

Chapter 2

Smart Gamification and Smart Serious Games

Alexander Uskov and Bhuvana Sekar

Abstract The nascent technologies—smart serious games and smart gamification—potentially present an effective fusion of smart technology and smart systems on one side, and applications of computer game mechanics in “serious” areas and gamification of business processes on the other side. They can combine the features and advantages of both areas, and, as a result, provide the end users with non-existing functionality, features and advances. This chapter is aimed to analyze current status of serious games and gamified applications in industry, examine “smartness” maturity levels of smart objects and systems, classify main components and features and present conceptual design model of smart serious games and smart gamified applications, identify technical skills required for a design and development of smart serious games and smart gamification of business, research and development processes and simulations.

Keywords Smart serious games · Smart gamification · Smart objects · Smart systems · “Smartness” maturity levels

2.1 Introduction

A fast proliferation of connected smart devices, smart systems, and emerging smart technologies provides users with enormous opportunities in terms of new approaches to carrying out of main business functions and processes, worker’s higher personal productivity and efficiency, reduced time and better quality of services provided. On the other hand, recent advances in computer gaming technology,

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digital games design, computer game engines stimulated active research in gamification of processes and activities in “serious” areas such as simulation of complex physical objects and phenomena, engineering, project management, healthcare, chemistry, planning, marketing, and other areas.

A combination of smart technology and smart systems with serious games and gamification technology is a nascent area that potentially can combine the features and advantages of both areas, and, as a result, provide users with non-existing functionality, features, and advances. In accordance with the IBM [1]:

- Smarter serious games can help users to solve serious problems because of active use of sophisticated visualization techniques, principles and technologies of computer and video games, smart systems and by active engaging users into problem solving process through curiosity, intrigue, innovation, competition, teamwork, creativity, collaboration, and crowdsourcing.
- Knowledge workers can run sophisticated contextual simulations of complex business processes or multipart systems or phenomena of different physical nature; however, sorting and interpreting experimental data often may fail to keep user’s attention; smarter serious games can help users to be focused on actual real-world scenarios and situations, apply different variables to various potential solutions and test those solutions, provide real training of users, change their skills and behaviors.
- Organizations are straining to interpret massive data produced by complex corporate computer information, manufacturing, security/safety monitoring, and other systems, and apply these data to make information-based decisions that minimize possible risks; smarter serious games-based analytics may help workers to process huge amounts of rough data and present essential outcomes in such a simplified way that even non-expert can understand it.

These days, only a few publications with a focus on smart gamification and/or smart serious games exist. As a result, we believe this nascent technology is at the very beginning of the “technology trigger” stage of the Gartner’s “Hype Cycle” for emerging technology [2] and “innovators” stage of the Roger’s “Diffusion of Innovation” technology adoption typology [3] (Fig. 2.1).

The chapter is organized as follows. Section 2.2 represents state-of-the-art in smart system and gamification markets. Smart systems, smart objects, and smart technology are discussed in Sect. 2.3. Gamification and serious games applications in industry are described in Sect. 2.4. Smart serious games and smart gamification are situated in Sect. 2.5. Section 2.6 concludes perspectives of smart gamification and smart serious games.

2.2 State-of-the-Art

Let us consider state-of-the-art in smart systems’ market in 2013–2018 (Sect. 2.2.1), gamification market in 2013–2020 (Sect. 2.2.2), and goal and objectives of current research (Sect. 2.2.3).

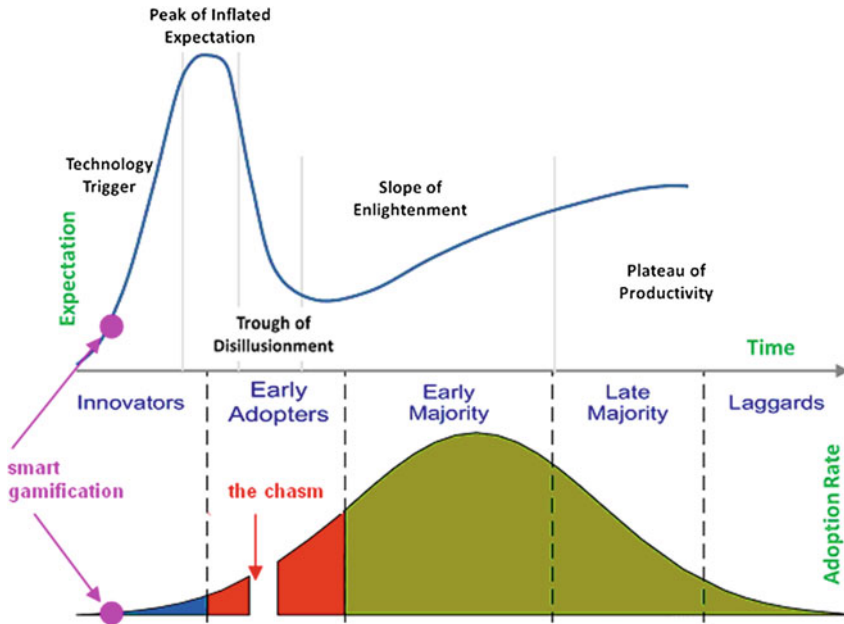


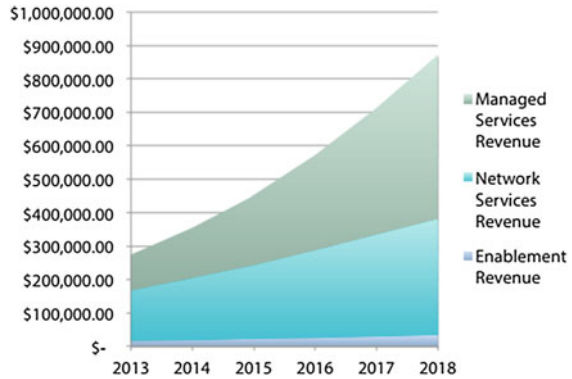
Fig. 2.1 Gartner's "Hype Cycle" for emerging technology [2] and Roger's "Diffusion of Innovation" (technology adoption) typology [3]

2.2.1 Smart Systems' Market

Smart systems' market in 2013–2018. "Smart Systems will drive a multiyear wave of growth based on the convergence of innovations in software architectures, back-room data center operations, wireless and broadband communications, and smaller, powerful, and numerous client devices connected to personal, local and wide-area networks. ... The rate of investment in smart systems will be measurably higher than in maturing information technology (IT) and network infrastructure technologies; we are forecasting smart systems growth at 3X the compounded rate of traditional Information and Communication Technologies (ICT); investment in smart systems ... will likely increase in scale to as much as 20 % of all of ICT investment within 5 years. A total Smart Systems (SS) market value forecast for 2013 is approximately \$275 billion. By 2018, the SS market is expected to grow to \$873 billion, representing a 5-year CAGR of 26 %" (Fig. 2.2) [4].

