# The design of Serious Games for Competency-based Education

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# Chapter 1

# Introduction

Play has always been an important part of human life, culture and society (Huizinga, 1938). Despite the fact that often in the collective imagination play is reduced to a voluntary entertainment activity to which both children and adults devote themselves for recreational purposes (Garvey, 1990), it can be very useful both for the development of the person (in its entirety), and for the acquisition of concepts and skills (Mitchell and Savill-Smith, 2004; Susi et al., 2007), and can also represent a mediator for the exchange of culture, information and strategies between generations. If we think, for example, of the ways in which we interface with children and teach them new things, the instrument used is almost always play. On the one hand, this is because play intrinsically brings with it an high level of engagement that helps to keep the interlocutor focused and concentrated; on the other hand, it is probably because, in my opinion, play is one of the simplest and most direct languages we can use to communicate. The importance of games is also underlined by the academic interest it has aroused and which has grown over time (e.g. Huizinga, 1938; Wittgenstein, 1953; Crawford, 1984; Caillois, 2001, etc.). Nevertheless, the concept of formalising and designing games so that they are aimed at explicit educational goals and not mere entertainment is relatively new. The term Serious Game, which identifies precisely this type of games, was coined only in 1987 by the American researcher Clark Abt. Since then, albeit very slowly, the stigma associated with the concept of educational play has been disappearing, allowing the recognition of their effectiveness and the positive impact they can have on the education of individuals. This was also and above all made possible by ever-increasing institutional initiatives, such as the call for further research efforts in the investigation of the potential of games as means of educational processes enhancement carried out by the Federation of American Scientists (2006). Today there is an extensive and robust body of research demonstrating the potential of games in terms of motivation (e.g. Connolly et al., 2012; Kordaki and Gousiou, 2017; Vlachopoulos and Makri, 2017), increased engagement and participation (e.g.

Fu et al., 2016; Dichev and Dicheva, 2017; de Freitas and da Silva, 2020; Ekici, 2021), improvements in academic and work related tasks (e.g. McKeown et al., 2016; Liu et al., 2017; Koivisto and Hamari, 2019; Bai et al., 2020), and conceptual and epistemological understanding (e.g. Squire and Jan, 2007; Barab et al., 2007; Squire and Klopfer, 2007; Klopfer et al., 2009). The potential of these effects has been observed so much that recently the research question is shifting from "do educational games work?" to "how and when do educational games work?" (Nacke and Deterding, 2017; Krath et al., 2021).

The importance of studying Serious Games grows more and more when we consider that the world we live in today, ever more intrinsically linked to technology, is a world where the speed with which society and technologies advance and the speed with which the educational system tries to adapt are quite different. Constantly training teachers, changing school culture and adapting academic structures is a considerable burden, both from an economic-implementation point of view and from a bureaucratic-social point of view, which in practice acts as an handbrake on the evolution of teaching methods. However, the distance between the world of work and the educational systems in particular will reach a critical breaking point sooner or later. This is further highlighted by the corporate tendency to no longer give priority to the educational level of candidates, as it is no longer aligned as the right indicator of 'know-how'. An educational model that tries to respond to these needs is Competency-based Education (CBE). Defined in 1970 by the United States of America Department of Education, CBE represents a complete innovation of education systems in favour of a clearer, more transparent, fairer and more focused education in today's world, and it aims to do so by redefining educational pathways on the basis of a new atomic unit aimed at demonstrating know-how: *competence*. In spite of the fact that the concept of competence has now become part of important institutional guidelines (e.g. Council of the European Union, 2006; EU Commission, 2016; Council of the European Union, 2018; OECD, 2018), the literature lacks a unified vision and interpretation, consequently causing confusion and disagreement. Furthermore, despite the fact that on paper Serious Games seem to be the perfect tool to implement Competency-Based Education interventions, the literature is still not very mature, with most of the efforts formally found in the medical and nursing context. In fact, the confusion around the concept of competence is probably one of major reasons for this.

The aim of this work is therefore to attempt to provide more clarity regarding some of the concepts related to the world of Serious Games and Competency-Based Education and how these two worlds can be linked in order to obtain tools that can help evolve the educational paradigm. To achieve this, in the following chapters I will address the concept of games in detail, exploring the literature and providing my own new definition. I will introduce the concepts of game taxonomies, taxonomies of game elements and the formalisations of games as information systems,

discussing important theories and examples found in literature and emphasising their importance in the context of the study of the concept of game. Moreover, together we will explore and discuss the findings present in literature concerning the effects of games on players.
In relation to the world of Competency-Based Education, I will try to shed some light on the concept of competence by analysing the definitions and formalisations found in literature with the aim of adopting one. We will explore the principles tied to the holistic view of competence as well as see some examples of Serious Games used in the Competency-Based context in order to assess their usefulness. From the explored theory, I will extract and propose seven principles of Competency-Based Education Compliance for Serious Games, with the idea of providing design-level guidance for the adaptation and design of educational games in the CBE context. Then, I will present a case study based on a Serious Game developed by me in collaboration with the Institute for Educational Technology of the National Research Council of Italy: uManager. I will present the game in its current state, discuss its problems in the context of Competency-Based Education and then propose a redesign rooted in the theory explored and presented in this work, culminating with the identification and formal description through an ontology of different competencies and the consequent production of several new game scenarios suitable for a Competency-Based approach. Finally, in the conclusions I will discuss the results achieved and future work ideas.

# Part I

# Understanding the concepts

# Chapter 2

# Serious Games

That playing is a serious thing is nothing new. Despite the fact that in the collective imagination playing is often seen as "a free activity standing quite consciously outside 'ordinary' life as being 'not serious', but at the same time absorbing the player intensely and utterly" (Huizinga, 1938) , since Plato's time, and up to the more recent psychologists and pedagogists Vygotsky and Piaget, in the academic field playing has been considered a natural learning mode since childhood.
Today, educational games, i.e. games that do not have entertainment or fun as their main objective but rather educational goals, are commonly called serious games (de Freitas, 2006; Charsky, 2010). The combination of the two terms 'serious' and 'game' forms an oxymoron that often leads to the idea that educational games are not fun. On the contrary, one of the main reasons why games are used for educational purposes is their intrinsic level of engagement and fun: by exploiting the dynamics of the game, a student can be more motivated to learn and can remain in a state of flow for longer. To give an example of this phenomenon, one only has to think of the fact that players of fantasy role-playing games often manage to obtain an almost encyclopaedic knowledge of the world in which the game is set, of the various creatures that inhabit it and of the complex political relationships between the societies within it. All this without ever opening a manual and without having the feeling of studying. Clark Abt himself, the researcher who first (1987) used the term Serious Game in its current sense, said that "*Games may be played seriously or casually. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining*" (Abt, 1987). The idea that learning cannot be fun and that SGs are a kind of "trap" has been widespread for years, so much so that there are examples of it in pop culture: in an episode of the famous cartoon "The Simpsons" (Season 15, episode 7), Bart, a child protagonist of the

series, learns the capital cities of the American states through an educational game; when he realises that the game is actually teaching him something, he gets angry and throws the controller at the screen, almost as if he was betrayed. Fortunately today, also thanks to the increasingly evident integration of games into our daily lives, the trend has changed. Many educational games are designed to promote learning at different ages and in a wide range of activities (Connolly et al., 2012; Boyle et al., 2014; Eck et al., 2015; Berta et al., 2015). Current research on game-based learning (Michael and Chen, 2005; Romero et al., 2014; Qian and Clark, 2016) highlights how SGs are able to enable new and innovative forms of learning through engaging experiences (Smith and Clark, 2011) that allow people to improve their knowledge and skills (McDonald, 2017). Serious games, in fact, allow to contextualise the player's experience by 'immersing' them in complex and realistic environments, thus supporting situated learning processes.
The concept, or rather, the realisation that games can be a suitable and interesting tool for pursuing educational and didactic purposes has grown so strong over time that it has given rise to neighbouring, albeit distinct concepts: "Game Based Learning" and "Gamification". While Game Based Learning (GBL) refers to the use of educational games (or games enriched with educational elements) in order to achieve specific educational objectives, to provide an aid in learning, to enhance teaching and to provide tools for student assessment (Shaffer et al., 2005; de Freitas, 2006b; Tang et al., 2009; Plass et al., 2015), Gamification refers to "the use of design elements characteristic for games in non-game contexts" (Deterding et al., 2011). Both are concepts close to Serious Games and consequently much of what we will discuss regarding games can also be used there. But as far as the work in this dissertation is concerned, we will mainly focus on Serious Games themselves.

In this chapter, we will address some concepts that are key in understanding and evaluating Serious Games. First, we will define what "game" means and what this term entails. We will follow by analysing and discussing game taxonomies, and their usefulness in allowing us to understand their diversity and variety. In order to further conceptualise and understand games and pave the way for their design and related processes, we will discuss how games can be viewed as complex systems and discuss a framework in detail. We will continue by analysing what is reported in the literature about their effects on players in order to understand their importance and the ways in which they can help us change today's educational paradigm.

## 2.1 What is a game?

The very same definition of what a game is has been the subject of academic interest and research (Huizinga, 1938; Wittgenstein, 1953; Crawford, 1984; Caillois,

2001; Lindley, 2003; Juul, 2005). One of the most interesting definition is given by Johan Huizinga, a Dutch historian and linguist, in his work "Homo Ludens", the playing man: he states that a game "*is an activity which proceeds within certain limits of time and space, in a visible order, according to rules freely accepted, and outside the sphere of necessity or material utility. The play-mood is one of rapture and enthusiasm, and is sacred or festive in accordance with the occasion. A feeling of exaltation and tension accompanies the action, mirth and relaxation follow*" (Huizinga, 1938, p. 132). While this definition is almost one century old, it highlights the most important aspects of games: gratuitousness, enjoyment, rules and the absence of a purpose (Kickmeier-Rust, 2009). It is important to note, however, that the absence of purpose is in fact a feature that is not always present and indeed is reductive in the context of a broad and general definition (Caillois, 2001). One only has to think of the games of chance in casinos, for example, where the profit motive and economic interests are clear. Or again, think of the role that play has in an anthropological and evolutionary sense within the animal world, where the act of playing has the purpose of practising certain skills (Kickmeier-Rust, 2009).

The challenge of identifying ever-present properties in games is highlighted in Wittgenstein's work (1953). He challenges the reader to identify elements that are common to all games and thus help define the term. Guiding the reader through an analysis of certain types and categories of games and their characteristics, Wittgenstein argues that the only thing we can observe is "*a complicated network of similarities overlapping and criss-crossing: sometimes overall similarities, sometimes similarities of detail*" (Wittgenstein, 1953, p. 32). He argues that the best way to characterise these similarities is through "family resemblances", and consequently to define games through a family of different definitions, rather than through a single, unique definition.

The quest to define games is nonetheless continued by Crawford, which in is work (1984) indicates four fundamental characteristics that he identifies as common in all games and that can help define the term game: representation, interaction, conflict and safety. He states that "*Games are objectively unreal because they do not physically recreate the situation they represent, yet those situations are subjectively real to the player*" (Crawford, 1984, p. 5). This representation is made dynamic through interaction, and this very dynamism is what distinguishes them from static representations such as art, puzzles and stories. Crowford argues that conflict arises directly from this interaction, and the consequent presence and nature of obstacles that prevent the player from easily achieving their goals: it is the dynamic and active obstacles that make a game such, as opposed to the static and passive ones that characterise puzzles and competitions. Finally, he states that a game is such if experiences of conflict and danger are provided in a context that excludes their physical consequences: in other words, games are a safe way

to experience reality. Interestingly, Crawford also further defines games as formal closed systems, being collections of interacting parts, defined by explicit rules and complete and self-sufficient.

Years later (2001), Callois returns to Huizinga's definition within his work "Man, Play and Games", calling it at the same time "too broad and too narrow". While he agrees that games are gratuitous and separated from reality, the points on which he focuses his attention, and in which he expresses his divergence, are those relating to the denudation of all material interest and the need for the existence of rules. Regarding the former, Callois highlights the existence of games of chance and how they, in one way or another, occupy an important part of the economy and everyday life of various cultures. He then expands the concept identified by Huizinga by stating that, rather than being characterised by the absence of material interests, games are instead characterised by the inability to create new goods, while allowing the exchange of property between actors involved. He calls this characteristic "Unproductive", and defines it as "creating neither goods, nor wealth, nor new elements of any kind; and, except for the exchange of property among the players, ending in a situation identical to that prevailing at the beginning of the game" (Caillois, 2001, p. 5). Regarding rules, he argues that many games do not imply them (e.g. playing with dolls) and that instead in these cases the premise is free improvisation, the pleasure of impersonating a role. He states that "each time that play consists in imitating life, the player on the one hand lacks knowledge of how to invent and follow rules that do not exist in reality, and on the other hand the game is accompanied by the knowledge that the required behaviour is pretense, or simple mimicry" (Caillois, 2001, p. 8). He therefore states that games can be characterised both by the presence of well-defined formal rules and by the make-believe nature of those activities that imitate real life.

More recently (2003), Craig Lindley defines games as "*a goal-directed and competitive activity conducted within a framework of agreed rules*" (Lindley, 2003). Lindley further draws the reader's attention to the role that rules play within his definition: while it is normally assumed that in order to play a game one must know its rules, the definition he has just proposed in fact simply implies that the activity performed respects them and that the players, implicitly or explicitly, accept them. Lendley continues his argument by stating that rules serve to establish what can and cannot be done by a player, and what are the consequences of actions performed within the game world. Playing successfully does not mean knowing all the rules in advance, but only those necessary to support a specific style of play. The player learns the rules that allow him to interact with the game system in a way that is fruitful with respect to his goals. If we pause for a moment to reflect, it is indeed evident that in many games complete knowledge of the rules is not a fundamental factor. For example, most chess players who have not dedicated themselves to the study of the game are unaware of the existence of the "en pas-

sant" rule: this rule states that if a pawn is moved two squares in one turn (a move only possible if the pawn had not been moved previously), it can be captured by an adjacent pawn during the next turn only, as if it had moved only one square. Knowledge of such *special rules* covering borderline cases is absolutely not necessary to play successfully. In fact, these are the kind of rules that are discovered by players as they become invested in the game and become more advanced.

The importance of rules is also central to Juul's definition (2005), which, however, introduces important notions concerning the interaction between players and the game world. Juul defines a game as "*a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are negotiable*" (Juul, 2005, p. 36). He categorically defines all games as having rules, although rather than expressing himself on the players' knowledge of the rules, he states that they must be sufficiently well defined that they can be programmed into a computer or at least not cause confusion for the players as to their interpretation. These rules must act as a pivot to allow for different possible outcomes. In order for the players to see the game as a playful activity, Juul states that the rules must take into account the skill level of the players. In tic-tac-toe for example, there is no rule that can rebalance the game in the case of perfectly played games. This means that when two skilled players play against each other, the result is always a draw, and the game ceases to be a gaming activity in the eyes of the participants. In other games, however, such as Golf, the rules explicitly specify the ability to rebalance the game according to the skill level of the players and the possible presence of a difference in level between them: handicaps. The introduction of such rules makes it possible to maintain variable outcomes even in the case of large differences in ability between the players involved, thus preserving the value of a playful activity. Another interesting point brought forward by Juul is the one concerning the quantification and valorisation of outcomes: the results of a game must be clear and indisputable, and this concept is the one that leads in the game of football to define as an objective 'score more goals than the opposing team' rather than 'kick the ball around the field'; similarly, it is equally important that some outcomes are better than others. The fact that positive outcomes tend to be more difficult to achieve than negative ones is what makes a game challenging and engaging. A game in which it is easier to achieve a positive outcome than a negative one tends to tire the player early and make him lose interest. It is precisely this challenge that gives rise to the conflict that leads the player to expend more effort in pursuit of the ideal outcome. This investment of energy on the part of the player is what often leads to a parallel emotional investment on the part of the player in the game (or in parts of it, such as towards the main character). Although this emotional attachment may also be dependent on the players' per-

sonal attitude, it can be one of the major players in a player's motivation to play a game.

The definitions given here are just a few of the many that exist, but in my opinion these represent the most important ones from a historical point of view and in terms of their influence and impact on literature. They help to weave a red thread that helps us understand the evolution of the term 'game' over time and the discussions around it. I will now try to provide my own definition of what a game is and its most important features and characteristics, a definition that can characterise and clarify the concepts discussed in this work. Much has changed over the years, especially recently, regarding the nature of games. They are increasingly integrated with technology and are more and more present in our daily lives. New technological frontiers have led to new systems of interaction between players and game systems and between players themselves, forcing us to rethink the ways in which we play and approach games. What may seem surprising, however, is that despite this natural evolution, many of the characteristics that I believe categorise games are among those already identified over time by other scholars. I believe games are defined by the *fun and engagement* that can be felt while playing, by their *goals* and their *rules*, by their *outcomes*, by the *conflict* that inherently arises and develops within them, and by the *safety* they offer to the players. In other words:

> *"A game is a fun, engaging, goal-oriented and rule-based activity that, through conflict resolution, allows for different, clear and quantifiable outcomes in a context that is always safe for the players involved."*

We will now address this features in detail, discussing and clarifying them in the context of this definition.

### Fun and Engagement

First and foremost, a game is a fun and engaging activity. This dimension is fundamental and is what distinguishes games from challenges, exercises and other similar types of activities. Although fun is a relative dimension that depends very much on the attitude of the person, a game to be such must be able to capture the attention and interest of the players. Some activities disguise themselves as games, using this term as both a sword and a shield at the same time to defend themselves against complaints from participants who find it boring and to spur their motivation. In the field of game research and gamification, this is often referred to as the 'chocolate-covered broccoli' principle. A chocolate-covered broccoli is simply that, and does not suddenly become a candy: at the first bite it reveals its true nature, destroying any hopes and expectations.
It is important to clarify how fun and engagement are characteristics and not

necessarily goals of the game. There are games designed only as recreational activities, where entertainment and fun are not only characteristics of the game, but also the main objective. But for a game to be such according to my definition, the necessary condition is that it is fun and engaging, and not that the main goal of the players is to have fun.

### Goals and Rules

Every game is goal-oriented. And every game has rules. Rules are a fundamental and very important aspect, and many games are typically accompanied by a well-defined set of rules. Although in my opinion the concept of rules is subordinate to the concept of goals (in the sense that rules derive directly from goals, and not vice versa), both serve to define a game. If I tell a child "Let's play!" his first instinctive response will be "what shall we do?". But subsequent questions will be directed at how the goal can be achieved, and which actions are allowed and which are not. In this sense, as Lindley suggests, the rules represent the framework within which the goals of the game are pursued. This framework can be explicit or it can be implicit, as long as it is clear to all players and everyone agrees on it. Again, playing successfully does not mean knowing all the rules in advance, and in fact what happens in many games is that players learn the rules as they play. On the contrary, players hardly ever start a game without knowing what the goals are. But at the same time, it is also true that with the same goals, two different sets of rules result in two different games. Take Rugby and American Football for example: the overarching goals are practically identical, but the difference in rules turns them into two completely different games. This is why a game is defined both by its goals and by the rules through which it is allowed to achieve them.

### Conflict

Crawford points to conflict as a defining element of games. He argues that conflict arises spontaneously from interaction within the game and is embodied in the nature of the obstacles that stand between the players and their goals: for a game to be such, the obstacles must be active, dynamic and responsive to the players' actions. Obstacles must look like actions performed by an intelligent agent. If obstacles are static or passive, then we are faced with a challenge or a puzzle. Solitaire played with cards, for example, is not very different in essence from doing a puzzle. It represents more of a challenge than a game: starting with a randomly shuffled deck, can I reorder it following certain rules within a certain number of steps? The obstacles (e.g. randomness in the order of the cards) do not actively respond to any of the player's actions and ultimately lead to a limited experience. As Crawford also pointed out, conflict exists not only explicitly in

games in which the players' objectives conflict with each other (e.g. in competitive games), but also in cooperative games: rather than arising between the players, in this case conflict arises between the team of players and the game system, which is to all intents and purposes their adversary. Unlike Crawford, however, I think that conflict arises directly from the existence of competing goals (between players in the case of competitive games, and between players and the game system in the case of single-player or cooperative games) rather than from interaction. Moreover, I think it is precisely the conflict that drives and shapes the interaction within the game. It is through understanding the conflict between one's own goals and the goals of others (whether those of other players or of the game system) that players evaluate how to move within the game world and how to interact with it.

### Outcomes

Outcome is one of the fundamental characteristics of games. As pointed out by Juul, a game needs to support through its rules (and I would add through its goals) different, quantifiable and valued outcomes. This concept is actually inherent in the concept of conflict itself: if there is only one possible outcome, conflict ceases to exist. A single possible outcome means devaluing the actions a player takes within the game world. It means not being able to lose. It ultimately means leading the player to diminish his effort. For example, think of a 'game' in which it is not possible to lose: why strive to conceptualise strategies? Why strive to understand the rules? Why keep a high level of attention through the session? If the players' effort does not influence the end result, they will naturally tend to decrease it. Likewise, it is also important that these diverse outcomes are correctly valued. It is not enough to have more than one outcome, but these need to be ordered in order of preference relative to the goals assigned. In other words, having more outcomes means that some will be better than others. It is crucial that players clearly and unambiguously understand the hierarchy of these outcomes, otherwise they will only be different in the game designer's mind. Finally, it is equally important that these outcomes are unambiguously quantifiable, and that they do not lead to discussion and/or confusion among the players. It is the reason we usually define clearly what winning means in the context of a game (e.g. scores more points than the opposing team within the time limit). It is the same reason why many games in which a neutral result is not expected (e.g. the draw in some competitive games) have rules that serve to clarify cases of apparent ties, and which clearly and unambiguously determine a winner. This is important in order to avoid that the conflict created within the game remains confined to this environment and does not transfer to the real-life context between the players.

### Safety

A game is a context in which to experience things safely. Many games contain within them a representation of reality, or at least a portion of it. The possibility of experiencing these contexts without necessarily having to pay the consequences is one of the most interesting and attractive aspects of games. Within a game, a person can try for the first time at the act of flying a plane, without risking his or her own life and without risking the possible damage caused to others by an accident. Similarly, a player can experience the thrill of commanding a legion of warriors in battle, without risking his own life. Even in games that are less focused on an imaginative representation of reality, such as sports, player safety is still a key element. The rules of these games themselves are made in such a way as to minimise the possibility of players' safety being compromised as much as possible. Even in games such as Poker, where a defeat could represent a real and important financial loss, there is the possibility, supported by the game rules themselves, of limiting losses and deciding in advance on betting limits and maximum capital that players can use. A game, to be such, must guarantee the chance to have experiences in a safe context, a setting where one can risk, be daring, fail and try again, without jeopardising the player's real life. Concerning money, the issue is more delicate, as the value of money varies from player to player depending on their disposable income: for some, betting 2€ means nothing, while for others it could mean the difference between eating a meal or not. In these cases, it is important that the game provides in its rules for the possibility of implementing limits and calibrating the game to various possible ranges, but it is even more important that state institutions establish strict rules to protect players, acting where the 'game' ceases to provide a safe environment and, on the contrary, exploits increasingly predatory mechanics.

## 2.2 Game Taxonomies

Designing games is a very complex process. Part of this complexity stems from the multidisciplinary nature that inherently characterises this process and the confusion that arises among members of the design team, which is as varied and heterogeneous as the process itself, even on the most basic concepts. One thing that can help dissolve this confusion is to establish a common design vocabulary (Church, 1999). This is even more important considering the increasing number of emerging game types, categories and forms, such as mobile games, location-based games, XR games, etc. As stated by Crawford, a taxonomy of games can teach us so much in the context of game design, illuminating common factors that bind families of games together and potentially suggesting unexplored areas (Crawford,

1984). There are numerous taxonomies of games (both Serious and not) in the literature (Djaouti et al., 2011; Jantke and Gaudl, 2011; Ratan and Ritterfeld, 2009; Laamarti et al., 2014; Crawford, 1984; Lindley, 2003) and none of them in my opinion can be considered as the 'ultimate taxonomy': a taxonomy is simply a way of organising a large number of related elements, and consequently different taxonomies can be useful in different contexts because they provide different and usefull points of view and considerations.

The taxonomy proposed by Crawford (1984) for example, although not very suitable today to classify modern games, can be extremely useful in giving us an insight into how the boundaries between game genres have become increasingly thinner and blurred over time. Crawford states that games can be divided into two macro categories, "Skill-and-action games" and "Strategy games", depending on the focus of the gameplay offered by the game. He argues that the first of these two categories, Skill-and-action games, brings together games that focus on real-time interactions, invest heavily in graphics and sound, and tend to use more specialised forms of interaction (e.g. joysticks instead of keyboards). Crawford includes in this macro-category combat games (such as Asteroids and Space Invaders), maze-based games (such as PAC-MAN), sports games, paddle games (i.e. games in which the player's interaction takes place through the use of a ball, as in PONG, a pivotal game in the category), and race games. Crawford also includes in this macro category what he calls Miscellaneous Games, i.e. games that do not fall directly within his taxonomy (as an example he cites Donkey Kong). In general, he argues that the main skills used in this category of games are those related to motor skills, hand-eye coordination and fast reaction times. Strategy

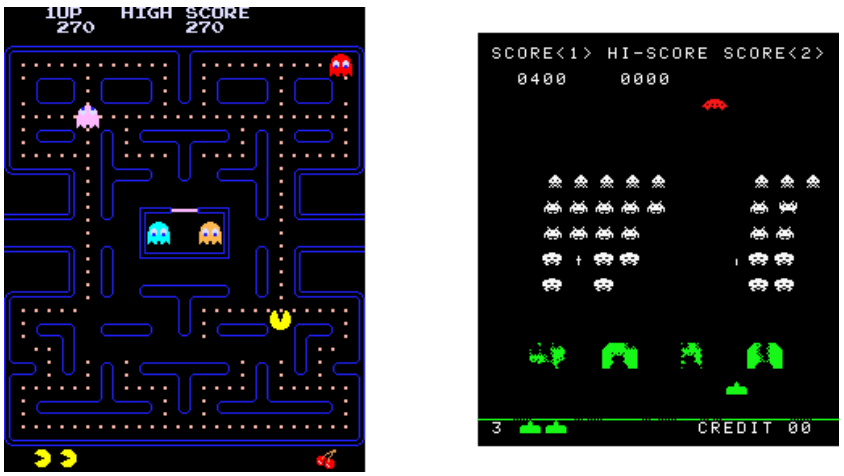


Figure 1: PAC-MAN on the left, Space Invaders on the right. Two of the archetypal Skill-and-Action Games in Crawford's Taxonomy

games, on the other hand, are characterised by a greater focus on "thinking" skills rather than motor skills, defining the major difference precisely in the absence of requirements related to the latter. This is why he also identifies the category with the name cognitive games. Crawford further subdivides Strategy Games into Adventure Games, D&D Games (what we would today call role-playing games), War Games, Games of Chance (such as blackjack), Educational and Children's Games (Serious Games), and Interpersonal Games (games that focus on relationships between individuals or groups, often through the use of emotion-based dialogues).

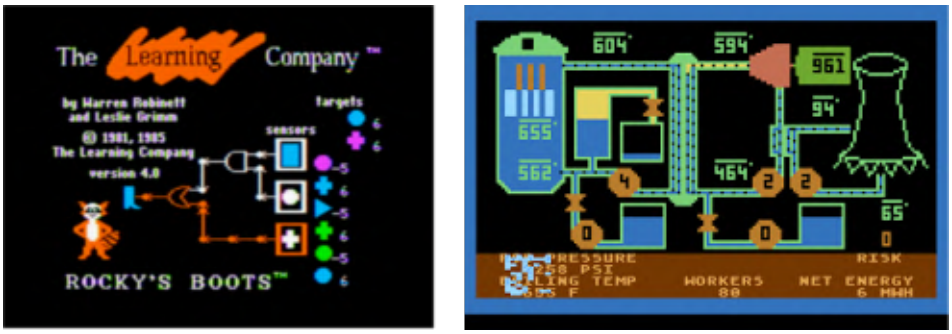


Figure 2: Rocky's Boots on the left, SCRAM on the right. Two Serious Games included in the Strategy macro category in Crawford's Taxonomy

Crawford himself accompanies his taxonomy with a discussion in which he expresses his awareness of its fragility and of the strong speed of change in the world of game design. He expected that the market would establish by brute force the successful genres and that after his work a new taxonomy with more defined genres in which to channel games could be drawn up. What has happened instead is that genres have contaminated each other more and more frequently, leading over time to the definition of countless new categories and, indeed, to the thinning of the boundaries between one and the other. The same need that led to the creation of the sub-category 'Miscellaneous Games' actually already at the time began to underline the difficulty of framing games in vertical categories and sub-categories. Today, for instance, there are innumerable games that mix the key elements of Crawford's two macro-categories: within the same games one increasingly finds both moments characterised by strong real-time interactions more based on motor skills and hand-eye coordination, and more time-relaxed moments, in which it is important to make strategic decisions without being temporally limited (or, especially in multiplayer games, limited simply by the practical coordination needs of the various players).

Precisely because of this contamination of genres that does not allow us to label games within a simple hierarchical system of categories and sub-categories, a type of taxonomy that can be very useful is one that analyses the dimensions

that characterise gameplay and creates a space in which games can be represented in a less discrete manner. An example of such a taxonomy is the one provided by Lindley (2003). He defines and proposes different classification spaces in order to propose a tool that can help understand and especially design games. The first of these spaces that is proposed is the two-dimensional triangular plane formed by Ludology, Simulation and Narratology: characteristics that Lindley calls game forms.

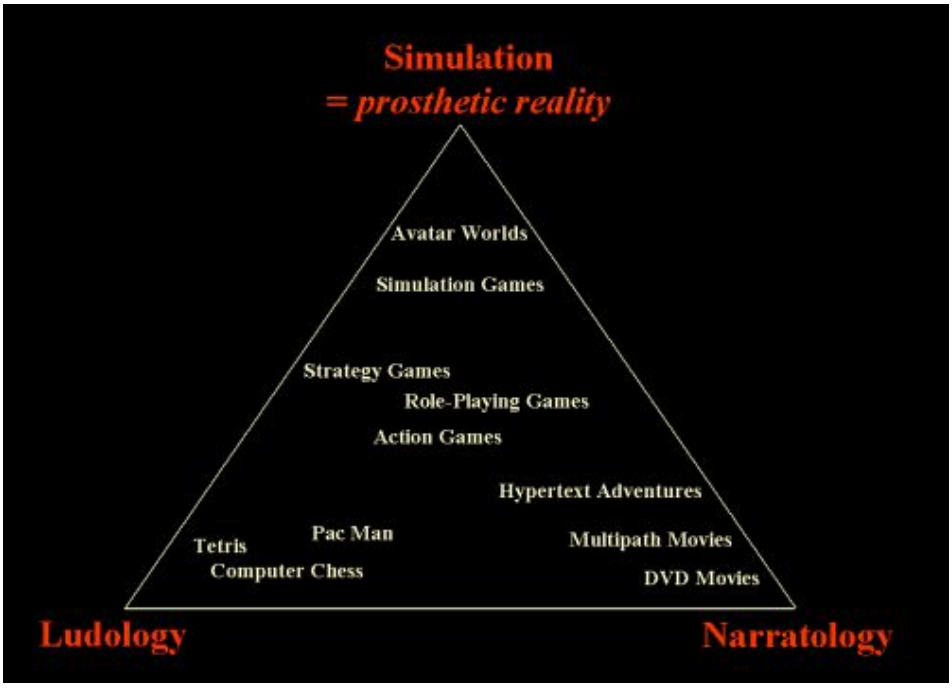


Figure 3: The bidimensional Ludology-Narratology-Simulation classification plane. Source: Lindley (2003)

With reference to Ludology, he states that interaction within game systems follows patterns, which he calls gameplay gestalts. "*A gameplay gestalt can have many forms for a particular game, capturing different playing styles, tactics and approaches to progressing through the game and (perhaps) eventually winning. In general, it is a particular way of thinking about the game state from the perspective of a player, together with a pattern of repetitive perceptual, cognitive, and motor operations*" (Lindley, 2003). Action Games, RPGs, Strategy Games are exactly that, recurring patterns of interaction that may occur within a game in a repeated, intertwined or alternating manner. The Ludology dimension identifies precisely how much a game is focused on the execution of particular gameplay gestalts with respect to the other dimensions.
With reference to Narratology, Lindley states that just as the gameplay of a game

can be described through its gameplay gestalts, the narrative component of a game also follows patterns and structures that can be called narrative gestalts. One of the most frequently used narrative structures in the gaming context is the three-act restorative structure. Prevalent in film and play scripts, this structure involves a first act in which the conflict central to the entire narrative is established, a second act in which the implications of this conflict are enacted, and finally a final third act in which the conflict is resolved. This type of narrative usually takes place around a central protagonist, and each act culminates in a crisis point whose resolution is not only necessary, but central to the continuation to the next act (or, in the case of the third act, to the resolution of the story). In the context of games, the three-act structure can be implemented and visualised at various levels: at the general level, with the first act coinciding with the beginning of the game, the second with the unfolding of the entire game and the third act with its end; but also at the game level step, where the conflict is represented by puzzles, puzzles and enemies placed as obstacles to the player and the achievement of his goals, and the first and third acts are typically represented by cut-scenes (non-interactive films) at the beginning and end of the level. The interactive part is often focused on the low-level conflict offered by the specific monster, the specific riddle or the specific puzzle, the resolution of which takes place through the implementation of gestalt gameplay. Most of the story is carried by non-interactive films, and in any case can hardly be strongly influenced by the player's actions: if we are defeated, for instance, the game does not end but gives us the possibility to restart from the last saved state, reinforcing the idea that we are actually retracing the steps of a story already written, and therefore different and independent from the gameplay. Narratology is precisely the dimension that expresses how much a game emphasises its narrative aspects, often to the detriment of ludology. The fact that these two dimensions are in competition is further emphasised by Lindley in his analysis of the tension between gameplay and narrative aspects: if most of a player's cognitive load is absorbed by gestalt gameplay, little will remain available for understanding complex narrative patterns ("why is the enemy against us afterall?") and vice versa. Lindley states that good game design succeeds in integrating these two aspects in a balanced manner, for instance by using cut-scenes as rewards at opportune moments within the rhythmic patterns paced by the gameplay, so that they are not perceived as interruptions.

Regarding the dimension of Simulation on the other hand, Lindley defines the term as "a representation of the function, operation or features of one process or system through the use of another". Accordingly, a simulation per se does not imply repetitive patterns of goal-oriented activities, nor specific patterns over time (thus clearly distinguishing itself from ludology and narratology). An example that Lindley gives is that of strategy games (such as RTS or Real Time Strategy games), which even in the context of competitive play against an opponent, allow

us to continue playing indefinitely even once we have achieved victory, continuing their simulation of a simple economic system: there are no longer any strictly ludic aspects, and the narrative component typically ends with victory. The real exit condition is determined by the player's boredom. In this sense, simulations are extremely useful for understanding the functioning of more or less complex systems and for training skills (think for instance of flight simulators).
At this point, having defined the three dimensions, it is possible to classify the games by positioning them within the plane in such a way that their distance from the vertices of the triangle is proportional to their embodiment of the elements proper to that dimension. For example, as can be seen in figure 3, games such as Tetris belong to the playful extreme, while role-playing games and RTS, having important elements of all three forms, reside in the centre of the plane. This type of classification, in addition to helping us better understand games, allows us to make important considerations regarding their design, emphasising the tension between the various forms or dimensions involved, favouring the brainstorming of game ideas and highlighting portions of the plane that are apparently sparsely inhabited and thus open contexts for active exploration.
Lindley, starting from this two-dimensional plane, creates three further classification planes. The first of these is achieved by adding the 'Gambling' dimension, understood as the gain or loss caused by random elements.

