Towards Transforming Game Premise: Validating an Approach for Developing Cooperative Serious Games

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Abstract

The development of cooperative serious games has specific challenges related to enabling players to achieve both gaming and learning goals in a cooperative fashion. The complexity of gameplay and learning objectives leads to the lack of guidance for the systematic development of cooperative serious games (SGs). To overcome the challenges, we propose a systematic approach to utilize elements of entertainment cooperative games to foster player engagement in SGs called "Transforming Game Premise" to overcome the difficulties. A three-phase guideline is proposed for transforming an existing cooperative entertainment game into a cooperative SG. To demonstrate the application of the proposed guideline, we developed a game prototype that follows the guided steps. We validate the guidelines by conducting two user studies. The first study aims at validating the game's effectiveness for learning purposes of a game developed according to our guidelines. The study showed that the developed game supports players in achieving the defined learning objectives. The second study is a qualitative study evaluating game developers' perception of the usability and usefulness of the Transforming Game Premise guideline. The latter study confirms that the proposed guideline is beneficial for systematically developing SGs. However, it also indicates that the guideline still needs more clarity in identifying the relation between game elements and players' interaction/cooperation.

Keywords: *Serious games development, Cooperative games, Cooperative serious games, Game premise;*

1 Introduction

Generally, the development of games for non-entertainment purposes [1], which are called "Serious Games (SGs)," is pricey due to the project requiring a large team of multidisciplinary people [1]. The team needs to comprise at least two groups of experts working on the same project, i.e., game development experts and pedagogical content/knowledge experts. However, both expert groups do not always share a standard work process and vocabulary. This issue can lead to time-consuming and increasing project budget and difficulty in communication at the early stage of development.

Moreover, the SGs development process is complex due to the specific requirements which require designers to consider both entertainment and pedagogical aspects. To be more specifics, the objective of SGs is to improve the competence(s) of the players/learners after playing games. SGs should be developed in a way that can convey knowledge or improve skills for players/participants and engage them through the whole game. Increasing players' motivation is a significant challenge for designing and developing SGs. SGs developers need to consider fulfilling functional requirements to find suitable formal game elements for the learning goals. However, developers also have to include non-functional requirements, which are the fun and entertaining aspects of improving players' engagement in the long term [2]. Additionally, SGs are developed by having a set of learning objectives in mind, leading to low flexibility in redesign and reusability of the products and a high amount of development efforts, i.e., cost and time [1], [3].

The developers need to manage the abovementioned challenges when involved in SGs development projects. By developing multiplayer cooperatives, SGs have more complexity with unique requirements [4]. The gameplay has to fulfill the needs of traditional multiplayer games, i.e., players' engagement and players' interaction, and to overcome the challenges in SGs design, including learning content, adaptation, and personalization [5]. Furthermore, cooperative games are characterized by communication and cooperation to achieve a goal. Both characteristics must be taken into consideration in the design. The developers need to consider embedded learning content and how to engage multiplayer and select game mechanics that make the players cooperate through the games. Even though there are many systematic approaches, such as guidelines, models, and frameworks presented in the literature for overcoming the challenges in SGs and cooperative SGs development, only a few approaches were applied to real-world projects. The gaps in usability and usefulness still need to be addressed [1], [6], [7]. For example, the existing approaches lack simplified tools that support incorporating game learning content among various team members, e.g., programmers, artists, and learning content experts.

Furthermore, we conducted an exploratory survey to investigate the reasons for the low number of systematic approaches adopted to real-world projects. We developed an online survey to ask game/serious game developers and researchers to give opinions using the systematic approach. More than half of our participants (57.1%, 16 of 28) responded that they experienced using a systematic approach in development projects. We asked the same participants with further questions if the participants typically apply systematic approaches to their projects. However, we found that only 10.7% (3 of 28) of the participants use systematic approaches as a "*common*" approach for their development projects. The top three reasons for refusing to use the systematic approach commonly are difficulty in learning new models or frameworks (50%, 8 of 16), unable to find models or frameworks that are useful for their projects (37.5%, 6 of 16), and the complexity of using model/ framework (25%, 4 of 16)—the results of the survey support what we found in the literature.

Therefore, it is vital to explore a systematic way to develop SGs to minimize the development efforts while maintaining the entertainment and pedagogical aspects of the game [1], [6] and consider the usefulness and usability of the proposed systematic approach.

We proposed the *Transforming Game Premise guideline* [8] to overcome the problems in SGs and cooperative SGs developments mentioned above, including difficulty in team communication, identifying the relationship between gaming and learning mechanics, and minimizing the cooperative SGs development process.

In the first iterative of elaborating the Transforming Game Premise guideline [8], we developed our guideline based on literature and lesson learned collected during the implementation process of the game prototypes presented in Grudpan et al. [9], [10].

