CLEVER: A Gameful Enterprise Learning System

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***Abstract*—Employees often lack the motivation to share their implicit knowledge with one another and are reluctant to engage in a collaborative forum for such knowledge exchange. To address this issue, we developed a gameful learning component of an enterprise knowledge management system (KMS) to help foster this process of collaborative and participatory learning. This paper introduces CLEVER, a serious game that combines trivia and strategy elements as game elements to motivate the players into knowledge exchange. Furthermore, we describe how CLEVER uses intrinsic and extrinsic motivational affordances to engage employees into enterprise knowledge learning.**

Keywords—gamification; gameful design; enterprise learning; knowledge management

I. INTRODUCTION

Knowledge management (KM) represents the process of effectively capturing, documenting, assimilating, sharing, and deploying organizational knowledge [1, 2]. Organizations often recognize the importance of knowledge exchange; however, the main challenge for companies is the reluctance of their knowledge experts to share their intellectual capital [1, 3]. While KM systems provide the information technology to store, retrieve, and share knowledge, users often lack the motivation to engage with them [4].

To address this issue, we have designed CLEVER, a gameful knowledge management system (KMS). CLEVER uses game design elements [5] to foster employees' intrinsic and extrinsic motivation [6] to engage with the KMS. It is composed of two parts: a gameful knowledge repository, where experts can share their knowledge with their peers, and a learning game, where employees can interact with and learn the content from the repository.

In this paper, we present the learning component of CLEVER. In the following sections, we describe the game's design and details about how it leverages intrinsic and extrinsic motivation affordances to engage employees with the app. This work represents an innovative approach for enterprise KM and a novel approach for engaging enterprise knowledge learning.

II. RELATED WORK

Knowledge exchange is effective within an enterprise when employees are motivated to share implicit or explicit knowledge [7]. Knowledge can be implicit or explicit [7]: *implicit knowledge* reflects the subjective inferences, personal experiences, and gut feelings, while *explicit knowledge* includes objective, rational, and technical information [1].

Knowledge management provides a measure of intellectual capital and knowledge mapping in domain areas ranging from sales and marketing, productivity, customer loyalty, training and recruitment, operations, and safety [1]. However, knowledge sharing is often limited by employees' lack of motivation to engage with their peers in knowledge transfer [1, 3, 4]. Therefore, we suggest that a gameful KMS can afford sharing and dissemination of knowledge by means of fun, enjoyable interactions.

A gameful system is augmented with *motivational affordances* [5], which are properties added to the system to allow its users to experience the satisfaction of their psychological needs [8, 9]. The self-determination theory (SDT) of human motivation distinguishes between intrinsic and extrinsic motivation [6]. Intrinsic motivation implies doing an activity because it is inherently interesting or enjoyable, whereas extrinsic motivation implies participating in an activity as it leads to an external outcome. Additionally, SDT posits that intrinsic motivation is afforded when the psychological needs of autonomy, competence, and relatedness are satisfied. Therefore, a common strategy to design motivational affordances is to provide the satisfaction of these needs.

Regarding the application of gamification to motivate employees in knowledge exchange, Wiegand et al. [10] conducted a literature review and identified human-work-related needs (i.e., mastery, autonomy, and self-expression) and gamification elements (i.e., points, levels, challenges, and social incentives) to foster intrinsic motivation and lower barriers to knowledge exchange. For knowledge exchange, the authors stated social capital enabled KM and identified 11 gamification elements as the missing link to connect human work-related needs and knowledge-exchange barriers.

In another approach, interactive game-based training provided engagement by giving users the power of narration, storytelling, and quick recall of information in an enterprise [11]. Game-based learning provided increased perceived performance within a learning and knowledge acquisition perspective [12]. Additional examples of gamified KM systems include associating meanings to documents to motivate employees [13], ProjectWorld, a gamified KMS for knowledge documentation and reuse [4], and measuring user engagement within an enterprise system [14]. KM Quest is a simulation game designed as a learning tool, but it is aimed for KM professionals rather than an enterprise KMS for all employees [15].