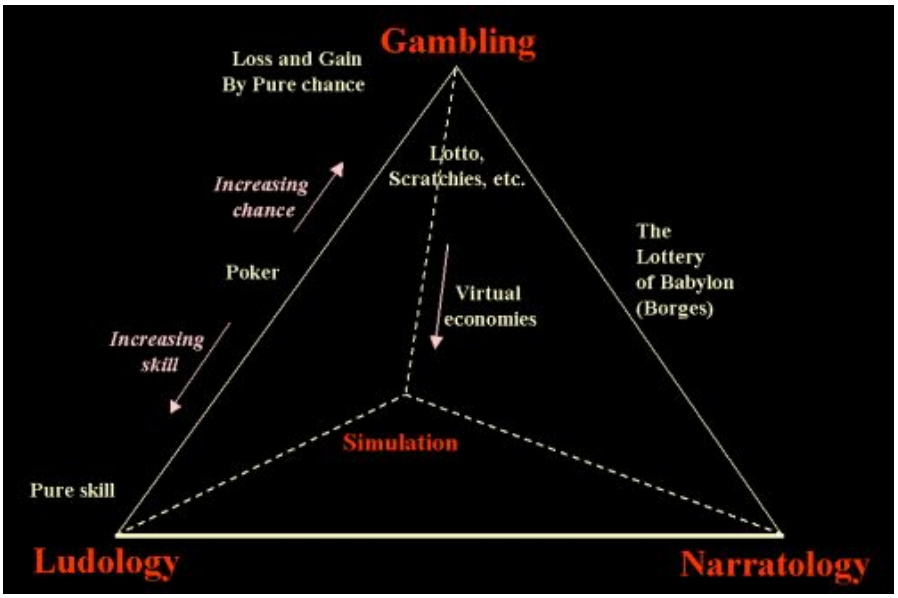


Figure 4: The 3D classification space obtained by adding Gambling to the Ludology-Narratology-Simulation plane. Source: Lindley (2003)

We can then distinguish games in this new three-dimensional plane by assessing

how important the role of randomness is within them. The game of Poker for example, in which one's skill can strongly manipulate the outcome of a game to the detriment of the fact that cards are dealt completely at random, will be positioned somewhere between Ludology and Gambling. Similarly, the line between gambling and simulation defines the space of simulative games in which the random element is important (e.g. simulations of virtual economies), while the line between narrative and gambling identifies the space of those experiences that are structured in time but are still strongly influenced by randomness.
The other two classification spaces that complete this framework offered by Lindley are both characterised by two opposing additional dimensions, representing the presence or absence of an element: the creation of a fictional world in one case and the 'virtuality' of the experience characterising the game (i.e. how virtual this experience is, as in the case of videogames, or how physical it is, as in the case of sports) in the other. The introduction of this dimension and its opposite gives rise to classification prisms.

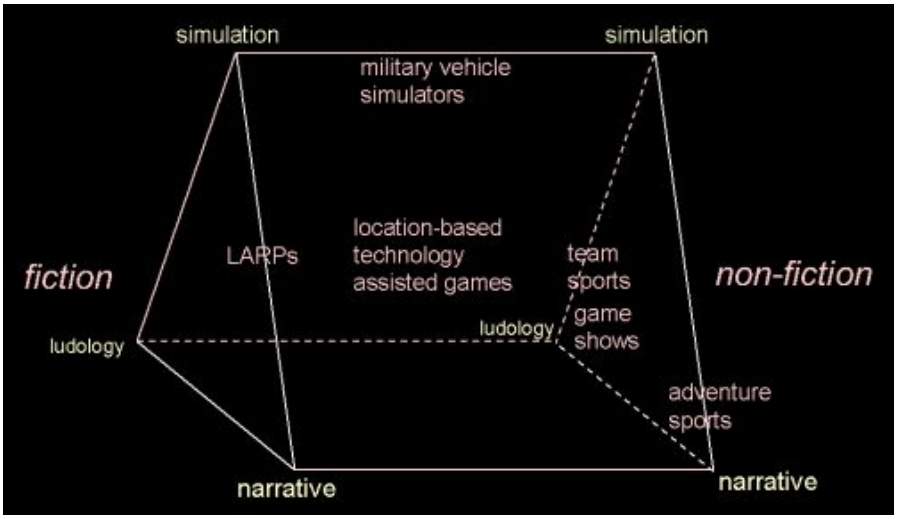


Figure 5: The 3D classification space obtained by adding Fiction and Non-Fiction to the Ludology-Narratology-Simulation plane. Source: Lindley (2003)

Although there is a clear correlation between physical experiences and non-fictional representations, and between virtual and fictional experiences, there are countless cases of games played physically but set in fantasy worlds (such as all LARP, Live-Action Role-Playing games, in which the role-playing takes place physically through the players' acting) and vice versa of virtual games but with worlds firmly anchored in reality (such as the various military-themed shoot-em-ups set in the various wars that really existed). This makes it necessary to maintain (and use) both of them, precisely because they provide different information, insights and

opportunities depending on what one wants to analyse in a game.

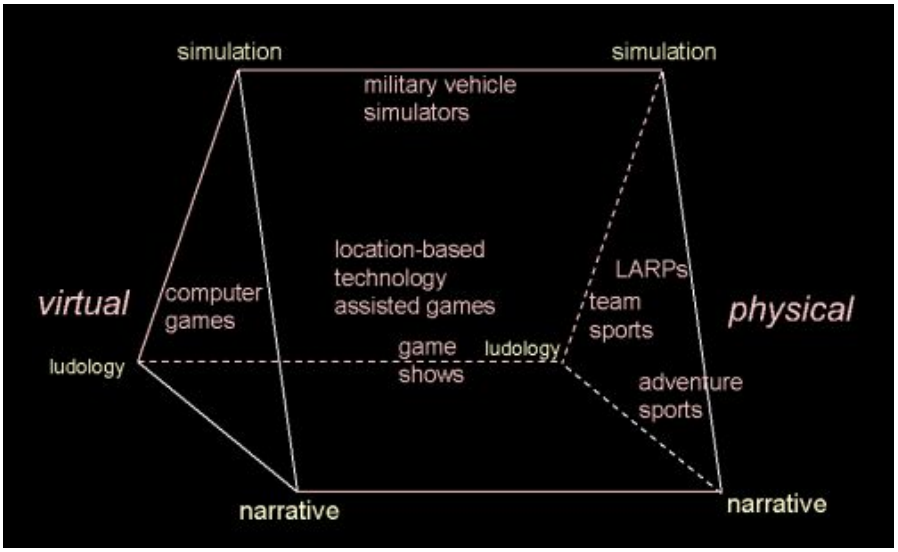


Figure 6: The 3D classification space obtained by adding the dimension of Virtual and Physical experiences and Non-Fiction to the Ludology-Narratology-Simulation plane. Source: Lindley (2003)

The use of these classification spaces and dimensions, as stated by Lindley himself, can be of great help to game designers, both in the form of high-level mapping useful to establish where and how to apply design patterns and other design techniques ( even borrowed from other design contexts, such as the writing of film scripts in the context of games that strongly emphasise the narrative component), in the form of facilitating communication between the actors in the game design process regarding the game's design direction, and in the form of stimulating deeper discussions regarding essential elements of the game design itself, such as "is it really possible to develop game mechanics that can actually advance the overarching narrative structure beyond the time scansion provided by the game's rhythms?". Furthermore, from the point of view of pure game classification and comprehension, these kinds of geometric visualisation spaces can be extremely immediate and easy to use, especially from the perspective of guiding the user towards game design elements that are important in distinguishing between various games.

In the specific context of educational games, much can be studied and understood from taxonomies specializing in Serious Games. An example of such a taxonomy is offered by Laamarti et al. (2014). In order to classify Serious Games, they try to identify and extract from the literature and applications therein the features that are most important for their design and that increase the potential for success of the game itself. The classification dimensions that emerge from this

study are the following: *activity*, *modality*, *interaction style*, *environment* and *application area*.

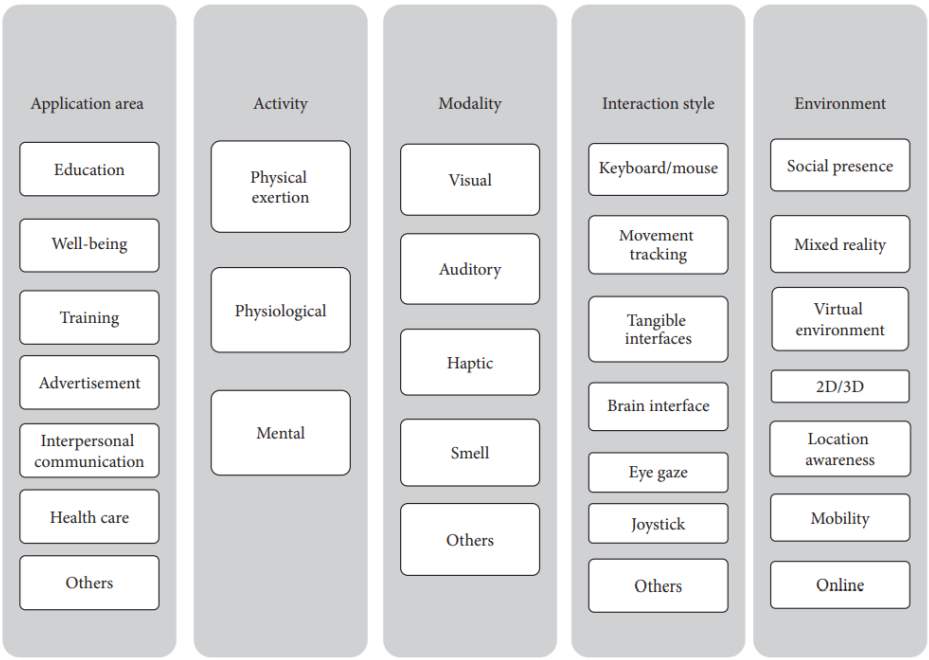


Figure 7: The Serious Game Taxonomy presented by Laamarti et al. (2014)

*Activity* is the dimension that describes the type of activity required by game mechanics and performed by players. The authors state that these activities can be physical in nature, such as in serious games for well-being and to contrast obesity, psychological in nature, such as in games for rehabilitation, or mental in nature, such as in games for interpersonal communication and training.
With *Modality*, instead, the authors refer to the means by which information is communicated from the game system to the players. This dimension includes the sensory modalities through which the experience is consumed (visual, auditory, tactile, etc.). Laamarti et al. point out with concrete examples from the literature how the choice and use of the correct sensory modalities according to the objectives of the Serious Game is crucial to its success, as in the case of visual feedback in mobile games and auditory feedback in well-being games.
Another important characteristic in order to classify Serious Games is that defined by the *Interaction style*, i.e., the interfaces used by players to interact with the game system (e.g., keyboards, mice, joysticks, movement tracking, eye tracking, etc.). Choosing the correct interaction style can strongly influence the success of the Serious Game. In the context of well-being and anti-obesity for example, the use of joysticks (even if they are specialized, such as those used by the Wii Fit

game) may not be sufficient to ensure proper player movement: in the case of the absence of tracking devices that monitor the legs, in fact, players could simulate full body movement while remaining comfortably seated on the couch.
With regard to the *Environment* the authors, focusing on digital games, identify six criteria that can be combined in order to describe the type of environment present in the game: whether the environment is 2D rather than 3D, whether it is virtual or uses mixed reality (i.e., mixes real and virtual world elements, as in Augmented Reality (AR) games), whether it is location-aware (i.e., takes into account the player's location within the real world), whether it is for mobile games or not (Mobility), whether it is playable online or not (Online), and whether it involves multiplayer or not (Social presence).
The last characteristic identified by Laamarti et al. is the *Application Area*, i.e., the application domain of the Serious Game. Interestingly, the authors report that the dominant areas within the Serious Games context are education and advertising, with a combined share of 57 percent of the entire market, with the remaining 43 percent divided among other areas including well-being, cultural heritage and health care.
Classifying Serious Games by means of this type of taxonomy and studying the results can provide invaluable insight, especially when accompanied by considerations of their success (or lack thereof), into understanding possible correlations between design choices made along these outlined dimensions and the achievement of their intended goals.

As we have seen, different taxonomies can shed light on different aspects related to game design and be useful in different contexts, depending on what one wants to analyze. Serious Games are first and foremost games (albeit characterized by goals other than pure entertainment), and so taxonomies drawn up for commercial games can be equally useful in studying, understanding, and designing them. Similarly, more specialized taxonomies in the area of educational games can help us understand what factors are important and frequently used in specific areas, and if used correctly, can help us make predictive estimates of their potential success. Ultimately, taxonomies prove to be an indispensable tool for game designers, and much can be gained from integrating them within one's designer tool-box.

## 2.3 Games as Systems

A system can be defined as a set of objects together with the relationships between them and between their attributes (Hall and Fagen, 2017). In the context of games, the need for communication of rules and their management implies a necessary exchange of information. The presence of this information exchange means that games can be considered as information systems (Salen et al., 2004). The

exchange of this information makes games dynamic systems that are constantly changing, and the fact that the effects of games can also have a tangible impact outside the game context, such as the acquisition of knowledge or the impact on players' emotions, categorizes them as both closed and open systems. Similarly, the subdivision of games into internal mini-games (as for example in the case of the video game Super Mario Party) fits perfectly into the characteristic of systems to present internal subsystems (Hall and Fagen, 2017). The characteristic that distinguishes game systems from systems in a more general sense is that the mini-games are always hierarchical, and their progression is always subordinate to the overall game system. As a matter of fact, the idea of representing and studying games as systems is not a new (e.g. Fullerton et al., 2004; Salen et al., 2004; Juul, 2005) and the literature presents numerous models designed to formalize this representation. Some of them focus towards a more structural and simplistic view, such as the MDA model (Hunicke et al., 2004) that represents games through three main components: Mechanics, Dynamics and Aesthetics. Similar structures, in the sense that the representation provided can always be traced back to the same higher-level parts of a system, can be observed in other models, such as the Means, Play and Ends (Browne and Maire, 2010) and the (Takatalo, Häkkinen, Kaistinen, and Nyman, 2010) model. The problem with these models is that they do not provide a detailed and careful view of the elements of a game system, a condition in my opinion that is crucial to being able to understand and study games. Other models, such as the Game Ontology Project (Zagal et al., 2005), focus on giving a more ontological view of the hierarchy of game elements and their relationships, remaining at a more abstract level. Among the models that focus more on the elements of a game system (e.g. Aarseth et al., 2003; Holopainen, 2011; Elias et al., 2012), one in particular in my view stands out for its versatility in the context of understanding all games (both physical and virtual, both educational and commercial): the Theory of Game Elements by Järvinen (2008). One concept that he states and that I find particularly important for the purposes of game design is that any game can be deconstructed into a unified set of theoretical concepts that can be used to construct new games. In order to better understand this Theory of Game Elements, however, it is important to discuss the concept related to state and changing states within game systems.

In fact, games constantly change their state (just think of the updating of a player's score or the physical movement of a pawn on a game board). Juul (2003) also states that it is the rules of the games themselves that provide for their dynamism, representing in fact the description of how the system changes from one state to another. On the basis of these considerations Järvinen suggests that a game can therefore be represented by a state machine and that, moreover, the definition of the possible states within the game system is a fundamental step for a clear definition of its rules. From this point of view, communicating to the player in a clear way

the state in which the game system is, is fundamental so that he can interact in a conscious and informed way. Järvinen defines the game states as the bearers of instantaneous information regarding the relationships between the various game elements, and also recognises them as the metronome of the game time. A change of state in a game (such as a "check" in chess) is such a significant moment that it can be used retrospectively to identify a precise moment within a game. The duration of a game is thus determined by the total duration of all its states. The same states of a game system can also be used to represent objectives: particularly important states (such as a checkmate) refer to more general and high-level objectives (winning the game through a checkmate), while minor states (such as the advancement of a pawn on the chessboard) refer to minor objectives (gaining control of some squares) which, although important, are always subordinate to higher-level objectives. Although players often spend most of their time pursuing low-level objectives, the system detects changes in the status of high-level objectives, such as a change in scoring. What happens then is that, in completing and monitoring activities, the player actually monitors whether or not the state changes he induces are conducive to achieving the set goals. Consequently, a clear understanding of game states is crucial for players. In order to be able to understand in depth the state changes of the game systems and their modalities, Järvinen therefore provides a taxonomy of game elements.

### 2.3.1 Järvinen's taxonomy of game elements

The model proposed by Järvinen (2008) identifies nine distinct game elements. According to the proposed theory, the process of designing and describing a game amounts to defining which elements will be used, what will be the relationships between them and what will be the attributes that will distinguish them within the various game states. Järvinen categorises these nine elements further into three distinct categories; systemic elements, behavioural elements and compound elements. Systemic elements are those that distinguish the game system and will represent the state the system is in at any given time. The behavioural elements identify the external sphere of the game, made up of the players and the various contexts in which the game takes place. The compound elements, on the other hand, are those elements through which the interaction between behavioural and systemic elements takes place. The list of elements is therefore as follows:

- Systemic elements
  - Components
  - Environment
- Compound elements

  - Ruleset
  - Game Mechanics
  - Theme
  - Interface
  - Information

- Behavioural elements
  - Players
  - Contexts

We will now briefly analyze and present each game element on its own.

### Components

Järvinen defines the components as the objects that the player can manipulate and place or use in the course of a game. They are characterised by various significant attributes, such as their physical appearance or the value they represent within the system (e.g. a monopoly banknote representing a certain amount of currency). Among the most important attributes is that of membership: a component can either belong to a player or belong to the system. This attribute of membership is a sufficient discriminator to classify them into *personals*, *of-others* (other players) or *of-the-system*. Personal components are those which represent the player himself (e.g. a token) or his possessions. Their function is to provide a tangible representation of themselves or to show their degree of success and/or progress within the game. It is important to note that some games (e.g. tennis) do not have a token representing the player: in these cases it is the player's own person that is considered a component. In the light of what has been said, the understanding of the objectives and the commitment with which they are pursued by the player may depend on the degree of identification between him/her and the component that represents him/her: for this reason, a high degree of customization of such a components may lead to an increase in the player's investment within the game. Similarly, the way in which the components of-others and those of-the-system are represented can accentuate the relationships of antagonism or empathy developed within the game. Consequently, the components are pivotal elements in determining the motivation levels of the players. The distinction between personal, of-other and of-the-system components implies, among other things, the opportunity of defining a whole series of game dynamics aimed at destroying, manipulating or taking over other components. Moreover, games often contain components whose role changes according to the actions of the players

(e.g. a ball). Their possession may be limited or temporary, but they still play a key role in the game.

### Environment

Environmental elements represent the physical or virtual constraints of the game system. Consequently, one of their tasks is to define the rules specifying how to interact with the space within the game system. Through these elements, the interaction between the components and the game space takes place. For this reason, environmental elements are often used during the design of the game to guide and limit the possible actions of the players. The creation of a detailed environment in which to play the game, although it can help to communicate to the player in an implicit but direct way the spatial rules in action, is not always possible: if for video games the environment, being simulated, can be extremely detailed and imaginative, for physical games it is often reduced to a play area or a playing field. Moreover, for some categories in particular, such as card games, the environment is not necessarily dedicated to the game. Järvinen identifies the following attributes in environmental elements:

- part/whole: this attribute defines the relationship between the environment and other possible sub- or super-environments. It also often defines a particular function that the environment performs as part of its super-environment.
- state: this attribute describes whether the environment, or a part of it, is occupied or not. It can also describes any other function it may have within the system.
- scale: this attribute defines the relationship between the size of the environment and the size of the components, and the relationship with its possible reference in the real world.
- vectors: this attribute defines the possible directions of movement.

Moreover, environments are also classified into the following categories:

- boards/fields: these include those environments that are defined to define the interaction between the various components or those that provide the ability of adding components. In any case, their function is to make explicit some of the rules (of interaction in the first case and of positioning in the second).
- setups: these are the elements that define the orientation of the components in the case there is no real game environment.

- ecosystems: those environments that include complex simulative models and resemble a real ecosystems. They are common within online virtual worlds.

### Ruleset

Järvinen states that although the rules are concretised and represented within high game elements, it is possible to extract them and consider them as a class of elements in their own right. This is reinforced by the fact that a manual or rule book is often provided with the game to document and facilitate understanding. The reason why rules are normally embodied within other elements is because of their inherent verbal and conceptual nature. Within this discussion, Järvinen places a particular focus on rules related to goals, identifying them as the true discriminators between game systems and other activities similarly represented as systems. In general, the set of rules is therefore first embodied in manuals and/or rule books, and then in procedures concerning the game elements named by them. Järvinen establishes a clear distinction, however, between procedures whose main actor is the game system and those whose main actor is the player. The latter are referred to as *game mechanics*. Procedures are then executed by the game system mainly to assign a value to different game states and outcomes, through the allocation of penalties or rewards, and to manage interactions between game elements. The system uses procedures to manage the information at its disposal. If, for example, we consider the case where a football game is being played, and one team scores a goal, the set of rules defines a procedure whereby that team gets a point and the field of play is reset. The set of rules then serves to manage the entirety of the game system. While procedures actually set the game system in motion, providing players with information about statuses, challenges, rewards, punishments, etc., game mechanics allow players to modify the current state of the game. In a sense, game mechanics define the input modes of the system while procedures implement the business logic and define the output modes.

### Game Mechanics

As already introduced, game mechanics describe the ways in which players can interact with game elements in order to influence the current state with the aim of achieving a given goal. To the input defined by a game mechanic, i.e. the sequential combination of game elements, the system responds with one or more procedures that are part of the ruleset. Kicking the ball (component) and moving (the player himself is a component) within the field (environment) is an example of game mechanics and of the related sequential combination of game elements; depending on where the ball will end up (inside the goal, outside or inside the field), the system will respond with the appropriate procedure, e.g. with a thow-

in. Game mechanics are essential elements as they are involved in every significant event in the system. From the player's point of view, performing game mechanics means performing an action within the game. For this reason, game mechanics can be easily, and rightly, described with verbs: move, move, shoot, etc. Consequently, the very nature of a game mechanic can define and characterise the game itself: "guessing" for example characterises quiz games, just as "shooting" characterises shoot-em-up games.

### Theme

Järvinen defines the theme as a compound element used to contextualise the set of rules and other game elements in ways different from those required by the game intended as an information system. While the ruleset in itself provides a context of meaning for the game system, the theme proposes a further level of meaning directed primarily at the players. Considering the definition of metaphor provided by Lakoff and Johnson (2008), who consider it as understanding and experiencing one thing in terms of another thing, the theme can be considered as an element that performs the function of metaphor in relation to the game system. Game designers use the theme to transform the information system characterised by the set of rules into a system full of elements that contribute to the player's experience. For this reason, themes in games often involve popular cultural references, in order to bin the player into a more familar territory. In the case where a game does not use any theme, its role is taken by the set of rules itself. In these cases, the whole metaphorical plane is missing and the game system is presented exactly as it is. Järvinen further states that a game theme is also defined by the ways in which information elements, such as components, environments, game mechanics and rulesets, are transformed into a metaphorical form by specific means and styles of representation. The assignment of metaphorical roles to players, according to the game objectives, represents the main way in which the players are included in this transformation process. Indeed, the way in which they experience themselves changes during the game, encouraging a process of decentralisation from the self. A theme can also be used to camouflage elements of the game that are familiar to the player, making them take on new forms and thus producing the possibility of providing a different experience. The choice of a theme is therefore important for player identification and experience, and consequently important for the success of the game.

### Interface

Järvinen defines the interface as the means by which players produce input to the system. It represents the necessary element to be able to manipulate game

elements. Consequently, the choice of certain interfaces makes possible the implementation of particular game mechanics. For example, consider the Wii Fit game, in which players use a special controller in the shape of a circle to play a number of exercise-based games: without the presence of a special controller, most game mechanics would have to be modified or even eliminated. In the case of video games, the structure of the interface is particularly important. In these cases it is so integrated in the game experience that it becomes possible to use it, at a design level, as a modulator of the level of challenge presented to the player: think for instance of the difference that the presence of a crosshair maker makes in the experience of a player playing a first person shooter. Learning to play a videogames implies learning to use the interface, making it a crucial part of the game's set of rules.

### Information

In Järvinen's theoretical model, information is a compound element that acts as a catalyst for the meaning of the other elements to which it is linked. One of the peculiarities of this element is that, from the player's point of view, it can be both acquired and produced. Information production occurs when a player performs one or more game mechanics, while acquisition often results from the application of procedures. This implies that the number of game mechanics present in a game system, together with the complexity of the information produced by players during their execution, directly impacts its complexity. Consequently, the less structured the information produced, the more complex its interpretation by the system becomes. Another important feature is related to the way in which players receive information from the game system. This information can be transmitted in a completely transparent way, without hiding anything, as in the case of chess, where the players know all the information contained in the system, or it can be disguised, as in the case of Blackjack, where the players do not know the order of the cards hidden in the deck. The way in which information is communicated to players is often sub-determined by the presence and nature of particular targets. Cheating in a game often translates precisely in the attempt to obtain perfect knowledge of the information contained in the game system: one of the strategies used to win at Blackjack is not by chance that of counting cards, i.e. obtaining transparent information where it was not provided in order to gain an advantage over the system. Similarly to environment and components, Järvinen categorises information according to the property attribute into: *personal*, *of-others*, *of-the-system*. This distinction becomes evident if we think for instance of quiz games: the information that each player possesses is not necessarily shared among all of them. Moreover, the information possessed by the system is the only one that determines whether an answer is ultimately correct or incorrect. Järvinen also proposes a

further way of categorising information, namely the object of information content:

- information about agents: information about the roles of players, both real and managed by the system (NPCs, AI), and their attributes.
- Information about objects: information about component attributes.
- Information about the system: procedures defined by the ruleset, together with information about game states.

Another important characteristic of information is defined by where it is stored. Some instances of the information element, such as received messages, direction vector information, etc., are stored directly within the system. Others, however, such as the time sequence of events occurring within a game, may be stored outside the game system. In the context of video games, this is often done by means of the save function, through which the entire state of the system is stored for later retrieval. Information is thus a crucial compound element within game systems, used to keep track of game states and attributes of the elements involved, but also to stimulate the curiosity of players and create particular emotional states.

### Players

According to Järvinen, players make the game system meaningful through their actions and decisions. While it is true that players' actions impact on the outcomes and states of the game system, it is also true that the system in turn, through its elements, has concrete effects on players. A particularly frustrating or difficult game (such as, for example, the series of games produced by From Software often identified with the simple name of "Souls Games") actually influences the emotional state of the player, stirring and exciting him. These dynamics represent for game designers an additional tool that allows the definition of paths that have a specific outcome in players. Regardless of the degree of freedom perceived by the players within the system, the predictability of the actions taken by the players and of the possible reactions is fundamental in order to draw up a coherent ruleset suitable for the objectives. Although the emotional state of the players is something that at first glance seems to fall into the category of non-predictable elements, through careful narrative and design choices it is possible to achieve planned results. This is very close to the ways in which an artist deliberately provokes certain emotions in his audience. From a systemic point of view, Järvinen identifies and extracts the relevant qualities of a player from the game elements themselves. These are:

- Player possessions

- Player agency (in relation to game mechanics)
- Player abilities, knowledge, and skills
- Player organisation (in relation to other players)

The model states that through these attributes it is possible to profile the players within the game system, and therefore anticipate, or try to anticipate, their behaviour.

**Contexts**

Järvinen defines the context, in its most basic sense, as the element that represents the space and time in which the game is set. Within a game there are often many contexts, and its theme can expand them further. From a game design point of view, the choice of the main contexts and of those introduced further by the selection of one or more themes is crucial. The contexts that embrace a game are one of the most important elements in determining the success or failure of a game, precisely because they are among the elements that have the greatest impact on the final experience made by players and on the development of their gaming habits. In fact, according to Järvinen's theoretical model, where the player element defines in a certain sense the behaviour and the relationship of a player towards the game, the context element expands the interaction to a higher level: the one of the player's habits and of his personal history, indirectly determining also when, where and with whom he will play.

## 2.4 The effects of playing Serious Games

Once games, their structure and characteristics have been formally defined, one of the most important questions that naturally arises is "what effects can Serious Games have on students and learning processes?". This natural question has been the subject of academic interest and research ever since the phenomenon of gaming and the presence of games within our daily lives quickly began to increase to the levels of cultural and social phenomenon reached today.
In 2006, in a report highlighting the strength and potential of games as a means of enhancing educational processes, the Federation of American Scientists (FAS) called for further efforts (including from the private and institutional sectors) to investigate the use of complex gaming systems in learning contexts (Federation of American Scientists, 2006). This need was further highlighted in 2009, in a special issue of Science (Hines et al., 2009). The presence of these calls is important especially in the context of previous historically negative views on games, such as

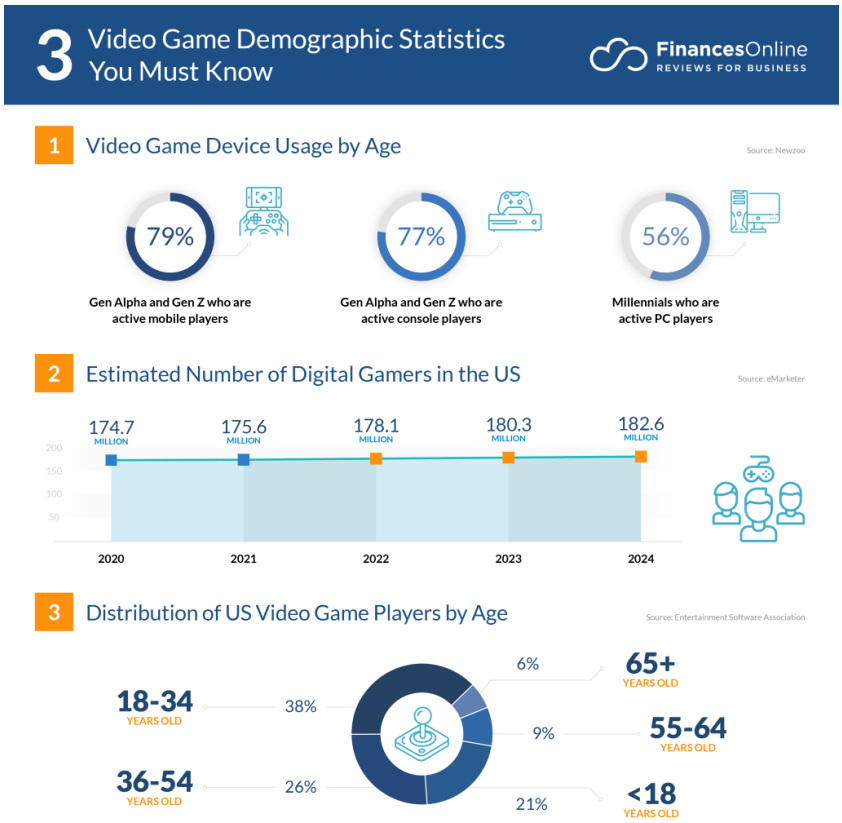


Figure 8: Demographics statistics on gaming in 2022. Source: FinancesOnline (2022)

the infamous association between playing violent games and increased aggressive behavior (Anderson and Bushman, 2001; Anderson, 2004) later challenged (e.g. Ferguson, 2007), and underscores the shift in academic and cultural perspective toward new positive views. Over time, academic research has demonstrated the potential of using Serious Games in terms of motivation (Connolly et al., 2012; Kordaki and Gousiou, 2017; Vlachopoulos and Makri, 2017), engagement and participation (Fu et al., 2016; Dichev and Dicheva, 2017; de Freitas and da Silva, 2020; Ekici, 2021), social collaboration and teamwork (Kordaki and Gousiou, 2017; Vlachopoulos and Makri, 2017), conceptual (Barab et al., 2007; Klopfer et al., 2009) and epistemological (Squire and Jan, 2007; Squire and Klopfer, 2007) understanding, and improvements in academic and work related tasks (McKeown et al., 2016; Liu et al., 2017; Koivisto and Hamari, 2019; Bai et al., 2020).

In a systematic review from 2012, Connolly, Boyle, MacArthur, Hainey, and Boyle analyze the literature in order to verify empirical evidence regarding the impact and outcomes of game use. Among the results found, they report outcomes

on motivation, knowledge acquisition and content understanding, perceptual and cognitive skills, psychological outcomes, and outcomes related to soft skills and social skills. Many of the studies related to knowledge acquisition referred to games developed ad hoc for specific curricular goals, with the exception of one case in which The Sims (a commercial game) was used to teach a language, and reported increases in student performance in both formal and informal settings. These studies also report a high level of enjoyment of play activities by students, along with a perceived increase in motivation. Regarding perceptual and cognitive skills, the authors report a majority of commercial games within the analyzed studies, along with increased evidence of the greater range of attention and visual perception reported in entertainment digital games players compared to non-gamers, with important findings regarding the mediation of gender differences with respect to mental rotation, spatial and attentional skills. Results also include improvements in performance regarding working memory, addition, auditory perception, selective attention tasks, and higher level thinking skills. Regarding motor skills, Connolly et al. report mixed results, with improvements in performance on depth perception and operative performance. Regarding behavioral change, the authors report again mixed results, with positive cases for example in the context of training young women with respect to engaging unwanted sexual attention, and more neutral cases in the context of developing empathy toward the homeless (with effects varying between positive and neutral, however not negative). Regarding social and soft skills, increases in self-efficacy are reported while regarding affective and motivational outcomes they are reported as among the most frequent outcomes, although mostly achieved using entertainment games. In general, the authors highlight the interesting fact that most of these studies use precisely games not categorized as Serious Games, undermining negative perceptions about them.

The results found by Connolly et al. concur with those found in another systematic review from a few years later by Clark, Tanner-Smith, and Killingsworth (2016). They report and highlight an increase in performance of students involved in digital games activities by 0.3 standard deviations compared to non-games conditions, in practice affirming the effectiveness of this approach. The results also point to the support that games have in the context of achieving educational goals related to intrapersonal skills such as intellectual openness, work ethic, conscientiousness and positive core self-evaluation. The authors also emphasise the importance of design of the intervention rather than the intervention as a mere medium, reporting an e analysed games are reported in this systematic review. Concerning the duration of game time, the authors present an improvement in the achievement of learning outcomes in the case of multiple game sessions compared to single sessions. Interestingly, this improvement is not significant when analysing the total duration of the game sessions, thus suggesting an advantage in breaking the game into several temporally spaced sessions rather than concentrating it all in one ses-

sion, regardless of duration. Concerning the presence of additional instructions, Clark et al. state that the addition of unintegrated, supplemental instruction does not lead to significant gains, pointing however to findings in the literature that affirm the potential of additional instructions and information specifically designed to enrich the game content as part of an integrated experience. Also interesting are the findings concerning player configuration: the authors find an improvement in performance in single-player games without competition and in collaborative team competition games compared to single-player games with competition elements. The latter are reported as the least effective form of play for enhancing learning outcomes. The authors also report a significant (albeit small) negative relationship between high contextualisation values (derived from the aggregate of several visual and narrative game characteristics) and learning outcomes. The findings suggest schematic games may be more effective than realistic or cartoon-like games, and similarly suggest that the absence of a narrative component may be more effective. The authors provide as explanations for this the increased cognitive load in students, biases and limitations in the choices made at the coding level of the review and/or the nature of the assessments in the studies reported.