In Grudpan et al. [8], we first explained the method for elaborating the guideline. Secondly, we proposed a three-phase approach to the guideline, including selecting a reference game, developing a game blueprint, and reframing the game premise. After that, a first user study was conducted to verify the educational value of the game prototype. We asked participants to complete a pre/post-test to verify the educational value of the game prototype. This first user study demonstrated the possibility of implementing the

Transforming Game Premise guideline practically by evaluating the learning improvement of the users/players with a pre-test and post-test set. Therefore, it is concluded by the first study that our guideline is practical for users/players to achieve the intended learning outcome.

This article is an extension of the work presented in Grudpan et al. [8]. The contribution of this article is more focused on developers' perspectives. In contrast, the previous results of Grudpan et al. [8] – [10] emphasize the player side, which measures the educational value of the game developed to follow the guideline only. This article highlights evaluating the usefulness and usability of the Transforming Game Premise Guideline from developers' perspectives. We conducted an additional user study to assess the effectiveness and usability of our guideline in a qualitative user study with the game and serious game developers from the academic and game industry. The evaluation of the useability and usefulness of the guideline addressed the following research questions:

RQ1: How can the Transforming Game Premise guideline support developers in developing cooperative SGs?

RQ2: How does the Transforming Game Premise guideline (procedure and documents) helpful in supporting developers in systematically converting cooperative entertainment games to SGs?

RQ3: What are the considerations developers need to consider for applying the Transform Premise guideline or approach in their studios or labs?

In section 6, the details of two user studies are presented. The first study was conducted to verify the game prototype's educational value that was developed following our guidelines. Later, the second study was conducted to evaluate the usefulness and usability of our guidelines by asking for opinions from game and SG developers. Section 7 presents the conclusion, limitations, and future work.

2   Background and Related Works

2.1   Challenges of Cooperative SGs Design and Development

Serious games have been defined as entertaining games with non-entertainment purposes [3]. SGs have specific requirements and design processes [1]. As mentioned above, the design and development of SGs require a development team consisting of game developers and education experts. However, due to this multidisciplinary, the team members often do not share a common vocabulary and domain viewpoints [1], [11], [12]. Therefore, to improve the method of the SGs development, the pedagogical contents must be translated and implemented into the game mechanics [1]. One of the biggest challenges in SGs design and development is to study the relationship between learning mechanics (LM) and game mechanics (GM) to improve the game design process [12], [13].

Sedano et al. [14] define cooperative games as games where players have individual actions but a common goal to be achieved together. Cooperative SGs are games in which all players have common goals [15], [14], or tasks [16] to accomplish together. The players have to communicate and cooperate to make the decision. Each member can have an individual role or ability needed to achieve a common goal. Designing and developing cooperative SGs is difficult due to the complexity of the mentioned characteristics. The cooperative games must provide the environment to engage a whole group of players [17]–[19].

Beznosyk et al. [15] identified closely- and loosely- coupled collaboration patterns, and they found that close collaboration provides higher enjoyment while increasing the communication challenges between the players. Emmerich et al. [20] analyzes pX and social interaction of three-game patterns: player interdependence, time pressure, and shared control. They found that high player interdependence indicates more communication and less frustration, whereas shared control results in lower competence and autonomy. Similarly, Johnson et al. [21], compares the impact of a teammate on pX in a cooperative

game. They found that playing with human teammates was associated with a greater sense of relatedness but less competence and flow than computer-controlled bots. The presented literature identified important factors and patterns of cooperation in games. Our previous work investigates which aspects of cooperation are affected by the game premise.

Thus, identifying the mechanic that influences players' cooperation and activities is essential. The learning process occurs during their interactions with the gameplay. Therefore, the game environment should be designed to support the interactions among players, notably, their cooperation aligning with the game's characteristics.

2.2 Gaps in Cooperative SGs development

Understanding game elements and their interrelationships are the basis of game design [18]. We can use the principle and creativity to design a new type of gameplay. Deterding [22] mentioned that using game design elements in non-game contexts can motivate and increase user activity and retention, known as gamification. However, designing SGs is more complicated because they have full-fledged game characteristics [22] and specific requirements to fulfill pedagogical goals [14], [23]. Generally, the learning objectives and serious contents are used to determine the elements of SGs. Focusing only on adding learning content to SGs can limit creativity and the flexibility of SGs designers, which affects the player's motivation for the games. Therefore, it is essential to consider ingeniously integrating learning content into the gameplay. Adding proper dramatic elements to games can be another option that can provide meaningful experiences and enable games to be more emotionally engaging.

There are various research attempts to investigate how to support understanding of the deeper relationship between different components in education SGs [1], [7], [23]. Amory [7] developed a framework called "Game Object Model (GOM II)" describing the relationships between pedagogical elements and games using Object Oriented Programming concepts. However, GOM does not construct the relationship among game elements as it could become complex, which is against this framework's purpose of being easily understandable. The Learning Mechanics-Game Mechanics (LM-GM) model [24] represents game flow that shows how to translate pedagogical practice components ("Learning mechanics") into concrete game mechanics by using graphical presentation. This model identifies abstract patterns of game flow and a list of elements in the game to support analysis. Still, it does not present a connection between concrete mechanics and a high-level education objective.