Smart classrooms' market in 2014–2018. "The global smart classroom market will grow at a CAGR of 31.25 % over the period 2013–2018. The two key factors contributing to this market growth are interactive display instruments and 3D education. Multiple global companies are among leaders in this area, including Apple, IBM, Microsoft, and SMART Technologies Inc." [5].

Fig. 2.2 Total smart systems and services market, 2013–2018 [4]



Smart education market in 2013–2017. “The global smart education and learning market is expected to reach \$220.0 billion by 2017 at a CAGR of 20.3 % between 2012 and 2017, including (a) services segment with projected \$97.9 billion by 2017 with a CAGR of 26.6 %, (b) content segment—\$72.9 billion in 2017, at a CAGR of 12.1 %, (c) software segment—\$37.2 billion, and (d) hardware—\$12.1 billion in 2017. Companies such as Ellucian, Inc. (U.S.), Smart Technologies (U.S.), Blackboard Inc. (U.S.), Kaplan Inc. (U.S.), Promethean World Plc (United Kingdom), Pearson PLC (United Kingdom), and Informa Plc (Switzerland) are among key players on the smart education market” [6].

2.2.2 Gamification Market in 2013–2020

In accordance with [7], “*Gamification* is the use of game design elements in non-game contexts. ... Whereas *serious games* describes the use of complete games for non-entertainment purposes, *gamified applications* use elements of games that do not give rise to entire games. ... Together with *serious games*, *gamification* uses games for other purposes than their normal expected use for entertainment (asserting that entertainment constitutes the prevalent expected use of games)”. As a result, *gamification* means an implementation and active use of computer game design concepts, game thinking, game mechanics, game analytics, computer game technology in business models, core activities, processes, procedures, services, products, etc. to improve user skills, experience, engagement, effectiveness, and productivity outside pure entertainment area.

Currently, gamification is at the Gartner’s “peak of inflated expectations” stage (Fig. 2.3) [2].

In accordance with Gartner’s predictions [8], “... many small businesses, as well as 70 % of the top 2,000 global organizations, will use “gamified” applications for marketing, employee performance and training, and health care by 2014”. According

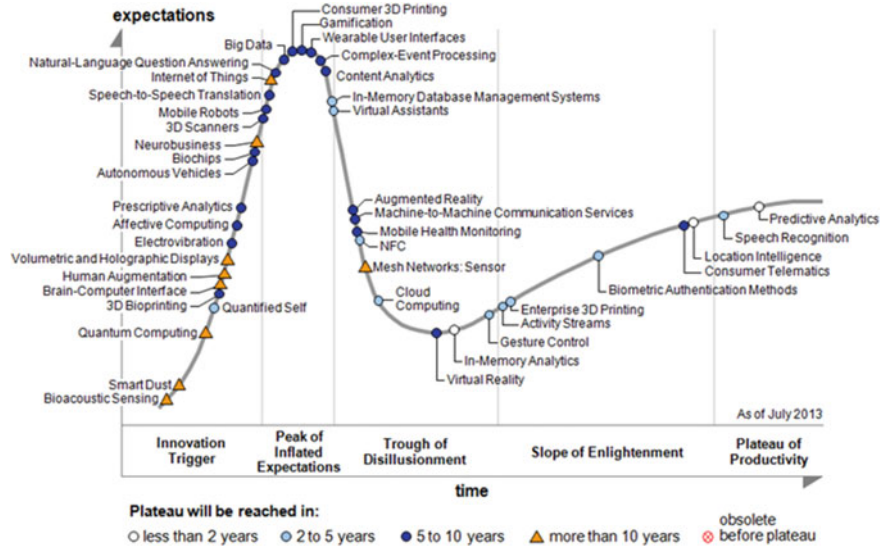


Fig. 2.3 “2013 hype cycle for emerging technologies” by Gartner [2]

to Frost and Sullivan research, global gamification market estimated at around \$900 million in 2014 will grow to \$8.3 billion in 2020 [9].

2.2.3 Research Goals and Objectives

The performed analysis of these and multiple additional publications relevant to (1) research, design and development projects, (2) description of pilot systems and applications, (3) current use and future trends of smart technology/systems and gamification, gamified applications and serious games in industry and by businesses clearly shows that (a) smart gamification and smart serious games will be an important research topic in several upcoming years, and (b) in the following 5–10 years it is expected to be adopted by society.

The goal of the on-going research project is to understand emerging smart gamification technology and smart serious games, classify their main components and underlying technologies, features and attributes, formulate requirements to produce well-skilled researchers, designers and developers of smart gamified applications and smart serious games.

The objectives of this chapter are to:

- Briefly describe current status of smart technology and smart systems as well as gamification, gamified applications, and serious games in industry.
- Analyze and classify smart entities and their “smart” features and “smartness” levels of smart entities.

- Analyze and classify smart gamification and smart serious games, their mechanics and/or techniques, their features and characteristics.
- Analyze and generalize corporate gamified applications in “serious” (non-entertainment) areas.
- Show a clear difference between smart serious games and smart gamified applications in industry.
- Identify a set of skills for developers of smart serious games and smart gamified applications.
- Predict perspectives of fusion of gamification and smart systems/technology in smart gamification as well as fusion of serious games and smart technology/systems in smart serious games.

2.3 Smart Systems, Smart Objects, Smart Technology...

In this section, the examples of various smart systems will be considered (Sect. 2.3.1). “Systems thinking”-based approach to classification of smart entities is represented in Sect. 2.3.2 as while Sect. 2.3.3 includes smart system characteristics and “smartness” levels.

2.3.1 *Smart Systems, Smart Objects, Smart Activities, and Smart Technology*

Smart systems and smart technology with various types of “smartness” maturity are already used in industry and businesses; several relevant examples include but are not limited to the following ones.

Smart system example—the Samsung Smart School [10]. The Samsung Smart School solution has three core components (sub-systems): the Interactive Management Solution (IMS), the Learning Management System (LMS), and the Student Information System (SIS). Its multiple unique features and functions are targeted specifically at smart school impact on education and benefits, including Increased Interactivity (II), Personalized Learning (PL), efficient Classroom Management (CM), and better Student Monitoring (SM). The details are available in Table 2.1 [10].

Smart object example—a smart material [11]. Smart material can detect certain signals, adjust sensitivity according to environmental changes, or restore degraded sensitivity. Categories of smart materials include piezoelectric, electrostrictive, magnetostrictive, shape memory alloys, optical fibers, catalytic and textile materials. The example of smart textile materials is a smart T-shirt: “... in battle soldiers could wear a T-shirt made of special tactile material that can detect a variety of signals from the human body, such as detection of hits by bullets. It can then signal the nature of the wound or injury, analyze their extent, decide on the urgency to react, and even takes some action to stabilize the injury”.