Results consistent with what has been discussed so far can also be found in the work of Boyle, Hainey, Connolly, Gray, Earp, Ott, Lim, Ninaus, Madeiras Pereira, and Ribeiro (2015). In this review, the authors systematically analyze 143 high quality papers published between 2009 and 2014 in order to verify findings regarding the effects of using games. The studies analyzed in the review report the use of entertainment games and games for learning in equal measure, used in both formal and informal settings in a variety of application areas (STEM, health, business, etc.). Most studies report the use of only one specific game (78%) with fewer of them reporting the impact of games in general. Outcomes in knowledge acquisition, perceptual and cognitive outcomes, affective and behavioral change, physiological outcomes, and outcomes in soft, social and specific skills are reported. Regarding knowledge acquisition, the review generally reports improvements in performance compared to non-gaming control groups, with two cases of mixed results. Interestingly, the vast majority of improvements in knowledge acquisition are reported in studies using games for learning, with only five cases present concerning the use of entertainment games, underscoring a growing interest in designing educational games specifically for these goals as opposed to using existing entertainment games, despite the costs in terms of effort and resources required to design and develop a game. Improvements in skills acquisition and knowledge retention in the medical setting (triage skills, cardio-pulmonary resuscitation and advanced cardiac life support) are also reported in the review. Respectively to perceptual and cognitive outcomes, attentional and visual perception benefits, improvements in performance regarding task switching, multi-tasking, implicit learning of sequential context, and the ability to deploy attention over space, time and

objects are reported. Boyle et al. also report increased motivation and promotion of skills related to problem solving along with benefits related to working memory and fluid intelligence. With respect to physiological outcomes, improvements in balance are reported from the use of games (although not different from the control group trained through traditional programs) and benefits concerning the use of exer-games for physical fitness. All studies concerning physiological outcomes use entertainment games. With regard to affective and behavioral change outcomes, the study reports improvements related to the use of games regarding levels of arousal, feeling of presence, situation awareness and faster performance when needed. Improvements through the use of specialized games, compared with control groups, are also reported relative to the development of prosocial behaviors, resistance to relapse in the context of alcohol dependence, and in the improvement of relationship satisfaction and intimacy motives in relationships with partners. Interestingly, also with regard to affective outcomes and behavioral change, most of the analyzed studies report the use of entertainment games. Finally, with regard to social and soft skills, the authors report findings suggesting that gamers do not play in order to satisfy their basic needs and rather, turn out to be highly social individuals. Evidence of benefits related to emotional expressivity and control, empathy, and interest in other cultures is also reported. A case of using a game in order to train soft skills in the context of disaster communication is also reported.

Similar results can again be found in another systematic review carried out by Vlachopoulos and Makri (2017). In this paper, the authors analyze 123 articles published between 2013 and 2016 in order to understand the effectiveness of digital games and of the advanced use of digital games within the classroom. Among the benefits of using games, improvements at the level of cognitive learning outcomes are reported and supported by empirical evidence, with regard to knowledge acquisition, conceptual application, content understanding and action-directed learning. The authors report findings related to the increased likelihood, in the context of problem-solving, of students learning when using games compared to traditional learning experiences. Especially in the context of medical education, Serious Games prove to be effective training methods, both for single-player and multiplayer games. An interesting finding reported in the review is that challenging games enhance player performance. The authors also report empirical evidence in other application areas, such as mathematics, history, languages, physical education, physics and marketing. Especially in the contexts of laboratory activities, the analyzed studies present evidence of students' preference for visualized simulations. From the reported analysis, the power of simulations is also evident in the context of clinical skill practice, nursing practice knowledge, critical thinking and decision making, as well as in terms of facilitators of flow experiences and learning. Students often perceive simulations as enjoyable learning tools, as they provide them the opportunity to observe the outcome of their actions and

apply decision making and problem solving. Vlachopoulos and Makri also find behavioral outcomes in the form of developing collaborative, social and emotional skills. At the level of social skills most of the studies analyzed report benefits and improvements, when using Serious Games and simulations, at the level of communication and teamwork, with studies reporting positive reactions to participatory simulations and evidence of improved quality of learning through the use of collaborative activities. The authors state that the use of digital games and simulations prompts students to interact not only with the game, but with their instructors and peers, fostering collaborative knowledge construction. Interestingly, the review also reports on some studies that point out how sometimes teamwork can be perceived negatively by students and consequently the performance of participants can be higher when playing individually. This further highlights how important it is to carefully design games according to the intended learning outcomes, choosing the most appropriate approaches from each time. Vlachopoulos and Makri also report how student engagement, motivation and satisfaction are among the most reported outcomes. Among the factors underlying motivation, the review reports challenge as the top ranked factor for online gamers, with recognition being the lowest. Moreover, studies highlight that students are found to be motivated by the positive social interactions made within games. Among the findings of the review, the importance of the role of emotional development as a facilitator of the improvement of learning outcomes is emphasized. In this regard, Vlachopoulos and Makri report of a progression within the student from negative emotions, such as anxiety, nervousness, and disappointment detected during the pre-intervention phases, to positive emotions such as confidence, excitement, fascination and enthusiasm both during the game sessions and during the post-intervention phases.

Although historically it has been pointed out that there was a stressful need to investigate more thoroughly the effects that Serious Games have at the level of learning outcomes (e.g. Young et al., 2012; Girard et al., 2013), much has been accomplished over the years, with numerous other studies whose findings agree and are consistent with those discussed in this section (e.g. Wouters et al., 2013; Bellotti et al., 2013; Backlund and Hendrix, 2013; Tsekleves et al., 2014; Carenys and Moya, 2016; Warren et al., 2016; Yu, 2019). Nowadays, awareness of the effects of serious games, game-based learning, and gamification is such that the question being asked is less and less “do they work?” and more and more “how do they work and when?” (Nacke and Deterding, 2017; Krath et al., 2021), opening a new and much-needed avenue toward a deeper understanding of the theories and psychological models underlying how games work and the design principles adopted.

# Chapter 3

# Competency-based Education

Competency-based education (CBE) is a term that stands for a completely different approach to education than we are typically used to. It represents a set of substantial changes to the way we commonly think about school culture, pedagogy and academic structures aimed at ensuring the success of all students, greater equity in learning processes and greater integration between the worlds of school and work (Sturgis et al., 2011; Lopez et al., 2017; Casey and Sturgis, 2018; Levine and Patrick, 2019). Coined in the 1970s by the United States of America (USA) Department of Education and initially focused towards adults and postsecondary academic institutions, CBE is increasingly gaining traction in all academic contexts, including those related to the K-12 system. Already in 2006, the European Union (EU), through the European Parliament and the Council of the European Union, produced an official recommendation on key competences for lifelong learning, in which member states were invited to develop "the provision of key competences for all as part of their lifelong learning strategies" following the EU reference framework "Key Competences for Lifelong Learning" (Council of the European Union, 2006) . Confirming the importance of such an action and the increasing topicality of the issue, the EU renewed and updated its recommendations in 2016 with 'A new skills agenda for Europe' (EU Commission, 2016) and in 2018 with 'Council Recommendation on key competences for lifelong learning' (Council of the European Union, 2018). The first working definition of CBE came only in 2011, during the first National Summit on K-12 Competency-Based Education (Sturgis et al., 2011). Through a list of five cornerstones, it attempted to provide guidance in understanding and standardising the concepts behind CBE and how to implement them in the existing school fabric. During the second National Summit on K-12 Competency-Based Education, held in 2017, this definition was taken and expanded into what is now the most updated definition (Levine and Patrick, 2019). This new definition, although sprouted from a K-12 context, contains principles applicable to every educational level, and consists of the following

seven cornerstones:

- Students are empowered daily to make important decisions about their learning experiences, how they will create and apply knowledge, and how they will demonstrate their learning.
- Assessment is a meaningful, positive, and empowering learning experience for students that yields timely, relevant, and actionable evidence.
- Students receive timely, differentiated support based on their individual learning needs.
- Students progress based on evidence of mastery, not seat time.
- Students learn actively using different pathways and varied pacing.
- Strategies to ensure equity for all students are embedded in the culture, structure, and pedagogy of schools and education systems.
- Rigorous, common expectations for learning (knowledge, skills, and dispositions) are explicit, transparent, measurable, and transferable.

In the traditional school context, student progress is strongly determined by seat time. The skills and abilities acquired are often implicitly indicated by the time spent in the educational system, to the detriment of the actual level of mastery achieved by the individual student: "Mark is a third year student" implicitly indicates that Mark mastered all the skills and concepts introduced in the previous years. What unfortunately often happens is that, partly because of the summative nature of the assessments used, students proceed to the next year despite not having fully understood some of the concepts studied or fully developed certain skills. This leads over time to the creation of gaps which are then difficult to recover, especially as the traditional school system does not provide the means to do so and students are forced (when they are able to) to seek help outside of the school. The current gap between the world of education and the world of work also depends on this: the achievement of a diploma or qualification is no longer seen by companies as a guarantee of *know-how*. (Bryant, 2013). The CBE, on the other hand, states that students should progress when they are ready, i.e. when they can demonstrate that they have acquired that particular competence. This also implies the option of repeating the test at a later date or of anticipating/postponing it, within a reasonable timeframe, to meet the different realities and needs of each student. It is important to stress that time is variable but not completely free. In order to maintain an implementable school structure and especially to maintain equity within school structures and paths, reasonable timeframes must be set: it

is not feasible, for example, to let a student take two years to learn single-digit multiplication.

But what does it actually mean to *demonstrate of having acquired a competence*? While some skills, such as arithmetic addition of two numbers, can be tested through the administration of a quiz or a traditional exam, other higher level skills, such as the understanding of the point of view of an author, may require the creation of a project or presentation to be assessed through ad-hoc rubrics. It is therefore important to rethink the way assessment is carried out, both from the formal point of view of how competences are tested, and from the point of view of *opportunity* and *transparency*. Communicating to learners in a clear and transparent way how they will be assessed and according to which metrics could also better guide them in understanding what they actually need to do to develop the competence as well as help them track their progress. Consequently, considering that mastery of a competence is not binary and comprises several levels, implementing assessment rubrics that explicit the various levels in simple and explanatory objectives can further contribute to increasing students' awareness of the subject, as opposed to a grading system based on just values as traditionally used.

Shifting the focus to competences also implies that the learning units, the modules designed for the acquisition of a competence, can be much more interdisciplinary: a competence can be addressed simultaneously in several subjects, and the learning pathway should take this into account. The structuring of interdisciplinary modules, which are often lacking in the traditional school fabric, would help learners to understand the dynamics and contents that unite the curricula of different subjects, giving them the opportunity to better understand the high-level concepts guiding the drafting of a learning plan and thus potentially increasing the level of engagement and involvement.

However, all these features make CBE a system that is not easy to implement in the current school structures. While some of the barriers to CBE deployment found in literature (Evans et al., 2020), such as the reluctancy of teachers to give students control of pacing, content and learning activities, or the external pressures to advance students at a certain pace need to be addressed at a systemic level, others, such as the lack of availability of frequent reliable data on how students perform on specific standards and skills, the difficulty of finding learning management systems to implement competency-based grading and the lack of time for differentiating content, structure, pacing to meeting student needs, and develop personalised lessons, can be facilitated by the use of Serious Games. SGs, in addition to increasing engagement and keeping students in a state of flow for longer, provide simulative contexts in which students can both acquire competences and, more importantly, test and demonstrate their mastery level in practical and applied contexts. SGs also inherently provide an adaptive environment where student progress can be tailored to their needs, rather than to those of the whole class

group. This is even more the case for those serious games that provide the option of shaping the game sessions in a personalised way. A further advantage provided by games is that of being able to assess the students during the game sessions themselves: the amount of data on the players' actions that can be extracted and analysed in real time is immense. However, not all SGs lend themselves well to be used in the context of CBE, and therefore a careful design and remodelling of game models is necessary.

## 3.1 “Competency” vs “Competence”

Despite the growing number of studies, covering different areas of application and professions, regarding competency development and assessment (e.g. Chung et al., 2011; Kang et al., 2015; Omran and Suleiman, 2017), one of the problems found in the literature is precisely that related to the understanding and use of the term “competency”. Numerous definitions can be found in the literature concerning this concept. For example, Mcclelland (1973) speaks of competence as “a personal trait or set of habits that leads to more effective or superior job performance”. Klemp (1980) refers to competency as “an underlying characteristic of a person which results in effective and/or superior performance on the job”. Jacobs (1989) states that “Competency is an observable skill or ability to complete a managerial task successfully”. Gilbert (1996) says that “the state of being competent refers to having the ability to consistently produce the results (the worthy outcomes of behavior) that are required for the most efficient and effective achievement of the larger organizational goals”. Draganidis and Mentzas (2006) defines a competency as “a combination of tacit and explicit knowledge, behaviour and skills, that gives someone the potential for effectiveness in task performance”. Other examples of definitions found in the literature are listed for convenience in Table 1.

Table 1: Definitions of Competency

| Authors | Definition |
|---|---|
| Mcclelland (1973) | competence is “a personal trait or set of habits that leads to more effective or superior job performance” |
| Klemp (1980) | competency is “an underlying characteristic of a person which results in effective and/or superior performance on the job” |

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Table 1 – *Continued from previous page*

| Authors | Definition |
|---|---|
| Boyatzis (1982, 2008) | competencies are “underlying characteristic of an individual that is casually (change in one variable cause change in another) related to superior performance in a job” |
| Hornby and Thomas (1989) | “Competency is the ability to perform effectively the functions associated with management in a work situation” |
| Jacobs (1989) | “Competency is an observable skill or ability to complete a managerial task successfully” |
| Spencer and Spencer (1993) | competencies are “motives, traits, self-concepts,attitudes or values, content knowledge, or cognitive or behavioural skills – any individual characteristic that can be measured or counted reliably and that can be shown to differentiate significantly between superior and average performers, or between effective and ineffective performers”. |
| Gilbert (1996) | “the state of being competent refers to having the ability to consistently produce the results (the worthy outcomes of behavior) that are required for the most efficient and effective achievement of the larger organizational goals” |
| Marrelli (1998) | “Competency is a measurable capability required to effectively perform work” |
| Athey and Orth (1999) | Competencies are a “set of observable performance dimensions, including individual knowledge, skills, attitudes, and behaviors, as well as collective team, process, and organizational capabilities, that are linked to high performance, and provide the organization with sustainable competitive advantage” |

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Table 1 – *Continued from previous page*

| Authors | Definition |
|---|---|
| Draganidis and Mentzas (2006) | a competency is “a combination of tacit and explicit knowledge, behaviour and skills, that gives someone the potential for effectiveness in task performance” |
| Hager and Gonczi (2009) | “competence is conceptualized in terms of knowledge, abilities, skills and attitudes displayed in the context of a carefully chosen set of realistic professional tasks which are of an appropriate level of generality” |
| Chouhan and Srivastava (2014) | “A competency is the capability of applying or using knowledge, skills, abilities, behaviors, and personal characteristics to successfully perform critical work tasks, specific functions, or operate in a given role or position” |
| Vitello et al. (2021) | “Competence is the ability to integrate and apply contextually-appropriate knowledge, skills and psychosocial factors (e.g., beliefs, attitudes, values and motivations) to consistently perform successfully within a specified domain. |

From the examples of definitions given, it can be seen that the term “competency” is often used interchangeably with the term “competence”, although the two are slightly different, creating confusion (Zemke, 1982; Moore et al., 2002; Vazirani, 2010). A distinction that often emerges from some authors’ discussions is that of linking the term competency with the behavioural part of the person, holistically including concepts such as self-concept, values, personal traits and motives (Spencer and Spencer, 1993; Campion et al., 2011; Chouhan and Srivastava, 2014) and referring to the term competence with a more task-oriented functional approach (Wong, 2020). This, however, contrasts with views such as that of Hager and Gonczi (2009), which include these aspects within a single, holistic concept of competence. Another, more harmonious and aggregating distinction is provided to us by Hyland, who suggests using the term *competence* to indicate “broad groups of general capacities” and the term *competency* “as a label for specific performances or aspect of activities” (Hyland, 1994). Vitello, Greatorex, and Shaw (2021) in their recent work they embrace this point of view, identifying with competence the

overall general concept and with competency the instance of the concept concerning specific competencies. In this paper I shall also adopt this point of view, both because I consider it satisfactory and balanced with respect to the rest of the literature, and in order to contribute to a convergence towards a single interpretation of the terms (rather than diverging by providing my own version of a definition) in order to make the concepts clearer and to facilitate discussion on the subject. For these reasons, I will adopt the definition of competence provided by Vitello et al., using the term competency to talk about the instantiation of the generic concept.

> *"Competence is the ability to integrate and apply contextually-appropriate knowledge, skills and psychosocial factors (e.g., beliefs, attitudes, values and motivations) to consistently perform successfully within a specified domain."*

This definition has the added value of retaining the advantages of an integrated and holistic perspective, which implies the need to see the concept of competence in relation to the characteristics of both the competent person and the context in which the implementation of that competence is situated (Hager and Gonczi, 2009). This approach has much greater explanatory and predictive power than more reductionist approaches that focus on elements such as externally visible outcomes (such as performance) or characteristics of a person removed from the context in which they are observed (Vitello et al., 2021). It is important to note that adopting this definition does not change the term *Competency*-based Education, which is in fact perfectly aligned. This is because in the educational context, CBE interventions are always focused on the acquisition of specific competencies. In fact, taking a holistic and integrated approach to the concept of competence does not preclude focusing on the specific elements in the context of educational programmes, products or services, but is important for the understanding of the concept itself and consequently for the decisions that will be made in these contexts (Vitello et al., 2021). An integrated and holistic approach, highlighting the importance of all contextual factors, makes narrow, rigid and schematic forms of competency-based interventions less appealing, empowering educators through guidance and giving them great freedom in choosing individual strategies to adopt, e.g. by specifying what students should be able to achieve without going into the implementation details of either training or assessment (Hager and Gonczi, 2009), setting standards rather than procedures. Although the development of competence "standards" can be frightening with regard to the prospect of inappropriately uniforming the ways in which tasks are carried out, an integrated approach is the best way to avoid this, making it impossible for these to be defined solely on the basis of externally visible outcomes, in effect allowing for diversity: when attention is focused on the attributes that contribute holistically to an outcome, one

quickly realises that the same outcomes can be achieved in multiple different ways. Furthermore, such a definition of competence helps to generalise the applicability of this type of educational intervention, as it is not linked to any particular domain (such as the managerial domain expressed in the definition of Jacobs), to any specific educational system or nation, nor to any particular age group or specific learning phases. Vitello, Greatorex, and Shaw (2021) enrich their definition by highlighting six principles that underpin the concept of competence, which will be reported in the following section.

## 3.2 Principles of Competence

Starting from the adopted definition, some key features of the concept of competence emerge clearly. The term *consistently* for instance emphasises how competence involves a constant demonstration of competent performance. A person's competencies are inferred from performance, rather than being observed directly (Hager and Gonczi, 2009), and in fact being consistent goes far beyond mechanically replicating within the exact same situations the exact same operations, but instead implies the concept of adaptability that allows us to perform competently in contexts similar (within the same domain) to the one observed (Figure 9).

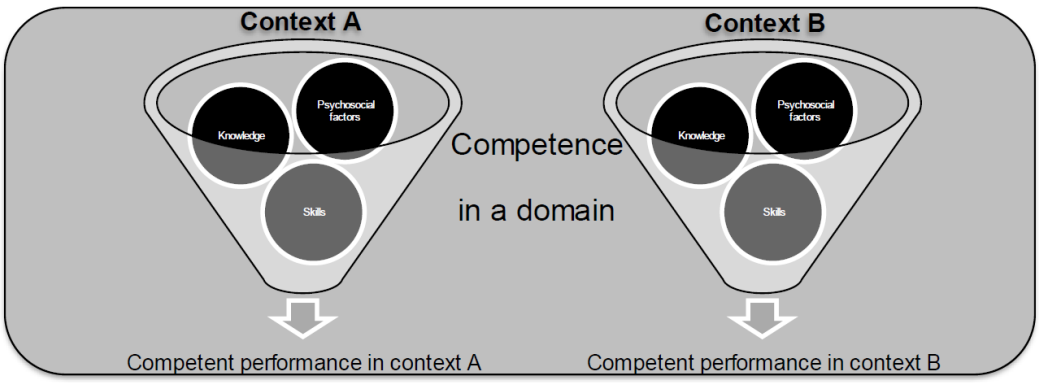


Figure 9: A visual representation of competence expressed in different contexts inside the same domain. Source: Vitello et al. (2021)

Note the clarification of "in similar contexts". Contextualisation of competence is another key element of the definition. A driver who demonstrates competence in driving a car on dry asphalt is not necessarily also competent on wet asphalt. In fact, the two contexts are so different that they identify two different competencies. The concept of a competent individual cannot exist without recognising

the interaction he or she makes with the context that surrounds him or her. This is further emphasised in the definition through the concept of the application of *contextually-appropriate* knowledge, skills and psychosocial factors .
These along with other features present in the definition are distilled by Vitello et al. (2021) into the following principles.

### Competence is linked to a domain and dependent on context

As briefly discussed earlier, the concept of competence is closely dependent on the context in which performance is observed and is similarly strongly linked to an application domain. Although the terms domain and context may be semantically close, in the context of the definition provided they take on two quite distinct meanings.
By *domain* the authors refer to the application domain, field of study or simply field of interest to which the specific competency belongs. Similarly to how, in the context of learning, becoming an expert implies the definition of boundaries relative to areas of expertise, in the context of competence people acquire competences defined within a defined area of knowledge and consequently teach, evaluate and make inferences relative to the competences of others within defined boundaries and areas (Vitello et al., 2021). In the vocational education and training (VET) context, domain represents a specific occupation towards which learning is directed (e.g. automotive mechanic) while in traditional educational contexts it refers to the subject matter being studied (e.g. history) or more generically to sets of skills and areas of knowledge, such as problem solving or critical thinking. More generically, domain can also refer to broader areas of interest, such as entrepreneurship. In fact, as reported by the authors of the definition, the concept of domain can vary greatly in terms of specificity: think for instance to the domain of physics in general versus the domain of quantum physics. Vitello et al. report how, in the academic context, the term domain is often not used in the case of broader content areas that intertwine different fields. In such cases, domain continues to refer to specific occupations or subjects, and it is the competence itself that then covers a broad area of knowledge that intersects multiple domains, as in the case of digital competences.
With the term *context*, on the other hand, the authors refer to the setting, situations and conditions surrounding the various demonstrations of competence. According to Hager and Gonczi (2009), context is considered indispensable in order to observe and measure a competence, to the point that it is impossible to do so without it. The authors emphasise how competent performances are situated in a particular place and moment in time and how they are deeply intertwined with the particular social and psychological conditions present. It is therefore important to conceive of context as being determined by the relationship between the

characteristics of the activities that are performed and the circumstances in which they are performed. This link between competence and context raises important questions regarding the transferability of acquired competences from the context in which they were obtained to others. If, for example, a driving licence followed a formal, holistic definition of competence, would it be fair to allow someone who acquired their driving licence in a left-hand-drive country to drive in right-hand-drive countries? Personally, I think that when the contexts are sufficiently similar, competences can be transferred, although the level of proficiency may change proportionally to the difference in context (e.g. with respect to the example given on the driving licence, the driver would remain competent although at a lower level).

### Competence is holistic

The authors of the definition report how the use of a holistic approach to the concept of competence is not new and, indeed, how it is present in a number of high-profile models (Salganik and Rychen, 2003; EU Commission, 2007; OECD, 2018). The concept of Competence is seen as part of a complex system that includes both internal personal factors, such as knowledge, skills, attitudes and values) and contextual factors. Vitello et al. state that this holistic view involves three interconnected aspects that together make up the concept of competence: the person, the context and the action. The latter is represented by performance, which thus remains a central aspect of the system. Without considering performance, considerations with respect to the other components of the system become disconnected. This view is helpful in maintaining alignment with the goals of the educational context (especially in terms of assessment), since it ensures that these conceptualisations of competence remain functionally relevant (Salganik and Rychen, 2003). A holistic approach also stresses the idea that the system must be considered in the completeness of its parts, implying that in order to achieve satisfactory levels of competence, proper attention must be paid to each of the aspects that contribute to its definition. Moreover, this view implies that in addition to the components, attention must also be paid to the relationships between them. This type of considerations avoid the formation of narrow and "atomistic" forms of competency-based training, leaving great flexibility and freedom to educators in developing and adopting the most suitable strategies and techniques according to their needs (Hager and Gonczi, 2009) but at the same time stressing the importance of evaluating these aspects during the design of educational interventions. For example, during the COVID19 pandemic, many teachers I interacted with told me about extremely interesting and promising courses and educational interventions that failed in practice because they did not take into account the many contextual factors surrounding the students (such as the presence of a stable Internet connection, the availability of digital devices at home, the students'

attitudes towards technology, etc.).

### Competence is about consistency

Vitello et al. emphasise how consistency of performance within a domain is integral to the concept of competence. Being able to perform competently on a consistent basis is much more important than performing on a single occasion within the concept of competence. Even in everyday language, by a competent person we mean a person who can perform reliably and to whom a task can be assigned with the expectation of success. In contrast, we hardly consider a person competent on the exclusive basis of a single performance observation. It is therefore not strange that consistency is a feature that often appears in the various descriptions of competence within numerous competency-based and professional qualification frameworks (e.g. Australian National Quality Council (NQC), 2007). On the other hand, the concept of consistency indirectly carries with it the concept of adaptability: a person consistently performs competently when he/she is able to do so across different contexts. In the real working world we hardly ever have to deal with the same situation all the time, and in fact each new situation requires adaptations and changes to our skills and constructs (Oates, 2003). This adaptability is a key concept of being competent, and is what distinguishes competence from the mere replication of a list of actions constituting a task. The importance of the concept that competence is what enables people to deal with complex challenges is also expressed in the view of OECD (2018). According to Vitello et al., consistency is the feature that allows us to make predictions about the future performance of a competent person, one of the most important aspects from the perspective of anyone interested in someone's competence (e.g. an employer). According to the authors of the definition, the attribution of a competency to a person in practice is equivalent to stating that that person will be able to perform in the future in a particular context. Since competence can only be verified during the performance of a competence-based activity, this view emphasises the importance of giving due attention and importance to the quality of the evidence collected in support of the claim of competence, since this will then be used to make future predictions.

### Competence involves applying contextually-appropriate knowledge and skills

The concept of competence encompasses both knowledge and skills (Athey and Orth, 1999; Draganidis and Mentzas, 2006; Hager and Gonczi, 2009; Chouhan and Srivastava, 2014; Vitello et al., 2021), and specifically, as discussed above, requires the ability to apply knowledge and skills that are required and appropriate

to the specific context in which one is present. A competency may cross multiple domains, and consequently require different skills belonging to different domains (such as architecture and mathematics). Indeed, within a knowledge area, specific skills and knowledge belonging to many different domains may be involved, and determining which specific skills and knowledge are appropriate for a context may be done with a community of practice (Lave et al., 1991; Wake, 2014). The important aspect, however, is that knowledge and skills are used in the context of competencies to adapt and respond to the needs posed by the context (Oates, 2003). For example, returning to the case of right-hand and left-hand driving, a competent driver uses his or her motor coordination skills and knowledge of the car's components used in driving (e.g. the position of the gear shift lever or the levers that control the headlights) to reassess and adapt to the change of context. With regard to skills in particular, Vitello et al. report how over time these have taken the foreground in discussions, assessments and frameworks relating to competences. Among possible explanations, the authors report how in practice competence is about what people actually can do, consequently bringing attention to the skills needed to perform a given task competently. But as already discussed, skills are only one part of the complex and holistic system that defines competence. Vitello et al. also underline how the choice of positioning the term "knowledge" before the term "skills" in the definition of competence is not accidental, and that it is infact determined by two precise reasons: the first is to highlight the importance of knowledge within the concept of competence, while the second is to underline the concept that skills are sustained and dependent on knowledge itself, which in fact represents a resource used in their development (Brockmann et al., 2008). Furthermore, the authors of the definition of competence state that the relationship of dependence and integration between knowledge and skills implied by the holistic nature of the concept of competence implies that the development itself of competences (and thus the design of competency-based interventions) can be facilitated by the implementation of opportunities that present these in an integrated manner, favouring approaches in which theory and practice are combined, enabling experiential learning.

### Competence involves psychosocial factors

With the expression "psychosocial factors" Vitello et al. refer to all those psychological and psychosocial factors that together with knowledge and skills contribute to forming the integrated system of competence. Beliefs, attitudes, values and motivations, together with personality traits such as emotional, behavioural or cognitive tendencies are examples of factors that fall into this set. Not surprisingly, numerous other definitions of competence include within them (either implicitly or explicitly) these factors (e.g. Spencer and Spencer, 1993; Athey and

Orth, 1999; Draganidis and Mentzas, 2006; Chouhan and Srivastava, 2014). If we think about it on the other hand, the concept of a "competent person" cannot exclude the personal element, the information and characteristics of the person who is to perform the task for which we are training them. This is also reflected by the institutional tendency, at the level of governance, to include particular values within educational curricula, with the aim of shaping the citizens and culture of a country (Morgan, 2019).
The psychosocial factors that intervene within the concept of competence can also be both domain-specific and general. A person's attitude with regard to performing tasks in a safe manner, for example, is a characteristic that in many domains falls within the definition of competence. Depending on the domain, this is declined differently, e.g. automatically wearing a hard hat for construction workers or automatically wearing a seat belt in the context of drivers. Similarly, a person's beliefs and goal orientations can strongly influence their motivation in demonstrating competence and completing tasks (Wigfield and Cambria, 2010). Vitello et al. also report on examples of empirical evidence found in associating psychosocial factors with performance in various fields (Baartman and Ruijs, 2011; Yuan et al., 2017; Bai et al., 2020b).
The authors also emphasise that psychosocial factors are not only important within the concept of competence, but are also key drivers in learning processes and competency development. In fact, these factors influence learning processes at different times and in different phases. They may, for example, influence the choice of one educational course rather than another, as well as participation in them and perseverance in following them. Vitello et al. claim that this happens because they not only support the learning of competences, but are themselves developed during learning processes.

#### Competence has different levels of proficiency

The concept of competence cannot be separated from its relation to different levels of ability or different levels of learning. Traditionally, especially in contexts such as Vocational Education and Training, competence is seen as a binary concept through which to determine whether a person is competent or not. Although this type of approach may be useful (and indeed used) in the context of the provision of qualifying qualifications both in professional and non-professional contexts, such as the provision of driving licences, it has the clear disadvantage of flattening and uniforming the concept of competence: focusing on binary assessments of minimum acceptable performance may discourage the pursuit of excellence and, indeed, lead to a deskilling phenomena (Hager and Gonczi, 2009). The definition of Vitello et al. instead focuses on a view of competence as a learning continuum: instead of containing exclusively binary evaluations, a whole scale of proficiency

can be attached to the minimum values to be attained that in fact defines different levels of competence. These levels may be described through the use of adjectives (e.g. sufficiently competent rather than highly competent), the explicit use of levels (e.g. competent at level 2) or may refer to particular levels of need described by the various tasks (e.g. competent in driving rather than competent in sporty driving). The definition of these different degrees of competence must be developed in such a way as to be functional not only for the learners, but also for the stakeholders involved in the specific domains (who use the assessments on the various competencies to make future performance forecasts), and may converge in the definition of actual competence standards. This kind of vision is not only extremely useful from the point of view of the implementation of educational and training paths, but also aligns with the most common forms of assessment used in school contexts.
The authors also report how in some cases, rather than focusing on performance levels related to competence, they focus on the level demanded by specific tasks. A high-profile example of such a view is provided by OECD (2018), who sees competence as the ability to respond to complex challenges. What Vitello et al. point out is that the concept of competence can also be relevant in the case of less demanding tasks. People may be competent in relatively low-level tasks and at the same time be non-competent in more complex tasks. However, this does not mean that information about the competences they possess cannot be useful and decisive for the stakeholders concerned.

## 3.3 Serious Games in CBE

The use of Serious Games, as we have seen above in section 2.4, results in positive effects with regards to numerous and diverse outcomes, such as knowledge acquisition, conceptual application, content understanding, action directed learning, affective and behavioural change, physiological outcomes, skill improvement, motivation, participation, egagement and improvement sin both academic and work related tasks (e. g. Connolly et al., 2012; Boyle et al., 2015; Clark et al., 2016; McKeown et al., 2016; Vlachopoulos and Makri, 2017; Liu et al., 2017; Koivisto and Hamari, 2019; Bai et al., 2020). These outcomes are perfectly aligned with the holistic and integrated concept of competence adopted in this work. Furthermore, Serious Games provide contexts that, being simulative, are particularly suitable for acquiring, practising and demonstrating competencies in a practical and situated manner. Compared to traditional educational interventions, Serious Games also have the added value of being learning environments in which players can progress independently of the rest of the class, fostering learning that is adaptive to the needs of individuals. In spite of this, it is difficult to find examples in

literature of Serious Games that present a design and structure that is explicitly conceived for the Competency-Based Education context, and that do not instead focus on a individual aspects and characteristics (e.g. knowledge acquisition) of the broader integrated concept of competence. In fact, Serious Games are still mostly designed from a curriculum perspective and have not been adapted to the competence-based approach of current educational policies (Romero et al., 2014).

One example of Serious Games designed for CBE is Elderquest (Pomidor et al., 2011, 2012), an adventure game set in a three-dimensional medieval fantasy world aimed at helping medical students develop and enhance their geriatric competencies. These are chosen amongst those identified by the Association of American Medical College (AAMC) in the geriatric context. The game is played from the perspective of the medical student and integrates key members of the geriatrics team to illustrate the interprofessional team-based model for geriatric care. The objectives of each level are linked to specific competences, with rewards and penalties delivered according to the level of mastery achieved by the student.

Figure 10: A screenshot of the Elderquest game.