Carvalho et al. [1] proposed an Activity Theory-based Model of Serious Games (ATMSG), the ATMSG use activity theory-based as theoretical background for the structured SGs. Compared to previous frameworks, the ATMSG offered a more precise model that can represent both high-level requirements of SGs and connection between concrete mechanics. ATMSG also proposed a taxonomy of SGs genres for identifying the SGs elements and support SGs design and analyst. However, the ATMSG is limited to single player only. This framework does not consider the interaction between players both in-game and social network which is important mechanic of the cooperative game. Additionally, the existing frameworks focused on relation of formal elements and the learning elements but lack of consideration in the effect of the dramatic elements on player motivation.

In this paper, we proposed a systematic approach to developing cooperative SGs. Our approach applies the concept of using the potential of commercial-off-the-shelf games (COTS) for learning purposes [25] to ensure that the game mechanics are well balanced to avoid players' engagement problems. Based on the concepts, we elaborated the Transforming Premise guideline, which includes selecting and adding learning contents of existing games. Then, we evaluate the game developed following our guidelines to confirm that formal elements of the chosen game can fulfill the learning objectives. The user study response to RQ1 is mentioned in the introduction.

2.3   Game premise

Dramatic elements can be used as tools for game designers to elicit an emotional reaction from players. Fullerton's definition of games includes premise as a dramatic element [26]. Premise establishes meaning to the players' actions through a setting or metaphor, and its base-level effect is to make players easily understand and operate essential features in the games [29], [31]. The game premise differs from the story in the narrative aspect. A premise stays the same throughout the game, unchanged by players' actions, whereas the game story builds upon the setting or theme (i.e., premise) and unfolds throughout the game's progression. For example, the premise of "SimCity"[27] is to build a city from scratch using limited financial resources. For the whole game, player actions mainly focus on the town's construction, while the game's story consists of the small events that affect a player's decision. Birk et al. [28] showed that identification and customization with an avatar can increase the players' intrinsic motivation. Iten et al. [29] showed the impact of meaningful choices in a narrative-rich game, leading to the players having more appreciation for the narrative and winning the game. Holmes et al. [30] studied the effect of game narrative and theme on player experience (pX). They found preferences toward "Horror" and "Sanitized" themes, whereas higher curiosity was observed in the horror scenario. In contrast to Holmes et al., our paper manipulates the premise of the players' role rather than comparing different aesthetic elements of the game.

A game premise is one of the dramatic elements commonly used in many games. The premise provides meaning to the players' actions through a setting or metaphor [26]. It helps players understand and operate essential features in the game effectively. It is different from a narrative storytelling aspect because it does not change throughout the game. Likewise, it does not change by players' actions.

In comparison, the story is built upon the setting or theme and is altered by the game's progression. According to the game premise, it is defined as the meaning or reason for players to act in plays. From SGs developers' perspective, it is interesting to utilize the effect of the game premise to develop effective SGs.

3   Research approach

To elaborate on the Transforming Game Premise guideline, we iteratively have developed our guideline in both the literature review and practical testing of the concepts to identify the refinement points. We employed the idea of reusing existing games or game components for non-entertainment purposes [25], [31]. Based on these concepts, we explored game elements that require developers' minimum effort to modify the existing games to minimize the development process. From the works of literature searched and our previous user study by Grudpan et al. [10], we found that the game premise is the prominent element that can be modified without consequence to the core gameplay. We combined the findings of our previous studies by Grudpan et al. [10] and lessons learned that we collected during the implementation of the game prototypes in Grudpan et al. [9], [10] to implement the first iterative of our Transforming Game Premise guideline Grudpan et al. [8].

In this article, we extend the work of Grudpan et al. [8]. We focused on the usefulness and usability of the Transforming Game Premise guideline on the developers' aspects. We invited game and SG developers to verify the effectiveness and usability of our guidelines. In this study, our participants, who are experienced developers, were asked to transform cooperative games into cooperative SGs using our guidelines. After that, they were interviewed to give an opinion on the usefulness and usability of the Transforming Game Premise guideline. Our research is organized as follows: Section 4 presents our proposed approach, i.e., the three-steps guideline. Section 5 applies the proposed guideline to demonstrate the overall process of the guideline. In section 6, we evaluate the effectiveness of our guideline in two axes, quantitative and qualitative, in two studies. In the first study, we aim to investigate the game's educational value transformed by using our proposed. The

second study seeks to measure the usability and usefulness of the proposed guideline by focusing on the guideline's target users, i.e., the developers.

4 A guideline: Transform cooperative games to cooperative SGs

Our guideline includes workflow and documents for collaboration among the developer team. The team is game designers, game programmers, and learning content experts. The guideline consists of a three-phase approach which is 1) selecting a reference game, 2) developing a game blueprint (ATMSG), and 3) reframing the game premise (The extension of ATMSG). The method for elaborating each phase describes as follows.

