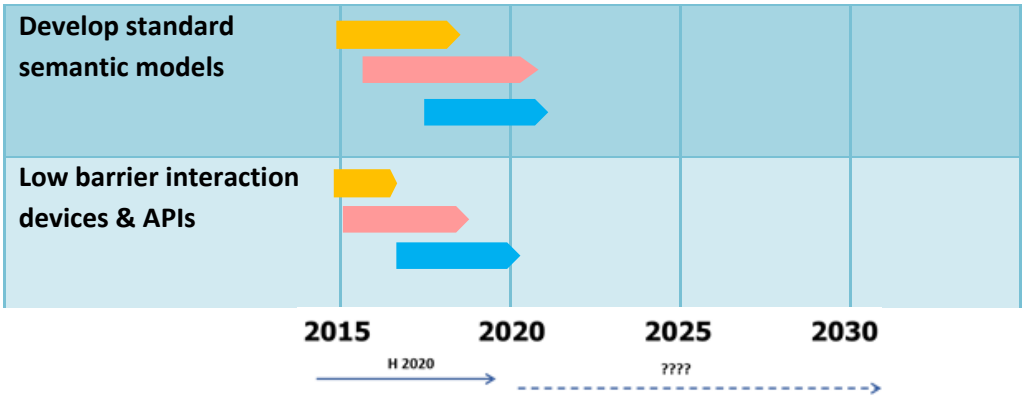


Figure 9: SG Development from Art to Science Timeline

In order to speed the development time of SGs and reduce the development cost tools are needed. These tools should not only be for developers to use, but should also be able to be used by SG stakeholders (commissioners, end-users, training managers, instructional designers, etc). These tools can range from visualisation tools (eg. rapid storyboarding tools that can be used to talk stakeholders through a game's flow) to authoring tools (eg. a tool that could convert a storyboard in to code segments with flow control). Critically tools should be developed for use by SG commissioners and users which enables them to express their game design ideas easily. The output of these tools can then be used directly to make the SG code. In this way the process of getting game ideas and specifications from users can be speeded up. Having visual tools will enable the stakeholders to visualise what the game will look like (something non-game designers/developers find very hard to do – they can only image a blank page...). This visual tool(s) will thus help users to be more precise and detailed in the descriptions of how they want the game to work. Tools which are able to produce software code as output will greatly speed the development. For this to work there is a need to develop standard semantic models and interoperability approaches. While these can been seen as programming related issues in companies SGs need to operate in strict security environments; and be able to talk to existing corporate systems (eg. systems that allow employees to register for training courses, HR record systems, etc). Finally, gain in development time and cost can be obtained by using cheap, off the shelf interface devices, like Wii, Kinnect, etc.

2.6 Topic 6: Development of remote/mobile SG learning

New devices and platforms have emerged during the duration of the GALA network – and they will probably continue to emerge. There is a need to research how these new devices and platforms can be effectively used in the corporate context.

2.6.1 State of the Art

Table 20: State of the Art: Development of remote/mobile SG learning

Development of remote/mobile SG learning	
Relevance/priority (on a 1-5 scale)	4 (high)

SoA/ SG Current Status description	There are slowly emerging serious games on smartphones – these are sometimes taster games used as part of the overall campaign and not full training applications.

2.6.2 Vision and Gap

Table 21: Vision and Gap: Development of remote/mobile SG learning

	Development of remote/mobile SG learning
Vision 2020	- Transfer of SGs to mobile platforms (tablet and smartphone) for easily reaching trainees everywhere - Scalability, in order to train increasing numbers of employees at the same time - Interoperability and standardization. This is useful not only to allow remote training, but also to make it possible for trainers to have a centralized control of all trainees' progress and remotely evaluate their performances. In this way these features support better and more effective performance evaluation and measurement, which are among the identified major gaps at the present (see item 2) of the Roadmap. The application of remote playing mode assumes the possibility of a remote supervision and an efficient and satisfactory remote evaluation performance by the trainer.
Gap Analysis	Centralized control of all trainees' progress and remote evaluation of their performance. In this way there is support for better and more effective performance evaluation and measurement, which are among the major gaps at the present.

2.6.3 Research Challenges

These are the research challenges for remote and mobile learning.

Table 22: Research Challenges: Development of remote/mobile SG learning

	Development of remote/mobile SG learning	Until when	Priority
	- Transfer of SGs to mobile platforms (tablet and smartphone) for easily reaching trainees everywhere	2016	4
	- Centralized control of all trainees' progress and remote evaluation of their performance.	2018	4
	- Interoperability and standardization.	2019	5

The diagram below shows the timeline for remote/mobile SG learning.