Another example of a game developed and used in the context of competences is the one provided by Haendler and Neumann (2019,b). The objective of this game is to train and assess competencies related to software refactoring, such as the application and analysis of strategies for selecting candidates for refactoring (Haendler and Neumann, 2019b). Players can choose between three distinct game modes: single-player, parallel multi-player (competitive) and alternating multi-

player (collaborative). Players navigate the System Under Analysis (SUA) in order to identify rafactoring candidates and solve them. In the competitive mode, players compete simultaneously on the same SUA in order to score higher than their opponents, while in the cooperative mode, players take turns working towards a common goal. Formal performance measures (normally used in this domain) are used to assess the player in real-time by providing feedback in the form of a score. This type of assessment based on standard indicators is important within the CBE context because it provides a performance measure comparable to those used in real work tasks belonging to the same domain.
In the context of managerial competencies, an example is provided by the Sustainable Manufacturing Game scenario developed for the TARGET project (2012). Within the scenario, players play the role of a newly hired Sustainability Manager. Through interaction and dialogue with NPCs, representing the company's Chief Executive Manager (CEO) and other managers (e.g. Production Manager, Logistics Manager, etc.), and with the in-game Enterprise Resource Planning (ERP) system, the player will have to carry out a Lifecycle Assessment (LCA), a report on the environmental impacts of produced òproducts. By carrying out all the necessary steps (setting the objectives, setting the boundaries, selecting the flow chart, selecting inputs and outputs, deciding on the data for inputs and outputs, setting the impact categories), the player will generate a virtual report that he/she will then hand over to the CEO. The correspondence between the steps required to carry out an LCA in real life and one in the game world together with the contextualisation of the need to communicate with the various managers of the company provides a simulative environment in which to train this competency.
In the context of intercultural competency, on the other hand, we find EU-Topia (Kechaï and Pierrot, 2015), a dialogue-based Serious Game developed to help trainees during work mobility periods in Europe. The game was developed to have a first-person perspective in order to emphasise and use non-verbal communication elements (such as facial expressions). Within EU-Topia, players have 24 hours of game time to complete 18 different immersive scenarios divided into three stages, linked together by a narrative component: at the beginning of the game, the player receives a letter stating that he/she has been accepted for an internship abroad but that, due to a high number of applications, he/she will have to prove the ability to adapt in unfamiliar cultural environments in order to confirm the acceptance. The dimensions of the intercultural competency are represented by six gauges, visible within the game in a section called "passport", in order to provide a score and feedback to the player related to his actions and his level of mastery of the competency.
Another recent example related to mathematical competencies is provided by the Serious Game Math is magic (Rossano et al., 2021). In the game, players take on the role of a wizard intent on saving the world through the use of magic math. To


Figure 11: A scene from the EU-Topia Game. Source: Kechaï and Pierrot (2015)

do so, they must explore the kingdom of Doctrine and adventure inside different dungeons in search of the magical ingredients needed to create the elixir needed to save the kingdom. In this quest, players will face duels against enemies. Combat in Math is magic is developed in turns, with the player's attacks being dependent on the answer to mathematical questions: each time the player provides a correct answer, the character will attack the enemy; otherwise, an incorrect answer will correspond to an attack by the enemy and the loss of life points. To help the players, a spell book can be consulted during the game, containing clues and mathematical notions useful for carrying out the proposed exercises. During the game, behind the scenes, a player profile is created in order to keep track of the competencies achieved and demonstrated during battles. In order to encourage the development of less developed competencies, the game will tend to propose during duels exercises associated with the categories on which the player performs less well, implementing adaptive learning reactive to the student's level.
Amongst the examples found in the literature, there is also a game that is available in both paper (board game) and digital versions: RETAIN (Bulitko et al., 2015; Cutumisu et al., 2019), a serious game directed towards Health Care Professionals (HCP) and aimed at the development and training of competencies related to neonatal resuscitation. Within the game, players use pieces of equipment, monitors and action cards in order to stabilise and treat a newborn infant within simulative scenarios based on a database of real-life deliveries. In the paper version, players work collaboratively in teams in order to train their knowledge and communica-


Figure 12: Screenshots from Math is magic. Source: Rossano et al. (2021)

tion skills. In the digital version, players work individually to test their knowledge and decision-making skills. The game provides constant feedback to the players during each task performed, reporting the health status and vital parameters of the newborn (e.g. hearth rate, oxygen saturation, etc.): correct choices correspond to an improvement of the newborn's health, while wrong choices correspond to its deterioration. RETAIN has been successfully tested with regard to knowledge improvement, knowledge retention and as a robust and objective summative assessment of neonatal resuscitation competence (Ghoman and Schmölzer, 2019; Ghoman et al., 2020,b).

It is no coincidence that two of the six examples given here (Elderquest and RETAIN) are aimed at Health Care Professionals. Indeed, the context of medical education, and in particular of nurse education, is one of the richest in competency-based interventions and Serious Games designed or contextualised in a competency-based perspective. One of the possible explanations is that in nursing education there is a strong focus on evidence-based practice and critical evaluation modules that emphasise the need for nurses to acquire usable knowledge that makes links between research findings and practice (Boyle et al., 2014). In a very recent work, Thangavelu et al. (2022) conduct a systematic review on the use and effectiveness of Serious Games in the context of the development of nursing clinical competencies. Within the twenty-two papers identified, a total of five core competencies were reported: management of nursing care, clinical reasoning skills, procedural skills, quality improvement and legal practice. It is important to emphasise that within this systematic review the concept of competence is understood in a holistic and integrated manner, in accordance with the definition I have adopted. The authors analysed the outcomes by dividing them into three categories: knowledge outcomes, skills outcomes and attitude outcomes. With regard to knowledge outcomes (reported by most of the studies involved), the review reports a pooled meta-analysis showing a statistically significant difference

with large effect size between the groups that used Serious Games and the control groups. A further subgroup analysis regarding core competencies shows a similar statistically significant difference with large effect size for the knowledge score in management of nursing care, whereas no difference is found regarding core competencies in clinical reasoning skills and procedural skills.
With regard to skills outcomes, the review carries out a pooled meta-analysis showing a significant difference in clinical skills performance between groups that used Serious Games and control groups. It is also reported that only one study addressed competency of quality improvement by assessing clinical performance in a practice setting. This study also shows statistically significant improvements in adherence to specific monitoring protocols six months after the Serious Games intervention.
The review also cites two studies in total with findings in attitude outcomes. While both report positive outcomes related to self-perception of knowledge in relation to operation theatre management, one of them also demonstrates a significant improvement in student nurses' attitudes towards patients and staff after the game intervention. Thangavelu et al. state that, following the findings of this review, it would be appropriate to combine Serious Games with popular mannequin-based simulations in a blended learning approach in order to optimise procedural skills performance. They also state that Serious Games could be useful in providing continuous nursing education and keeping students' competencies up-to-date.

What ultimately emerges from the literature regarding the use of Serious Games in explicitly competency-based contexts is that outside the field of nursing and, to a lesser extent, medical education, greater efforts need to be made to clear and accelerate this type of use. Serious Games are tools that are perfectly aligned with the concept of competence, and one of the explanations that I can come up with regarding the rarity of studies on this subject, compared to the large body of research on them in general, is that we often focus (perhaps) too exclusively on knowledge-related outcomes, leaving aside the great power that games have of being environments in which we can have evidence-based experiences and evaluations, in contexts that are relevant to reality, safe for the players, motivating and effective.

## 3.4 Proposed Principles of Competency-Based Education Compliance for Serious Games

One of the ways in which the development of Serious Games-based interventions in the competency-based context can be facilitated is to establish guidelines that can clarify the *how*. From the study conducted on games, their characteristics,

structure and effects, as well as the study on competency-based education and the integrated and holistic concept of competence, the idea that Serious Games can be suitable tools for these interventions clearly emerges. Further reinforcing this idea is the fact that the seven cornerstones for Competency-Based Education identified in the work of Levine and Patrick (2019) find an almost direct mapping with characteristics of Serious Games. As pointed out earlier, although these cornerstones were defined in the K-12 context the concepts and content encapsulated in them are generic and applicable to any educational level and stage of learning. For this reason, in this section I will discuss how these cornerstones can be implemented within Serious Games, distilling them into principles of compliance with the aim of establishing useful design guidelines to facilitate the design and inclusion of Serious Games-based interventions in the competency-based education context.

### 3.4.1 Transparency

> *"Rigorous, common expectations for learning (knowledge, skills, and dispositions) are explicit, transparent, measurable, and transferable."*

In the competency-based context, it is important to communicate clearly to the players the outcomes related to the competencies being addressed. The concept of clear and quantifiable outcomes is one of the key concepts in my (as well as numerous other) definitions of a game. To engage and motivate players, the outcomes of a game must be multiple and diverse, and must be directly related to the effort invested by the player. Similarly, these different outcomes must be valued correctly and clearly for the players, who must be able to unambiguously understand the hierarchy and relationships between these outcomes. If this is not done, it becomes difficult to understand their diversity and players will be confused as to which outcomes and goals to achieve. Similarly, these outcomes must be quantifiable in a clear and unambiguous manner so as not to create confusion in the player's mind.

One way to clarify outcomes is to formalize them into objectives to be shown to the player during game-play, making sure that at the beginning of each level the player knows in a clear and unambiguous way which competences he/she will be working on in this session and above all which actions will lead him/her to work on that competence. It is also important that cause-effect chains linked to these actions are constant within the game. For example, within First Person Shooter (FPS) games, the player often learns very quickly that to eliminate an enemy,

one must hit him with bullets. This cause-and-effect rule is soon assimilated by the player and becomes part of the expectation model with which he/she will evaluate the situations encountered and consequently with which will determine playing strategies. In the event that these chains are changed (e.g. in the case of armoured enemies for FPS games), the need to communicate the change to the player is crucial. Often these changes are communicated through the visual channel (by changing the model of the enemies and including elements that communicate the change in some way, e.g. a shield) and, in the case of substantial changes in expectations, they may also be emphasised by small cut-scenes (e.g. the entry of a formidable and special enemy onto the field). Maintaining clarity and transparency in the objectives and consistency in the effects caused by players' actions and interactions will reduce the occurrence of moments of frustration and foster understanding of the consequences of one's actions.

### 3.4.2 Progress

*"Students progress based on evidence of mastery, not seat time."*

The idea of basing student progress on mastery evidence rather than seat time finds fertile ground in Serious Games, and indeed in games in general. Within them, players progress between levels through the completion of specific tasks, and not merely on the basis of how long they stayed within a specific level. Although it is possible to incorporate time constraints within levels, e.g. by providing a time limit within which to complete the level, these are always functionally linked to the completion of certain actions or the achievement of specific goals. Even in cases where time constraints set minimum times rather than maximum limits, e.g. "resist the assault of enemies for two minutes", the player is constantly and actively engaged in interacting with the game system. In fact, this type of time constraint is often even more related to the demonstration of mastery, and can be seen as an example of "demonstrate for at least x minutes that you are competent at this type of task". No game allows players to passively advance from one level to the next solely on the basis of how much time has passed, and indeed such a mechanic, which takes the player from active protagonist to passive spectator, would remove the element of conflict from the game and lead directly to a natural decrease in players' interest and effort invested: "why should I put in the effort if I'm going to pass the level (win) soon anyway, no matter what I do?"

### 3.4.3 Assessment

*"Assessment is a meaningful, positive, and empowering learning experience for students that yields timely, relevant, and actionable evidence."*

In competency-based education, assessment is the tool that can transform the evidence produced by the learner into an empowering learning experience. It is a time in which students receive formal feedback regarding their performance and their level of competence mastery. This feedback is essential in order to validate their expectations, understand where to invest further effort and define an action plan regarding the consolidation of their competence. For this to happen, the assessment must be explicit and explanatory: if the player does not receive information about his assessment and the mistakes made, he/she will not be able to reflect on it and close the experiential cycle. Many games provide feedback on the player's performance at the end of the various levels in the form of a score, often contextualising it within a reference scale (e.g. awarding three out of five stars). In order for this feedback to turn into empowering assessment, however, it must be accompanied by the criteria that were used during the evaluation. Awarding three stars out of five will have little impact on the player's self-reflection process if it does not specify *why* he/she scored that rating instead of another. Furthermore, the choice of when to evaluate the player has an equally important impact. As we have said, many games provide a performance evaluation at the end of a level, and this is no accident: an evaluation must be accompanied by a moment of "pause" in the game flow so that the player's reflection process can be ensured and the flow is not interrupted. However, this does not mean that the game cannot assess players during the game session and indeed, the constant presence of feedback can help the student to recalibrate his or her attention, estimate their progress and re-evaluate their strategies. What is important is to consider the overall cognitive load required by the game in the totality of the system (narrative component, gameplay, feedback, assessment, etc.) and thus to reserve the most important and formative assessments for the less demanding moments naturally present within the game flow, such as the end of a level. Another important element in order to maximise the learning power of the assessment is to establish and communicate to the player *at the beginning* of the game level the criteria according to which he/she will then be assessed: by doing so, the objectives of the level will be clearer and the player will have the opportunity to direct his/her effort and attention in a more informed manner. Similarly, just as in real life the achievement of certain educational milestones is accompanied by a concrete artifact (such as a

diploma or certificate), it is important to accompany in-game milestones with virtual tokens (e.g. badges and achievements) that can be displayed, in order to reward players and at the same time give them the opportunity to demonstrate their level of mastery. The ability to see the tokens of other players or the presence of leaderboards may also represent an additional motivating element that should not be underestimated. Finally, providing platforms where it is possible to view the assessments made in the game can help to integrate Serious Games-based interventions within traditional educational programmes, enhancing the role of educators and making them participants in the process.

### 3.4.4 Agency

> *"Students are empowered daily to make important decisions about their learning experiences, how they will create and apply knowledge, and how they will demonstrate their learning."*

Student agency is an important concept within competency-based education because it is the element that makes students truly protagonists of the learning process. One of the ways in which we often think of agency within games is in relation to interaction and how they interface with the game system. But this view is extremely reductive. In reality, player agency is the ability to affect and change the game world through meaningful decisions. It is the ability to influence what is happening within the game world, and it is the characteristic through which players feel they can control outcomes. The key expression related to the understanding of agency is precisely *meaningful decisions*: the decisions of the players must have the right weight, and lead to concrete consequences both good and bad. The Serious Game must present the opportunity to make these decisions, expressed through the presence of options and choices within the game, and above all it must give the player the ability to make choices freely and in a committed manner, even if they lead to negative consequences. Losing in a Serious Game is OK, as long as the defeat depends on the player's decisions, is the result of the player's choices and that the cause-effect chains that led to the defeat are clear, so as to allow the player to reflect on their decisions. Similarly, it is important to visualise the result of one's choices, and to be able to influence change in the game world: the game must react to the player's decisions in an organic way, so as to enhance and emphasise them. Only then will players feel that they can have a real impact through their decisions, thus leading them to a more critical and reasoned

approach.

### 3.4.5 Pacing

*"Students learn actively using different pathways and varied pacing."*

Adaptive leaning is another of the advantages offered by Serious Games. In contrast to more traditional educational models, in a Serious Game each student can continue his/her progress independently of the rest of the class, following his or her specific skills, knowledge and aptitude for learning. One of the simplest ways in which a Serious Game can ensure this is through the ability to save games, interrupt game sessions and resume them seamlessly at a later time. Providing the ability to break the game session without losing progress gives students a high degree of freedom in organising their learning. This becomes even more important in the context of games that allow them to work on different competencies separately (e.g. through the division into focused levels and game scenarios). The option of undertaking inside the game different paths and scenarios aimed at different objectives (e.g. focusing on different competences) is important from the point of view of ensuring that students can define their own paths. Similarly, the ability to interrupt and resume sessions at a later point in time must be capitalised on in allowing players to switch from one pathway to another in a free and non-penalising manner, allowing session after session to decide which objectives they will work on. To help the student visualise these paths, a Serious Game can present a high-level view of his or her overall progress, represented for example by a map in which the various scenarios appear as stages. This type of visualisation can also help clarify any dependency or propaedeutic relationships between the various scenarios and paths, for instance by linking them directly and in an ordered manner.

### 3.4.6 Support

*"Students receive timely, differentiated support based on their individual learning needs."*

The use of Serious Games already inherently provides more opportunities for teachers to provide personalized support to players: within the game sessions, while students are performing activities, teachers are free to provide personalised

help based on the difficulties encountered by individuals. To increase the level of personalised support provided, a Serious Game can include the presence of focused feedback, for instance through the implementation of virtual companions and other NPCs through which to provide advice and clues. The simulative nature of the games also allows these clues to be processed automatically following a transparent analysis of the players' performance and choices so that they can be individualised and contextualised in relation to the needs of each learner. To further enhance support, in the context of interventions designed for integration with traditional educational activities, a Serious Game can also provide for the presence of direct contact mechanisms with educators, either synchronously (e.g. by opening a private chat) or asynchronously (e.g. via a ticketing service). In this case, the design of the Serious Game must provide a system or platform for educators that not only facilitate this type of communication, but at the same time provides data on the player's game so that the students' requests can be contextualised. In the context of additional systems and platforms to accompany a Serious Game, another way to enable differentiated support to be provided within a Serious Game is to provide for the potential addition of extra content by educators: even the simple option of adding a customised text for each level to be shown to students at its beginning can allow for a high degree of contextualisation of the topics covered and adaptation to the needs of individual students and classes.

### 3.4.7 Equity

> *"Strategies to ensure equity for all students are embedded in the culture, structure, and pedagogy of schools and education systems."*

Equity is a fundamental concept not only within competency-based education, but in fact within the whole educational context. All students have the right to enjoy educational interventions equally, and our goal as designers is to avoid as much as possible that the interventions we design can be discriminatory in any way. One of the advantages of Serious Games in this context is that they can easily be set up to support multiple languages. The increasingly intercultural nature of classrooms and educational contexts means that, even in the context of national interventions in non-English speaking countries, the game should also be playable in English. This decreases the chances of foreign students with difficulties in the national language of the intervention country being excluded. Likewise, it is important to assess the technical realities of the contexts in which the interventions will be implemented. In order to ensure that a Serious Game is used outside the

school context, it is important to design the game in such a way that it can also be run on less-than-stellar hardware. For this reason, performance considerations (e.g. the choice of 3D virtual environments instead of 2D) are particularly important although often dismissed as irrelevant. The choice of the platform on which the game will be run is equally important: smartphones together with tablets today account for 62.01% of the market share with computers dropping to 37.99% (Statcounter, 2022), so designing a game to be usable via mobile platforms can guarantee a greater number of students reached. Even in the case of interventions designed to be used within school facilities, minimum requirements should be assessed to enable schools with older equipment to participate.

# Part II

# Adapting a Serious Game for CBE

# Chapter 4

# uManager

uManager is a construction/management serious game in which students try their hand at building and managing a touristic village. Similarly to commercial games such as RollerCoaster Tycoon (Sawyer, 1999) and SimCity (Wright, 1989), players start with an empty plot of land and a description of customers' preferences and habits, and through careful planning and assessment they aim to build the perfect village relative to customers' demands and take the market by storm. The game has been designed to both allow players and students the acquisition of economic, financial, and management concepts, as well as to foster and consolidate the skills at the base of decision-making processes and of critical thinking. During its lifespan, uManager evolved to be a comprehensive educational environment for school classrooms and other structured learning contexts. It aims to be a tool that can help teachers in both setting up learning paths that can adapt to each student individually and in assessing them. The entire system consists of various components:

- **an agent-based simulation engine**: the beating heart of the system, it processes data from players' actions and simulates the virtual consumers that make up the market.
- **the game**: the first and most important of the two components through which players interface with the simulation engine. Within the game, students receive information about the market and the assets available to them, build their village by selecting the services they think best meet demand, and visualise and analyse feedback from consumers and economic data using analytical tools.
- **a virtual social network**: the second of the components aimed at players. Following in the footsteps of social networks such as Tripadvisor and Yelp,

students have at their disposal a social network where they can see the reviews that virtual consumers leave at the end of their holiday, analyse trends and become aware of the reputation that their village is building up.

- **the teachers' platform**: the tool through which teachers can build, customise, monitor and analyse their students' gaming sessions.

All the components (except for the simulation engine) were developed to be used on the web through a simple browser, in order to meet the technological difficulties often present in schools. At a more abstract level, the teachers' platform represents an Input/Output interface between teachers and the system, while the game and the social network together represent an Input/Output interface between players and the system (Figure 13). In the following sections, the various components will be presented in details and the design process at the core of the choices made will be discussed.

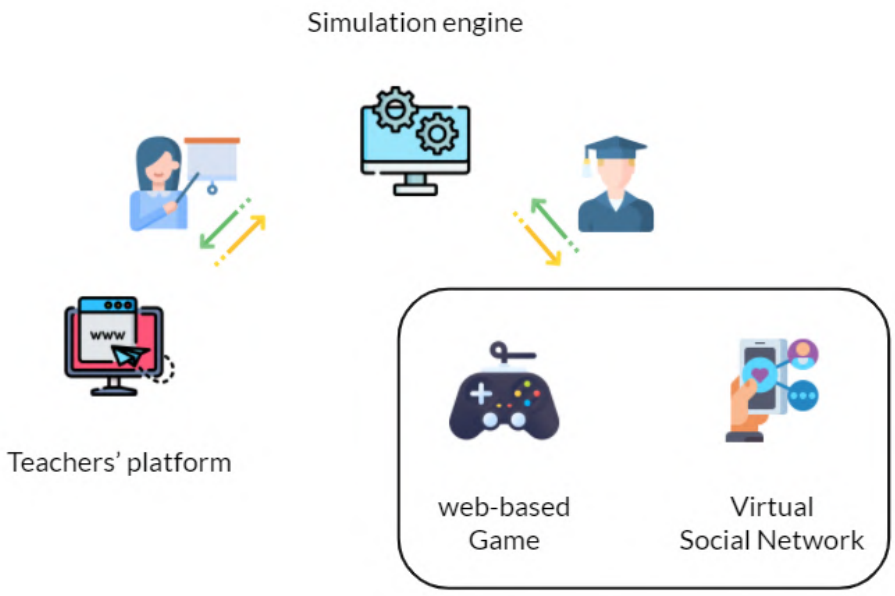


Figure 13: An overview of the system from an user I/O perspective

## 4.1 The Simulation Engine

From the very beginning of uManager's design phase, the idea was to immerse players in a simulated environment that was as close to reality as possible, an environment in which they could freely experiment and acquire knowledge and

skills that they could later use in the real world. To achieve this goal, the first step was to model the market at the base of the simulation following a realistic and reliable segmentation. Five customer types, each characterised by different interests and a different spending capacity, were identified and initially labelled with the names of real existing categories: *young people*, *working class families*, *middle-class families*, *businessmen* and *VIP*. In order to remain further faithful to reality, the numerosity of a given category of client decreases as their spending power increases: young people, for example, who have a limited budget, will always be present in much greater numbers than VIPs, who have a much higher spending power. This first choice of labels, however, soon proved to be a failure: during the first experimental trials, despite the fact that each customer category was accompanied by a complete description of interests, needs and characteristics, a huge bias emerged on players' side. What the students found themselves doing was constructing their own description and understanding of the categories that transcended the information provided within the game, and instead relied on individual life experiences and knowledge. To solve this problem, using defamiliarization, the names of the categories were soon replaced with fictional ones, so as to directly eliminate the bias at its root: young people thus became the *Sulibans*, working-class families became the *Vulcans*, middle-class families became the *Romulans*, businessmen became the *Klingon* and VIPs became the *Enolians*.

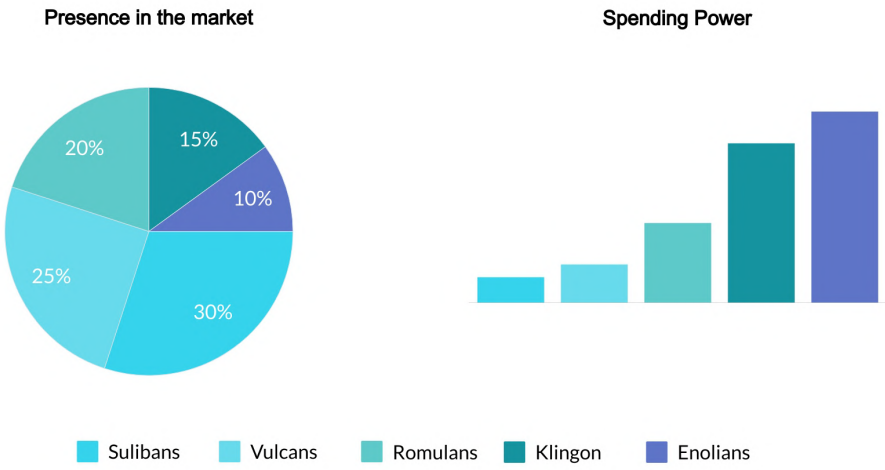


Figure 14: The different categories of clients that compose the market

In order to characterise and detail the various categories of customers, five

common areas of interest were identified during the design phase: accommodation, relax, entertainment, restaurants and green areas. Each of these areas was further defined by five characteristics (independent and different for each area) that make it possible to formalise the interests, needs and preferences of the customers (see Table 2 for an example). In this context, these characteristics represent the dimensions of a multi-dimensional space that models the area of interest. If we express the customer's preferences on each dimension as a value between -2 and 2, and treat them as a coordinate for the relative axis, then we can model the category of customers itself as a point inside this space. For convenience, instead of using directly such a point, we will consider the vector pointing from the origin of the axes to it. In the same way, it is possible to define a whole series of services linked to these areas of interest to be made available to players in order to create their own village. Students can then choose what to build from an array of different assets, each defined inside such a model. Within this formal structure, it becomes simple to define whether a given category of client is satisfied by a given service built by the player: it is enough to verify the correlation between the client-vector and the service-vector. Normalizing the correlation in the continuous initerval [-1,1] one obtains the litmus paper related to customer's expectations: a positive value indicates satisfaction, a negative value indicates displeasure, while a value close to 0 indicates indifference.

| **Dimensions of the area of interest "Accomodation"** |
|---|
| Level of comfort |
| Presence of external spaces |
| Cleaning Service/ Room Service |
| Privacy |
| Presence of ancillary services |

Table 2: The different dimensions for the area of interest "Accomodation"

In order to allow the player to acquire and enhance skills related to resource management, an additional level has been added to complement the services: the *personnel*. Each service, from accommodation to catering services, needs staff with certain qualifications and in appropriate numbers. The presence, qualifications, number and quality of staff are all characteristics that the player directly manipulates and that affect the proper functioning of a given service. Consequently, a service which on paper meets the customer's needs perfectly, but which is undersized or inadequately staffed, will contribute to displeasing the customer.

Within this model, the simulation is therefore able to compute the degree of customer satisfaction, in relation to their preferences and expectations, each

time they visit the player's village. This measure, instantaneous in nature, is called *perceived quality*. In order to make the simulation close to reality and to provide a tool that allows virtual agents to decide whether to visit the village or not, two further concepts have been introduced: the concept of advertisement and the concept of reputation. As far as the former is concerned, the advertising channels able to reach consumers have been modelled in a similar way to the preferences concerning the areas of interest. Consumers are defined within the space of "communication preferences", just like the communication channels available to players. Each consumer category can only be reached (and thus become aware of the existence of a given village) by related communication channels. Inside the simulation, the measure of how many clients the advertisement campaign reach is called *visibility*. Reputation, on the other hand, represents the " collective memory " of the experiences made by consumers, belonging to the same category ,within a given village. Just like in real life, consumers are often strongly influenced by the experiences of their peers. Within the simulation, at the end of each stay, each consumer uses their perceived quality to build this "shared memory": a positive experience will increase the likelihood that a new consumer will choose to stay in the village; similarly, a negative experience will discourage new customers. The 'historical' nature of reputation prompts players to think carefully and critically about the choices they make: getting it wrong repeatedly over a long period of time will inevitably lead to market alienation.

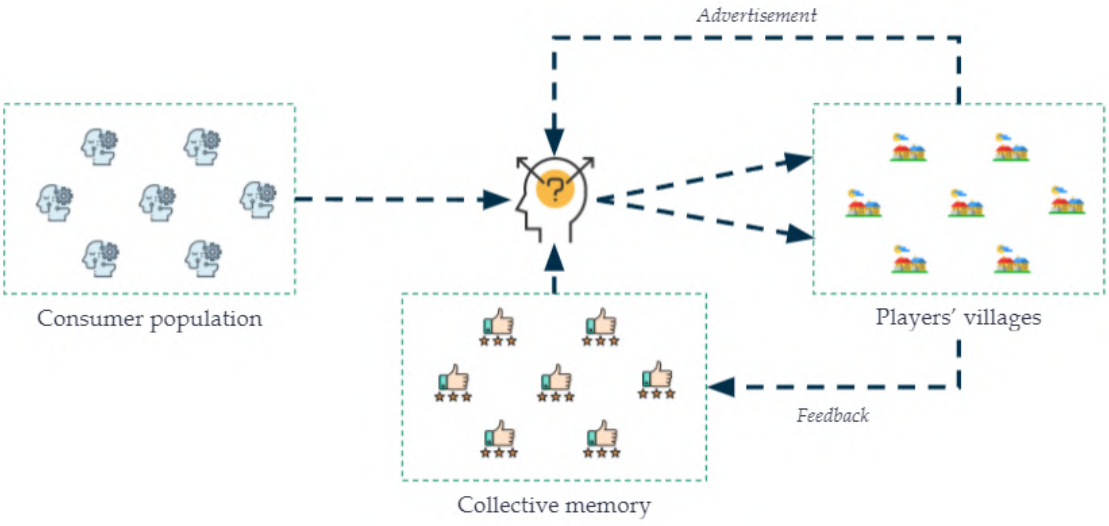


Figure 15: The decision-making process of virtual consumers inside the simulation

## 4.2 The Game

In uManager the player starts the game with a sum of money, obtained in the form of a loan which he has to repay monthly through a ten-year repayment plan, and a completely empty plot of building land, including a beach. During the very early stages of the game, the player is assigned and presented (through a detailed description of interests and needs) with a target market segment. Despite this assignment, the player's village can still attract and serve customers from all the market segments present in the game. The main difference is that while the student receives a detailed profiling for the assigned target, no information is provided on the remaining market segments. This design was made to make the players understand the impact that critical information, such as market research, can have on the planning and overall success of a company. Within the game, all the data related to the model (such as the representation of assets and market segments within the space of the areas of interest) are shown in the form of textual information: from the numerical model, for each asset and for each market segment, ad hoc texts have been produced to allow the player to infer the underlying data.

| | Comfort | External Spaces | Cleaning Service Room Service | Privacy | Other Services (Kitchen, Laundry) |
|---|---|---|---|---|---|
| Tent | -2 | 2 | -2 | -2 | 2 |
| Camper | -1 | 2 | -2 | -1 | 1 |
| Bungalow | 1 | 1 | 1 | 2 | 2 |
| Duplex Bungalow | 1 | 1 | 1 | 1 | 1 |
| Hotel | 2 | -2 | 2 | 2 | -2 |

| | Comfort | External Spaces | Cleaning Service Room Service | Privacy | Other Services (Kitchen, Laundry) |
|---|---|---|---|---|---|
| VIP | 2 | -2 | 2 | 2 | -2 |
| Senior | 2 | 1 | 1 | 2 | 0 |
| Family | 0 | 0 | 2 | -1 | 1 |
| Young | -2 | 2 | -2 | -2 | 2 |
| Low cost | -1 | 1 | 0 | -2 | 2 |



Figure 16: Transposition from the numerical model to the text presented to players.

In order to choose the right services and satisfy the customer optimally, the player must therefore critically read the customer's profile and the assets' descriptions, understand them and match them. This encourages the development of critical reading and understanding skills.

For each service added, as already seen in the section on the simulation engine, the game allows students to hire and manage the required staff. Considering the nature of the services available within the game (accommodations, catering services, relaxation services, entertainment services and management of green areas), some categories of staff can be hired with the idea of being used across the village on several similar structures (e.g. the same hotel cleaning staff cleaning multiple

hotels inside the village), while other types of staff (e.g. cooks) must be hired and assigned exclusively to a single structure. Also in this case, the numerical and qualification relation required by each structure is not explicitly stated, but has to be inferred from the descriptions of the service structures and the professional figures to be hired. An underestimation of the staff required will lead to malfunctions in the facilities and a lowering of the quality perceived by the client, while an overestimation will have a considerable impact on the costs of the company.


Figure 17: The in-game hiring process. The window shows the job description together with the salary that will be paid to the employee.

The progress of the game in uManager is marked by two parallel dimensions: the time dimension and the dimension related to the game difficulty and the active game mechanics. Within the game, the time progression is automatic and visible to the player through the graphic interface: seven real seconds correspond to twenty-four hours in the virtual world. At the end of each virtual week, the game simulates the arrival of new customers in the village, their stay and their purchases. Similarly, this virtual passage of time is also used to account for financial deadlines, to pay instalments on loans, salaries, etc. This time structure also introduces micro-deadlines within which the player can make changes to implemented new management policies before impacting the next round of incoming customers, reinforcing planning and deadlines management skills.

Parallel to this temporal progression, each game proceeds within what is called a *game model*. Each game is subdivided into logical blocks called *levels*,


Figure 18: The in-game Calendar, showing the virtual days, weeks, months and years passed since the start of the game.

characterised by the focus on certain skills and competences: this structure allows to set gradual educational goals in the game design phase and provides tools to ensure that students' attention is focused on particular elements and competences (e.g. by disabling and/or enabling only a subset of the game mechanics present). Each level is accompanied by a list of micro- and macro-goals that determine players' progress within the levels themselves and thus the game model. A level actually represents what a module would represent within a course.

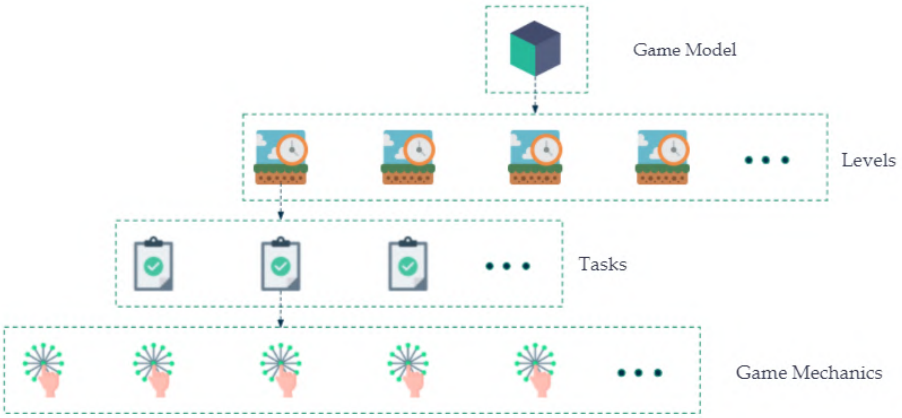


Figure 19: An overview of the game model.

In order to move from one level to another, players must demonstrate that they have acquired and mastered the subject through the completion of set objectives. The presence of these objectives also helps the player outside the function of assessment by providing practical input about the most important elements to focus on at a given time. This guarantees a learning path that adapts to the needs of the student and allows for the exploration and consolidation of the new notions encountered. Once all the objectives have been achieved, a level is completed and progression to the next one is automatic. The player will be notified of both the new objectives and the new active game mechanics each time he/she reaches a new level. This structure allows multiple game models to be design in order to aim for different educational goals, amplifying the customization options available to teachers.

In uManager, players can also deal with economic difficulties encountered


Figure 20: The in-game view of the current objectives and their progress status.

during their company's journey by asking for loans. At any time, players can request a sum of money as a loan, and if the request is considered suitable by the simulation (certain feasibility indices are checked, such as the company's current debt and the frequency with which loans are requested), they will receive three loan proposals with different repayment options: shorter repayment periods correspond to lower interest rates. Each proposal will be detailed to the player with the number of years required for repayment, a percentage indication of the interest charged, together with the amount of the monthly instalment. Players are free at any time to view a summary of their financial situation relative to the loans, obtaining precise information on the capital paid back and the capital still to be returned for each active loan. Players are also free to pay off their loans early and at any time by paying back the unpaid amount by selecting the appropriate entry in the loans-summary screen.