4.1 Phase1: Select a reference game

To explore the existing serious games or COTS games that can be used as reference games for developing cooperative SGs, we suggest that developers conduct Selection Criteria. The criteria consist of information describing learning activities that instruction intends to add to SGs [1]. The details of three topics developers need to consider for selecting the COTS game are described below.

- The similarity of the candidate game and learning activities: Generally, SGs' formal elements, such as rules, gameplay, and character, are developed based on the learning objectives. Formal elements of the game are the factors needed to be considered from a candidate COTS game before it is selected for the transformation into SGs. Then, the candidate game should have gaming activities such as actions, tools, and goals similar to the learning activity. For example, a cooperative board game can train players to collaborate among the involved stakeholders in urban logistics planning [9].
- The similarity between real-world and game scenarios: The game should have a similar environment with the learning contents to minimize the design process effort. For example, a game that includes a map of networked locations for traveling activities can be a prominent candidate for developing a logistics game.
- The characteristics of the cooperative activities: Looking for a game with interactive activities that support the required learning objectives. For example, to develop a multiplayer cooperative rehabilitation game, we should look for the existing games requiring players' physical activities to cooperate in the gameplay, such as the cooperative mode of the Guitar Hero game.

4.2 Phase2: Develop a game blueprint

In this phase, a blueprint of the cooperative SGs is developed to ensure that the selected game can fulfill the learning requirements. This phase has two steps. The first step is to analyze the game activities of the selected game. The second step is to brainstorm for the addition of the required learning contents to the individual state of the game. The details of each step are described as follows.

4.2.1 Step 2.1: Analysis of the selected game

The selected game is analyzed using the Activity Theory-based Model for Serious Games (ATMSG)[1]. The ATMSG is a model for SGs analysis. The model allows the developers' team to deconstruct the architecture of SGs. The architecture consists of a flow chart, and a table of gaming, learning, and instruction activities (see Figure 1). This step aims to analyze the selected game's structure to identify suitable elements and states for the assigned learning objectives. We follow the guideline of ATMSG to illustrate the game flow and the game activities of the selected game. In this step, the development team can use the initial parts of the ATMSG diagram, which consists of a flow chart (game flow) and

game activity taxonomies (actions, tools, goals), to select suitable reference games. Game designers and programmers should involve in this step to support the team in drawing flowcharts and tuning the game mechanics.

4.2.2   Step 2.2: Brainstorm to add learning activity

We continue to fill out the game's learning and intrinsic instruction elements (see Figure 1). This phase illustrates game flow, game elements, learning elements, and intrinsic instruction elements. The table can help the team to have a clear picture of how players cooperate and interact. The team can consider adjusting formal elements of the game while still clearly spotting how the adjustments affect each other elements.

These two steps support the developer team in selecting reference games and creating the initial game blueprint. The game blueprint allows the team to have a common view of the game architecture and identify the game elements suitable for the defined learning objectives.

4.3   Phase3: Reframing game premise

In this phase, we focus on the implementation process. Our guideline supports the iterative development process. We suggest developing a game prototype based on the game blueprint from the second phase for the first prototyping. Programmers can focus on implementing the formal elements, i.e., the gameplay rules. After that, we propose the steps to modify the dramatic details related to the game premise. Thus, we advise programmers to arrange flexible source code for rephasing the objects. All texts embedded in the game should be easily accessible and editable by educational experts who can modify the learning contents of the game.

The guideline in this stage includes documenting and keeping track of transforming the original game's premise to SGs. To ensure that the game is documented systematically, we describe the four steps of game documentation which support the communication among game designers, educational experts, and programmers.

4.3.1   Step 3.1: Labelling game elements derived from the game premise

We labelled game elements and tools, which are a row in gaming activity, in the ATMSG table.

4.3.2   Step 3.2: Listing game elements of the original game in the Version table

To keep track of the naming of the game elements of the original game version with our modified version, we recommend creating a Version table in the changes section of the document. In this step, game designers and game programmers must cooperate to extract all the game elements into the table. The storyboard and user interface of the original game are the additional documents required in this step.

4.3.3   Step 3.3: Phasing game elements

The game elements in Step 3.2 are phased and added in the column next to the original game in the Version table. The Version table is a checklist for game designers and programmers to modify the naming of the game elements. The document also helps educationists and experts with no technical background change the entertainment games into SGs without needing to deal with the technical aspects. We recommend that programmers implement the game with the flexibility to import the new version of the text file into the game project.

4.3.4 Step 3.4: Adding the modified game elements back to the ATMSG table

We added another layer of rows to the bottom of the ATMSG table. This last layer helps the developer team track and trace back to the original design of the game, which can be used later when the team needs to redesign or change the learning contents of the game.

5 Appling the guideline to transform the Pandemic game to the Urban Logistics game

We implemented a cooperative game using our proposed guideline to verify that the procedure is repeatable and can be one of the options for developing cooperative SGs. An urban logistics scenario is selected to use as a scope for developing the prototype.