Table 2.1 Key features, impact and benefits of the Samsung Smart School solution [10]

The Samsung Smart School solution					
Core subsystems	Key features	II	PL	CM	SM
Interactive management (management of communication capabilities between teacher and students)	Screen sharing	•		•	•
	Content sharing and remote app execution	•		•	•
	Group activity	•	•	•	
	Remote control and monitoring of student tablets		•	•	•
	Messaging and Q&A	•	•	•	•
	Quizzes and instant polling	•	•	•	•
	Split screen	•	•		
	Enhanced pen stylus	•	•	•	
Student information system (for managing student information)	Monitoring of student attendance	•	•	•	•
	Management of special education plans	•	•	•	•
	Management of student contact information	•	•	•	•
Learning management system (to be used during and after class to help teacher with classroom management and lesson planning)	Upload and share course materials (files)		•	•	•
	Create schedules		•	•	•
	Post to school/subject boards	•	•	•	•
	Access student information (files)				•
	Participate in forums	•	•	•	•
	Create tests and quizzes			•	•
	Send/Receive messages		•	•	•

The legend used: *II* increased interactivity, *PL* personalized learning, *CM* efficient classroom management, *SM* better student monitoring

Smart technology example—the Savant smart home technologies [12]. Smart home technologies provide users with an unmatched level of efficiency, simplicity, control, and automation. Particular smart home technologies include:

- Home or room climate control technology that is aimed at monitoring and control of heating, cooling, air freshness, thermostats, windows shades, draperies.
- Intelligent lighting technology that is focused setting, activation and deactivation of numerous possible lighting schemes at “smart home”.
- “Smart home” energy technology is aimed to reduce energy consumption, conserve resources and save money—all without sacrificing comfort or convenience.

- “Smart home” safety and security technology with a “single press of a button” will lock exterior doors and activate doors’ and windows’ security system(s), view surveillance cameras, motion detectors, links to the local police station or a private security company, etc.
- “Smart home” scheduling technology is aimed to schedule watering the lawn, turning lights “Off” or “On”, and others.

Smart activity/process example—the Decimal Software LLC smart shopping list application [13]. Smart shopping activity may be supported by smart phone with multiple applications to help a customer to:

- Support multiple shopping lists.
- Create reminders in a calendar for desired items or a list.
- Assign aisles to items to help guide a customer through the store in a preferred order.
- Add a budget available to the shopping list—in this case each item will show a subtotal to help customer to stay within desired budget.
- Manage item’s expiration date.
- Store anything with a barcode like discount coupons.
- Provide local currency support (currency conversion), etc.

2.3.2 “Systems Thinking”-Based Approach to Classification of Smart Entities

The above-mentioned examples as well as numerous additional examples of smart entities could be classified using the “Systems Thinking” approach, i.e. in terms of smart systems, smart objects, smart activities/processes, and smart technologies/services (Table 2.2).

Despite the great variety of known and emerging smart entities, their features (or functions) are defined by smart systems’ features [11]. In Table 2.3 the adjusted and significantly extended version of that classification is proposed along with added sections of goals and components.

2.3.3 Smart System Characteristics and “Smartness” Maturity Levels

Based on “Systems Thinking” approach, the description of nine main characteristics of a smart system are given in Table 2.4 including goal, components, links, inputs, outputs, interfaces, constraints/limits, boundary, and environment.

In general case, a smart system may contain a number of subsystems, and, in its own turn, a subsystem may contain a huge number of smart objects. For example,

Table 2.2 Classification of smart entities (with examples)

Classes of smart entities	Examples of class instances
Smart systems	Smart phone
	Smart classroom
	Smart school (university)
	Smart city
	Smart society
Smart objects	Smart sensor (transducer)
	Smart fabric material
	Smart medical device
	Smart meter
Smart activity/Processes	Smart learning
	Smart gamification
	Smart manufacturing
	Smart shopping
	Smart computing
Smart technology/Services	Smart sensor technology
	Smart RFID technology
	Smart metering (mesh technology or point-to-point technology)
	Smart grid technology
	Internet of Things

in general case, a smart city (as a smart system) may contain several sub-systems—smart energy management, smart transportation and logistics, smart healthcare, smart governance, smart education and smart training, smart security, smart infrastructure, etc., and possibly a huge number of smart objects (sensors, meters, actuators) in each sub-system [9, 14]:

- Smart energy management and distribution and utility network subsystem of a smart city may contain multiple smart objects such as meters of water, electricity and natural gas, parking lot meters, traffic control cameras, security surveillance cameras, etc.
- Smart transportation and logistics network sub-system of a smart city may contain various smart objects such as parking lot management, monitoring of traffic intensity on main city interactions and highways within city, control and monitoring of location of school buses, public transportation buses and trains, emission control, car-to-car communication, control and monitor of traffic lights on major city avenues, etc.
- Smart human/community/society network sub-system of a smart city may contain a great variety of smart objects, for example, various safety-focused sensors: surveillance cameras, fire detection, CO₂ detection, detection of suspicious individuals and substances, radiation detectors, etc.

Table 2.3 Smart entity’s features [11] and added goals and components

Features/Functions	Goals	Components
Acquisition (sensing) of real-world raw data or signals, and, possibly, a local pre-processing of raw data	To (1) collect the required raw data needed for an appropriate sensing, and, thus, monitor a situation, condition, object, system, environment, etc., (2) convert sensor data into correct secure format for further processing, (3) in some cases; process data in real-time in a local area network	High-sensitive sensors, transducers, machine-to-machine communication, scene analyzers, local area network, etc.
Transmission of raw data and/or pre-processed sensory information	To transmit the sensor raw or pre-processed data to the local and/or central control unit using safe, secure and flexible communication technologies and/or data exchange protocols	Transmitters, wide area network, Internet, etc.
Big data processing and comprehensive analysis of obtained information (smart analytics) at control units in accordance with real-world business/safety/security models	To manage and control the entire system by (1) receiving required raw data or pre-processed sensory information, (2) smart analytics, including big data processing and complex data analysis—both are beyond human intelligence), (3) producing conclusions, (4) predicting the future based on current data, (5) making decisions, (6) determining the actions required to implement decisions made, and (7) giving instructions to actuators, components, or subsystems of a smart system	Central Processing Unit (CPU), invariant analysis systems, visualization system, big data storage units, data mining systems, predictive analytics systems, pattern analysis systems, etc.
Transmission of instructions	To transmit (a) decisions made and (b) associated instructions produced to actuators or designated smart system’s components using secure communication technology and/or data transmission protocols; in some cases, natural language synthesis is needed	Transmitters, wide area network, Internet
Activation (adapting, triggering) of physical and/or virtual actuators	To initiate or take appropriate actions or perform activities to provide system’s reaction on received raw data	Actuators, adapters