While the above research focused on theoretical models and extrinsic affordances for training and learning, little research has been done to investigate the influence of intrinsic motivation within an enterprise KM context. There is also a lack of empirical research investigating intrinsic motivation within a KMS. Our research is important because it investigates the influence of intrinsic and extrinsic motivational affordances to provide a knowledge learning strategy within a KMS. Our exploratory study using focus groups provides many strategic deployment opportunities for gamification specific to KM by leveraging employees' motivation.

Fig. 1. CLEVER's game overview.

III. CLEVER: A GAMEFUL KNOWLEDGE MANAGEMENT SYSTEM

The organizational issue of motivation for KM needs to be addressed in two different activities: knowledge sharing by intellectual capital experts and learning of previously shared knowledge by employees.

Thus, we designed CLEVER [16], a gameful KMS composed of two components to respond to both these needs:

1. *Sharing*: This component is a gameful knowledge repository; and
2. *Learning*: This component is implemented as a game to promote learning of content stored in the knowledge repository.

Both the sharing and learning components are combined within a client, which is a single page application used to interact with the KMS's components. The focus of this paper is describing how CLEVER motivates employees to interact with the system to learn from previously shared knowledge. Thus, only the client and the learning components were designed and implemented thus far. While the proposed KMS would use gamification to motivate users, the learning component described in this paper is an example of a serious game for learning, part of the larger gameful KMS.

CLEVER is a strategic, turn-based trivia game in a digital play space (see Fig. 1). Its idea is inspired by traditional board games, such as chess and checkers, and strategy games, such as Risk [17], Antike II [18], and Diplomacy [19]. This theme was selected after an initial survey of employees of the partner company where the prototype would be implemented; this was the theme preferred by most employees. The players' goal in the game is to eliminate all enemy units on the board. It can be played with a minimum of two and a maximum of four players. All players play against each other on a single map.

A. Digital Map

The game's digital map is constructed from tiles, which are represented as 6-sided polygons (hexagons). A tile can either be blocked or occupied by a single unit. Some tiles are always blocked, including archways, ruins and mountains, meaning they cannot be occupied by units.

Furthermore, deep forests may be used by the player to conceal a unit from his opponents. A unit inside a deep forest is only visible to its player; however, they can be spotted in combat if an enemy unit is within attack distance.

B. Units

The game includes four different races (humans, orcs, elves, and dwarves), which serve only an aesthetic purpose, meaning that game mechanics are not changed by races. In addition, there are three types of units (see Table I). Each type of unit differs in health points (HP), attack and movement range. Therefore, different types of units allow users to pursue individual strategies due to their varying characteristics.

TABLE I. TYPES OF UNITS.

Unit Type	Health points	Attack range	Movement range
Archer	650	3	2
Fighter	800	1	3
Tank	1500	1	2

C. Gameplay Phases

Gameplay is divided into two phases: placement and turns. The game begins with the placement phase. Once placement is over, players take turns, which are divided into trivia and action phases (see Fig. 2). The goal of the trivia phase is to collect energy by answering questions with different levels of difficulty. In the action phase, players use the collected energy to perform game actions (e.g., movement, combat, or healing).

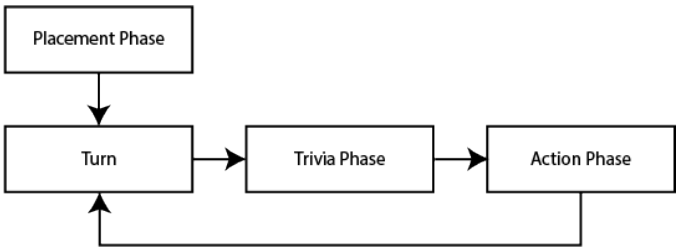

Fig. 2. CLEVER's gameplay phases.

1) Placement phase

During this phase, players simultaneously place their units. Each player must place their four units on a space in the player's corner (starting point).