5.1 Phase1: Select a reference game

We began by analyzing the urban logistics scenarios from the literature and identified the learning objectives. Then, we created the selection criteria to choose the reference games. We investigated the popular cooperative commercial games then developed the following criteria to filter the number of games.

The main criteria used in the selection of the reference games are defined as follows:

i). A game that needs the players to deal with a map of networked locations is the type of environment required for a logistics game. ii). A multiplayer game requires the players to help each other complete the game goal. iii). A game that mandates the players to cooperate on the decision level., iv). A game where the players need to make decisions based on their roles. We found that the Pandemic board game [32] was one of the most promising games that could be used as a reference game for our prototype implementation because it satisfied all the requirements in our criteria.

Originally, Pandemic [32] was a turn-based multiplayer cooperative game where the goal was to stop spreading diseases on the map before the Pandemic occurred. The players must cooperate to make a series of decisions to win the game. Gameplay: The game starts with the spreading of infections. The player needs to take action during their turn, which consists three phases. Action-phase: the player needs to execute movement actions and the actions for treating/discovering. Draw-phase: the player draws the cards that allow movement and cure actions from the deck. Infection phase: The player draws cards from the infection deck, and the infection progresses on the map. Win/Lose conditions: The game ends when one of the following loss conditions occurs. i). The player runs out of cards from the player deck, ii). all infection markers are set on the map and iii). an outbreak occurred more than eight times (a city has more than three infection items, leading to a cascade spreading to adjacent towns). Players need to discover a cure for all diseases to win the game. The game is designed so that the more turns the players use, the higher the chances of losing the game by running out of cards or the outbreak. The game design forces players to work cooperatively to discover cures for the diseases within limited game turns. The gameplay of the Pandemic forces players to cooperate in making a decision similar to the situation required in urban logistics planning. Thus, the game is selected to be a reference game.

5.2 Phase2: Develop a game blueprint

We deconstructed the Pandemic game by using the ATMSG[1]. Based on the ATMSG methodology, we identified subjects and activities from the urban logistics scenarios. Then, we created the game blueprint that shows game elements' relations with the learning objectives following the ATMSG procedures. We utilized the taxonomies, including Gaming, Learning, and Instruction activities provided in the ATMSG model [1], to support developers in filling out the activity table (see Figure 1).
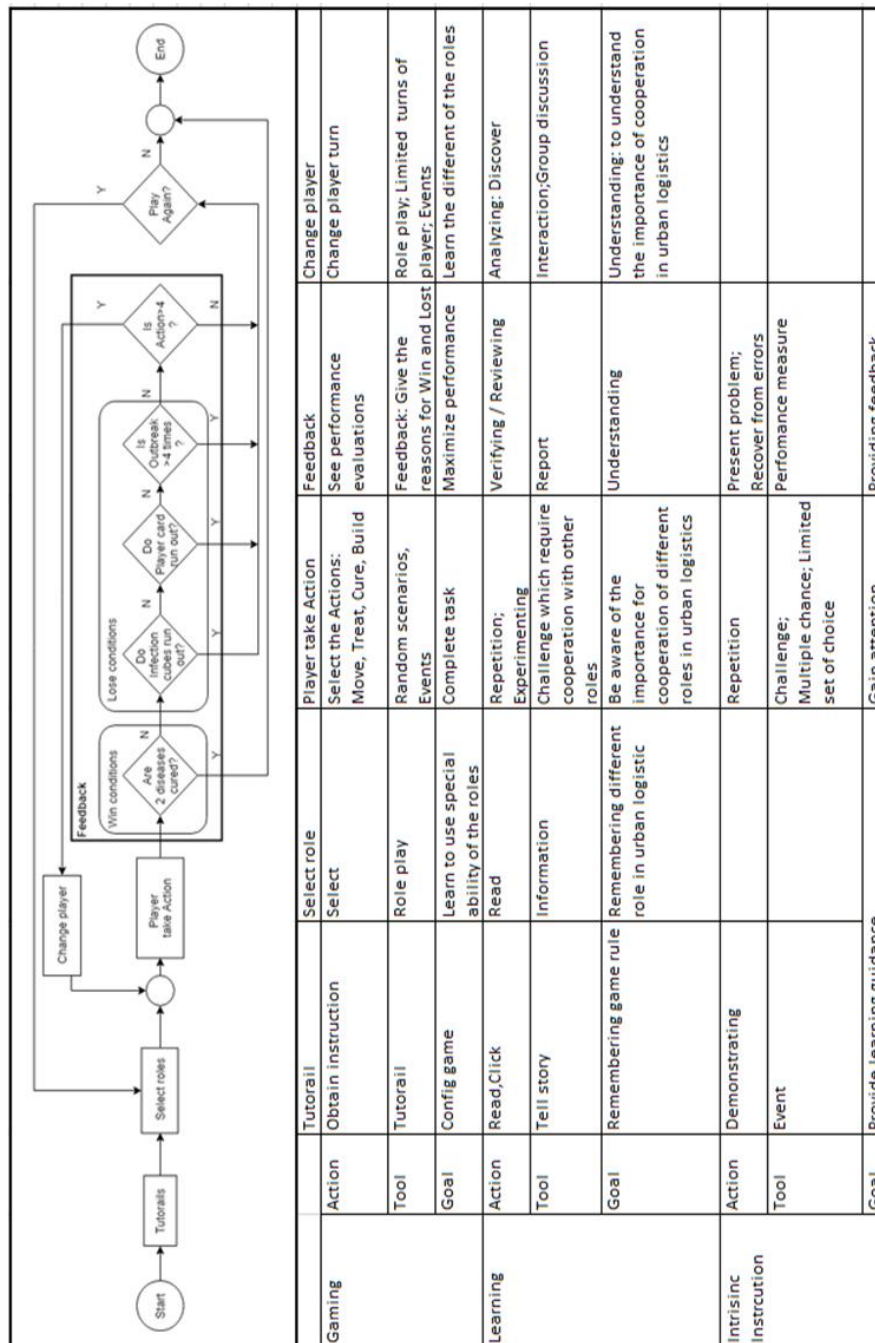
		Tutorail	Select role	Player take Action	Feedback	Change player
Gaming	Action	Obtain instruction	Select	Select the Actions: Move, Treat, Cure, Build	See performance evaluations	Change player turn
	Tool	Tutorail	Role play	Random scenarios, Events	Feedback: Give the reasons for Win and Lost player; Events	Role play; Limited turns of player; Events
	Goal	Config game	Learn to use special ability of the roles	Complete task	Maximize performance	Learn the different of the roles
Learning	Action	Read,Click	Read	Repetition; Experimenting	Verifying / Reviewing	Analyzing: Discover
	Tool	Tell story	Information	Challenge which require cooperation with other roles	Report	Interaction;Group discussion
	Goal	Remembering game rule	Remembering different role in urban logistic	Be aware of the importance for cooperation of different roles in urban logistics	Understanding	Understanding: to understand the importance of cooperation in urban logistics
Intrisinc Instrcution	Action	Demonstrating		Repetition	Present problem; Recover from errors	
	Tool	Event		Challenge; Multiple chance; Limited set of choice	Perfomance measure	
	Goal	Provide learning guidance		Gain attention	Providing feedback	