Table 2.4 Classification of main characteristics of a smart system

Characteristic	Details or comments
Goal (purpose)	To integrate sensors, infrastructure components, processes, technology, users, and analyze/process big data in order to produce quality knowledge, enable collective real-time awareness, complex multi-aspect services, and help end users to make highly efficient on-time crucial decisions
Components (smart objects, smart processes or activities, smart technologies or services) or subsystems (or sets components)	Various components from miniaturized (micro) parts to large sub-systems of a system, for example: (a) a ubiquitous broadband infrastructure, Web-based software systems and applications, hardware/equipment, network technologies, (b) miniaturized connected sensors with broad range of sensing capabilities such as security/safety sensors and surveillance cameras or sensors to monitor human body main parameters (blood pressure, temperature, etc.), (c) managed services, for example, to monitor environment safety, network security, server load, etc.
Links between components	Secure radio/electrical (wired or wireless), physical (mechanical, pneumatic, hydraulic), thermal, Internet-based, infrared, etc. connections
Inputs	Very large amounts of rough data and meaningful information from the environment, for example, from sensors, devices, machines, information systems, people, maps, etc.
Outputs	Quality knowledge-based recommendations and, if necessary, immediate actions using various types of software systems, information technology, Web services, actuators (hydraulic, pneumatic, electric, electronic, thermal, mechanical), etc.
Interfaces	IP Internet protocols, RFID protocols, various types of machine-to-machine or sensor-to-processing unit data exchange and control protocols, etc.
Limits (constraints)	Examples: (a) weight, type, and size of sensors, (b) time to process rough data, (c) form of processed data representation (should be easy-to-understand by end users), etc.
Boundary	It significantly depends on system's purpose; for example, a boundary of a human body, a boundary of corporate office, school classroom or lecture hall, a boundary of a city, etc.
Environment	It significantly depends on systems' scope

- Smart information network subsystem of a smart city may contain numerous smart objects such as real-time big data processing and analysis systems, forecasting of emergency/disaster events and immediate broadcasting/warning in case of high probability of those events, remote maintenance system, etc.

2.3.4 “Smartness” Maturity Levels of a Smart System

In order to differentiate smart systems based on their “smartness” maturity level, the classification of intelligence levels and abilities of smart technologies from [15] is used (Table 2.5); it also contains proposed corresponding examples from computer science and computer engineering.

Table 2.5 Classification of “smartness” maturity levels of a smart system [15] and proposed corresponding examples from computer science and computer engineering

“Smartness” maturity levels	Details	Examples from computer science/engineering
Adapt	Ability to modify physical or behavioral characteristics to fit the environment or better survive in it	Adaptive networks, adaptive hyper media, adaptive mesh refinement
Sense	Ability to identify, recognize, understand and/or become aware of phenomenon, event, object, impact	Sensors, wireless sensor networks, smart materials, face-in-a-crowd recognition
Infer	Ability to make logical conclusion(s) on the basis of raw data, processed data and/or information, observations, evidence, assumptions, rules, and reasoning	Reasoning systems, expert systems, inference engines, fuzzy logic, big data analysis systems, data mining systems
Learn	Ability to acquire new or modify existing knowledge, experience, behavior to improve performance, effectiveness, skills, etc.	Intelligent agents, genetic programming, neural nets, smart e-learning systems
Anticipate	Ability of thinking or reasoning to predict what is going to happen or what to do next	Robots, smart (driverless) cars
Self-organize	Ability of a system to change its internal structure (components), self-regenerate and self-sustain in purposeful (non-random) manner under appropriate conditions but without an external agent/entity	Traffic networks, Internet connection patterns, some objects at the cellular or nano-technology level

2.3.5 Smart Systems: A Long-Term Perspective

Based on performed analysis and developed classifications of smart systems and entities (Tables 2.2, 2.3, 2.4 and 2.5), we predict that in long-term perspective smart systems will:

- Be used almost everywhere in the physical and cyber worlds.
- Serve as a contact point or a bridge between physical and cyber worlds.
- Stimulate a fusion of physical and cyber worlds; for example, by strong support of a shift from self-sourcing and in-sourcing to cloud sourcing (where specialized cloud products and services and their deployment and maintenance is outsourced to and provided by one or more cloud service providers) and crowdsourcing (where the collective “smartness” of the public and professional community will help to complete business-related tasks that a company would normally either perform itself or outsource to a third-party provider).
- Stimulate an integration of heterogeneous systems to help to control huge chaotic systems, for example, the invariant analysis can detect abnormal situation by extracting internal system dependency from the data without any domain knowledge or super resolution technology can help to enhance the resolution of an image—a face in a crowd from a low resolution surveillance camera.
- Predict possible future problems by sensing current changes (i.e. micro or macro changes, short-term and long-term changes), predict future scenarios and analyze their probabilities, and take preventive actions to eliminate or significantly minimize risks.
- In general, prevent human beings, communities and society from disastrous events.

2.4 Serious Games and Gamification in Industry

The main terms of serious games are described in Sect. 2.4.1. Gamification is discussed in Sect. 2.4.2.

2.4.1 Serious Games

In accordance with IBM, Serious Games (SG) have capabilities to “... (1) solve complex problems collaboratively, (2) make business processes more efficient, (3) achieve predictive modeling and real-time visualization, (4) increase ROI from processes, time, and resources, and (5) provide 108 % more retention of knowledge, compared to traditional methods” [1]. This motivates companies to design, develop,

and implement full-scale SG in their business functions and processes. “Business process improvement has been responsible for reducing cost cycle time by as much as 90 % while improving quality by more than 60 % ” [16].

The SG definition. We define the SG as follows: *Serious game is a software system that combines “serious” dimension (a non-entertainment goal and context) and “gaming” dimension (game design concepts and models, game structure, game mechanics/techniques, and game-like graphic user interface).*

The SG classification. A well-though classification of the SG is necessary for a deep understanding of the SG purpose, scope, domain, type, gameplay, audience, etc., and, as a result, for a better to-be-proposed fusion of the SG with smart systems and technologies. A variety of possible SG classifications are available, for example, in [17–20]. One of the most detailed one—the G/P/S/ classification [17] is presented in Fig. 2.4.

- In accordance with the G/P/S model:
- The SG purpose may be of various types, such as message broadcasting (educative—edugames, informative—newsgames, persuasive—advergames, political games, subjective—military games, and arts games), training (mental or physical), and data exchange.
 - The SG scope may consist of game’s market/domain (such as state and government, military and defense, healthcare, education, corporate, religious, culture and art, ecology, politics, humanitarian, advertising, scientific research, and entertainment) and public/audience (for example, general public, professionals, and students).