To guide the player in the analysis of the choices made and of the feedback received from the simulation and the customers, the game is complemented by a series of analysis tools. Students can view at any time several graphs relating to various analysis dimensions (the degree of accommodation occupation, the comparative view of values and costs of the individual categories of services implemented in their village, the number of quotes requests received from the various market segments, etc.) and various financial recaps presented in traditional tabular forms (such as the annual financial summary and the balance sheet). Careful use of these tools, assisted by the analysis of the feedback visible through the virtual social net-

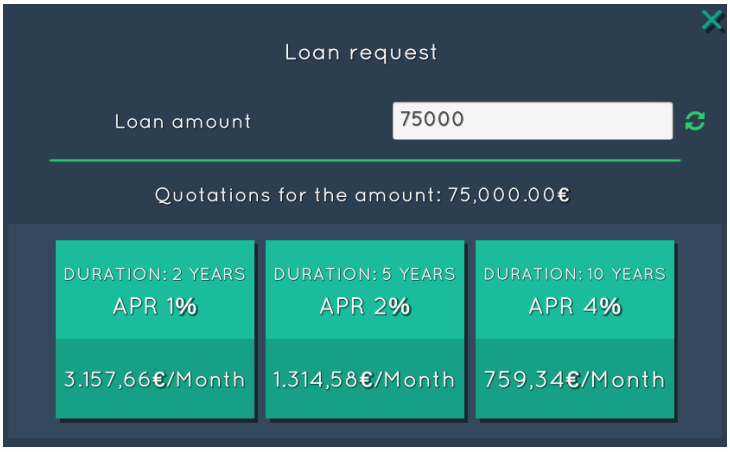


Figure 21: Financing proposals formalised by the system after a loan application.

work, is fundamental to understanding the company's economic performance and to identifying any problems early on, in order to promptly intervene.

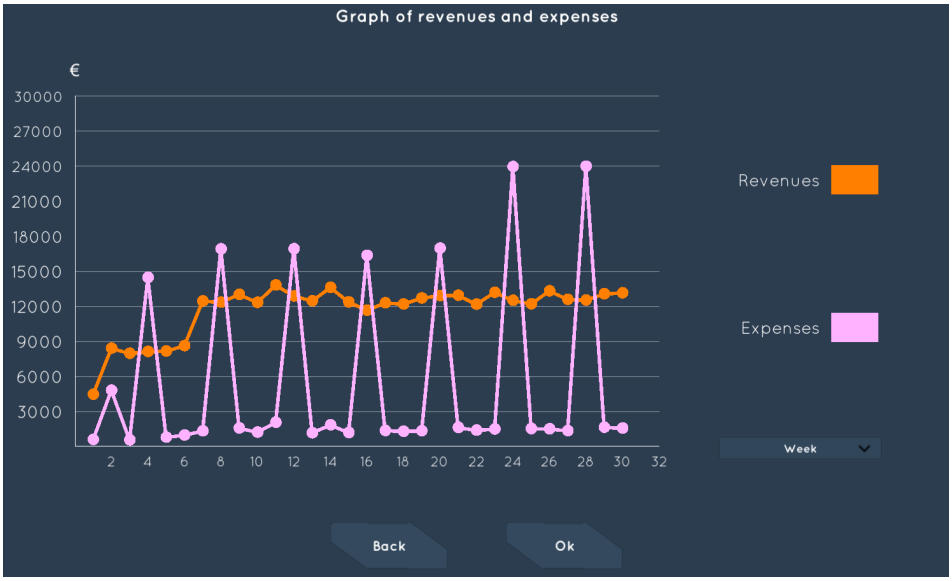


Figure 22: An in-game graph reviewing revenues and expenses.

Finally, to support the player in exploring the new features introduced by each level and in approaching new game mechanics, uManager features a virtual avatar that communicates with the player via messages. The interface related to these messages has been made to resemble the most common messaging apps, in order to be familiar and effective. The player can therefore easily re-read all the messages received during the game session, even the oldest ones. The avatar is a

first tutoring point, answering the most natural doubts and making it easier for players to understand the game and the objectives. Whenever the avatar sends a new message to the player (e.g. when a new game mechanic is introduced or an objective is reached), the game displays a notification icon alerting the player.


Figure 23: The messages sent by the avatar to the player.

## 4.3 The Virtual Social Network

The game environment is supported by a virtual social network, called *uManager Advisor*, thanks to which the agents staying in the village are able to leave reviews visible to the players. Each review will show in text form the customer's judgement of perceived strengths and weaknesses in the village, together with an overall score ranging from zero to five stars. For the best and worst services, the review will express a judgement taking into account both the perceived quality and the staff adequacy. Following the style of major social networks, each review is also characterised by the "date" on which it was left (a reference to the virtual week since the village opened) and a certain number of likes: extremely similar

reviews, belonging to customers of the same category, are aggregated together. The number of likes represents precisely the number of reviews that have been aggregated, and consequently the number of consumers who share that opinion. An indication of the number of *views* is also visible on the village's social network page. This information allows the player to check how many customers have been reached by his/her advertising campaign, both in terms of new customers reached in the last week of activity, and in terms of the total number of customers reached since the village opened.

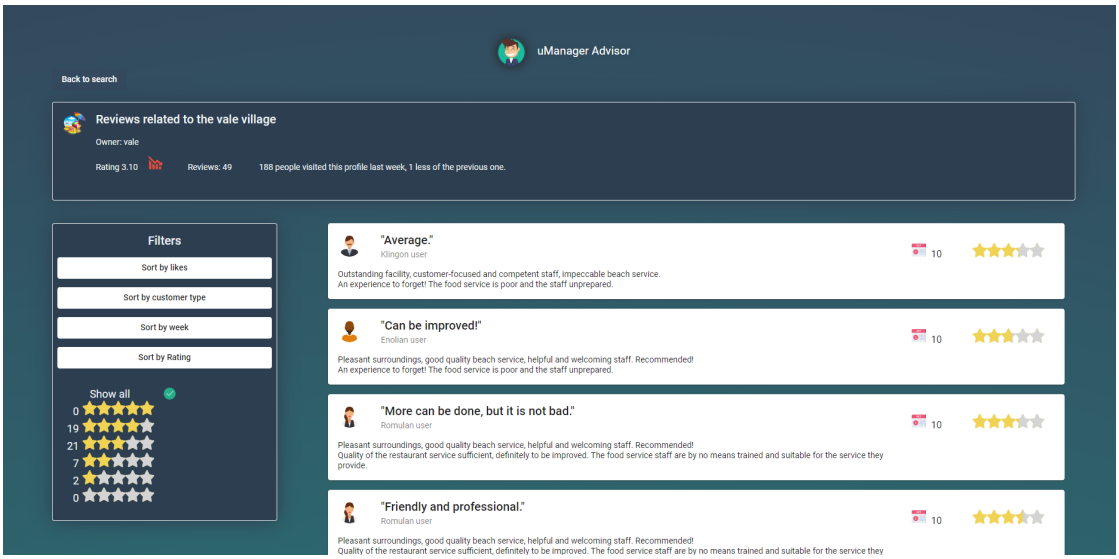


Figure 24: The page relative to a player's village inside the virtual social network.

From a formal point of view, at the simulation level, reviews are objects characterised by seven properties:

- The set of evaluations on the quality of services present in the village (including accommodations), grouped into a single value for each area of interest.
- The set of staff evaluations, grouped in a single value for each service category present in the village.
- The reference to the village for which the review was made.
- The name of the customer category (market segment) that left the review.
- The virtual week (counting from the beginning of the village's activity) in which the review was left.
- The number of likes the review has received.

- The overall rating, i.e. the arithmetic average of the ratings.

Each of the ratings contained within the review object are numbers ranging from 0 to 1, where 0 equals the worst possible type of experience and 1 equals the best possible type of experience. Each agent saves their review at the end of the virtual week of their stay in the village, coinciding with the end of their holiday. Rather than communicating these values as they appear in the model, in order to allow the player to develop those skills related to the reading and the analysis of the feedback sent by customers (which in the business context is increasingly consumed daily through social networks), these are processed by the system and the data is composed and presented as a comment. Figure 25 shows a review in details, just like it is presented to players.


Figure 25: An example of customer's review as can be seen by the players.

As can be seen, the review shown to the player consists of the following elements:

- a header, summarising the overall evaluation.
- the indication of the category of client (market segment) that left the review, both in text form (in the example "Enolian User") and in the form of an avatar (in the example the image at the top left of the review tab).
- The indication of the week in which the review was left (in the example the pair of calendar icon and number immediately to its right)
- The overall rating expressed in stars, the number of which ranges from 1 to 5.
- The number of likes the review has received.
- The actual text of the review that serves to make explicit the evaluations relative to the services and the staff; to help the player focus on the most important aspects, relative to the growth of his village, the text only shows the evaluation relative to the service perceived as best and the one perceived as worst.

If there is only one category of service in the village, the generated text will show the rating for the only service present.

In order to obtain the final textual review, a series of texts, modular and generic, were hand-authored so that they could be composed and joined together. These text modules were written in such a way as to make explicit the degree of satisfaction intended and were catalogued in a database with a numerical label reflecting their "value": a value close to zero will indicate a text expressing disapproval and displeasure, while a value close to one will indicate liking and satisfaction. In order to reduce as much as possible the chance of presenting reviews that are too much similar to each other, several equivalent variations were produced for each text. The system then analyses the review as represented in the simulation model, identifies the best and worst services and, depending on the data, randomly retrieves one of the suitable and adequate text variations. These text-modules are then composed into a single text and displayed to the players.

One of the most interesting things about this social network is the chance to explore pages belonging to other villages, in addition to one's own. This allows for comparative analysis and helps students to better understand the mechanisms involved in this type of feedback.

## 4.4 The Teachers' Platform

The teacher's platform is another of those tools that has been developed for uManager and plays a key role inside the learning environment. It is the interface between the system and the teachers. Through the platform, they can organize their own groups of players, the game sessions carried out by their students and monitor and analyse their progress.

Once registered on the platform, and thus following the creation of a personal account, the first operation required of a teacher is to create the *groups*. These represent logical groupings of students, and are used to organize and manage the work carried out on students who are united by the course they will be following and the learning objectives they intend to achieve. While the most natural and instinctive logical grouping is that of the school class, the teacher is left the option of working with groupings of students that make the most sense within his or her instructional design. If, for example, a teacher is running the same course in four different classes, and he/she is interested in monitoring and reviewing the students' progress across the whole school context, he/she can simply create a logical group that contains them all. In addition to choosing a name for the groups he has created, the system allows the insertion of notes that can describe the group and help the teacher to identify them correctly. At this stage the platform also allows the teacher to enable or disable the virtual social network for that group

of students. If the social network is disabled, it will be possible for the players to view a series of graphs summarising the same information contained in the reviews (an indication of the quality perceived by consumers, the visibility of the village in relation to market segments as well as the trend relative to the reputation the village is building).

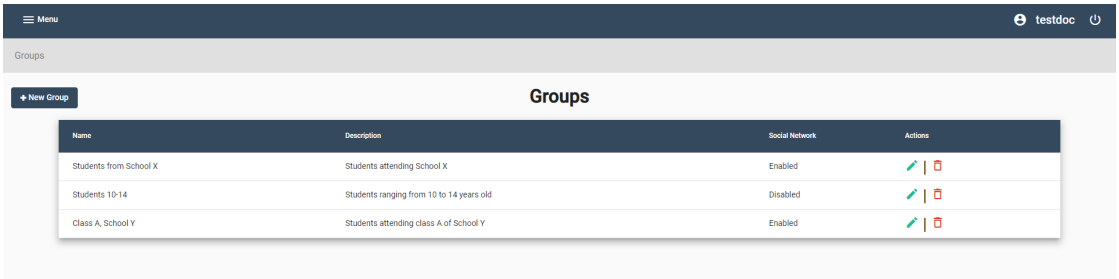


Figure 26: The view inside the teacher's platform in which groups can be created and organized.

For each group created, the teacher can then define the various *sessions*. Within this model, sessions represent the games played by the players for a specific learning objective. For example, a session might represent the games played to master the concept of a scarce resource. They are independent of the number of times the player accesses the game and the number of villages the player creates. When creating a session, the teacher will be able to assign a name and description (similar to groups, helping them to navigate through the recorded sessions), but above all will be able to select the game model that will be used within the players' games and the market segments that will be present within the session. These two features give the teacher a high degree of control over the structure of the sessions created, both from the point of view of the levels the players will face (and therefore the game mechanics that will be available and the order in which they will be enabled), and from the point of view of the homogeneity/heterogeneity of the market segments present. If the teacher wants to make a comparative analysis between students, for example, it could be useful to have them all play within a reduced market, in order to homogenize the starting conditions and eliminate unhelpful variance.

Once a new session is created, the teacher is given a code that students can use to join it. In this way, by self-registering players using the code, the teacher is relieved of the burden of having to manually enter all the students taking part in the session, easing the workload. Within the session detail view, teachers can view a list of players who have joined the session and their villages in a summary table. The table also shows the cash value of each village, an indication of the virtual week the player has reached (counting from the creation of the village) and an

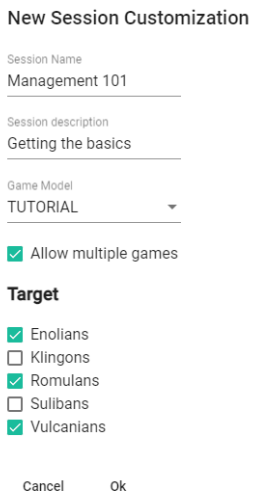


Figure 27: The view relative to the creation of a new session.

indication of the market segment assigned to them. On the same page, the teacher has at his disposal a pie chart showing the current distribution of the market segments assigned to the players, as well as several charts allowing comparative analyses.


Figure 28: The view relative to session details.

These graphs are present for a number of dimensions that strongly relate to success in the game, such as quality perceived by consumers or the difference between value and cost of production, and allow the simultaneous display of data from a selection of any number of villages in the session, within a given time period chosen by the teacher (measured in virtual weeks).

The platform also provides the ability to monitor and view data relating to


Figure 29: The graphs used to do comparative analysis between players.

an individual village at a greater level of detail. By clicking on a particular village, the teacher will be able to access a view that will also show in detail the game mechanics currently active in the player's game. In this same view, a number of graphs will be available. These graphs are similar in function to those used for comaprative analysis between students, but are focused on selected data and metrics useful in analysing the progress of individual players.

In its entirety, the teachers' platform represents the tool that allows for the creation of learning paths and the focusing of students' playing time according to specific learning objectives. It further represents the tool through which the monitoring of students' progress but also the evaluation of the activities carried out in the game and the achievement of the set objectives can be carried out.

# Chapter 5

# uManager: the path towards CBE Compliancy

uManager is a SG that has already been designed to foster the development and enhancement of certain skills and competencies, particularly those related to critical thinking (Gentile et al., 2018, 2019). Players' choices, which pass through a small number of game mechanics (GM), impact on numerous variables of the simulation model. A critical understanding of the links and relationships between game mechanics and internal system varibles is necessary in order to achieve in-game success.

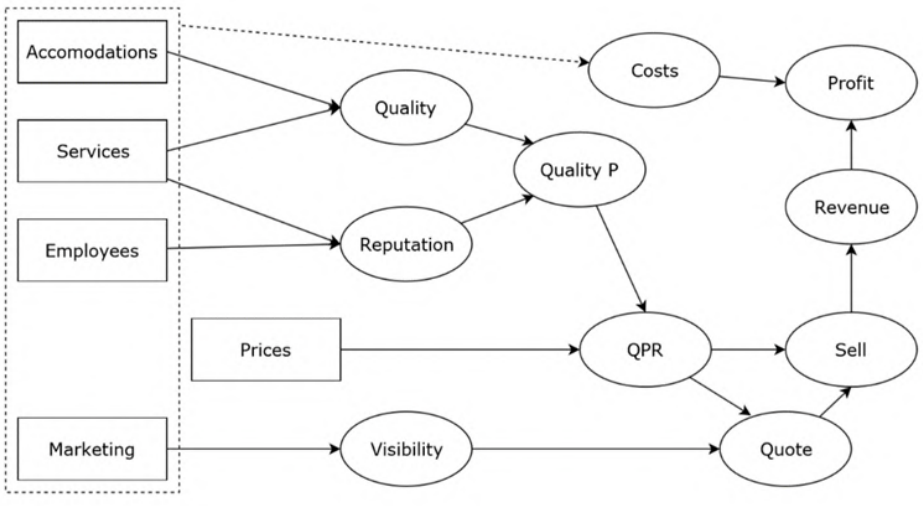


Figure 30: The causal network of GMs and game variables present in the game. QPR stands for *Quality-Price Ratio*.

A diagram showing these relationships is shown in figure 30. In the diagram, GMs are identified by rectangles while simulation model variables are identified by ovals. In addition, the dashed box indicates the mechanics that directly impact the variable *Costs*, one of the variables most involved in determining profits.

Various trials (Gentile et al., 2018, 2019; Signa et al., 2021) have confirmed the correlation between disposition to critical thinking and success in the game and have suggested that the use of uManager can provide a training tool for these skills. What uManager lacks is a re-design that can highlight all the various skills and competencies that can be developed through the use of the game, and above all make it compliant with the principles defined in the previous chapters. In order to achieve this, it is essential to first carry out a thorough and systematic analysis of both the knowledge model in uManager and the competences that can be identified in it. Ontologies are a particularly suitable tool for describing knowledge and thus for accomplishing this task. Before continuing with the analysis, I will briefly introduce them and describe the ontology chosen for this work.

## 5.1 Choosing an ontology

Ontologies are an important tool for formally representing, manipulating and sharing knowledge. An ontology can be defined as a formal, explicit specialisation of a shared conceptualisation, consisting of concepts and the relationships between them (Gruber, 1993). The ontology concept is the basis of the Semantic Web, a technology defined as an extension of the traditional Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation (Berners-Lee et al., 2001). The idea behind the Semantic Web is to use Unified Resource Identifiers (URIs), normally used to indicate web pages, to identify any kind of knowledge entity and any relationship between them. The real power of ontologies and consequently of the Semantic Web, is achieved when they are made public and freely accessible, in fact helping to define vocabularies of terms and relationships consistent within the various ontologies with which concepts and knowledge can be expressed. An example of a project for the collection and cataloguing of ontologies is offered by The Linked Open Data Cloud (LOD, 2022), which to date gathers more than 1,200 datasets and related ontologies belonging to numerous domains, enabling cross-domain ontological knowledge explorations. This type of initiatives and open linked data has the capacity to enable both machines and human agents to explore networks of interlinked concepts, enabling more intelligent inferences to be made using the knowledge made available (Heath and Bizer, 2011).

In the context of competences, a recent work (Paquette et al., 2021) underlines that there are only a few generic models in the literature, abstracted

from particular domains and suitable to be transformed into ontologies for the Semantic Web. The authors identify the following four: the Reusable Competency Definition from the IEEE RCD standard and the IMS RDCEO specification (IEEE, 2008; IMS, 2002), the HR-XML Competency model (Allen et al., 2001), the Achievement Standards Network Description Language (ASN-DL) (Chapman and Sutton, 2019), and the Rezgui et al. (2014) competency ontology. With the aim of creating a new competency ontology model that can be used in the Semantic Web context, Paquette et al. adapt one of their previous generic model (Paquette, 2014) into a formal ontology (COMP1) and analyze it together with the four found models in order to extract ten important meta-features: model format, competency format, association between competencies, skill association to a competency, knowledge association to a competency, performance/Proficiency Scale, association of competencies to documents and activities, association of competencies to actors, evidence of acquisition, context of acquisition. The authors condense the results of this analysis into a table shown in the figure 31.

| *Model Features* | Competency Model or Ontology | | | | |
|---|---|---|---|---|---|
| | **RCD/RDCEO** | **HR-XML** | **ASN-DL** | **COMP1 (TELOS)** | **REZGUI** |
| **Model format** | Metadata Relational Model | Metadata Relational Model | RDFS Ontology | RDFS Ontology | RDFS Ontology |
| **Competency format** | Natural language statement | Natural language statement | Natural language statement | Internal structure as a KSP triple + Natural language string | Internal structure as KSPC quadruplet + Natural language |
| **Association between competencies** | None | Limited to a subsume taxonomy | Elaborated map of associations | Limited to a subsume taxonomy | Subsumes, composed of, requires, similar to |
| **Skill association to competency** | Skill is some kind of competency | Skill is some kind of competency | Link between competency and skill | Skill (skos concept) is part of a competency | Skill (skos concept) is part of a competency |
| **Knowledge association to competency** | Knowledge is some kind of competency | Knowledge is some kind of competency | Knowledge is some kind of competency | Knowledge (skos concept) is part of a competency | Knowledge (skos concept) is part of a competency |
| **Performance/ Proficiency scale** | None | Competency weight | Level in a proficiency scale | Links to performance criteria, class and level | Links to performance criteria, class and level |
| **Link to documents and activities** | None | None | Multiple kinds of correlation links | Prerequisite and target competency links | Link to ePorfolio resource |
| **Link to actors and learners** | None | Link to owner of the compentency | None | Actual competency link to learner and facilitator | Actual competency link to learner and facilitator |
| **Evidence of acquisition** | None | Multiple evidence properties | Assessed competency link from a resource | Many to many link with evidence sources | Properties of evidence record and evidence source |
| **Context of acquisition** | None | User Area | Standard document properties | Learning scenario | Has context properties link to a skos concept |

Figure 31: A summary of the analysis of the five models made by Paquette et al.. Source: Paquette et al. (2021)

On the basis of the model analysis performed, the authors decide to define a new

ontology (COMP2) that is able to satisfy certain important design constraints. First of all, this ontology must be able to be processed by both human and machine agents, so that the competency assessment process can be hybrid and collaborative, and the necessary tasks can be divided between them according to efficiency and needs. To achieve this, Paquette et al. states the importance of a structured model, closer to those found in COMP1, ASN-DL and Rezgui et al.. The ontology developed must also be characterised by a scope broad enough to guarantee its use in various different contexts. To this end, the authors consider important the extension of the elements of the RCD standard so as to include elements describing the assessment, certification, registration and comparison of competences, together with the contextualisation of competency acquisition and related performance levels. This extension must, however, remain functional, keeping the number of elements of the ontology restricted so as to remain applicable within reasonable human efforts. Paquette et al. argue that this can be achieved through greater structuring of the model, exploiting the use of links to external vocabularies and ontologies and at the same time restricting the number of relationships between competencies and specific learning resources. It is also important for the ontology to be sufficiently flexible with respect to the needs of use: it must be possible to use a subset of the ontology's elements if their totality is not necessary, adding them from time to time according to the specific scope. For this reason, the authors propose a model structure composed of hierarchical stages, which from level to level expand the concepts treated and add new elements. Finally, this ontology must be generic, reducing as much as possible the number of elements linked to specialised contexts and domains. While remaining as general as possible, the opportunity to introduce contextually specific knowledge elements through interaction with external ontologies and vocabularies is maintained. Finding myself in agreement with the features indicated by the authors and considering that this new ontology, COMP2, emerges from an analysis of the most important efforts to date in the literature, I decided to adopt it to describe the domain and competence-related concepts developed in uManager. In the next section, I will briefly introduce COMP2 and its components.

### 5.1.1 The COMP2 ontology

As previously introduced, COMP2 is an ontology formalised by Paquette et al. and composed of various stages that gradually expand the concepts covered in order to provide flexibility and reduce the overall complexity as required. The main and most important concepts are contained in the first of these stages: the core competency model (Figure 32). COMP2 organises the competence entity into three structural parts: knowledge, skill and performance. The knowledge component is selected within a knowledge domain model formalised as a Concept

Scheme (an aggregate of concepts) of the Simple Knowledge Organisation System (SKOS). The skill-related component, on the other hand, refers to those general skills that are used in the process of manipulating and using knowledge. This application link is made explicit within the ontology, and is assisted by the ability to use optional performance indicators relating precisely to the application of the skill to the specified knowledge. The skills themselves are chosen within an ordered list formalised as a SKOS Ordered Collection and present a property specifying their meta-domain (cognitive, affective, psychomotor and social). The authors point out that, depending on the needs, any Ordered Collection of abilities can be used, for example the taxonomy of Bloom et al. (1956) for cognitive abilities and that of Krathwohl et al. (1964) for affective abilities. In this work I decided to use the taxonomy of Paquette (2010), both because it is sufficiently granular (it has ten levels) and because it can be used in all four skill meta-domains identified in COMP2, as well as being suggested in the authors' work. The general skills identified in the taxonomy are grouped into four ordered macro stages of the information processing cycle, with each skill representing a specific step:

- Receive (Levels 1-2)
  - **1 - Acknowledge**: pay attention to knowledge objects.
  - **2 - Integrate**: identify knowledge elements already present in memory related to the new stimulus. Memorise new knowledge in a way that is congruent and related to previously acquired knowledge.
- Reproduce (Levels 3-5)
  - **3 - Specify**: illustrate concepts through the production of instances (e.g. examples). Discriminating between different concepts by producing specific instances of each of them that are not also instances of the others. Clarifying the description of knowledge by adding new attributes and links not initially provided.
  - **4 - Translate**: produce similar knowledge or present it in new forms.
  - **5 - Apply**: use knowledge to produce new goal-driven instances. Use process models to systematically produce new instances by setting values for some independent concepts and obtaining corresponding values for dependent concepts.
- Produce/Create (Levels 6-8)
  - **6 - Analyze**: deduce new knowledge from the one provided. Classify through the use of taxonomic classes. Predict the outcome of a given process. Diagnose the components of a system, producing a list of those that do not reach certain levels of performance standards.

  - **7 - Repair**: Replace components of a system in order to achieve better results.
  - **8 - Synthesize**: induce a concept from a set of examples, traces or statements. Plan a process by producing a set of products that respects time and resource constraints. Create a new model that integrates facts, abstract knowledge and/or partial models initially provided.

- Self-manage (Levels 9-10)
  - **9 - Evaluate**: attribute values to knowledge in relation to its usefulness, relevance, etc., in order to be able to evaluate it.
  - **10 - Self-Control**: initiate and influence the evolution of oneself and/or others by starting intervention processes, either through communication or actions. Control events and adapt to them, using knowledge and its evaluations to improve the general or specific knowledge possessed by oneself and/or others.

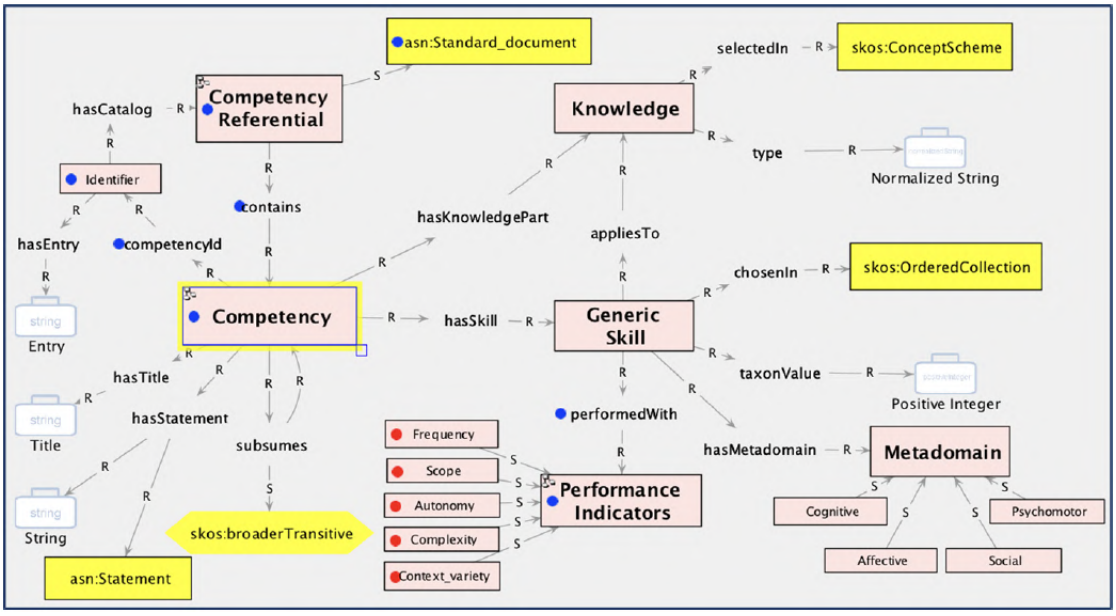


Figure 32: COMP2 Core competency model. Source: Paquette et al. (2021)

Within COMP2, both the knowledge-related and skill-related parts are mandatory, whereas the skill-related performance indicators part is optional. The competency class also has additional properties that are intended to aid its description. It has a title, a natural language statement and an identifier that allows it to be associated with a catalogue, called “Competency referential”. The purpose of such

a catalogue is precisely to group together various related competencies in a structured manner. Finally, competences can be linked to each other via the subsumes relation, a specialisation of the SKOS Broader Transitive property. A competence that subsumes another implies that these two are linked by a hierarchical relationship and that the latter is a broader concept than the former.

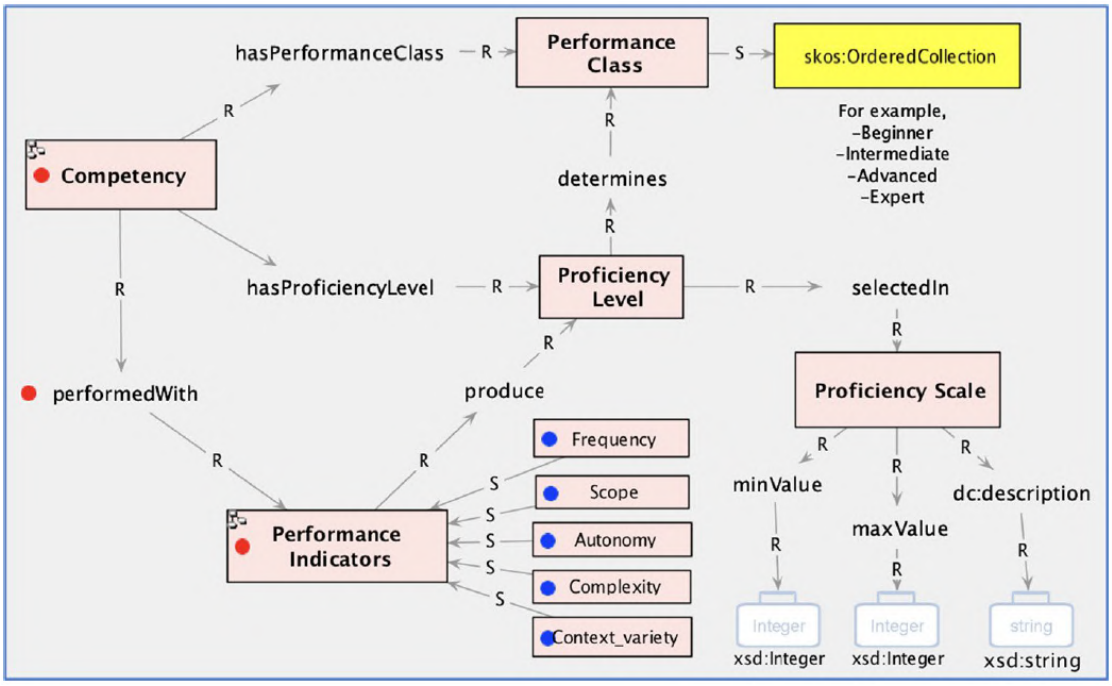


Figure 33: The second stage of COMP2. Source: Paquette et al. (2021)

Stage 2 of the ontology expands and introduces the classes and components required to describe the proficiency level and performance class (Figure 33). In COMP2, performance is measured through five indicators (Frequency, Scope, Autonomy, Complexity and Context Variety) that are combined into a single proficiency level. This level is represented by a numerical value selected within a Proficiency Scale characterised by a textual description, a minimum and a maximum value. According to the numerical ranges defined within the scale, it is then possible to determine a suitable performance class, formally defined as a SKOS Ordered Collection, aimed at transforming the numerical values provided by the proficiency level into values useful for linking educational activities to standards and levels of competence (e.g. “beginner”). The performance class can be also useful in the context of Serious Games to translate this proficiency level into scores and other measures used by games to provide feedback on the players’ performance (e.g. at the end of a level).

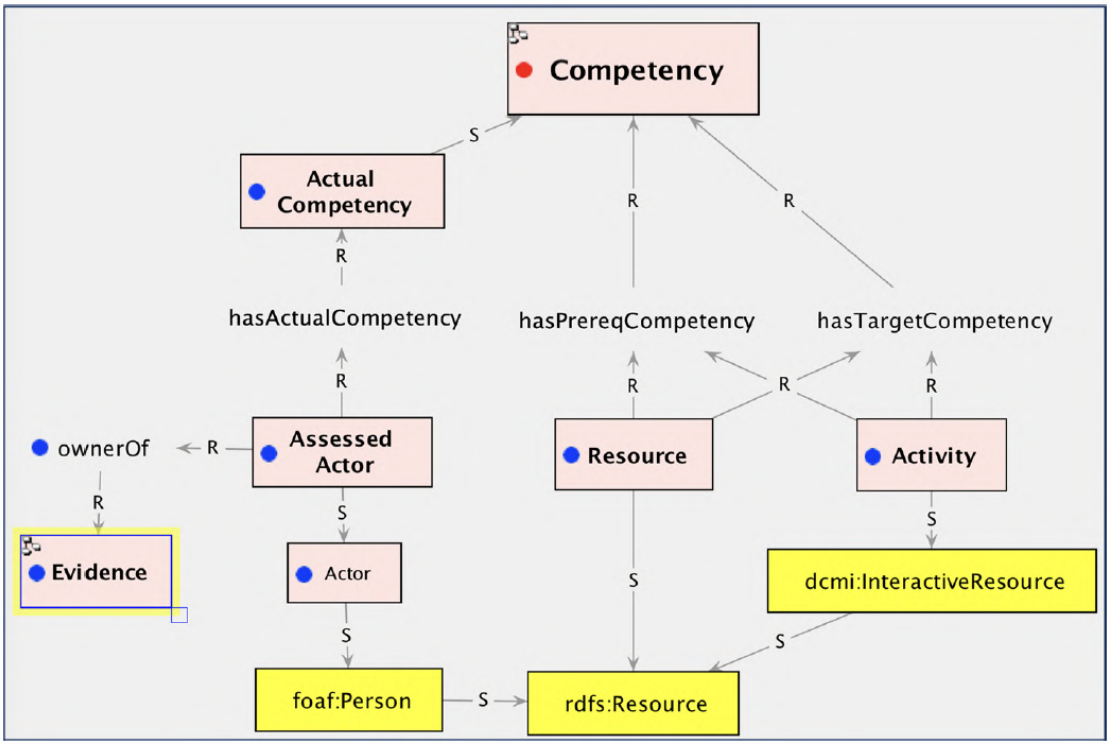


Figure 34: The third stage of COMP2. Source: Paquette et al. (2021)

Stage 3 of the ontology, on the other hand, deals with providing the elements and classes necessary to describe the scenarios in which the skills are used and trained (Figure 34). The sub-model introduced, independent of stage 2, introduces Resources, Activities and Actors. COMP2 links Activities and Resources to Competencies by establishing prerequisite and target relationships: while the competencies indicated as targets are the competences that are acquired or demonstrated through the use of resources or the performance of activities, those identified by a prerequisite relationship indicate the need to possess that particular competence *before* being able to correctly address the indicated resource or skill. The presence of these relations thus allows the introduction of the concept of Evidence (expanded within Stage 4) of the acquisition of a competence by an Actor. This sub-model is interesting in the context of Serious Games because it potentially allows for the definition of relationships between competences and levels of the game, and more generally, between competences and activities carried out within the game. This stage may therefore also be useful in understanding the dependency and order relationships present between game activities and in making sure they are ordered and organised in such a way that competencies can be developed in a coherent and organic context.