Figure 1. *Game blueprint*

5.3 Phase3: Reframing game premise

We developed a modified version of the original Pandemic game for our user study by simplifying the game to its core mechanics. The simplified version of the original Pandemic game ensures that the game can be played within 30 minutes. This time restriction is the requirement for the lecturers to adapt the game to be applied during a class session. As a result, we picked up some of the game elements and reduced the map size from 48 to 24 nodes. Then, we assigned each node's name as the city's street name that conducted the user study. The goal of the original Pandemic game is changed according to the urban logistics scenario. Thus, instead of discovering the cure, the goal is to solve traffic congestion and pollution by building an Urban Distribution Center (UDC).

The number of achievements has decreased from 4 to 2. The game strategies were added to tutorials and embedded in the learning contents derived from urban logistics scenarios. In addition to reducing the game's complexity, we added an option to introduce a subset of the additional game mechanics from the original game. These elements would not affect the main gameplay but provide the other dramatic elements required to make a stronger connection with the game premise. Initially, there are five roles of task and requirement. However, we adopted only 3 out of 5 roles for the stakeholders in the urban logistics scenario, i.e., operational expert, dispatcher, and medic roles.

We modified the game premise, which is the setting behind the game. The names of the players' actions and the names of their roles also need to be modified because they are different from the original Pandemic game version.

Our learning goal is to understand the concept and relation of stakeholders in urban logistics. Thus, we applied the urban logistics scenario to the game. There are three types of city stakeholders in the game, i.e., the Mayor, Logistic Service Provider (LSP), and Shop owner. The players have to cooperate to solve the traffic congestion and pollution problems caused by goods delivery from manufacturers outside the city.

Our design process focused on modifying the game elements' names, such as actions, roles of the players, and phrases in the tutorial, while keeping the game mechanics identical to the original version. Before the tutorial mode, the added story mode must be played to describe all stakeholders' roles, requirements, and relationships.

Table 1. *Phased game element.*

Game elements	The name of the game element indifferent versions of the game	
	Pandemic version	*Urban logistics version*
Game action	Treat	Release traffic jam
	Cure disease	Construct a UDC
	Build research station	Located at a UDC landmark
	Share knowledge	Share solutions
Other elements	Outbreak rate	Pollution rate
	Infection rate	Procurement rate
	Epidemic card	Market Expansion
Roles	Medic	Shop owner
	Dispatcher	Logistic Service Provider (LSP)
	Operations expert	Mayor

6 User studies

We have carried out two different user studies to evaluate the developed guidelines. In the first study, we investigate if the students (i.e., the game user described in the section 5) achieved the intended learning outcome. We used a pre-test and post-test evaluation according to [8]. Since the developer of the guidelines also worked on transferring the COTS game as described above, it limits the objectivity of the usefulness quite much. In a second study, we asked experienced developers of both serious and entertainment games to use the guideline and evaluate if the guideline, based on their experience, supports the process sufficiently well.