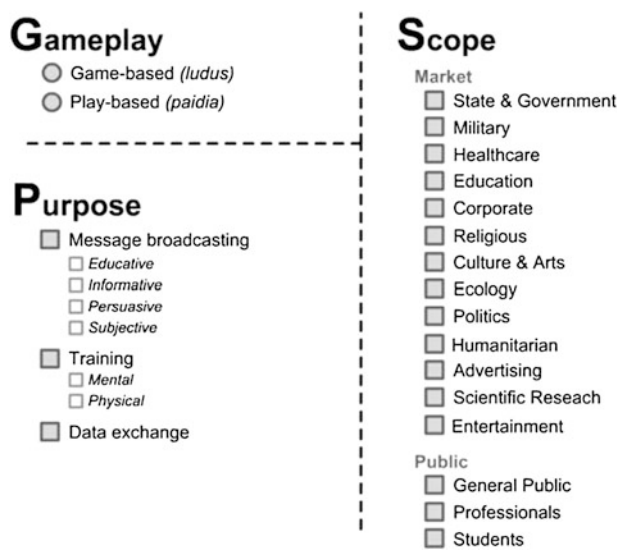


Fig. 2.4 A “printable page” format of the G/P/S model [17]

- The SG gameplay may be of the following types: game-based (with a clear game goal) and play-based (without clear game goal).

Creative power of the SG. Researchers at the University of Washington (U.S.A.) reveal the creative power of crowds playing the developed *Foldit* game. They compared games strategies with the best-known scientist-developed methods to cure AIDS. The game drew 46,000 participants whose gameplay took just 10 days to solve a problem scientists had been working on for 15 years. It generated a crowd-sourced discovery of the mystery of how a key protein may help cure AIDS. Researchers called some *Foldit* game strategies “shocking” in how well they mimicked some of the methods already used by protein scientists [21].

2.4.2 Gamification

Definition of gamification. We define gamification as follows: *Gamification is a process of incorporating “gaming” dimension—game designs, structure, mechanics and game-like graphic user interface into an existing non-entertainment entity “dimension” (such as software system, an enterprise mobile application, corporate or learning community, a community of customers, a website, etc.) in order to motivate professional development and growth, personal productivity and efficiency, quality of learning or training, active participation and engagement, interaction, and/or long-term loyalty.*

Gamification mechanics/techniques. Game mechanics that are incorporated into a gamified software system or application may have a significant impact on type of player or user, who may or may not efficiently use those techniques and get maximum benefits from it. A compilation of relevant examples that are based on ideas in [22–24] is available in Table 2.6.

Serious games and gamified applications in industry. In accordance with [25], 53 % of surveyed 1,021 technology stakeholders and critics agreed that “... by 2020, there will be significant advances in the adoption and use of gamification”. These days many global companies, including Microsoft, IBM, Oracle, Adobe, Cisco, Siemens, SAP, Google, Accenture, American Express, Caterpillar, Ford, etc. already started an implementation of gamification techniques and gamified applications to support their main business functions, processes, and/or activities.

More than 60 examples of successful use of gamified applications in “serious” areas, or *Serious Gamified Applications (SGA)*, and the SG by various corporations and companies have been reviewed and analyzed by authors; a summary of about 30 relevant analyzed examples is presented in Table 2.7.

Benefits of the SG and the SGA use in industry. The outcomes of performed analysis of successful SG and SGA applications in industry (Table 2.7) clearly show that active use of the SG and the SGA for improvement of business processes amplifies worker’s positive psychology, and strengthens and extends the PERMA concepts [26] including:

Table 2.6 A summary of game mechanics, types of players, and their possible benefits [22–24]

Type and name of game mechanics	Details of game mechanics	Types of players	Possible benefits
1. Progression gamification mechanics			
Badges, trophies	An indicator of accomplishment or mastery of a skill; it is especially meaningful within a community or group that understands its value	Achievers, explorers	Engagement, loyalty, influence, time spent, fun, User-Generated Content (UGC)
Points	Used to keep score and establish player's status. Players earn points through activities, sharing, contributing, or by creating something useful to community	Achievers, explorers	Engagement, loyalty, influence, time spent, virality, fun, UGC
Level or status within a professional community	Levels indicate long-term or sustained achievement; they are used to identify status within a community and to unlock new missions, badges, activities, and rewards	Achievers, explorers	Engagement, loyalty, time spent, influence, virality, fun
Leadership boards	Tools to monitor and display desired actions	Achievers, explorers	Engagement, loyalty, influence, time spent, UGC, virality, fun
2. Feedback gamification mechanics			
Quests/ Challenges	“Challenges” usually imply a time limit or competition whereas “quests” are meant to be a journey of obstacles the user must overcome	Achievers, explorers	Engagement, loyalty, revenue, influence, time spent, virality, fun, UGC
Immediate feedback or response to actions	Encourage users to continue or adjust their activities with onscreen notifications, text messages or emails. Congratulate a user for reaching a goal, encourage the next step to a milestone or promote a new reward	Achievers, explorers	Engagement, loyalty, revenue, influence, time spent, virality, fun, UGC
Transparency	Show users exactly where they stand on the metrics that matter to you and to your audience. Individual and team profiles show progress in real-time and historically. Leaderboards show who's just ahead and who's behind as well as overall ranking on any number of metrics	Achievers, explorers	Engagement, loyalty, revenue, influence, time spent, virality, fun, UGC

(continued)

Table 2.6 (continued)

Type and name of game mechanics	Details of game mechanics	Types of players	Possible benefits
Cascading information theory	Information should be released in the minimum possible snippets to gain the appropriate level of understanding	Achievers, explorers	Engagement, influence, time spent, virality, fun, UGC
Appointment dynamics	At a predetermined times a user must return for a positive effect	Achievers, explorers	Engagement, influence, time spent, virality, fun, UGC
Countdown	Users are only given a certain amount of time to do or to complete something	Achievers, explorers	Engagement, influence, time spent, virality, fun, UGC
Combos	Reward skill through doing a combination of things	Achievers, explorers	Engagement, influence, time spent, virality, fun, UGC

3. Behavioral gamification mechanics

Goals (short-and/or long-term)	Missions or challenges give players a purpose for interaction, and educate players about what is valued and possible within the experience	Achievers, explorers, socializers	Engagement, loyalty, influence, time spent
Epic meaning	Users will be highly motivated, if they believe they are working to achieve something great, something inspiring, something bigger than themselves.	Achievers, explorers, socializers	Engagement, loyalty, influence, time spent, fun, UGC
Discovery or exploration	Players love to discover and to be surprised	Explorers, achievers	Engagement, loyalty, influence, time spent, fun
Community	Community gives meaning to goals, badges, competitions, and other mechanics. Sharing participant achievements creates energy in the community by making people aware of what others are doing. They learn about goals, badges, and rewards that they may want to pursue	Socializers, achievers	Engagement, loyalty, revenue, virality, UGC
Community collaboration	Connect users as a team to accomplish larger tasks, to drive competition, and to encourage knowledge sharing. Show team members how they are contributing to the group's success. No one wants to let down their team members	Achievers, explorers, socializers	Engagement, influence, time spent, virality