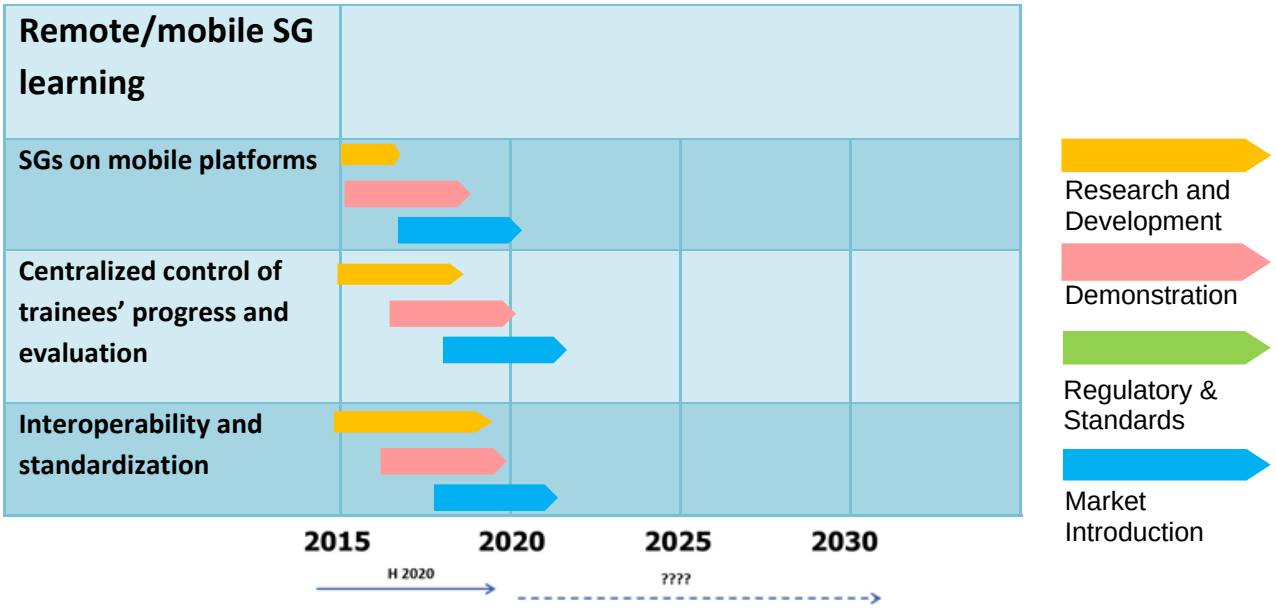


Figure 10: Remote/mobile SG learning Timeline

The appearance of smartphones and tablets recently has posed a challenge for SG developers and users. Do they move their games onto these devices (one key advantage of which is that employees can do training while commuting on public transport and in their own time) or not? There could be an issue with the growth of casual games on these platforms that serious games running on them may not be taken seriously. The issue of centralised control was identified for requiring further work. Many companies have HR (Human Resources) IT systems which record the training and development activities of employees. It would therefore be ideal that SGs could a) be selected from course lists in such systems, b) the individual's SG result recorded in the system (so that for example further training opportunities could be identified). In order to achieve this ideal it is necessary that SGs can interoperate with such systems. There has been some work on integrating SGs in LMS systems and this work needs to continue.

3 Prioritisation and conclusion

There is a long tradition of the use of Serious Games for corporate training (Cohen & Rhenman, 1961) and there has been a significant growth of interest and research in the application of serious games. In particular there has been a digital turn (Aldrich 2005; Faria 2001; Gibson & Aldrich 2007), which has led to an upsurge in interest. In a corporate setting, serious games can be used not only for training but also as organizational change interventions – to improve organizational processes, for cultural change/adaptation, and for strategy development. There has been a recent growth in the use of gamification within companies for both internal uses (encouraging employee engagement) and external uses (encouraging customer engagement). Innovatively, digital serious games may be distributed through an organisation by a process of viral diffusion enabling a rapid uptake of serious games and encouraging mass participation – thus achieving a low cost per participant. There are, however, still some barriers to be overcome before SGs in companies reach their full