6.1 The first study: Game validation

The first user study response to RQ1: How can the Transforming Game Premise guideline support developers in developing cooperative SGs? We first validate the educational value

of the game prototype developed following our guideline to ensure that the guideline can support players to achieve learning objectives embedded in the game premise.

6.1.1 Measurement

To validate the proposed guideline, a set of 15 multiple choices questions is used to evaluate players' knowledge improvement according to the learning objectives of the implemented SG. The progress of the questionnaire score is the key to this validation. Participants are asked to complete the questionnaire before and after the game session to measure their improvement.

The questions are derived from the learning objectives embedded in the game. The learning objectives are 1) to understand the concept of urban logistics, 2) to understand stakeholders' requirements in urban logistics, and 3) to understand the roles of stakeholders in urban logistics. Each learning objective contains five questions. The total is 15 questions.

We used the same set of questions to investigate memory retention. After joining the study for ten days, we asked the participants to answer the questionnaire again. Additionally, we conducted a semi-structured interview with 14 questions about their attitude and memorization regarding the learning content and game premises.

To explore the effect of the premise, we conducted a semi-structured interview with eight questions related to participants' attitudes toward the game premise and player roles and learning contents after the play session for the first study.

6.1.2 Procedure

Two participants were randomly paired as a team in each session and randomly assigned to one game version. First, the participants were informed about the study and asked to complete a consent form followed by a demographic's questionnaire to assess their learning style, experience with board games, experience in digital games, and current gaming habits. After that, the participants were asked to complete a personality test and conduct a pre-test. Subsequently, they performed the game session starting from the story mode, two of the tutorials, the normal gameplay mode, then the normal gameplay mode with special abilities. The post-test is conducted immediately after the gameplay session is over. Finally, the examiner conducted a semi-structured interview by asking questions about the premise and satisfaction of the learning content.

Ten days after the first study, we asked the university students in the Logistics and Management class (n=52) to join the second study to evaluate memory retention. The participants were asked to repeat precisely the same experimental procedure. In the end, the examiner conducted a semi-structured interview by asking questions related to memorization.

6.1.3 Participants

We recruited 74 university students (46 female) for the experiment; 52 of them were bachelor's students who studied the supply chain economics and logistics course (n= 52), and 22 students were master's students from the management course (n=22). All the students were from the Industry Engineering Faculty. For the knowledge background, the master's student has more experience in studying logistics while the bachelor's student registered supply chain economics and logistics as the primary course. They were between 18 and 34 years old.

6.1.4 Results and analysis

We first conducted a paired sample t-test to indicate that our game design successfully fostered learning based on the three learning objectives embedded in the game. The results from the pre-test (M = 6.32, SD = 3.12) and post-test (M = 7.47, SD = 2.75) indicate that the addition of premises can foster learning i.e., t(36) = 2.745 and p = .008. After that, we

investigated the effect of the game premise on memory retention by comparing two studies with ten days gap.

6.1.5   Effect of the game premise on memory retention

In the first round, we began by conducting paired sample t-tests (only students from the supply chain economics and logistics course, n=52) between the two rounds' overall pre-test scores, post-test scores, and scores improvement of all participants (see Figure2):

Pair 1: Pre-test scores of round 1 and 2 (M = 2.25, SD = 3.15) The analysis revealed significant improvement in round 2, t(54) = 5.152, p = .000

Pair 2: Post-test scores of round 1 and 2 (M = 0.808, SD = 308) The analysis revealed no-significant difference, t(54) = 1.89, p = .064

Pair 3: Round 2's post-test scores and round 1's pre-test scores (M = 3.135, SD = 2.82) The analysis revealed significant improvement in round 2, t(54) = 8.01, p = .000