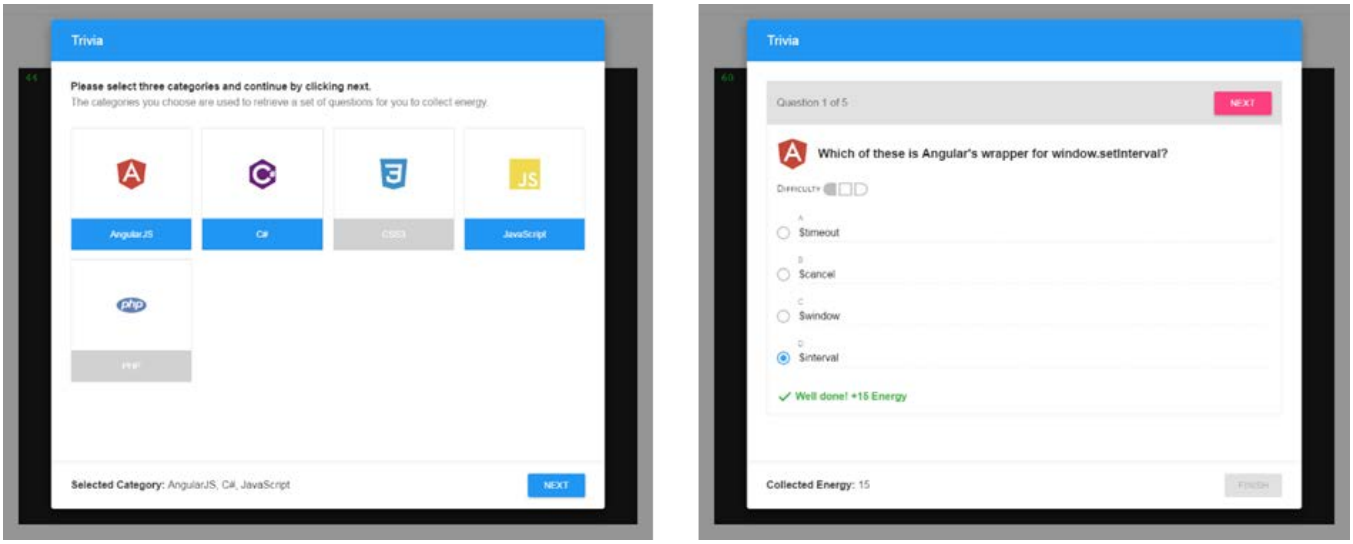

Fig. 3. Category selection (left) and trivia dialog (right), showing the amount of energy gained for a correct answer.

The phase ends when all players have placed all their units. There is no specified limit for types of units. Thus, players can freely choose their units.

2) Trivia phase

Once placement is over, the first player (top-left corner) must explicitly start their turn. First, the player must choose three categories. Once the categories are selected, the game will randomly retrieve a set of five questions from them, with different levels of difficulty: two easy questions, two normal questions, and one hard question. The player must then answer each question (see Fig. 3).

When a question is answered correctly, the player receives energy points depending on the level of difficulty. Furthermore, a player will also lose energy by giving an incorrect answer (see Table II). If the player answers all questions correctly, they are rewarded with a star. A star is an in-game reward which can be used for special actions in the game (charge and heal).

TABLE II. LEVELS OF DIFFICULTY FOR QUESTIONS.

Difficulty	Energy gain (correct answer)	Energy loss (incorrect answer)
Easy	15	15
Medium	20	10
Hard	25	5

Once the player has answered all questions and earned enough energy to at least move a single unit, the system game will automatically start the action phase. If a player has not collected enough energy to perform an action, the turn is over and the system game will continue with the next player's turn.

3) Action phase

In the action phase, players use the collected energy to perform game actions. Each action will consume a certain number of energy points and some actions also consume stars (see Table III).

Each unit can only perform one action per turn, except when using charge, which allows the same unit to perform two actions in the turn.

TABLE III. IN-GAME ACTIONS AND THEIR ENERGY COSTS.