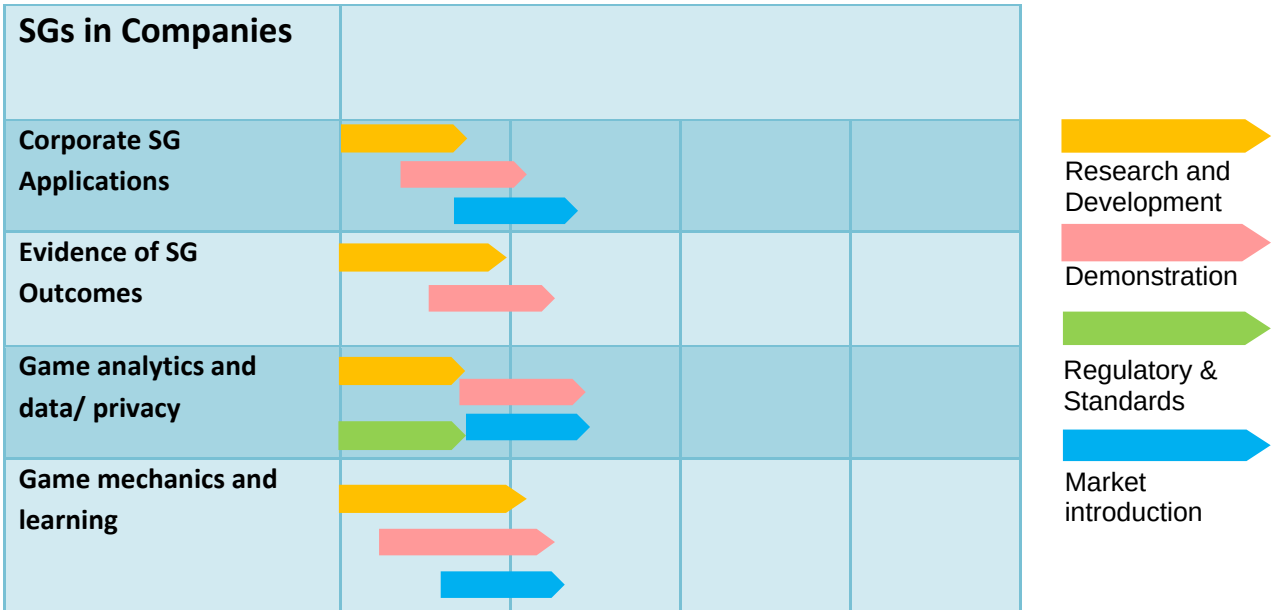
potential. Research needs to be carried out to help overcome some of these barriers and further develop SGs for use in companies. Research on the following topics has been identified as important:

1. Corporate SG Applications
2. Evidence of SG Outcomes in companies: learning & commercial outcomes
3. Game analytics & data and privacy issues
4. Game mechanics and learning
5. SG development from 'art' to science
6. Development of remote/mobile SG learning

From the above discussion of the roadmap for SGs in companies we can identify the key priorities. The major issue facing SGs in companies is a lack of awareness of SGs and their benefits – this was seen in the surveys that we conducted of companies (Azadegan, et al., 2012). This means that the highest priority is to produce the evidence for the effectiveness of SGs and for their commercial impacts/benefits. This is a research challenge that can be addressed by collaboration between game developers and experts in evaluation. The provision of such evidence will greatly help convince companies to adopt existing SGs and commission the development of new ones.

There is a preponderance of quantitative business games (or simulations) on the market. Most of these target the financial operations of a hypothetical company. It's now time to better understand what companies need and how to make improved SGs that deliver effective and cost-effective results. There is a need to carry out research to understand whether SGs are effective team building tools (as their developers and vendors claim); and to understand whether these games produce any commercial benefits for the companies using them. These two questions do not have any hard evidence to back them up.

So in terms of the overall priority of topics we present the timeline related in the diagram below. None of these research challenges will take a long time to solve, providing the researchers and resources are available:



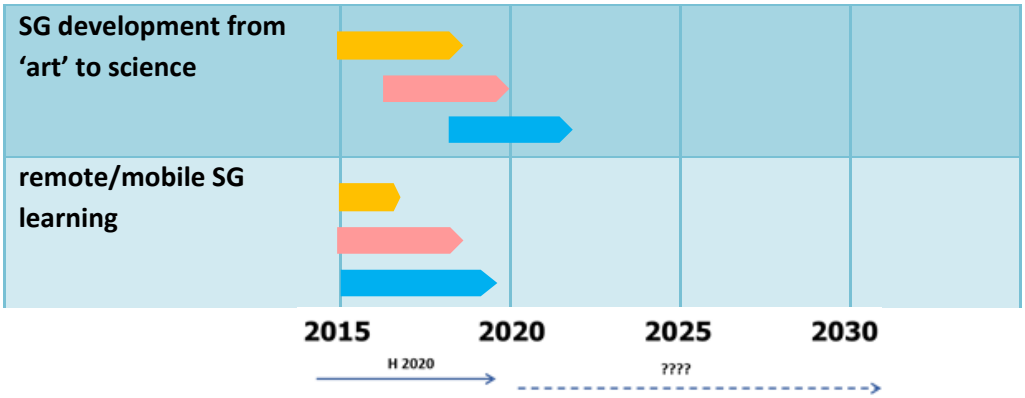


Figure 11: SGs in Companies Overview Timeline

Building game analytics into SGs will also help adoption – as the assessment of learning would be carried out by the game and not by the company. Understanding how game mechanics can drive learning will help to build more effective SGs that deliver learning in shorter amounts of time. Moving SG development from an 'art' to a science will also help reduce the cost and development time of SGs. This will aid the development of new business models for SGs. Both of these will help companies to adopt SGs.

Finally, application domains of SGs in companies and new technologies and devices, tablets and mobile learning, need to be taken into account. These will both be driven by the market. As companies demand that new devices be used for SGs then they can be developed. Similarly for new applications – it is best to base the development of new games by finding out what companies want. This can be done informally, through specific-commissions, or through market research. It is fruitless of developers to develop new SGs based on their own intuition about what a good SG would be, without establishing a market need for the product and assessing the existing competition (cf. the point about business games above). There is space to develop new and innovative SGs for companies, but we cannot predict what these will be or which areas of business they will target.

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