(continued)

Table 2.6 (continued)

Type and name of game mechanics	Details of game mechanics	Types of players	Possible benefits
Ownership	Creates loyalty by owning things	Achievers, explorers, socializers	Engagement, loyalty, revenue, influence, fun
Virality	Users are more successful in the game, if they invite colleagues	Achievers, explorers, socializers	Engagement, influence, fun
On-boarding	Players use learning-by-doing paradigm. Simple missions help new users become engaged immediately as they master basic tasks, rather than being stumped by an unfamiliar interface or a detailed manual	Achievers, explorers, socializers	Engagement, loyalty, influence, time spent
Competition	Raise the stakes for accomplishing a goal by showing users how they compare to others, as individuals or in teams. Encourage competition with time-based, team and individualized leaderboards	Achievers, socializers	Engagement, loyalty, revenue, influence, time spent, virality, fun, UGC

- Positive emotions (experiencing joy, pleasure, fun, safety, etc.).
- Engagement (being constantly involved in activities).
- Relationships (enjoyable/supportive interactions).
- Meaning (creating a purposeful narrative).
- Accomplishment (achieving goals, following core values, etc.).

Additionally, the SG and the SGA placed on corporate web site promote [27, 28]:

- Better retention and efficient memorization factors.
- High customization of information.
- Better interactivity and maximum implication.
- Attractive and non-intrusive advertising.
- Better “word of mouth” virality.
- Better dissemination and promotion of web-published information.

Table 2.7 Serious games and serious gamified applications in industry [24]

Company	Main business activity to support	The SG or the SGA used
IBM	Communication (corporate social communication and collaboration)	<i>IBM Connections</i>
Oracle	Communication (support of communication to about new software features)	<i>Prune The Product Tree</i>
SAP	Communication (corporate social networking)	<i>Two-Go</i>
Scrum Alliance	Communication and collaboration (support of software development teams' communication/ collaboration)	<i>Knowsy</i>
Qualcomm	Planning (better understand how customers use its products, identify key marketing messages for the launch of its asset-tracking product line, and discover new product opportunities)	<i>ProductBox</i>
VersionOne	Planning, communication and collaboration (support of agile software development teams)	<i>Speedboat, Buy a Feature</i>
Computer Science Corp	Planning (accelerate time to market)	<i>Development/Test-as-a-service</i>
HP	Planning and management (increase of sales)	<i>Project Everest</i>
IBM	Planning and management (reduction of cost of internal business)	Document translation
HP	Planning and management (user engagement)	HP Operations Manager
PWC	HR management (employee recruitment)	<i>Multipoly</i>
Google	HR management (employee recruitment)	Google code jam
Accenture	HR management (employee flexibility)	<i>Liquid Workforce</i>
American Express	HR management (business travel support)	Global Business Travel
IBM	Management (business process management to drive innovation)	<i>IBM Innov8</i>
Microsoft	Quality management (improvement of productivity and software quality assurance)	<i>Language Quality Game, Ribbon Hero</i>
Cisco	Quality management (improvement of global sales experience)	<i>The Hunt</i>
Microsoft	Quality management (gamification of threat assessment process)	<i>Elevation of Privilege</i>
Microsoft	Software development (software development/ coding skills improvement)	<i>Pex4Fun</i>
	Software development skills improvement)	
Cisco	Testing (testing of network planning skills)	<i>myPlanNet</i>
Cisco	Training and team working (building a team and team working)	<i>The Threshold</i>
Oracle	Training (employee on-boarding)	New Hire
Siemens	Training and development	<i>Plantville</i>
NTTData	Training (leadership training)	<i>Ignite Samurai Leadership</i>

(continued)

Table 2.7 (continued)

Company	Main business activity to support	The SG or the SGA used
SAP	Training (sales training)	SAP Road Warrior
SAP	Marketing and branding	<i>Paul the Octopus</i>
HP	Improvement of conference papers’ selection	HP global technical conference

2.5 Smart Serious Games and Smart Gamification

The outcomes of performed analysis of existing smart entities (Table 2.2), classification of general features of a smart entity (Table 2.3), classification of “smartness” maturity levels of smart entities (Table 2.5), existing serious games and gamification mechanics and benefits for users (Table 2.6), and existing successful the SG and the SGA in industry (Table 2.7) enabled us to predict a further development in those areas:

- *Smart Serious Games* as an efficient fusion of smart systems and/or smart technologies and serious games (Sect. 2.5.1).
- *Smart Gamification* as an efficient fusion of smart systems and/or smart technologies and gamification components—computer game design concepts and methods, game mechanics, game analytics, and game-like graphic user interfaces (Sect. 2.5.2).

Also the SSG and the SGM conceptual design model is presented in Sect. 2.5.3. Skills required for the SGM and the SSG are mentioned in Sect. 2.5.4.

2.5.1 Smart Serious Games

Smart Serious Games (SSG) will incorporate some or all “smartness” abilities of smart systems (as in Table 2.5). This prediction is particularly based on the fact that some advanced analytical adventure games like *Journey*, *L.A.Noire*, *Portal 2*, *Gabriel Knight* already require;

- Raw data collection about current situation, visible obstacles, visible and intuitive opportunities, etc.—it is expected that eventually it will be transformed into “sensing” ability.
- Analysis of raw data and decision making, which will be transformed into “inferring” ability (or smart analytics).
- Adaptation to a level of user skills and knowledge, which eventually will be transformed into “adapting” ability (as in Table 2.5).

A proposed classification of the SSG is presented in Table 2.8 with relevant examples. It is based on ideas of the G/P/S/ classification in Fig. 2.4; however,

Table 2.8 Proposed classification of the SSG

The SSG feature	The SSG characteristic	The SSG details (types, classes)	Relevant examples [18, 19, 24]
Purpose	Decision-making	Mechanisms for making better decisions faster	<i>ProductBox</i>
	Simulation	Face-to-face or electronic simulations of situations that might play out in reality	<i>Packet Tracer, Millennium Challenge 2002</i>
		Subjective (military games, art games)	<i>America's Army</i>
	Sharing of knowledge	Educative (edugames)	<i>The Beer Game, Autopsie d'un meurtre</i>
		Informative games (newsgames)	<i>September 12th</i>
	Persuasion	Persuasive games	<i>Dying in Darfur</i>
	Data collection/exchange/exploration	Games based on data collection and data exchange	<i>Portal 2</i>
		Focus on research, discovery, innovation	<i>Foldit, Buy a Feature</i>
		Adventure games	<i>Journey, L.A. Noire</i>
	Motivation	Badges, scores and rewards, incorporated into work	<i>Ribbon Hero</i>
	Training	Focus on analytical skills	<i>Lure of the Labyrinth</i>
		Focus on technical skills	<i>Prog&Play</i>
		Focus on management skills	<i>Innov8, Multipoly</i>
		Focus on communication skills	<i>Prune The Product Tree</i>
		Focus on team working skills and collaboration	<i>Novicraft, PowerUP, The Threshold</i>
Scope	Domain	Corporate	<i>Electro City</i>
		Education	<i>Enterprise Battle</i>
		State and government	<i>Cyber Budget</i>
		Healthcare	<i>Fatworld</i>
		Marketing	<i>Flip Mobile</i>
		Military	<i>America's Army</i>