Action	Energy
Move	35
Defend	50
Attack	70
Charge	30 (+70) + ★★
Heal	50 + ★★

The available actions are:

Move: A player can move a unit according to its movement range. A unit can move from its location to adjacent spaces and can also skip over blocked spaces. Units may only occupy spaces that are not blocked nor yet occupied by other units. A space is also blocked when it is taken by a player's piece.

Defend: Defending a unit means that the system will add a certain number of health points (armour) to the unit. The amount of armour is determined by a set of three questions, one question from each difficulty level, that which the player must answer (the first right answer adds 200 HP and each additional right answer adds 50 HP more). Answering these questions is similar to the trivia phase. The defensive bonus continues for one round, then fades away.

Attack: A unit can only attack enemy pieces within its attack range. After initiating an attack, the player gets another set of three questions, one question from each difficulty level, to determine the attack damage. The number of correct answers decides how powerful the attack will be (the first right answer adds 150 hit points and each additional right answer adds 100 hit points more). If a player can answer all three questions correctly, they can answer another question to land a critical hit. The base damage for a critical hit is 350; moreover, an additional damage depending on the critical chance (between 5% and 15% of the base damage) is added to the base damage to make this attack extremely effective. When a player eliminates a defending piece, the attacking unit moves to the newly conquered space and the game awards the player with a domination point.

In addition, the game implements a "Rock – Paper – Scissor" principle, making certain units more or less effective against others (see Table IV).

TABLE IV. EFFECTIVENESS OF UNITS AGAINST OTHER TYPES OF UNITS.

Attacker	Defender		
	Archer	**Fighter**	**Tank**
Archer	1.0	0.75	1.5
Fighter	1.5	1.0	0.75
Tank	0.75	1.5	1.0

Charge: This is one of the available special actions in the game and enables a unit to be used twice before falling asleep.

Heal: Healing a unit will permanently restore 300 health points. This special action requires 50 energy points and two stars. It may be beneficial when a unit is low on health.

D. End of Game

The game ends when only one player has units left on the board.

E. Asynchronous Gameplay

With the workplace requirements in mind, CLEVER can be played asynchronously. Each turn was designed to take less than five minutes to be completed. Whenever it is another player's turn, the next current player will be notified. A turn does not automatically begin, and players can freely decide when they start their turn. A turn begins when a player starts to answer the first question. Therefore, CLEVER can be easily played by employees in between their tasks.

IV. GAME ELEMENTS

CLEVER uses a meaningful combination of game elements to foster players' intrinsic and extrinsic motivation to engage with knowledge from the repository. Table V describes the most important game elements used to design CLEVER's learning component.

A. Intrinsic and Extrinsic Motivation

CLEVER was designed to purposefully satisfy players' intrinsic needs of competence, autonomy, and relatedness, as suggested by self-determination theory [6, 9]. It affords the satisfaction of each of these psychological needs in the following ways.

Competence: Players receive immediate feedback after answering a question correctly, in the form of energy and stars, which helps them feel competent. The strategic aspect of the game, combined with the combat mechanic provides a layer of challenge that affords a gameful experience and leads to a feeling of competence. Moreover, players are rewarded with domination points if an enemy unit is eliminated.

Autonomy: Players can freely choose their race and units at the beginning of the game. Additionally, players can individually choose their categories for each round. Moreover, the strategic nature of the game allows players to make tactical decisions using different types of units. Players can approach games differently which results in a nonlinear gameplay. This helps them feel autonomous and in control of their destiny in the game.

Relatedness: Players can play together with peers from their company, which provides the feeling of relatedness. Players establish a social connection, even if it is just for helping or challenging one another during the fleeting tasks created during a game session.

Furthermore, employees might also feel competent and autonomous as they learn new content by choosing trivia categories in which they have a learning interest. However, the key element is autonomy, because employees' can choose what to learn and when to learn.