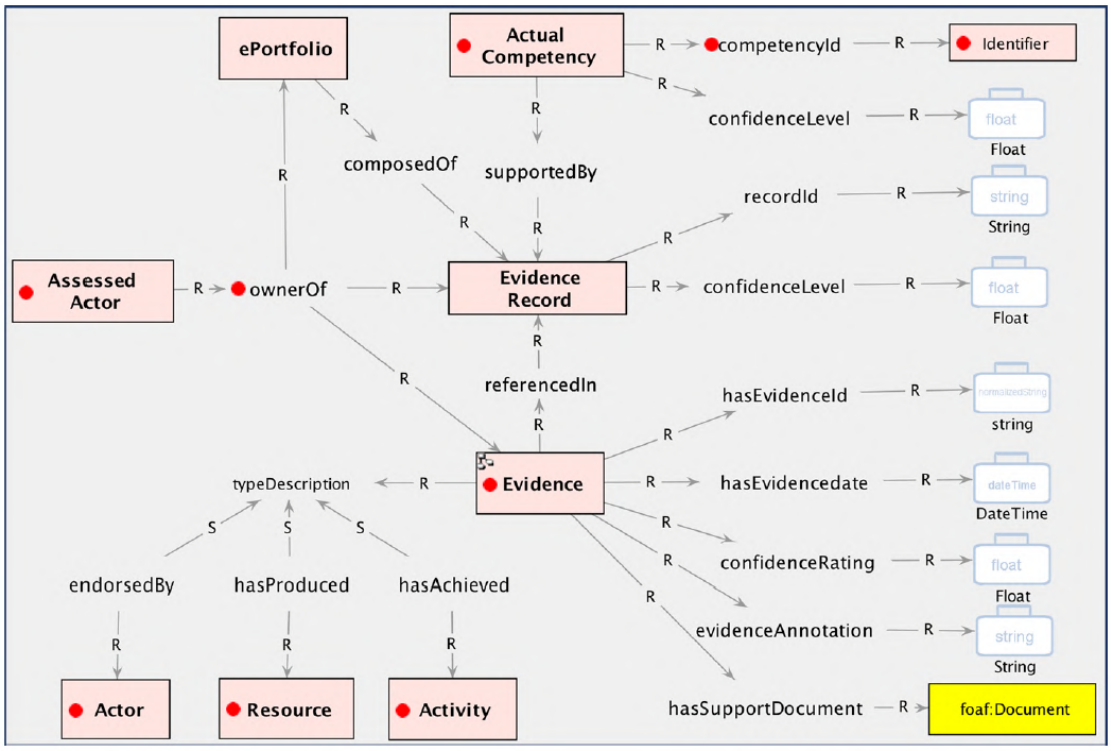


Figure 35: The fourth stage of COMP2. Source: Paquette et al. (2021)

Stage 4 of COMP2 deals directly with the concept of Evidence, introducing the classes of Evidence Records and ePortfolios (Figure 35). All assessed competences belonging to an Actor can be grouped in an ePortfolio together with the Evidences linked to them. Accordingly, an ePortfolio represents the set of competences acquired by the Actor, organised in a contextualised manner with respect to the ways and occasions in which these were demonstrated. Similarly, an Evidence Record is a set of Evidences obtained by an Assessed Actor relating to the demonstration of ownership of a specific competency. Each competency can thus be linked to an Evidence Record, and each Evidence Record refers to Evidences linked to a single competency. It is important to note that an Evidence Record may refer to more than one competency, and in this case be part of more than one Evidence Record. These records are also characterised by a Confidence Level, which is calculated from the individual Confidence Ratings of each Evidence in the record. To complete the description of the Evidence concept, this sub-model introduces some additional properties: the date on which the Evidence was produced, its confidence rating, a descriptive annotation and a type descriptor (an endorsement by an actor, a produced resource or a performed activity). An Evidence can be further linked to a Support Document, i.e. a token representing it (such as a

document, certificate, etc.) that can also provide information on the context in which the Evidence was produced. In the context of games this Support Document may refer to badges, achievements and other virtual tokens used to demonstrate achievement.

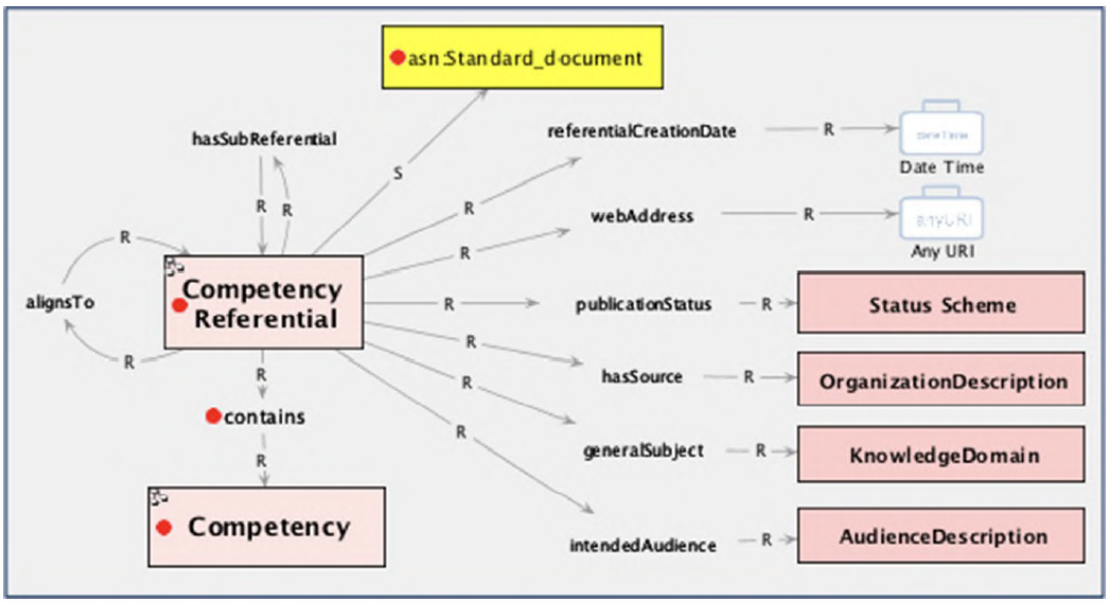


Figure 36: The fifth stage of COMP2. Source: Paquette et al. (2021)

The last stage of COMP2, stage 5, focuses on the description of the Competency Referential concept (Figure 36). The purpose of this sub-model is to provide the classes and tools for organising, aligning and comparing at a high level competences from different sources. Within this stage, the relationships between different Competency Referentials are defined together with the ability to structure a Referential in a hierarchical manner, subdividing it into various modules. Two Competency Referential may thus be linked by an alignment relation (*alignsTo*) if they are related, or by a composition relation (*hasSubReferential*) if one contains the other. The Competency Referential class is further enriched by certain properties useful for its description: its creation date, its web address, its publication status and source, the general subject to which it refers and its intended audience.

I will use COMP2 specifically in the context of the description of competences found in uManager as a result of its domain analysis.

## 5.2 Analysis of the knowledge domain

The first step necessary to carry out an analysis of the knowledge elements present in uManager and to identify the competences linked to them is to create an ontology of the knowledge domain. Starting from the causal network of GMs and the game variables identified in Figure 30 it is in fact possible to begin an exploration of the concepts linked to them and the properties involved in the relationships between them. For example, starting with the employees, the concepts of employee salary, professional level and employee type emerge immediately. Similarly, starting from marketing, it is possible to identify and add the numerous concepts related to the market, such as market segment, customer, preferences expressed by market segments, etc. This first step-by-step construction of the ontology led to the result visible in Figure 37: within it, the black rectangles represent the knowledge elements while the purple hexagons represent their properties.

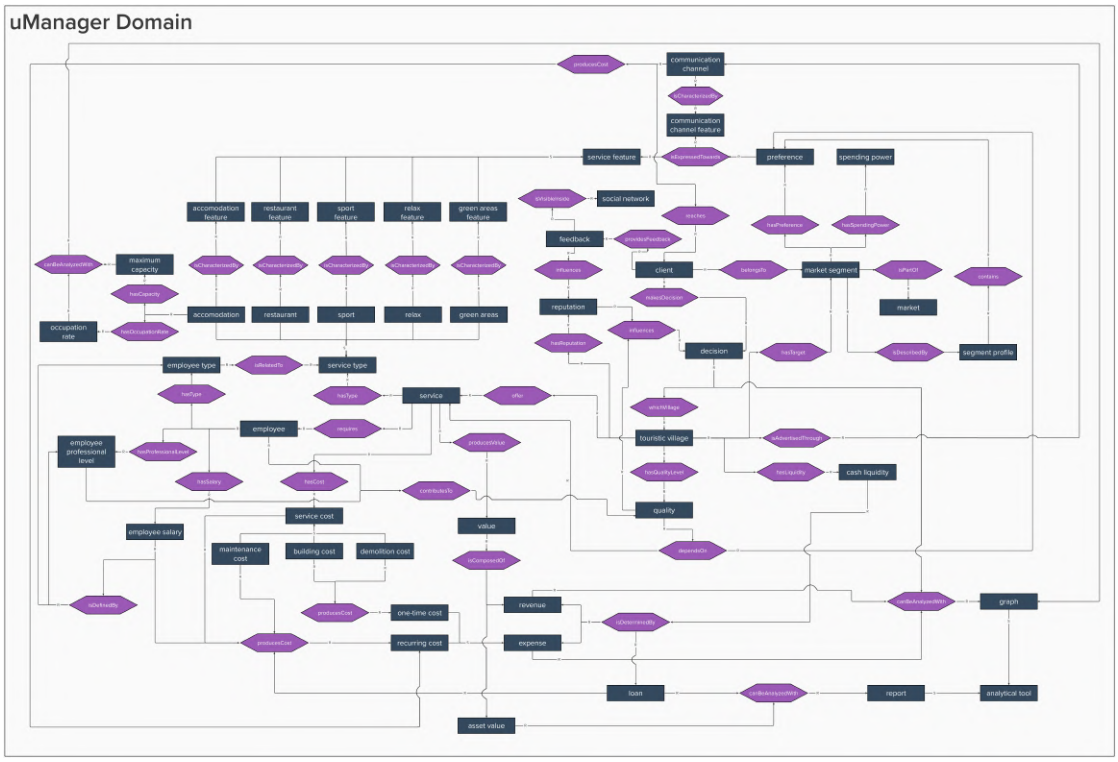


Figure 37: The complete knowledge domain ontology of uManager.

As can be seen from this initial formulation, the concepts present within the uManager knowledge domain are very numerous, as are the properties that bind these concepts together. The main purpose of such a domain ontology is to express in

a clear and simple manner the knowledge present within the game and the ways in which blocks of knowledge are bound together, but this first result is so dense that it is difficult to read and use. Similarly, this density of concepts also makes the extraction of the competencies involved complex. One of the things for which it is extremely useful, however, is to allow the identification of sub-domains once all the various knowledge elements present in uManager have been summarised. Breaking the entire domain into smaller, more focused subsets makes it possible to solve the problems related to the complexity of the model found. Analysing the uManager knowledge model as a whole, it is therefore possible to identify six different sub-domains: *Market*, *Customer Choice and Feedback*, *Services and Employees*, *Quality*, *Economy*, and *Analytical Tools*. Below, we will analyze each of these sub-domains in detail, extracting their associated competences.

### 5.2.1 Sub-domain I: Market

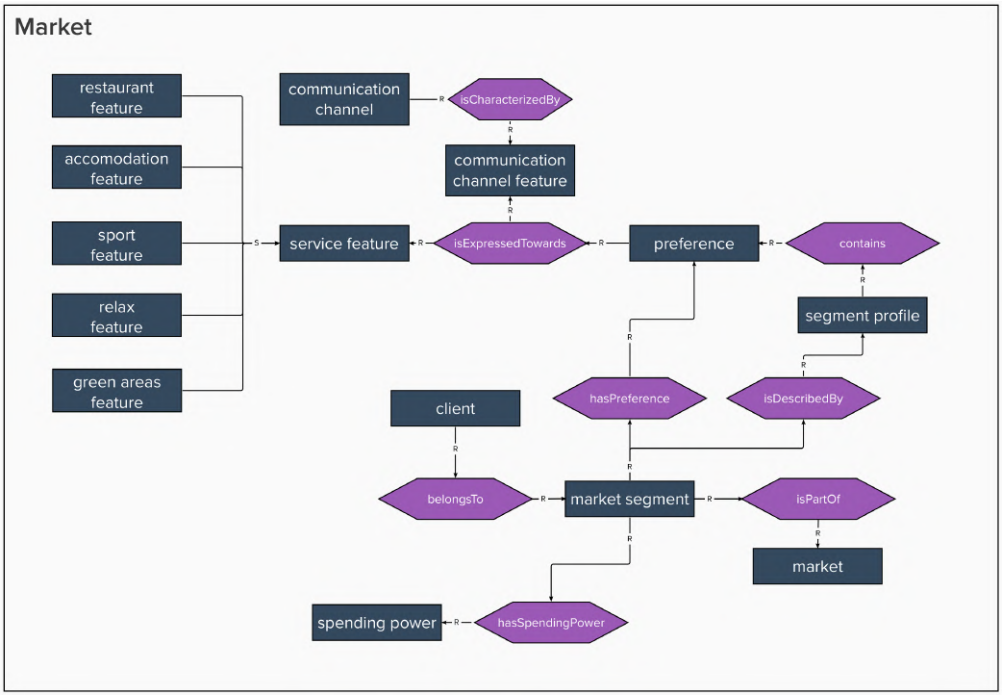


Figure 38: The Market sub-domain.

This sub-domain is the one that contains the knowledge elements describing the higher level concept of the market. In uManager, each customer belongs to a *market segment*, and together the various segments constitute the totality of the available *market*. Understanding the needs of individual customers is closely linked

to understanding the concept of market segmentation. In fact, in uManager, the different customers belonging to the same market segment are so similar to each other that the concepts of *spending power* and *preference* are actually more related to the segment itself than to the customer. For this reason, the textual profile that provides a description of preferences is directly linked to the market segment and is called *segment profile*. Another fundamental concept for understanding the market in uManager is that of preferences: a market segment expresses preferences with respect to the ideal characteristics that the communication channels through which it is intercepted and the services present and offered within the village must have. This notion is formalised within the sub-domain via the two knowledge elements *service feature* and *communication channel feature*. While the communication channel features directly describe the *communication channel*, the service features are declined into the specialised features according to the various types of services. Thus, *restaurant feature*, *accomodation feature*, *sport feature*, *relax feature*, and *green areas feature* are related to service feature through a *subsumes* relationship.

### Extracted competency: Classify Market Segments

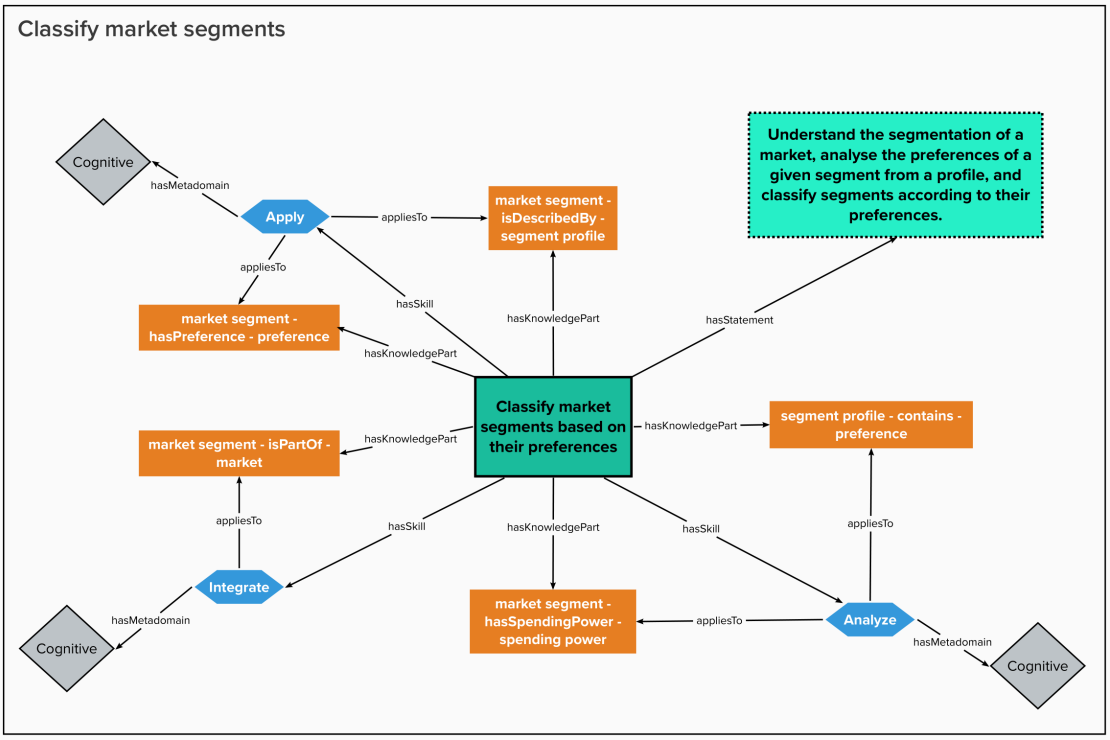


Figure 39: The COMP2 representation of the "Classify Market Segments" competency.

From the analysis of the first sub-domain and its knowledge elements emerges the "Classify Market Segments" competency shown in Figure 39. In the diagram the orange rectangles represent the knowledge parts, the blue hexagons represent the generic skills, the grey rhombuses represent the metadomains of the generic skills, the central green rectangle with a continuous border represents the competency while the light green rectangle with a dashed border represents the natural language statement of the competency. This legend will be respected in all subsequent diagrams relating to the representation of competences through the use of the COMP2 ontology. In addition, all the knowledge parts identified are in the form "class - property - class" and belong to the sub-domain analyzed, in this case the Market sub-domain. Similarly, all the generic skills used belong to the taxonomy of Paquette (2010). For this reason, this information is emitted from the ontology diagrams for ease of reading.

Going into the details of the "Classify Market Segments" competence, this can be described through its natural language statement: *understand the segmentation of a market, analyze the preferences of a given segment from a profile, and classify segments according to their preferences.* To do this, a knowledgeable person must first *integrate* the knowledge part *market segment - isPartOf - market* within his/her knowledge. In addition, it is necessary to *apply* the knowledge parts *market segment - hasPreference - preference* and *market segment - isDescribedBy - segment profile* in order to be able to retrieve the information needed for classification. Finally, a knowledgeable person must be able to *analyze* the knowledge parts *segment profile - contains - preference* and *market segment - hasSpendingPower - spending power* in order to be able to deduce the new knowledge and be able to perform the classification.
This competency is currently not explicitly verified within uManager and therefore a new ad hoc scenario or level needs to be designed in order to be exercised and evaluated.

### 5.2.2 Sub-domain II: Services and Employees

The second sub-domain identified is that of concepts and properties related to the services offered by the tourist village and the employees required for their operation. In uManager, each *touristic village* offers *service*s. Each service instance is characterised by a *service type* and requires *employee*s for its proper functioning. As in the case of market segment preferences, the concept of service type is further specified in five sub-elements linked by the subsumes relationship: *accomodation*, *restaurant*, *sport*, *relaxation*, *green areas*. Each of these specialised elements is characterised by the corresponding service feature. In addition, accommodations are further related to the concepts of *maximum capacity* and *occupation rate*. In fact, in uManager, the management of the maximum number of customers that can

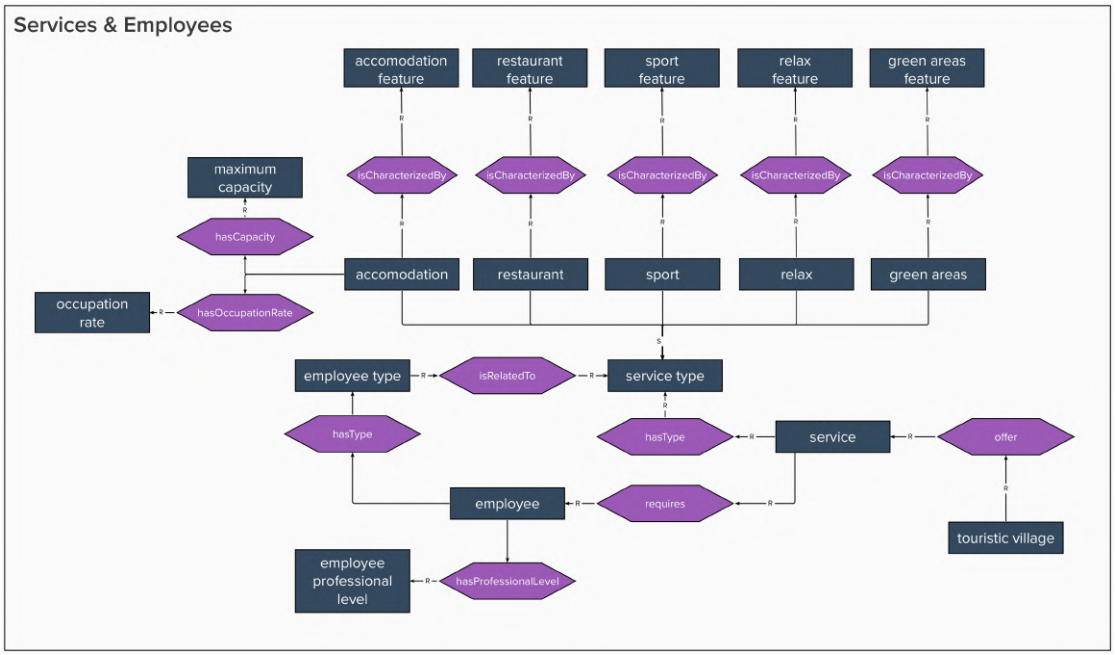


Figure 40: The Services and Employees sub-domain.

be accommodated at the same time within the village and the current occupation rate of the accommodations is crucial in order to be able to keep the company profitable and to evaluate its choices in the context of service offer (e.g., a low occupation rate could indicate a high level of customer dissatisfaction). It is also important to note that the *accomodation feature*, *restaurant feature*, *sport feature*, *relax feature*, and *green areas feature* maintain the same name used in the sub-domain related to the market: this is precisely because they represent the exact same element of knowledge. On the other hand, employees also possess an *employee type*, closely related to the various service types. In addition, an employee is characterised by a certain *employee professional level* (low, mid or high) that serves to predict performance and professionalism.

### Extracted competency: Service Management

From the analysis of this sub-domain the "Service Management" competency shown in Figure 41 can be identified. The provided natural language statement describes it as: *manage in a competent manner the services that make up the touristic offer and the necessary employees for their operation.* As for the previous competency, all of the knowledge parts used in "Service Management" belong to the same sub-domain: Services and Employees. In order to achieve this competency, one has to be able to *apply* the knowledge parts *service - hasType - service type*

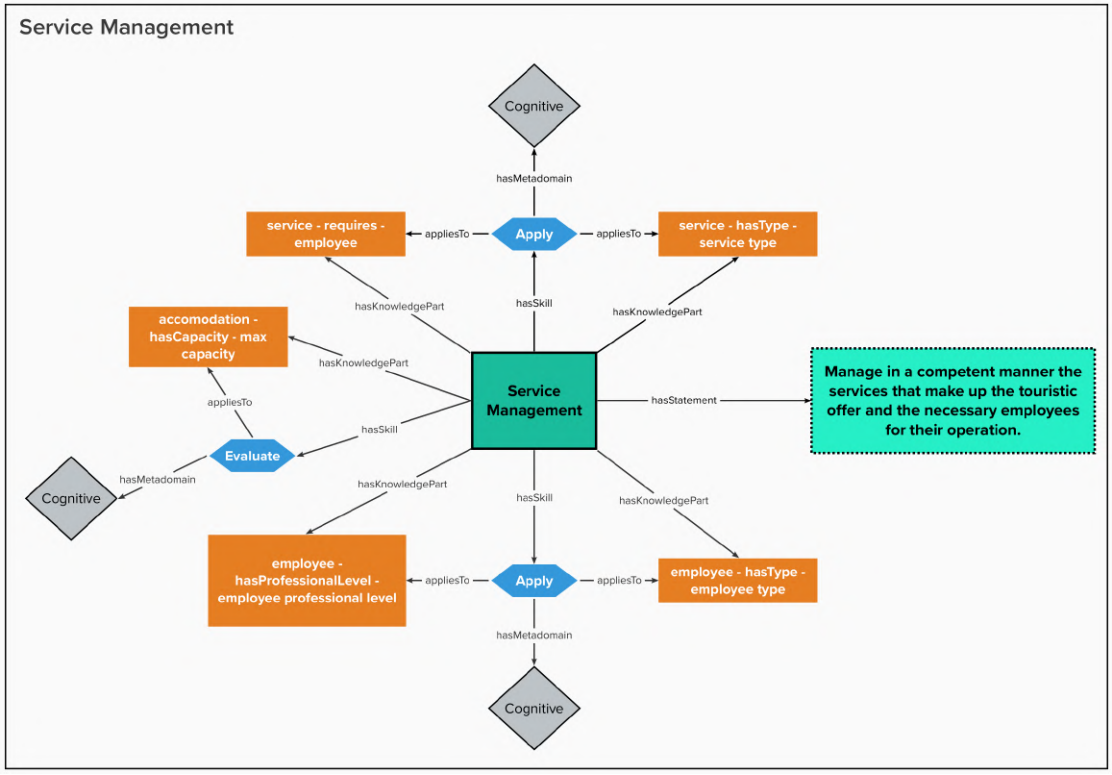


Figure 41: The COMP2 representation of the "Service Management" competency.

in order to be able to distinguish and build the various service types. At the same time, one has to *apply* the knowledge parts *service - requires - employee*, and *employee - hasType - employee type* in order to make the existing services operational. Consequently, a competent person must also be able to *apply* the knowledge part *employee - hasProfessionalLevel - employee professional level* in order to be able to select the most suitable professional figures. Finally, one must be able to *evaluate* the maximum capacity of the accommodations expressed by the knowledge part *accomodation - hasCapacity - max capacity* in order to guarantee the proper functioning of the village.
Again, uManager does not present a level where it is possible to work on this competence in isolation. In fact, this competence in uManager currently can only be demonstrated in a composite manner with other competences relating to other sub-domains, making its evaluation complex. Therefore, a new ad hoc scenario must be designed.

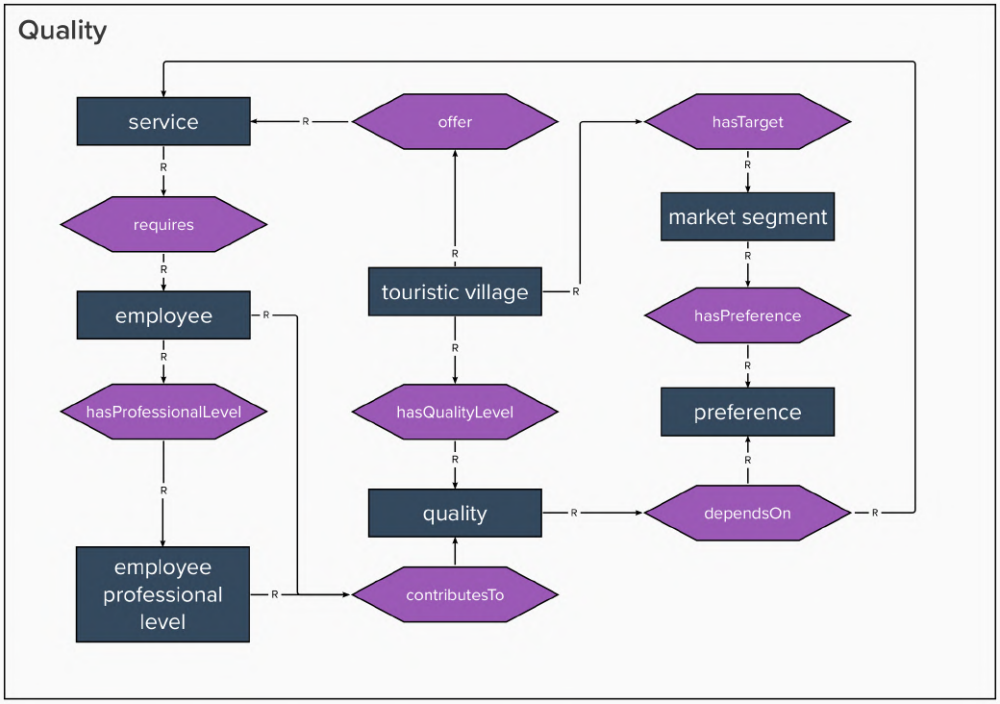


Figure 42: The Quality sub-domain.

### 5.2.3 Sub-domain III: Quality

The third sub-domain identified is that of quality-related concepts. The concept of *quality* is a fundamental concept within the game. Since we can hardly speak of "objective" quality, in uManager we speak of quality perceived by the customer, and in particular, we refer to customers belonging to the *market segment* assigned as target to the *touristic village*. More in detail, the quality of a village directly depends on two factors: the *preferences* expressed by the market segment and the *services* offered by the village. When the features presented by the offered services match those expressed by the preferences of the market segment assigned as target, a high quality value is obtained. Otherwise, the quality level will be low. Furthermore, the quality of a village is indirectly influenced by two other elements: the *employees* hired and their *employee professional level*. This is because although a service may, on paper, have all the features preferred by a market segment, its proper functioning depends on the presence of employees, which must be managed both from the point of view of the type of employee hired and the number of employees in relation to the number of services present. In addition, the professional level of an employee directly describes his or her levels of performance and professionalism, and thus contributes concretely to the market segment's perception of the quality of the village. Given the same number of services and types of employ-

ees, the higher the professional level of employees, the higher the likelihood that customers will be satisfied with their experience. Again, some of the knowledge elements present the same name as those introduced in other sub-domains: this is because they are the same knowledge elements. This will happen in the other sub-domains as well and shows the connection points between them.

**Extracted competency: Improve the Quality of the Offer**

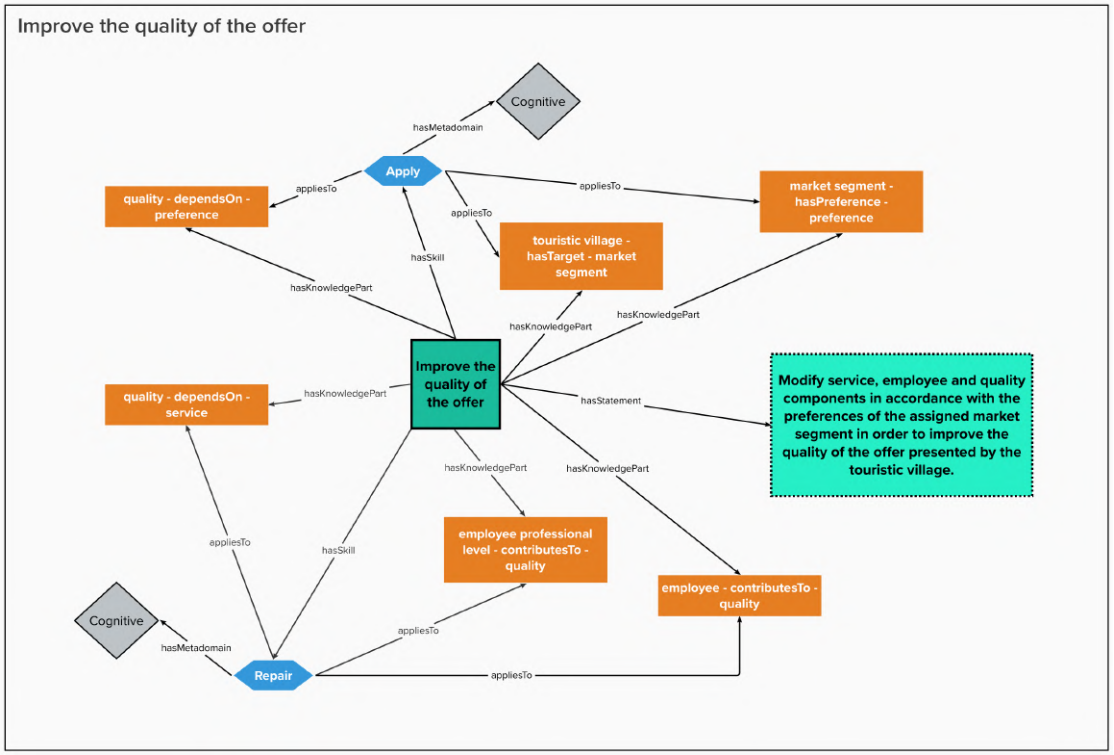


Figure 43: The COMP2 representation of the "Improve the Quality of the Offer" competency.

The competency "Improve the Quality of the Offer" is central to achieving success in the game, and emerges naturally from the Quality sub-domain. All knowledge parts involved derive precisely from this sub-domain. The natural language statement describing this competence is as follows: *modify service, employee and quality components in accordance with the preferences of the assigned market segment in order to improve the quality of the offer presented by the touristic village.* In order to achieve this competence, a person must first be able to *apply* the concepts contained in the knowledge part *quality - dependsOn - preference.* In order to contextualise quality as the quantity perceived by the assigned market

segment, one must also be able to *apply* the knowledge parts *touristic village - hasTarget - market segment* and *market segment - hasPreference - preference*. In order to effectively improve the quality of the village, a competent person must be able to *repair* the components related to the knowledge parts *quality - dependsOn - service*, *employee - contributesTo - quality*, and *employee professional level - contributesTo - quality*. In other words, it must be able to modify and replace components related to these knowledge elements in order to achieve a better result. The quality of a village is one of the quantities that is indirectly verified most often within the game. The entire life cycle of a touristic village revolves around the understanding of the quality dimension. The problem in assessing and demonstrating this competence lies again in the compound nature of the uManager metrics: for example, there is currently no way to verify quality without using analysis tools or understanding the feedback provided by the customer, tying the verification of this competence in an intertwined way with that of other different competences. To solve this problem, it is therefore necessary to develop a new, more focused scenario in which it is possible to work on this competence in isolation.

### 5.2.4 Sub-domain IV: Customer Choice and Feedback

This sub-domain is the one that contains the knowledge elements linked to the concept of customer choice and feedback. Each customer becomes aware of the existence of a *touristic village* the moment he/she is reached by the relative advertising campaign carried out through a *communication channel*. Once aware of the existence of the village, the customer makes a *decision* concerning whether to go to the village. This decision is strongly decided by two factors: the customer's perceived *quality* of the village, defined as seen in its sub-model, together with its *reputation*. The reputation of a village is determined by the collection of all the experiences of the customers who have stayed there: the more satisfied customers are with their experience, the higher the village's reputation will be. Since it is influenced by all the previous experiences made by customers, the reputation of a village is a slow-moving quantity: a village that enjoys a good reputation will be resilient to a few new negative experiences. Similarly, if a village enjoys a bad reputation, it will be complex to improve it: only by persistently providing high levels of customer satisfaction will it be possible to change the situation. Formally, a customer expresses an opinion on his or her experience through *feedback* that is posted on the virtual *social network* at the end of his or her stay. This feedback is visible to players in the form of a textual review on the social network page related to the village in question, and will influence the reputation of the village, and thus ultimately the decisions of future customers.