(continued)

Table 2.8 (continued)

The SSG feature	The SSG characteristic	The SSG details (types, classes)	Relevant examples [18, 19, 24]
		Culture and arts	<i>Grotte de Gargas</i>
		Ecology and environment	<i>Climate Change</i>
		Politics	<i>Debate Night</i>
		Humanitarian	<i>Deliver the Net</i>
		Advertising	<i>Blam Blam Fever</i>
		Scientific research	<i>Foldit</i>
	Audience	General public	<i>Creepy Crossword</i>
		Professionals	<i>Maritime Warfare</i>
		Students (elementary/middle school)	<i>GeoDefi</i>
		Students (high school/college)	<i>Virtual U</i>
Gameplay	Type	Game-based (with clear game goal)	
		Play-based (without clear game goal)	
	Goal	Choices: (1) Avoid, (2) Match, (3) Destroy	
	Means	Choices: (1) Create, (2) Manage, (3) Analyze, (4) Solve, (5) Move, (6) Select, (7) Shoot, (8) Write, (9) Random	
Smartness (smart features from Table 2.3)	Acquisition (sensing) of real-world data or signals	Adding real-world input data to the SG (for example, acquisition in real-time of real patient’s physiological parameters (temperature, blood pressure, pulse, cholesterol level, etc.) as input data for personalization and adaptation issues of the predictive treatment scenarios in serious games-based therapies)	[29]
	Real-time processing of real-world data, inferring, smart predictive analytics	Adding real-world business models and analytics to the SG (for example, processing of real-world big and dynamic data into integrated simulation-based the SG that uses optimization)	[30]

(continued)

Table 2.8 (continued)

The SSG feature	The SSG characteristic	The SSG details (types, classes)	Relevant examples [18, 19, 24]
		techniques to minimize risks due to decisions made in Supply Change Management area	
	Adapting, or activation of physical or virtual actuators	Adding adaptation and/or actuation functions to the SG (for example, resetting of outdoor holiday light decorations by sending actual machine-to-machine data or signals according to smart design system’s recommendations)	

it significantly extends by adding multiple additional characteristics (in the “purpose” section, specifically, decision making, simulation, sharing of knowledge, persuasion, data collection/enhance/exploration, motivation) and new unique features (the SSG smart features, from Table 2.3). Particularly, the SSG should provide acquisition (sensing) of real-world data or signals, real-time processing of real-world data, inferring, and smart predictive analytics, and adapting, or activation of physical or virtual actuators. In other words, the SSG will be very instrumental in an effective fusion of real-world (real objects), cyber-world (serious games and/or gamified applications), and smart entities—smart software systems, smart objects, smart technology, smart activities, etc. (as in Tables 2.2 and 2.3).

2.5.2 Smart Gamification

Smart Gamification (SGM) is aimed at a fusion of smart systems, smart features, smart technology, smart sensors, etc., and gamification components—game mechanics, computer game design concepts and methods, game analytics, and game-like graphic user interfaces. The SGM can be implemented using the following approaches:

- Gamification Components (GC) based approach: in this case, a set of software applications with various GCs (such as game mechanics, game design concepts, game-like Graphic User Interface (GUI), etc.) is implemented either directly into current corporate Business Functions and/or Procedures (BFP) or into existing Enterprise software Applications (EAs) that support BFPs.
- Gamification Platform (GP) based approach: in this case, an external GP is used to develop a specialized full scale serious game for a company to support its BFPs—either all business functions and procedures or a sub-set of them.

In both approaches, a required component of either the SGM or the SSG is a set of to-be-implemented smart features (from Table 2.5) including:

- Acquisition (sensing) of real-world raw data or signals, and, possibly, a local pre-processing of raw data.
- Transmission of raw data and/or pre-processed sensory information.
- Data processing and comprehensive analysis of obtained information (smart analytics) in accordance with real-world business functions.
- Transmission of instructions.
- Activation of physical (devices) and/or virtual actuators (software systems and tools).

2.5.3 The SSG and the SGM Conceptual Design Model

Design of the SSG or the SGM depends on multiple factors including existence or absence of corporate software application(s) to be gamified, external gamification platform to be used, existence or absence of appropriate SG, selected set of gamification components, and selected set of smart features to be implemented.

The proposed SSG and SGM conceptual design model is presented in Table 2.9. It clearly shows a process of construction of various types of the SG, the GA, the SGM, and the SSG. The following legend is used in Table 2.9:

- BFP—a set of company’s Business Functions and/or Processes (BFP).
- EA—a set of Existing software Applications (EA) to support company’s BFP.
- GA—a Gamified Application (GA) to support company’s BFP.

Table 2.9 Proposed SSG and SGM conceptual design model

BFP	EA	SG	GP	GC	SF	Outcome	Case (details)
BFP	–	–	–	–	–	–	There are no apps to support BFP; neither gamification nor smart features are implemented
BFP	EA	–	–	–	–	EA	Neither gamification components nor smart features or serious games are implemented
BFP	–	SG	–	–	–	SG	Serious game
BFP	EA	–	GP	–	–	GA-GP	GP-based gamified application (GA-GP)
BFP	EA	–	–	GC	–	GA-GC	GC-based gamified application (GA-GC)
BFP	EA	–	GP	–	SF	SGM-GP	Smart gamification based on GP approach (SGM-GP)
BFP	EA	–	–	GC	SF	SGM-GC	Smart gamification based on GC approach (SGM-GC)
BFP	–	SG	–	–	SF	SSG	Smart Serious Game (SSG)

- SG—external existing fully completed Serious Game (SG) that could be used by a company to support its BFPs—either all or part of them.
- GP—external Gamification Platform (GP) that can be used to develop a specialized SG for a company to support its BFPs—either all or part of them.
- GC—a set of corporate software applications with implemented Gamification Components (GC) such as game mechanics, game design concepts, game-like GUI, etc.; GC are implemented either directly into current BFPs or into existing EAs that support the BFPs.
- SSG—a completed smart serious game for a smarter support of company's BFPs.
- SGM—a set of Smart Gamification (GM) components to better (smarter) support company's BFPs.
- SF—a set of smart features (as explained in Table 2.5).