Moreover, the game also potentially affords *extrinsic motivation* as a complement to intrinsic motivation. However, the potential sources of extrinsic motivation may be perceived differently depending on players' personality and preferences. For example, competitive players may feel extrinsically rewarded when they win a combat in the game. Additionally, performing actions can be seen as a reward for answering questions during the trivia phase. Loss aversion is also a form of extrinsic motivation. It is implemented in the trivia phase where players lose energy for wrong answers. The fear of losing energy is a powerful reason for players to carefully think about their answers to the questions.

TABLE V. GAME ELEMENTS USED IN CLEVER.

Game Element	Usage in CLEVER
Challenge	Players engage in the task of eliminating all enemy units on the board. In order to perform actions, they must answer random sets of questions with varying levels of difficulty.
Combat	The combat mechanic affords competition in the game.
Social interaction	CLEVER allows players to meet, talk and play together.
Control	Players can choose between four races and three different types of units, as well as categories during the trivia phase. Moreover, the strategic part of the game allows players to make tactical decisions throughout the game.
Loss aversion	Players lose energy for incorrect answers during the trivia phase.
Theme	CLEVER employs a medieval fantasy setting as an abstraction which makes it possible for players to engage with the concepts of strategy without experiencing war.
Pieces	Players control four units on the board. The appearance of the unit depends on the race.
Goals	CLEVER presents a clear goal to players: eliminate all enemy units (pieces) on the board.
Difficulty	A turn always begins with the trivia phase. In this phase, players must answer a set of questions with varying levels of difficulty: easy, normal, hard.
Aesthetics	CLEVER uses simplistic and non-realistic graphics to drive user engagement. Furthermore, the game partly implements animations for receiving stars, energy and fighting.
Learning	CLEVER promotes learning and engages people to interact with content (questions) from a knowledge repository.
Replay	There is more than one viable approach to achieving the goal the game.
Rewards	Players are rewarded with stars, energy and domination points.
Turns	CLEVER is strongly inspired by turn-based strategy games. Thus, it uses player turns where one player gets to perform actions depending on the amount of energy collected during the trivia phase before it is another player's turn.
Feedback	Players receive immediate feedback for answering questions and performing in-game actions.

V. Preliminary Evaluation

An early prototype of CLEVER was evaluated through an exploratory focus group study with nine participants to gather players' thoughts, experiences, and motivations to interact with the game [20].

While individual impressions of the game were diverse, many lauded that *strategy* and *trivia combined* as game elements helped differentiate it from other trivia or strategy games. Therefore, this combination was effective in motivating players to interact with knowledge through trivia questions.

The preliminary study also showed that the game elements helped foster the employees' intrinsic and extrinsic motivations to interact with a KMS. These motivations fostered player engagement with the gameful system and, thus, with knowledge from the repository, which may lead to improved learning. However, participants felt that this kind of gameful KMS is better for learning or reinforcing explicit rather than implicit knowledge. Therefore, the trivia elements helped participants learn small new pieces of content as they searched the available material or even the Internet to find the correct answers, as well as helping them remember content which they had previously learned in a course or their own studies.

In future work, we will present results of a second evaluation study conducted with the final prototype with the goal of evaluating how CLEVER affects employees' motivation and behaviour when playing it asynchronously in between their daily work activities, as well as how enjoyable and engaging players found the game when playing it outside of a lab setting.

VI. Conclusion

CLEVER demonstrates that gameful elements can help foster employees' intrinsic and extrinsic motivations to interact with a KMS. Specific game elements like strategy, competition, conflict, trivia, challenge, and achievement can fulfil players' intrinsic needs of competence, autonomy, and relatedness. Rewards and loss avoidance can afford extrinsic motivation. These motivations together can foster player engagement with the gameful system and, thus, with knowledge from the repository, which may lead to improved learning.

In future work, we will also implement the gameful knowledge repository of CLEVER, which will provide additional sources of extrinsic motivation, as players might feel motivated to contribute difficult questions to the repository to challenge their opponents in the game. Furthermore, it will also gamify the second portion of KM, which will foster knowledge experts' motivation to contribute with quality questions to the repository. This exchange between knowledge experts introducing questions to the repository and learners interacting with the questions by playing CLEVER will represent an effective KM implementation for organizations.

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