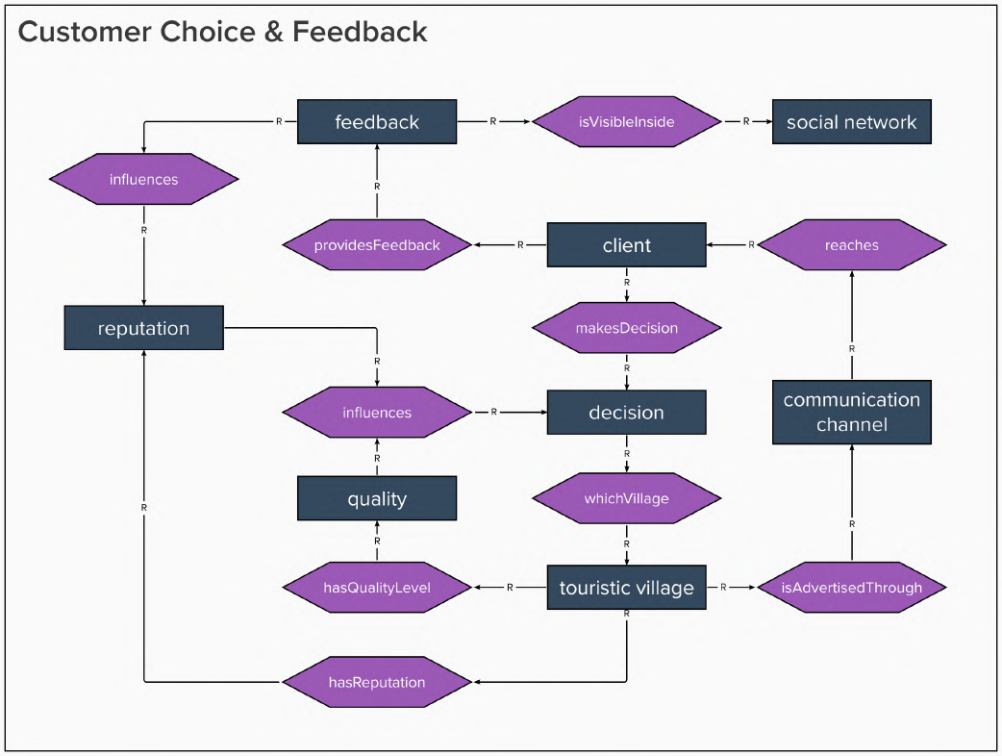


Figure 44: The Customer Choice and Feedback sub-domain.

**Extracted competency: Improve Customer Acquisition and Retention**

The competency arising from the sub-domain Customer Choice and Feedback is "Improve Customer Acquisition and Retention". Again, all the knowledge elements used are uniquely part of this sub-domain. This competency is described by the following natural language statement: *choose the appropriate communication channel to reach the customer. analyze the feedback provided by customers in order to improve customer acquisition and retention.* In order to achieve this competence, a person must be able to *apply* the knowledge parts *reputation - influences - decision* and *feedback - influences - reputation.* The understanding of the concepts located in these knowledge parts is essential in order to be able to understand the causal relationships related to a customer's feedback and a village's reputation with regard to the choices of future customers. In addition, one must be able to *analyze* the feedback represented by the knowledge part *feedback - isVisibleInside - social network* in order to deduce the relevant opinion and experience. Finally, a competent person must be able to *repair* the system components related to the knowledge parts *communication channel - reaches - client* and *quality - influences - decision.* In addition to understanding their importance within the client's de-

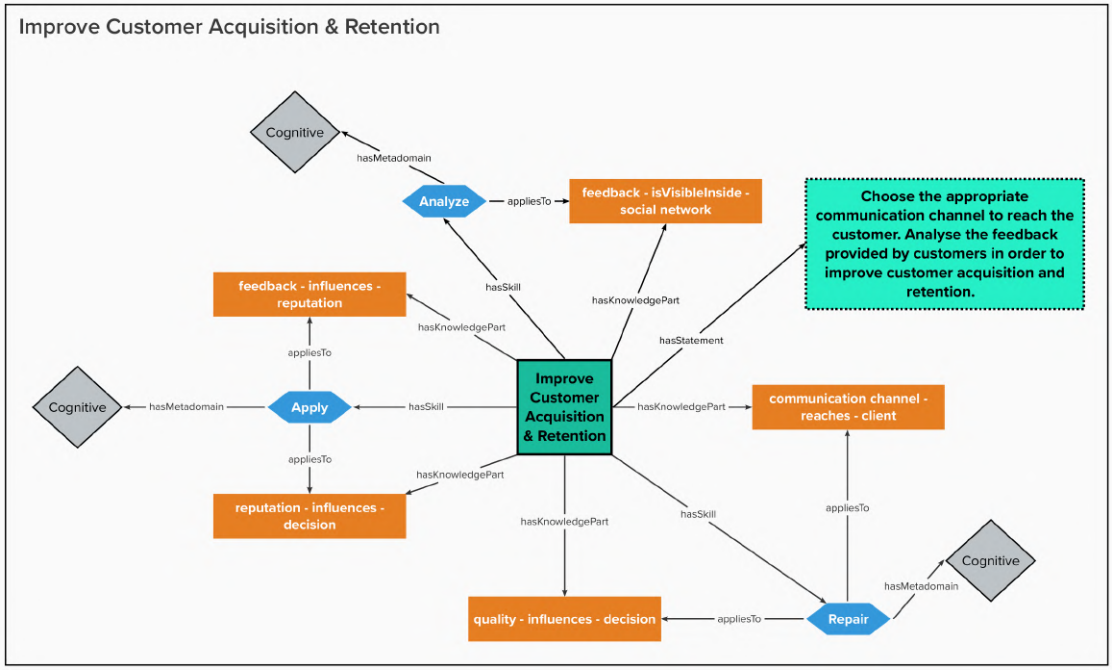


Figure 45: The COMP2 representation of the "Improve Customer Acquisition and Retention" competency.

cision, in fact, the communication channels and the elements that contribute to the quality of a village are the components on which the player can directly and concretely act in order to change the situation and obtain better results.
Yet again, the composite structure of uManager and its dynamics makes the evaluation and direct demonstration of this competence complex, so a new ad hoc scenario must be designed.

### 5.2.5 Sub-domain V: Economy

Understanding the economic concepts in uManager is crucial for success in the game. These are identified within the economy sub-domain. Each *touristic village* offers *service*s to its customers. Each of these services involves *service cost*s and produces *value*. With regard to costs, each service is accompanied by three types of costs: building, maintenance, and demolition. The *building cost* is a *one-time cost* that is charged to the village when a new service is built. Once built, each service has a *maintenance cost*, a *recurring cost* that is charged every month and that must be paid as long as the service is present in the village. Should one wish to remove a service from the village, one must pay the related *demolition cost*, a *one-time cost* that represents the expense related to the physical destruction

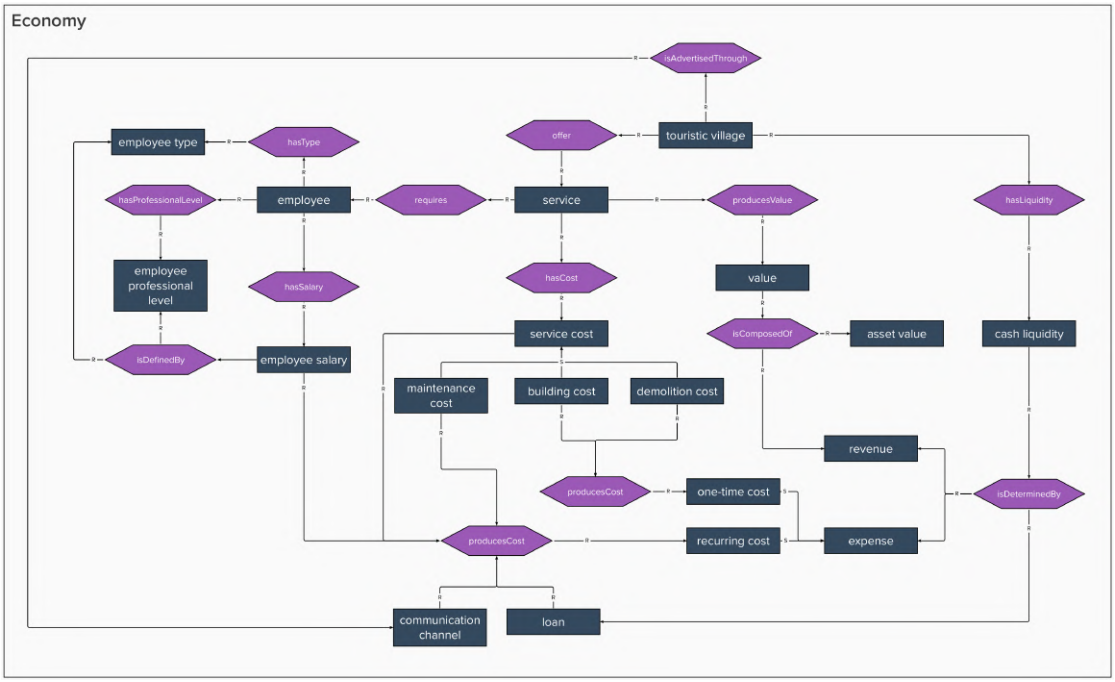


Figure 46: The Economy sub-domain.

of the structure representing the service. Once a service has been destroyed, its maintenance cost will no longer be charged. *Building cost*, *maintenance cost*, and *demolition cost* are specialisations of the knowledge element *service cost*, and are therefore linked to it via the subsumes relationship. Furthermore, one-time cost and recurring cost are two types of *expense*, also linked to it by subsumes relations. With regard to the value produced by a service, on the other hand, this is formed by two components: the asset value relative to the building and ownership of the service itself, and the economic *revenue* given by the direct returns produced by the consumption of the product.
Among the other costs that indirectly come from the services are those related to the employees necessary for their operation. As we have seen in the sub-domain on services and employees, each *employee* has a *employee type* and a *employee professional level*. These two factors are what determine the *employee salary*: a cook will have a different salary than a waiter. Similarly, a cook with a high professional profile will have a higher salary than a cook with a low professional profile. As long as the employee in question remains employed within the resort, he will be entitled to his salary each month, making the *employee salary* a recurring cost. The last two elements that contribute to the costs of a touristic village in uManager are those related to the use of a *communication channel* to launch an advertising campaign and that related to the payments of a *loan*. Both are

recurring costs that have to be paid as long as the advertising campaign is active, in the case of the communication channel, or as long as the loan has been fully repaid.
Finally, expenses and revenues, together with the liquidity provided by the loans, define the *cash liquidity* of a resort, one of the most important resources for running the business. Understanding the difference between one-time and recurring costs together with the relationship between the value produced by the various services and the costs associated with them and the management of the resort is crucial in order to achieve success in the game.

**Extracted competency: Develop Economic Growth Strategies**

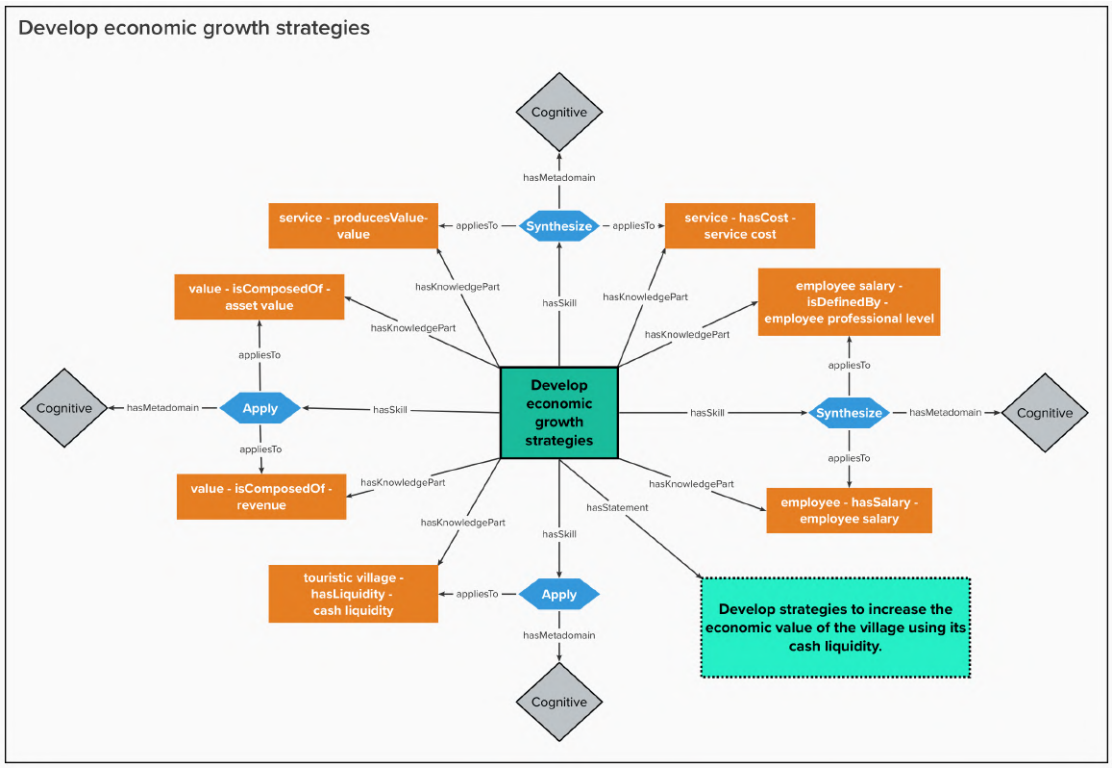


Figure 47: The COMP2 representation of the "Develop Economic Growth Strategies" competency.

The sub-domain Economy contains some of the most important elements among those in uManager, and not surprisingly it gives rise to two different competencies. The first of these, "Develop Economic Growth Strategies" is described by its natural language statement as follows: `Develop strategies to increase the

economic value of the village using its cash liquidity". In order to achieve this competency, a person must first of all be able to *apply* the concepts contained in the knowledge part *touristic village - hasLiquidity - cashLiquidity*. At the same time, the concept of increasing economic value implies an understanding of the various types of value that can be acquired in the context of uManager. Consequently, a competent person must be able to *apply* the concepts described by the knowledge parts *value - isComposedOf - asset value* and *value - isComposedOf - revenue*. In addition, one must be able to apply the generic skill *synthesize* to the knowledge parts *service - producesValue - value* and *service - hasCost - service cost*, i.e. one must be able to induce new concepts from existing ones and must be able to plan a process through the production of instances that respect constraints relative to available resources. Likewise, one must be able to *synthesize* the concepts related to the knowledge parts *employee - hasSalary - employee salary* and *employee salary - isDefinedBy - employee professional level*. The development of economic growth strategies must therefore take all these elements into account.
Although this competence is easier to verify within uManager, to achieve a more focused and secure result a new scenario should be designed.

### Extracted competency: Evaluate Different Expense Types

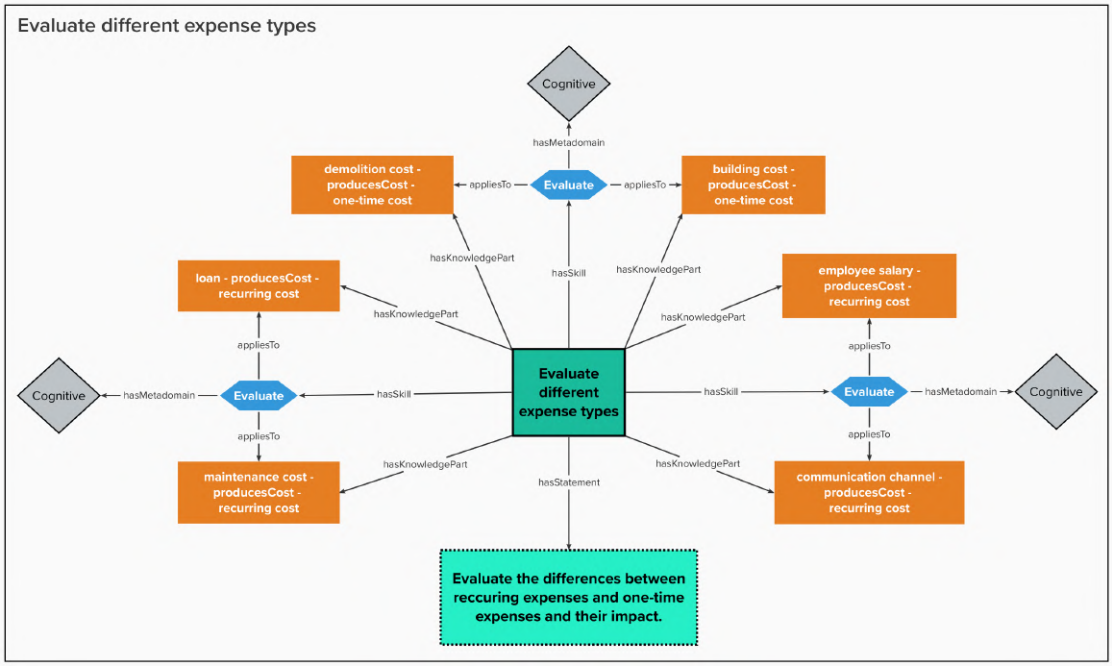


Figure 48: The COMP2 representation of the "Evaluate Different Expense Types" competency.

The second competency emerging from the Economy sub-domain is "Evaluate Different Expense Types". The description in its natural language statement is as follows: `Evaluate the differences between recurring expenses and one-time expenses and their impact". To demonstrate competence, a person must be able to *evaluate* the costs described by the concepts related to the knowledge parts *building cost - producesCost - one-time cost* and *demolition cost - producesCost - one-time cost*. Similarly, one must be able to *evaluate* the other type of costs contained in the knowledge parts *maintenance cost - producesCost - recurring cost* and *employee salary - producesCost - recurring cost*. The knowledge parts mentioned so far are those that deal with describing the costs associated with the services, their operation and the employees needed for their operation. But the management of a holiday resort includes other, equally important costs. Consequently, a competent person must also be able to *evaluate* the concepts contained in the knowledge parts *loan - producesCost - recurring cost* and *communication channel - producesCost - recurring cost*. This competence is extremely important in order to be able to manage a company, and in particular a touristic village within uManager.
There is currently no level or scenario in the game that directly deals with demonstrating this competence, so a new one must be designed.

### 5.2.6 Sub-domain VI: Analytical Tools

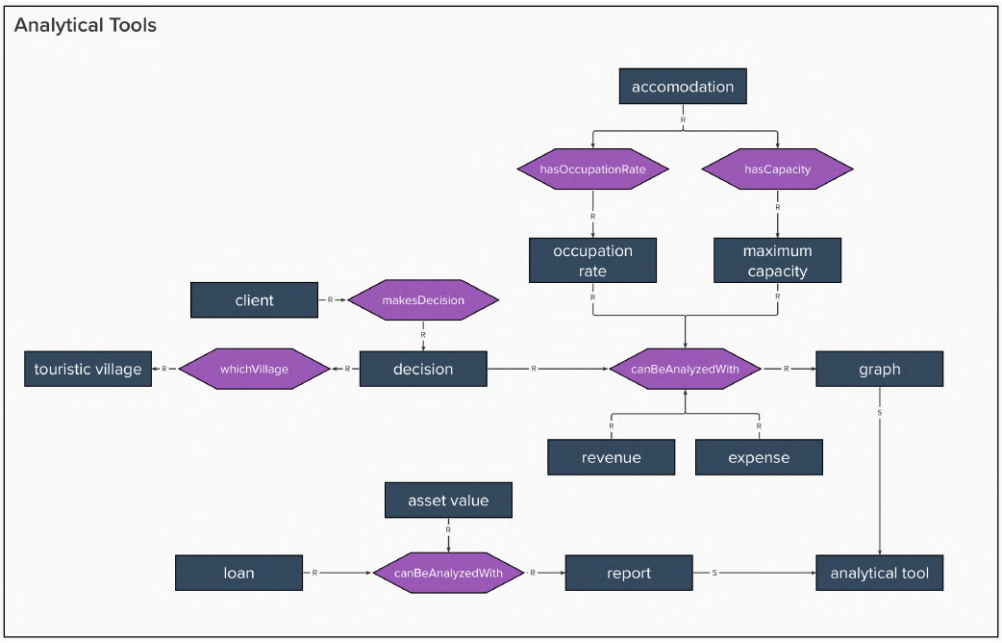


Figure 49: The Analytical Tools sub-domain.

Finally, the last sub-domain identified is that of the concepts related to the analysis tools in uManager. The *decision* of a customer, the *occupation rate* and the *maximum capacity* of an accommodation, the *revenue*s, and the *expense*s of the resort can be analyzed through the use of two-dimensional *graph*s. Similarly, the current status of the *loan*s and the *asset value* produced by the various services built within one's village can be analyzed through the use of financial *reports*. Both graphs and reports are specialisations of the *analytical tool* concept, and are consequently linked to it by the subsumes relationship. The use of these tools allows players to be able to analyze and evaluate the situation of their village, so that they can make choices grounded in evidence.

**Extracted competency: Assess the Situation**

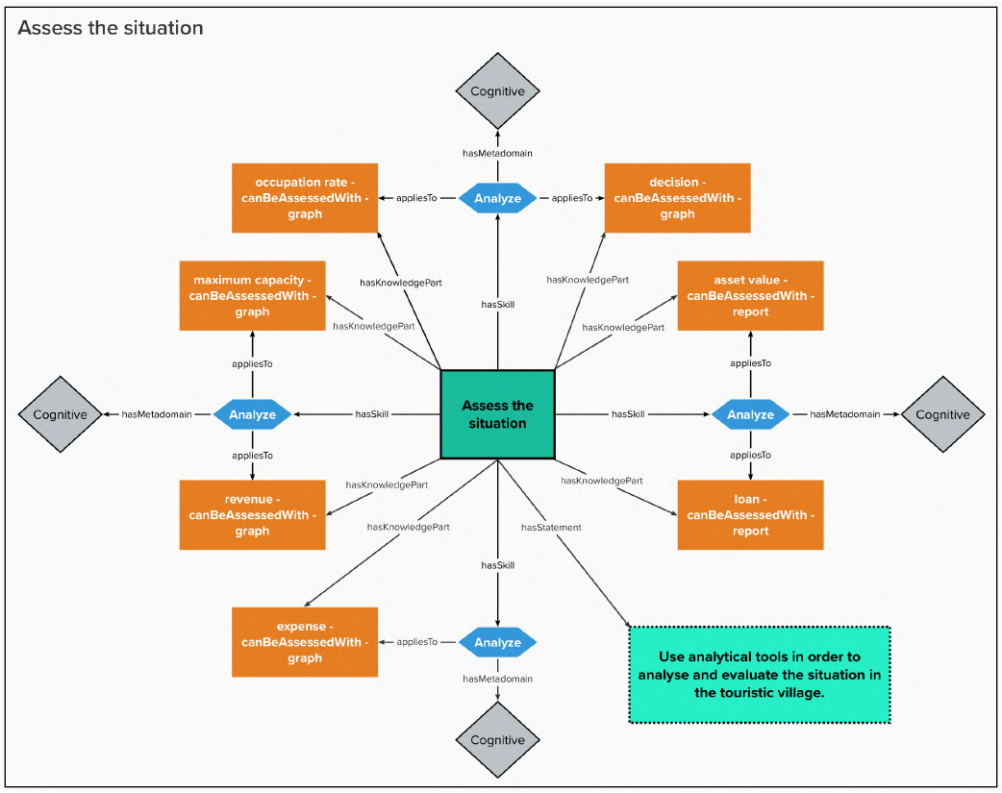


Figure 50: The COMP2 representation of the "Assess the Situation" competency.

The last competency identified, "Assess the Situation", emerges directly from the sub-domain Analytical Tools. The natural language statement associated with this competency describes it as follows: *"use analytical tools in order to analyze and evaluate the situation in the touristic village"*. In order to be able to esti-

mate the current situation in the tourist village, a competent person must first be able to *analyze* revenues and expenses through the use of graphs, as described in the knowledge parts *revenue - canBeAssessedWith - graph* and *expense - canBeAssessedWith - graph*. In addition, in order to get a more detailed picture and understand causes and effects, a competent person must be able to *analyze* the parts of knowledge *maximum capacity - canBeAssessedWith - graph* and *occupation rate - canBeAssessedWith - graph* related to accommodations. Similarly, understanding one's customers' decisions is a key element, and consequently a competent person must be able to *analyze* the concepts contained in the knowledge part *decision - canBeAssessedWith - graph*. To complete the picture of competence in the use of analytical tools in order to estimate the village situation, a person must be able to correctly use the available reports, and therefore must be able to *analyze* the concepts expressed by the knowledge parts *loan - canBeAssessedWith - report* and *asset value - canBeAssessedWith - report*. Only by analyzing all the available information is it possible to get a complete picture of the village situation and, consequently, to carry out an assessment.
Although this competence is used extensively in most of the phases and scenarios currently present in uManager, once again the composite nature of the activities makes it difficult and complex to evaluate it in isolation. Consequently, an ad hoc scenario should be designed in this case as well.

## 5.3 New proposed scenarios

As seen in the previous section, the new competencies identified as a result of the domain analysis require new ad hoc game scenarios in which they can be exercised and tested. The creation of new scenarios, moreover, gives us the opportunity to establish in a formal manner what will be the indicators through which the players' performance will be assessed. The adopted COMP2 ontology already defines five classes of performance indicators to be linked to competencies: *Frequency*, *Autonomy*, *Scope*, *Context Variety*, and *Complexity*. In addition, based on these five indicators, COMP2 provides a Proficiency Scale. The purpose of this scale is to summarise the findings from the five indicators defined above in a single value. In addition, as described in stage two of COMP2, it is possible to further define ranges within this Proficiency Scale in order to obtain Performance Classes useful for describing the level of competence achieved by the person assessed. These five indicators, however, must necessarily be evaluated within the individual contexts defined by each Scenario in order to accomplish the duty assigned to them. For this reason, together with the discussion and description of each Scenario that I will make below, I shall include a discussion of how the five performance indicators are derived each time and how I extracted the relevant Performance Classes.

Another important concept defined within COMP2 is that of evidence records and ePortfolios. An evidence record is in fact a token that demonstrates the possession and achievement of a certain performance class related to a competency. Within games, these evidence records can be implemented by means of collectible badges and achievements to be displayed within the profile of individual players. The player's virtual profile can thus itself become an ePortfolio, in which the status of a specific student's acquisition of various competences can be verified.

Lastly, when defining the various scenarios, it is important to identify which competencies are directly affected by the actions performed within the scenario itself, and which are required as prerequisites in order to be able to perform the relevant tasks correctly. Once again, COMP2 defines these concepts as relationships between activities (in this case the game scenarios) and competencies. The two relationships are *hasPrereqCompetency* and *hasTargetCompetency*. Once all the various new proposed scenarios have been defined, these relations will be further detailed in an ontology map containing the competencies found and the new activities designed.

### 5.3.1 Market Classification Scenario

The first scenario proposed is related to the "Classify Market Segments" competency. This scenario involves two phases: the first dedicated to acquiring information on the preferences of each segment, and the second in which the player actively classifies random customers in their segment. During the first phase, the player will be presented with the profile descriptions of the market segments involved in the scenario. Students will be able to view the various profiles, switching from one to the other, without time constraints. When they feel ready, players can move on to the next phase by pressing a button on the interface. During the second phase, players will be faced with several gathering points, one for each market segment involved in the scenario. Each gathering point will feature a banner containing the name of the segment. In the centre of the screen will be a customer represented by a person avatar. The customer will communicate some of his preferences to the player via chat bubbles. At this point, the player will have to drag the person to the gathering point of the relevant market segment via a drag and drop mechanic. Once released at the gathering point, the customer avatar will provide visual feedback regarding the correctness of the classification (e.g. celebrate in the case of a correct classification, or get angry in the case of an incorrect classification). Players will also be able to press a button to request help, and in this case the client avatar will provide hints and additional information to help complete the task.

On the basis of this initial description of the scenario, it is possible to decide how to decline the performance indicators and how to define proficiency levels

| Scenario #1 | |
|---|---|
| **Name** | Market Classification Scenario. |
| **Description** | Players read and analyse the information contained within various market segment profiles. Subsequently, when they are ready, they classify customers by dragging their avatars to meeting points characterised by a banner containing the segment name. Clients provide information to players regarding their preference through chat bubbles. Players can request help in the form of suggestions by pressing a button. In this case, the customer avatar will provide hints and additional information again through the use of chat bubbles. |
| **Structure** | 3 Stages of increasing difficulty. Each stage composed by two phases: information extraction phase, and classification phase. |
| **Prerequisite Competency** | None. |
| **Target Competency** | Classify Market Segments. |
| **GMs** | Drag & Drop Avatars. Ask for help. |
| **Performance mapping** | |
| **Frequency** | Percentage of correct answers.<br>[3 points] |
| **Autonomy** | Use of the help function.<br>[2 points] |
| **Context Variety** | Number of market segments.<br>[3 points, value fixed by stage] |
| **Scope** | Number of features expressed in the preferences.<br>[3 points, value fixed by stage] |
| **Complexity** | Context Variety score + Scope score.<br>[3 points, value fixed by stage] |
| **Performance classes** | Beginner (Stage 1) : $6 \leq Score \leq 8$<br>Intermediate (Stage 2) : $9 \leq Score \leq 12$<br>Expert (Stage 3) : $13 \leq Score \leq 14$ |
| **Evidence Record** | One Badge and one Achievement for each stage completed (performance class achieved). |

Table 3: Table summarising the Market Classification Scenario.

and performance classes related to the competency. The Frequency indicator can refer to the percentage of correct classifications, and be described by three different values: *one*, in case less than half of the answers provided are correct, *two* in case at least half of the answers provided are correct, and *three* in case all answers provided are correct. The Autonomy indicator can refer to the use of the help function, and be described by two values: *one* in case help is requested, and *two* in case no help is used. The Context Variety indicator can refer to the number of market segments involved in the scenario, and be described by three values: *one* in case the market is split into three different segments, *two* in case there are four market segments, and *three* in case there are five market segments. The Scope indicator can refer to the amount of preference features included in the profile and used for classification, and be described by three values: *one* in case only preferences related to accommodations and restaurants are present, *two* in case preferences related to all types of services are present, and *three* in case preferences related to all types of services are present together with preferences related to communication channels. Finally, the Complexity indicator may be a function of combinations of the other indicators, and in particular Context Variety and Scope. The values linked to Complexity will thus be three: *one* in case Scope and Context Variety have total sum two, *two* in case the sum is greater than two but less than or equal to four, and *three* in case the sum is greater than four and less than or equal to six. At this point, based on these values, the Proficiency Scale is defined by the sum of the five indicators, varying between a minimum of five and a maximum of fourteen. Three different performance classes can then be defined within this scale: *Beginner*, for values between six and eight, *Intermediate* for values between nine and twelve, and *Expert* for values between thirteen and fourteen. In the event that the player obtains a score of five the value will not be considered sufficient to demonstrate competence.

Once the performance indicators and the Proficiency Scale have been defined, we can then determine three stages of varying difficulty aimed at demonstrating the possession of one of the three defined performance classes. By fixing the values for Context Variety, Scope and Complexity we can define three stages with increasing difficulty, leaving the Frequency and Autonomy indicators free in order to assess the player's performance within that difficulty class. A stage will consist of both phases, and after its completion an evidence record will be obtained, relating to the accomplishment of the performance class in question in the form of badges and achievements, and proceed to the next stage. To make the scenario easier to read, it has been summarised in Table 3.

| Scenario #2 | |
|---|---|
| **Name** | Service Management Scenario. |
| **Description** | Players receive instructions on the types of services to be covered and the minimum number of customers to be accommodated. Subsequently, players must build and manage these services within a new village in such a way as to ensure their proper operation and to accommodate the specified number of customers. Players will be able to request assistance from the uManager guide avatar, who will provide information and tips related to the concepts developed in this scenario. |
| **Structure** | 3 Stages of increasing difficulty. |
| **Prerequisite Competency** | None. |
| **Target Competency** | Service Management. |
| **GMs** | Build Services. Hire Employees. Select Employee Professional Levels. Ask for help. |
| **Performance mapping** | |
| **Frequency** | Percentage of functional services and of accommodated clients.<br>[3 points] |
| **Autonomy** | Use of the help function.<br>[2 points] |
| **Context Variety** | Number of minumim clients to accommodate.<br>[3 points, value fixed by stage] |
| **Scope** | Number of service types to be implemented.<br>[3 points, value fixed by stage] |
| **Complexity** | Context Variety score + Scope score.<br>[3 points, value fixed by stage] |
| **Performance classes** | Beginner (Stage 1) : $6 \leq Score \leq 8$<br>Intermediate (Stage 2) : $9 \leq Score \leq 12$<br>Expert (Stage 3) : $13 \leq Score \leq 14$ |
| **Evidence Record** | One Badge and one Achievement for each stage completed (performance class achieved). |

Table 4: Table summarising the Service Management Scenario.

### 5.3.2 Service Management Scenario

The second scenario I propose is that related to the "Service Management" competency. In this scenario, players will have to build and manage service instances within a village in order to guarantee a certain number of service types to a certain number of customers. Since this competence does not refer to the perceived quality of a certain market segment, the player will not be asked to create an offer based on preferences. Instead, players will simply have to ensure that they cover the required service types and ensure their correct and optimal functioning. At the beginning of the scenario, a message screen will inform players of the specific objectives, and in particular which services to cover and how many customers to accommodate within the village. Subsequently, a new uManager session will be started, starting with an empty village. Players will have to build the required services and hire the employees needed to operate them. In addition, players must ensure that they offer enough facilities to accommodate the number of customers indicated in the scenario at the same time. Should players find themselves in difficulty, they can request suggestions and help at the touch of a button. In this case, the uManager guide avatar will pop up on the screen and provide the player with a choice of topics on which to request help (e.g. accommodations, restaurants, hiring employees, etc.). Once players feel like they have completed the requires steps, they can press a button to be evaluated by the game system. Feedback will be given as a result of this evaluation in the form of an end of stage screen.

From this description, we can then decline the performance indicators in order to classify the player's performance. The Frequency indicator will refer to the percentage of correctly managed services, i.e. fully functional, together with the amount of accommodated customers expressed as a percentage of the minimum value indicated by the scenario. The corresponding values will be: *one* in the case where less than half of the services present have been managed correctly or in the case less than 60% of the indicated customers can be accommodated, *two* in the case where at least half of the services have been managed correctly and at least 60% of the indicated customers are accommodated, and *three* in the case where all services have been managed correctly and all indicated customers are accommodated. The Context Variety indicator will refer to the number of clients to be accommodated. Its values will be: *one* in the case of being required to accommodate at least five clients, *two* in the case of being required to accommodate ten, and *three* in the case of being required to accommodate twenty-five. The Autonomy indicator will refer to the use of the help function, and will assume the following values: *one* in the case where the help function is used, *two* in the case where it is not used. The Scope indicator will refer to the quantity of types of services required within the scenario. It will take the following values: *one* in the case where only two service types are requested, *two* in the case where three

are requested, and *three* in the case where all service types are requested. Again, the Complexity indicator will be a function of the Scope and Context Variety indicators. Its values will then be defined as: *one* in case Scope and Context Variety have total sum two, *two* in case the sum is greater than two but less than or equal to four, and *three* in case the sum is greater than four and less than or equal to six. As with the previous Scenario, the Proficiency Scale will be defined by the sum of the five indicators, varying between a minimum of five and a maximum of fourteen. Three different performance classes will be defined within this scale: *Beginner*, for values between six and eight, *Intermediate* for values between nine and twelve, and *Expert* for values between thirteen and fourteen. In the event that the player obtains a score of five the value will not be considered sufficient to demonstrate competence.