2.5.4 Skills Required for the SGM and the SSG

Design and development of the SGM and the SSG require solid analytical, technical, and management skills in Computer Science (CS). “A modern, high-end computer game today costs on the order of \$50 million dollars” [31].

Substantial collaborative efforts of various specialists in the CS—project managers, software engineers, advanced programmers, graphic user interface designers, human-computer interaction experts, specialists in computer graphics, databases, artificial intelligence, intelligent systems, networking and security—are necessary to produce the SGM and the SSG for real-world complex business functions, procedures, tasks and simulations. As a result, Table 2.10 presents the proposed list of team members for the SGM and the SSG design and development project, their important skills, and an approximate list of courses to be taken to develop skills, required by the SGM and the SSG design and development projects. Details related to proposed skills are available in [32] including, for example, several advanced programming assignments aimed at advanced game programming skills such as operations with 3D vectors, Virtual Machines (VMs) concept, and bit flags; those assignments are going well beyond regular topics and assignments in traditional programming courses.

2.6 Perspectives of Smart Gamification and Smart Serious Games

The research, development, commercialization and acceptance of the SGM and the SSG in society, industry, and businesses will lead to a fusion of physical and virtual

Table 2.10 Proposed lists of the SGM and the SSG team members, their skills and courses to be taken to develop required skills [32]

Type of a member of the SGM or the SSG development team	Examples of required skills	Relevant CS courses to be taken to develop required skills
The SGM or the SSG development project manager	Strong management skills	The SG development project management
	Strong analytical skills	The SG design and development
	Strong system and software engineering skills	The SG engine development Storytelling
	Great experience in the SG design and development	Software project management
		Software engineering
		Agile software engineering Systems analysis and design
Lead the SGM/SSG software developer or engineer	Strong system and software engineering skills	The SG design and development The SG engine development
	Strong software development skills	Advanced game programming
		Advanced game engine modification
		Storytelling
		Software engineering
		Agile software engineering
		Web and mobile software systems
The SGM/SSG software developer and/or programmer	Strong software development skills	Advanced programming in C++, C#, Java, PHP, Assembler
	Strong programming skills	The SG design and development
		The SG engine development
		Advanced data structures and algorithms
		Applications of data structures and algorithms Advanced game programming
The SGM/SSG network developer and/or programmer	Strong knowledge of networking, operating systems	Computer architecture
		Operating systems
		Net-centric computing
	Strong knowledge and skills in Web services and Web programming	Integrative programming and technology
		Open Computing Language (OpenCL) Web technologies and services

(continued)

worlds, and, as a result, to a design, development and formation of a smarter

Table 2.10 (continued)

Type of a member of the SGM or the SSG development team	Examples of required skills	Relevant CS courses to be taken to develop required skills
	Strong network security knowledge	Information technology infrastructure
		Computer networks and system security
		Mobile and wireless networks
		Advanced mobile programming
Computer graphics developer and/or programmer	Strong computer graphics skills	Linear algebra
	Strong GUI development skills	Computer graphics
		Advanced computer graphics
		OpenGL
Physics and characters programmer	Strong programming skills	Advanced GUI and Human-Computer Interfaces (HCI)
		Image and pattern recognition
		Physics
System security developer and/or programmer	Excellent knowledge of physics	Advanced physics
	Strong skills in secure coding	Developmental psychology
		Integrative programming and technology
	Strong integrative programming skills	Computer networks and system security
SGM/SSG artificial intelligence developer or programmer	Strong system security programming skills	Software and Web applications security
		Applied cryptography
	Strong knowledge in artificial intelligence	Artificial intelligence
		Smart systems
	Strong programming skills in artificial intelligence	Smart autonomous robots
		Advanced mobile programming
		Smart agents

society.

The obtained research outcomes and findings enabled us to formulate the main expected evolution and development tendencies in the SGM and the SSG areas; they include but are not limited to:

- **An effective fusion of smart technology and smart systems with gamification techniques and serious games will be based on adding “smart” features**

to SG, gamification and gamified applications. The new smart features of the SSG and the SGM—adapting, sensing, inferring, learning, anticipating, self-organizing—will make users, environment, processes, activities, solutions and outcomes smarter and more efficient [15, 33].

- **The SGM and the SSG will evolve to “smart” tools to help users to solve “serious” problems.** This is because the SGM and the SSG will actively use sophisticated visualization techniques, principles and technologies of computer and video games, and smart systems and smart technology [1]. The SGM and the SSG will help users to be focused on actual real-world scenarios and situations, apply different variables to various potential solutions and test those solutions, and change/improve/update their skills and behavior [34].
- **The SGM and the SSG analytics will help entire organizations/corporations.** They will help to (a) interpret and process massive data produced by complex corporate computer information, manufacturing, security/safety monitoring, and other systems, (b) apply these data to make smart (intelligent) decisions that minimize possible risks, (c) present essential findings and outcomes in such a simplified way that even non-expert can understand it, (d) optimize gamification techniques in order to influence user productivity, effectiveness, motivation, behavior, invention abilities, etc. [27, 28, 35].
- **The SGM and the SSG will evolve to “smart” tools to significantly increase user engagement.** According to [36], “... 21 % of software development project initiatives fail due to poor levels of user engagement”. The key components of user smarter engagement are: (a) exploration (be curious, view, search, collect, analyze, summarize, generalize, propose, investigate, innovate, etc.), (b) compete (challenge, pass, win, beat, train, learn, etc.), (c) collaborate (crowdsourcing, share, work as a team, help, exchange, etc.), (d) express (be creative, select, customize, design, showoff, etc.), (e) be smart (sense, adapt, infer, conclude/deduce, learn, anticipate, self-organize, self-sustain, self-reorganize, etc.) [26].
- **Active implementation and use of the SGM and the SSG will provide businesses and companies with significant benefits.** Those benefits may include but are not limited to (a) improving performance, productivity and effectiveness of entire team and individual team members, (b) enjoyable quality training and the acquisition of new knowledge and skills, (c) energizing employees through smarter wellness and health initiatives and activities, (d) harnessing and leveraging the insight of customers, business partners, (e) engaging customers as part of a long term relationship development strategy, (f) innovating through the collective insights of crowd sourcing and the Internet of Things (IoT) [28, 35].
- **The SGM and the SSG will amplify worker’s positive psychology.** The SGM and the SSG will strengthen and extend the PERMA concepts [26] including (a) positive emotions (experiencing joy, pleasure, fun, safety, etc.), (b) engagement (being constantly involved in activities), (c) relationships (enjoyable/supportive interactions with others), (d) meaning (creating a purposeful narrative), and (e) accomplishment (achieving goals, following core values, etc.).

- **Active fusion of the SGM, the SSG, and mobile, social, and virtual collaboration platforms.** The SGM and the SGG will be strongly integrated with new generations of mobile, social, and virtual collaboration systems and technical platforms.

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Fusion of Smart, Multimedia and Computer Gaming
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