Three consecutive stages can be defined, aimed at demonstrating the possession of a specific class of performance, by fixing the values for Context Variety, Scope, and Complexity. Players will then be assessed by their performance within these classes, as measured by the Frequency and Autonomy indicators. An evidence record consisting of a badge and an achievement will be provided to the player upon completion of each stage in order to demonstrate possession of the relevant performance class. The scenario is summarised in Table 4.

### 5.3.3 Situation Assessment Scenario

The third proposed scenario will deal with the elements and concepts related to the competency "Assess the Situation". In order to exercise and demonstrate this competency, the proposed scenario will be divided into two distinct phases. During the first of these two phases, players will be faced with a game already started and a village already established, including services, employees hired, advertising campaign initiated and loans obtained. In this phase, all game mechanics for modifying game components will be disabled. Likewise, the economic simulation will be disabled. In fact, players will be confronted with a snapshot of the village taken at a certain point in time. Using the available analysis tools, such as graphs and financial reports, players will have to perform an analysis of the current state of the village. During this phase, players will also be able to request assistance from the game system by pressing a button. The avatar of the uManager guide will appear on the screen providing help and advice regarding the concepts covered in this scenario (e.g. analytical tools, graphs, reports, etc.). Once the users feel satisfied with their analysis, they can move on to the next phase by pressing a button. The second phase of the scenario deals with verifying the soundness of the analysis performed by the players. The students will have to answer three multiple choice questions designed to test their analysis ability. Examples of these questions are *"Is the village able to accommodate X customers?"* and *"With the*

| Scenario #3 | |
|---|---|
| **Name** | Situation Assessment Scenario. |
| **Description** | Players will be faced with a game already started and a village already started and built. All game mechanics related to the modification of village components will be disabled. Using the analysis tools, students will have to assess the situation of the touristic village. At this phase, players may request the help of the uManager guide, who will provide assistance and suggestions related to the concepts covered in this scenario. When they feel ready, players may advance to the evaluation phase where they will have to answer some multiple choice questions in order to verify the soundness of their analysis. |
| **Structure** | 3 Stages of increasing difficulty. Each stage composed by two phases: analysis phase, and evaluation phase. |
| **Prerequisite Competency** | Service Management. Classify Market Segments. |
| **Target Competency** | Assess the Situation. |
| **GMs** | Use graphs. Use reports. Ask for Help. Answer Questions. |
| **Performance mapping** | |
| **Frequency** | Percentage of correct answers.<br>[3 points] |
| **Autonomy** | Use of the help function.<br>[2 points] |
| **Context Variety** | Village dimension.<br>[3 points, value fixed by stage] |
| **Scope** | Number of service types.<br>[3 points, value fixed by stage] |
| **Complexity** | Context Variety score + Scope score.<br>[3 points, value fixed by stage] |
| **Performance classes** | Beginner (Stage 1) : $6 \leq Score \leq 8$<br>Intermediate (Stage 2) : $9 \leq Score \leq 12$<br>Expert (Stage 3) : $13 \leq Score \leq 14$ |
| **Evidence Record** | One Badge and one Achievement for each stage completed (performance class achieved). |

Table 5: Table summarising the Situation Assessment Scenario.

*current configuration of services, employees, loans, and advertising campaigns, is the village able to sustain the expenses it incurs on an ongoing basis?"*. Once players have answered all questions, the game system will provide feedback on the performance in the form of an end-of-stage screen.

From the point of view of performance indicators, the Scope indicator will refer to the various types of services present in the village, assuming value *one* in the case where only accommodations and restaurants are present, *two* in the case where at least three types of service are present, and *three* in the case where all types are present. The Context Variety indicator on the other hand will refer to the context determined by the size of the village and consequently the number of elements within it. Its values will therefore vary between *one* in the case of small villages, *two* in the case of medium-sized villages, and *three* in the case of large villages. The Frequency indicator on the other hand will refer to the number of correct answers given: a value of *one* will indicate only one correct answer, *two* will indicate two correct answers, and a value of *three* will indicate that all answers were given correctly. The Autonomy indicator will represent any request for assistance, with a value of *one* if the help function is used, and *two* if it is not. The Complexity indicator will be treated as seen above, i.e. it will be represented by the relationship between the Scope indicator and the Context Variety indicator, and in particular will assume the following values: *one* in the case where the sum of the scores is two, *two* in the case where the sum of the scores is between three and four, and *three* in the case where it is greater than four. The Proficiency Scale will be defined in accordance with those seen above: it will be determined by the sum of the five indicators and consequently its values will lie between a minimum of five and a maximum of fourteen. Similarly, we will define the same performance classes as previously seen: *Beginner*, for proficiency between six and eight, *Intermediate* for proficiency between nine and twelve, and *Expert* for proficiency between thirteen and fourteen. A proficiency value of five will show a lack of competence.

As seen in the previous Scenarios, three different stages of increasing difficulty can be defined in order to prove and test the different performance classes. This will be accomplished by fixing values for the Complexity, Context Variety, and Scope indicators. Each time a student will reach a performance class, an evidence record will be produced in the form of a badge and an achievement. The scenario is summarised in Table 5.

### 5.3.4 Quality Improvement Scenario

The fourth scenario proposed is the one related to the competency "Improve the Quality of the Offer". Within this scenario, players will be faced with a game that has already started. The presented village will be already constructed and the players will be able to view at any time both the assigned market segment and the

| Scenario #4 | |
|---|---|
| **Name** | Quality Improvement Scenario. |
| **Description** | Players will be faced with a game that has already begun, characterised by an already constructed village and an assigned market segment. The players will have to identify errors within the village and correct them in order to increase the perceived quality of the target segment. The economic simulation will not be active during this scenario. Players will be able to request assistance from the uManager guide avatar, who will provide information and tips related to the concepts developed in this scenario. |
| **Structure** | 3 Stages of increasing difficulty. |
| **Prerequisite Competency** | Service Management. Classify Market Segments. Assess the Situation. |
| **Target Competency** | Improve the Quality of the Offer. |
| **GMs** | Build Services. Demolish Services. Hire Employees. Fire Employees. Select Employee Professional Levels. Use graphs. Use reports. Ask for help. |
| **Performance mapping** | |
| **Frequency** | Percentage of errors corrected.<br>[3 points] |
| **Autonomy** | Use of the help function.<br>[2 points] |
| **Context Variety** | Location of the errors.<br>[3 points, value fixed by stage] |
| **Scope** | Number of service types included.<br>[3 points, value fixed by stage] |
| **Complexity** | Context Variety score + Scope score.<br>[3 points, value fixed by stage] |
| **Performance classes** | Beginner (Stage 1) : $6 \leq Score \leq 8$<br>Intermediate (Stage 2) : $9 \leq Score \leq 12$<br>Expert (Stage 3) : $13 \leq Score \leq 14$ |
| **Evidence Record** | One Badge and one Achievement for each stage completed (performance class achieved). |

Table 6: Table summarising the Quality Improvement Scenario.

relative profile in which the preferences are described. The presented village will contain errors that will lower its quality. Players will have to identify these errors and correct them by demolishing structures, building new ones, modifying the list of hired employees and changing their professional level. To focus the players' efforts on the knowledge and skill portions identified within the competency, the economic simulation will not take place. Players will in fact have to make the changes as if the village were stationary in time. Players in this scenario, too, will be able to request help by pressing a button. In this case, the uManager avatar will pop up on the screen with a choice of topics on which to request help and tips (e.g. services, employees, market segment profile, etc.). As soon as they are satisfied, they can signal the end of the changes by pressing a button and move on to the evaluation carried out by the game system. uManager will provide feedback on the performance in the form of an end-of-stage screen.

As far as performance indicators are concerned, within this scenario the Frequency indicator will refer to the percentage of errors corrected by players. Its possible values will be as follows: *one* in the case in which less than half of the errors will be corrected, *two* in the case in which at least half of the errors present will be corrected, and *three* in the case in which all errors will be corrected. The Context Variety indicator this time will refer to the context in which these errors will be found, assuming the following values: *one* in the case where the errors are present only in the choice of the type of service offered, *two* in the case where the errors refer to both the type of service and the type of employees hired, and *three* in the case where the errors are present in the type of service, the type of employees and the chosen professional profile. The Scope indicator will refer to the amount of service types present within the scenario and will take the following values: *one* in the case where only three service types are present, *two* in the case where four types are present, and *three* in the case where all service types are present. The Autonomy indicator will refer to the use of the help function and will take the values *one* in the case of using the function, and *two* in the case of not using the help function. Again, the Complexity indicator will be a function of the Scope and Context Variety indicators, assuming the values: *one* in case Scope and Context Variety have total sum two, *two* in case the sum is greater than two but less than or equal to four, and *three* in case the sum is greater than four and less than or equal to six. The Proficiency Scale will be defined as seen in the other Scenarios, by the sum of the five indicators, varying between a minimum of five and a maximum of fourteen. Three different performance classes will be defined within this scale: *Beginner*, for values between six and eight, *Intermediate* for values between nine and twelve, and *Expert* for values between thirteen and fourteen. In the event that the player obtains a score of five the value will not be considered sufficient to demonstrate competence.

As in the other Scenarios, by fixing the values of Scope, Context Variety and

Complexity it is possible to define three stages of increasing difficulty in which to verify the possession of the three performance classes through the evaluation of the Frequency and Autonomy indicators. A badge and an achievement will be provided at the completion of each stage in order to provide an evidence record to the players regarding the achievement of a given performance class. This scenario is summarised in Table 6.

### 5.3.5 Customer Choice & Feedback Scenario

The fifth proposed scenario deals with the competency "Improve Customer Acquisition and Retention". Within this scenario, similar to the previous one, players will be faced with a game already started, with a village already built, a market segment assigned and an advertisement campaign started. This time, however, the focus of activities will be directed towards the acquisition and retention of customers belonging to the target segment. To do this, in addition to being able to manipulate the mechanics related to services and employees in order to improve quality, players will also have to manage the village's advertising campaigns and visualise and analyse the feedback offered by customers within the village. The analysis of this feedback will be the basis for the decisions made by the students. For these reasons, within this scenario, the economic simulation will be active, and from week to week new customers will come into the village, carrying out their own experiences and providing feedback on the social network at the end of their stay. One of the important elements is that the village will also be open to other market segments, although the players' interventions will have to be focused on the assigned segment. This implies that students will have to be able to discern the source segment to which the feedback belongs and act accordingly. As in the other scenarios, players will be able to ask for help by pressing a button. In this case, the uManager guide avatar will appear on the screen and present the player with a series of topics in which to ask for advice and suggestions (e.g. the social network, client feedback, etc.). When players are satisfied with the changes made to the village, they can signal the end of the activity to the game system by pressing a button. Subsequently, the game system will carry out an analysis of the growth in the number of customers in the assigned market segment and provide feedback to the players via an end-of-stage screen.

In terms of performance indicators, in this Scenario the Frequency indicator will refer to the percentage of growth of the customer base belonging to the assigned market segment. Its values will be as follows: *one* in the case the growth of the user base is less than 20%, *two* in the case the growth is at least 20%, and *three* in the case the growth reaches 40%. Within this scenario, the Scope indicator will refer to the types of services that can be modified within the village, and will be described by the following values *one* in case only three service types are included

| Scenario #5 | |
|---|---|
| **Name** | Customer Choice & Feedback Scenario. |
| **Description** | Players will be faced with a game that has already started, characterised by a village already built, a market segment assigned and an advertising campaign initiated. By visualising and analysing the feedback provided by customers on the virtual social network, players will have to modify the components of the village and the advertising campaign in order to increase the number of acquired and retained customers belonging to the target market segment. Players will be able to request assistance from the uManager guide avatar, who will provide information and tips related to the concepts developed in this scenario. |
| **Structure** | 3 Stages of increasing difficulty. |
| **Prerequisite Competency** | Service Management. Classify Market Segments. Improve the Quality of the Offer. Assess the Situation. |
| **Target Competency** | Improve Customer Acquisition and Retention. |
| **GMs** | Build Services. Demolish Services. Hire Employees. Fire Employees. Select Employee Professional Levels. Change Communication Channel. Use graphs. Ask for help. |
| **Performance mapping** | |
| **Frequency** | Percentage of customer growth.<br>[3 points] |
| **Autonomy** | Use of the help function.<br>[2 points] |
| **Context Variety** | Number of market segments present.<br>[3 points, value fixed by stage] |
| **Scope** | Number of service types included.<br>[3 points, value fixed by stage] |
| **Complexity** | Context Variety score + Scope score.<br>[3 points, value fixed by stage] |
| **Performance classes** | Beginner (Stage 1) : $6 \leq Score \leq 8$<br>Intermediate (Stage 2) : $9 \leq Score \leq 12$<br>Expert (Stage 3) : $13 \leq Score \leq 14$ |
| **Evidence Record** | One Badge and one Achievement for each stage completed (performance class achieved). |

Table 7: Table summarising the Customer Choice & Feedback Scenario.

in the scenario, *two* in case four service types are present, and *three* in case all service types are included. The Context Variety indicator, on the other hand, will refer to the context determined by the number of market segments present, and will take the following values *one* in the case where only the target market segment is present, *two* in the case where three different market segments are present, and *three* in the case where all available market segments are present. The Autonomy indicator will again refer to the use or non-use of the help function, with the same values as defined in the other Scenarios: *one* in case help is requested, *two* in case it is not requested. Similarly, for this Scenario the Complexity Indicator will be determined by a function of the Scope and Context Variety indicators, using the values already defined above: *one* in case of total sum two, *two* in case the sum is greater than two but less than or equal to four, and *three* in case the sum is greater than four and less than or equal to six. Given the similar structure to the other scenarios, the same Proficiency Scale and performance classes will be used. The scale will be defined by the sum of the values of the five indicators, with a range from five to fourteen. There will be three performance classes: *Beginner*, for proficiency values between six and eight, *Intermediate* for proficiency values between nine and twelve, and *Expert* for proficiency values between thirteen and fourteen. Again, a score of five on the Proficiency Scale will indicate an inadequate level of competence.

The same reasoning applied to the previous Scenarios regarding the implementation of stages to establish performance classes will also be adopted here. By fixing the values of Context Variety, Scope and Complexity, three different stages of increasing difficulty will be defined. Likewise, an evidence record in the form of a badge and an achievement will be produced upon reaching each performance class. This scenario is summarised in Table 7.

### 5.3.6 Expenses Evaluation Scenario

The sixth proposed scenario directly addresses the concepts related to competency "Evaluate Different Expense Types". In order to test the competence of the players, the scenario will consist of two distinct phases. During the first phase, players will be introduced to a game that has already started, with a village of a certain size already created, an advertising campaign already started, and loans already active. Game mechanics related to the modification of components associated with services, employees, communication channels, and loans will be disabled, so that players will be able to view the village without being able to modify it. The displayed village will also behave like a snapshot taken at a certain point in time, so the economic simulation will also be disabled. The purpose of this first phase is to allow the player to analyse the various costs established by the presence of services, advertising campaigns, hired employees, etc. . When the players

| Scenario #6 | |
|---|---|
| **Name** | Expenses Evaluation Scenario. |
| **Description** | Players analyse the snapshot of the proposed village in order to estimate its costs and impact. Then, when they are ready, they will make predictions and answer questions regarding the nature and effects of the observed costs. During the exploration phase, players will be able to request the help of the uManager guide, who will provide hints and tips on various topics related to the scenario. |
| **Structure** | 3 Stages of increasing difficulty. Each stage composed by two phases: analysis phase, and prediction phase. |
| **Prerequisite Competency** | Service Management. Assess the Situation. |
| **Target Competency** | Evaluate Different Expense Types. |
| **GMs** | Explore a Village. Use graphs. Use reports. Make predictions. Ask for help. |
| **Performance mapping** | |
| **Frequency** | Percentage of correct predictions.<br>[3 points] |
| **Autonomy** | Use of the help function.<br>[2 points] |
| **Context Variety** | Village dimension.<br>[3 points, value fixed by stage] |
| **Scope** | Types and sources of expense.<br>[3 points, value fixed by stage] |
| **Complexity** | Context Variety score + Scope score.<br>[3 points, value fixed by stage] |
| **Performance classes** | Beginner (Stage 1) : $6 \leq Score \leq 8$<br>Intermediate (Stage 2) : $9 \leq Score \leq 12$<br>Expert (Stage 3) : $13 \leq Score \leq 14$ |
| **Evidence Record** | One Badge and one Achievement for each stage completed (performance class achieved). |

Table 8: Table summarising the Expenses Evaluation Scenario Scenario.

feel ready, they will be able to move on to the next phase by pressing a button. The second phase of the scenario will see the players engaged in predictions regarding the costs observed within the village, expressed through multiple-choice answers. Examples of questions within this phase are *"After how long do you think the monthly costs will reach the one-time costs of constructing the buildings of the village?"* and *"How heavy are the costs related to the salaries of the employees compared to the total costs incurred by the examined village?"*. Three questions will be administered within this stage, and once the players have answered the last of these questions the game system will provide feedback against the measured performance in the form of an end-of-stage screen. As in previous Scenarios, players will be able to request assistance from the game system, during the exploration phase, by pressing a button. In this case the uManager guide avatar will appear on the screen and offer the player various topics in which to ask for advice (e.g. employee salaries, building costs, maintenance costs, loans, etc.).

As for performance indicators, in this scenario the Frequency indicator will represent the number of correct predictions (answers to questions). The corresponding values will then be: *one* in the case where only one correct prediction is provided, *two* in the case where two predictions are correct, and *three* in the case where all predictions are correct. The Context Variety indicator, on the other hand, will refer to the context determined by the size of the village, the number of services present, the number of employees hired and the amount of loans. Its values will therefore be: *one* in the case of a small village, *two* in the case of a medium-sized village, and *three* in the case of large villages. The Autonomy indicator will again refer to the use of the help function, and will take the value *one* in the case of the function not being used, and *two* in the case of the player requesting assistance. The Scope indicator instead will refer to the types of costs included in the village snapshot: it will take the value *one* if only costs deriving from services and employees are present, *two* if costs related to advertising campaigns are also present, and *three* if all types of costs are present, including loan instalment payments. Once again, the Complexity indicator will be determined from the sum of the Context Variety and Scope values, assuming value *one* if the sum is two, *two* if the sum is between three and four, and *three* if the sum is greater than four. Consequently, the same Proficiency Scale (with values between five and fourteen) used in the other scenarios will be used, along with the same performance classes: *Beginner*, for proficiency values between six and eight, *Intermediate* for proficiency values between nine and twelve, and *Expert* for proficiency values between thirteen and fourteen. Similarly, a proficiency score of five will indicate an inadequate level of competence.

Similarly to the first Scenario, in order to obtain contexts in which to test the different performance classes, three different stages will be obtained, each characterised by the two phases. The stages will once again be defined by the

fixing of the values corresponding to Context Variety, Scope and consequently Complexity. Again, the achievement of a performance class will be marked by the production of an evidence record in the form of a badge and an achievement. This scenario is summarised in Table 8.

### 5.3.7 Economic Strategies Scenario

The last proposed scenario deals with the second competency identified within the Economy sub-domain: "Develop Economic Growth Strategies". In order to develop and demonstrate this competency, the proposed scenario begins by presenting the player with a game that has already begun. Within this game, students will find an assigned market segment, a tourist village already built with an advertising campaign already underway, employees hired and a fair level of quality perceived by the target audience. Analysing the current situation, the players will have to develop strategies and subsequently implement them in order to increase the economic value of the village. To do this, the economic simulation will remain active during this scenario, and new customers will arrive week by week to consume the services offered by the village. Once the players are satisfied with the changes made to the various components of the village, they can signal the end of the phase to the game system by pressing a button. The system will then run a simulation of a predetermined duration (three months, six months or one year) to check the growth of the economic value of the business at the end of the period. Then, the system will provide feedback to the players in the form of an end-of-stage screen. As in the other scenarios, players will be able to request assistance and advice by pressing a special button. In this case the avatar of the uManager guide will appear on the screen, providing help and tips on various topics (e.g. cash liquidity, asset value, revenues, etc.).

Regarding the performance indicators, within this scenario the Context Variety indicator will refer to the size of the village, assuming the following values: *one* for small size villages, *two* for medium size villages, and *three* for large size villages. The Scope indicator, on the other hand, will refer to the time distance at which the assessment of economic value growth will be made, assuming the following values. *one* in the case of assessment after three months, *two* in the case of assessment after six months, and *three* in the case of assessment after one year. The Frequency indicator will then refer to the percentage of growth in economic value measured at the end of the valuation period. The values linked to Frequency will thus be *one* in the case of a growth of less than 15 %, *two* in the case of a growth of at least 15 %, and *three* in the case of an economic growth of more than 25 %. The indicator of Autonomy will once again refer to the use of the assistance function, with value *one* in the case of use of the function and value *two* in the case of not using this function. The Complexity indicator will be linked as usual

| Scenario #7 | |
|---|---|
| **Name** | Economic Strategies Scenario. |
| **Description** | Players will be confronted with a village that is already established. Following an initial assessment, they will have to develop and implement strategies aimed at increasing the economic value of the business, with measurement after three, six or twelve months, and carried out through the modification of various components. Players may request assistance from the uManager guide avatar, who will provide information and tips related to the concepts developed in this scenario. Once satisfied, players will be able to move on to the evaluation by the game system. |
| **Structure** | 3 Stages of increasing difficulty. |
| **Prerequisite Competency** | Service Management. Classify Market Segments. Assess the Situation. Improve the Quality of the Offer. Improve Customer Acquisition and Retention. Evaluate Different Expense Types. |
| **Target Competency** | Develop Economic Growth Strategies. |
| **GMs** | Build Services. Demolish Services. Hire Employees. Fire Employees. Select Employee Professional Levels. Change Communication Channel. Use graphs. Use reports. Ask for help. |
| **Performance mapping** | |
| **Frequency** | Percentage of economic growth.<br>[3 points] |
| **Autonomy** | Use of the help function.<br>[2 points] |
| **Context Variety** | Village dimension.<br>[3 points, value fixed by stage] |
| **Scope** | Time span for the growth evaluation.<br>[3 points, value fixed by stage] |
| **Complexity** | Context Variety score + Scope score.<br>[3 points, value fixed by stage] |
| **Performance classes** | Beginner (Stage 1) : $6 \leq Score \leq 8$<br>Intermediate (Stage 2) : $9 \leq Score \leq 12$<br>Expert (Stage 3) : $13 \leq Score \leq 14$ |
| **Evidence Record** | One Badge and one Achievement for each stage completed (performance class achieved). |

Table 9: Table summarising the Economic Strategies Scenario.

to the sum of the scores found in Scope and Context Variety, with value *one* in the case of a sum equal to two, *two* in the case of a sum between three and four, and *three* in the case of a sum greater than four. The same considerations made in the other scenarios will be applied for the Proficiency Scale, defined by the sum of all of the indicators and values between five and fourteen, and the performance classes: *Beginner*, for proficiency values between six and eight, *Intermediate* for proficiency values between nine and twelve, and *Expert* for proficiency values between thirteen and fourteen. As usual, a proficiency value of five will show the lack of competence.

The same reasoning as carried out earlier will also be applied with regard to the demonstration of performance classes relating to competency. By fixing the values for Scope, Complexity and Context Variety, three different stages of increasing difficulty will be defined. Similar to the other scenarios, an evidence record in the form of a badge and an achievement will be produced upon reaching a performance class. This scenario is summarised in Table 9.

### 5.3.8 A Map of the relationships between scenarios and competencies

The proposed scenarios have been named and ordered in such a way that they can be carried out sequentially without running into problems related to the skills required as prerequisites. Nevertheless, various dependency relationships arose when they were defined, and it is therefore useful to define a map in which these relationships are made explicit. Figure 51 provides precisely a visual representation of this map.

An analysis of this map immediately shows that Scenario #1 and Scenario #2 are atomic scenarios: each of them works exclusively on one competence and does not require any other competence as a prerequisite. This implies that in reality, as long as these two scenarios are completed before the others, they can be carried out in any order, still maintaining a coherent path. Scenario #3, on the other hand, has as its target competency "Assess the Situation" and requires both competences covered in the first two scenarios as prerequisites. The reason why this scenario is listed as the third is precisely because of the dependency relationships these first three competences have with the rest of the scenarios. The fact that almost all the subsequent scenarios require all three of these first competencies implies that these are somehow more central to the processes and activities carried out within the game. Another important element that emerges from the map is the fact that Scenario #7 requires all of the other competencies identified in uManager. It is no coincidence that the concepts related to the development of economic growth strategies require an understanding of all aspects of the tourist village and the ways

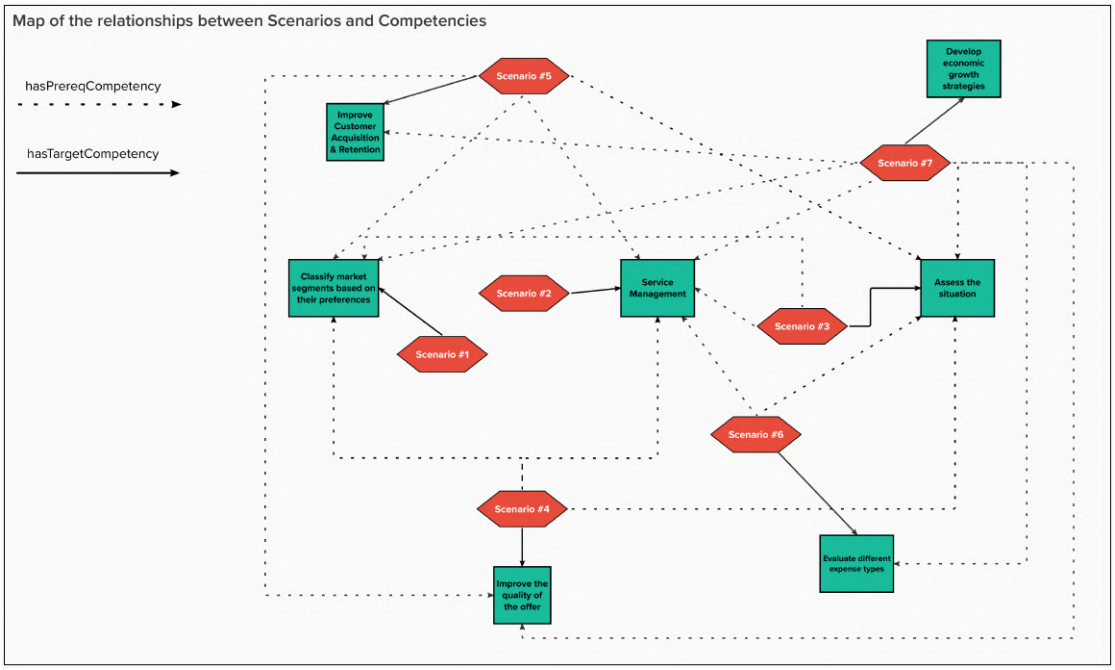


Figure 51: The map of the relationships between Scenarios and Competencies.

in which it can be analysed. A fact that underlines this concept even more is that the activities characterising Scenario #7 were usually initiated in the advanced and final stages of the current uManager game mode, the one in which profit maximisation was sought.
Such a view of the requirements and objectives of each scenario as a function of competence is of fundamental importance in the context of enabling designers and especially educators to develop learning paths within the game in a solid and coherent manner.

# Part III

# Conclusions

# Chapter 6

# Conclusions and Future works

The idea behind the re-design of uManager was precisely to modify the Serious Game in such a way that it could become compliant with the proposed principles of Competency-Based Education, and in doing so to show how this process can be implemented, providing guidelines and examples for the design and adaptation of other games. One of the most important things that had to be defined in order for uManager to be compliant with the proposed principle of *Transparency* was precisely to make an ontological analysis of the knowledge domain involved in the game and, consequently, to extract key competences that could be trained. This analysis not only brought greater clarity from the point of view of the learning objectives, the concepts covered and the competences touched upon, but also made it possible to clearly and precisely establish seven new learning scenarios, one for each competence. The production of these scenarios more focused on specific competences was a key element, considering that current game models involved complete games, which always start with an empty building plot and end when the final objectives are reached. One of the difficulties present before the definition of the new scenarios and which further emerged during the competence analysis was precisely the composite nature of the game activities performed in uManager so far, which made the analysis and verification of a specific competency complex. The map of the relationships between scenarios and competences shown in Figure 51 also clearly shows the dependencies between the various scenarios and indirectly between competences, empowering educators and enabling them to create new learning paths targeted to their needs, facilitating the process of integrating the game within existing curricula.

From the point of view of the *Agency* principle, the new scenarios allow players to take an increasingly leading role in their own learning process. The definition of specific game levels linked to certain competencies allows for greater awareness of the educational objectives pursued. At the same time, all of the proposed scenarios involve the careful use of knowledge and, above all, of meaningful choices.

The result of these choices is always shown in the form of feedback, either at the end of the scenario (once the choices have been finalised) or within the game scenario itself, as in the case of Scenario #1. A higher level of feedback could further benefit the game, especially when provided directly by in-game customers. Right now, the player does not see the avatars of the customers while they are inside their village, and this decreases the chances of providing feedback and increasing the player's awareness of the fact that their actions actually change and shape the game world. To improve this aspect, I believe that the implementation of avatars representing customers wandering within the village while using services is important. This implementation provides the opportunity to explore new forms of feedback: for instance, a customer could immediately express dissatisfaction upon leaving a service by means of an angry cloud above his head, allowing the player to continuously and immediately observe the consequences of his actions.

With regard to the principle of *Assessment*, the design of the new scenarios significantly improved the position of uManager. In the current version of the game the student is assessed transparently, and the transition to the next game level takes place automatically and seamlessly when the objectives are reached, without interrupting the game session. The student has to infer the degree of success in completing the level by himself, using the analytical tools and indicators available to him. This needed to be changed. In order to transform the assessment into a moment of enhancement of the learning experience, the methods and criteria that are used must be clear and above all must be communicated to the student at the beginning of the activity. The definition of performance indicators within each scenario gives us precisely this opportunity. Informing the student of which indicators will be used during the evaluation empowers him/her by giving them the opportunity to fully understand the outcomes of the evaluation. This can be done through the implementation of information screens at the beginning of a scenario or, alternatively, at the time of its selection. For the same reasons, when the assessment occurs the game session must be (at least temporarily) suspended, and the results must be clearly visible to the player. This is why feedback on whether or not a performance class has been reached is returned at the end of stages, at times when the game is currently at a standstill and the cognitive load is lower. This gives the learner the time to self-reflect and understand their assessments, so that they can reflect on what has been done correctly and what they still need to work on. Moreover, in order to help teachers analyze players' progress and provide more comprehensive and informed monitoring, the teachers' platform must be integrated with information on the various actions taken by players in the game. This information should be organised in a timeline that can provide the necessary context for understanding players' intentions.

As far as the *Support* principle is concerned, uManager is already fairly well positioned. The nature of Serious Game already inherently provides more opportu-

nities for teachers to provide personalised assistance to players when the activities are carried out inside the classroom. In addition, the presence of a guide avatar within the game allows for a form of feedback and suggestions targeted to the needs of individual students, and based on the current state of the game. The seven designed scenarios make extensive use of this feature, providing the option to call up the guide and request help and suggestions. To further increase the level of support in uManager, especially in the context of asynchronous sessions conducted outside the classroom, a system of communication with educators can be implemented. Communication can take place either in the form of a ticket (thus asynchronously) or in the form of a direct chat (synchronously). The hub for receiving these communications could be integrated within the teachers' platform in order to unify the educators' user experience. Finally, in order to increase the level of customisation and support provided to students by educators, it would be appropriate to provide the option of customising, via the teacher platform, the messages presented at the beginning of the scenarios. In this way, activities could be further contextualised in the framework of the rest of the curriculum.

From the point of view of *Progress*, the definition of the new scenarios allows uManager to position itself rather well. All of the proposed scenarios require the player's advancement to take place through an actual demonstration of mastery of the competency, and not through a mere temporal advancement. The definition of such scenarios was crucial, as many of the game mode stages in uManager so far relied precisely on the passage of time to allow the player to acclimatise with the new game mechanics. Instead, this objective should be achieved in specific tutorials, whose sole purpose is the discovery and understanding of the mechanics, clearly separated from scenarios aimed at learning objectives.

As for the principle of *Pacing*, the fact that uManager is a Serious Game aimed at adaptive learning provides numerous advantages. Each student has the ability to advance within the game independently of the rest of the class. In addition, the implementation of the option to customise learning paths via the teacher platform allows them to be contextualised to the needs of one' own students. Another plus point in uManager is that the game is automatically saved with each action taken by the players. This makes it possible to interrupt the various scenarios, start new ones and pick up where one left off at any time, switching from one to the other freely. Furthermore, the implementation of the player's profile as an ePortfolio, e.g. through the creation of a new page within the virtual social network, would enhance the current capabilities of uManager by providing a space where students can view current progress and decide on future goals.

In terms of *Equity*, uManager is already very well positioned. The game is completely free of charge. The ability to choose different languages also makes it easier to use for foreign students with language difficulties. uManager has also been developed to be lightweight and does not require a high-performance computer or

special installation processes: the game can be played using a simple web browser and an Internet connection. An improvement that could be implemented from the point of view of greater accessibility, given the opportunity players have to continue the game sessions outside of school facilities, is to provide a version of the game that can be played on smartphones and tablets: today there are many families in which students do not have a computer at home. The option of accessing the game from a mobile phone could help in these situations by providing wider and easier access to everybody.

Overall, the work presented in this study aims to advance the research from the point of view of the planning and design of Serious Games contextualised in the world of Competency-based Education. Schools nowadays needs new innovative tools that can act as catalysts for the change of the educational paradigm and Serious Games can be an excellent answer. While the trend to date is to continue to design Serious Games almost exclusively for the sole purpose of acquiring knowledge, I argue that these are the perfect tool to implement Competency-Based interventions within educational pathways, as evidenced by the emerging popularity demonstrated in the medical and nursing sector, where CBE approaches are generally more mature. I also hope to have shed some light on the confusing concept of competence by exploring the literature body and adopting and discussing a holistic definition that in my opinion perfectly describes the concept, while also heeding the call of Vitello, Greatorex, and Shaw to converge towards a single definition rather than continuing to diverge through different discordant formalisations. In terms of future work, surely the most urgent goal is to find the resources to bear the costs of an implementation of the new version of uManager, so that the impact of the new Competency-Based approach can be empirically verified in practice. Furthermore, the processes implemented to design this adaptation could be further refined following further case studies and subsequently re-defined within a new formal framework. While the work set out in this thesis aspires to be a concrete and important contribution to the advancement the state of research, the field of application of Serious Games to the Competency-Based Education context is still immature and needs further research efforts. In this sense, I hope to have sparked the interest of other scholars in this interesting and promising field.

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