Pair 4: improved scores of round 1 and 2 (M = -1.442, SD = 4.18) The analysis revealed significant decrease on scores in round 2, t(54) = -2.49, p = .016
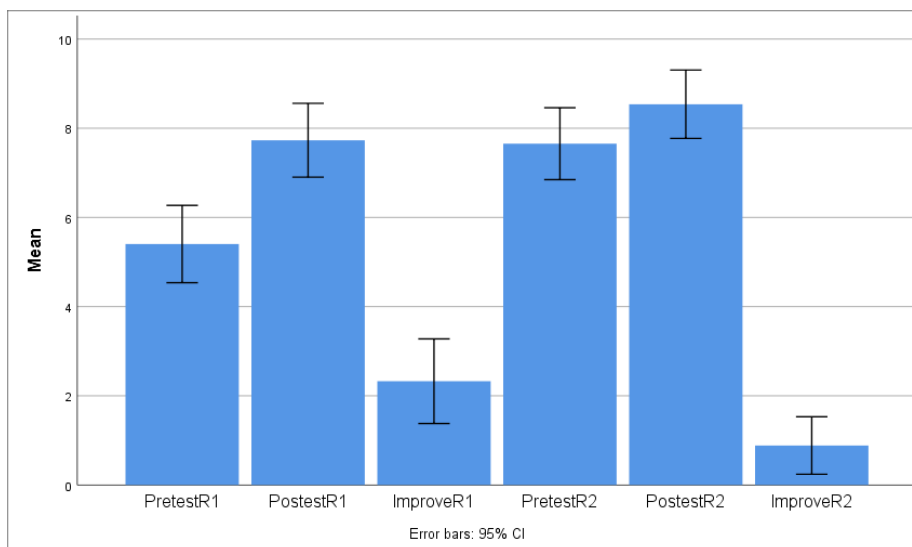

Figure 2.   *The average score for pre-test and post-test*

6.1.6   Semi-structure interview

In the second round of the study (after ten days), we asked the participants whether they still remembered the learning contents of the game. If yes, what reminds you of the learning contents? We conducted a Chi-square test to examine the relation of the frequency of the participants who answered "Yes" to the questions related to learning and memorization. The relation between these variables is significant i.e., (4, N = 52) = 10.658, p = .031.

Then, we asked them to identify which of the following game's elements can remind them of the learning contents: components, objects, and phases. We found that 32 of 52 participants mentioned that Ability, Goal, and Story are the game components that recalled their memory. They are the components derived from the game premise. Moreover, P34, P62, and P78 mentioned that playing a role as logistics stakeholders help them remember the urban logistics planning conditions.

6.1.7   Discussion

The significant difference in pre-test and post-test scores in the first and second rounds of play sessions showed players learning improvement. In contrast, the improvement score in the second round significantly decreased in scores in the second round. The results showed the possibility of practically implementing the Transforming Game Premise guideline by evaluating the players' learning improvement with a set of pre-test and post-test. Therefore,

it is concluded that our guideline is practical for players to achieve the intended learning outcome.

Even though this study indicates the success of transforming an entertainment game into a serious game using the proposed guidelines, we have to keep in mind that the case scenario and guidelines were developed by the same research team, thus influencing the results. Secondly, the online survey showed that game developers face challenges in finding suitable new models or frameworks. Therefore, in the next step, it would be necessary to test to what extent external game developers would perceive the guidelines as support.

6.2   The second study: Transforming Game Premise guideline validation

In this second user study, we evaluated users' (i.e., game developers) perception of the usability and usefulness of the Transforming Game Premise guideline. This user study responds to this article's RQ1, RQ2, and RQ3. For RQ2, we would like to know how the Transforming Game Premise guideline (procedure and documents) helps support developers in systematically converting cooperative entertainment games to SGs. For RQ3, we would like to know the considerations developers need to consider for applying the Transform Premise guideline or approach in their studios or labs are.

The goal was to obtain user feedback to address the issue, particularly usability, from game design and development experts. They are from the academic and game development industry and envision profit from utilizing the guideline. The participants were asked to play the game developed to verify the guideline, following our guidelines in section 5. After that, they were asked to transform the game into a different learning content by following the proposed Transforming Game Premise guideline. The procedure of the user study is presented in the next section.

6.2.1   Procedure

To verify the usefulness and usability of the Transforming Game Premise guideline, the participants who were experienced in the game and serious game development projects were invited to join a workshop. In the workshop, the participants were grouped according to their familiarity. The participants who were colleagues were in the same group. Each group consists of two to three participants. In each group, the participants need to include at least one participant who has experience in game design or serious game design, while another participant needs to have experience as a programmer in-game or serious game development projects. Each group attended the workshop separately on different days to ensure that the participants were closely observed during the sessions.

The objective of the workshop is to verify the Transforming Game Premise guideline. The participants were asked to play our game prototype and use the Transforming Game Premise guidelines to modify the game to a new game version with a different set of learning contents. Before starting the experiment, the Transforming Game Premise guideline was described to the participants. Participants were guided to do the task as follows steps.

Firstly, the participants were asked to choose two different scenarios, which later would be used to modify the game. The two scenarios are Pandemic management and Marine Spatial planning. The two scenarios are selected for this assignment because it requires the involved stakeholders' cooperation to solve the problems, similar to the urban logistics scenario.

After that, the guideline and documents for the Transforming Game Premise were given to the participants. The participants were asked to follow the guideline. The assignment is to transform the original games (urban logistics games) into the chosen scenario (Pandemic management or Marine Spatial planning). The participants were asked to follow the guideline and documents to finish the final step of the transformation. Finally, they were

interviewed to discuss the usefulness and usability of the Transforming Game Premise guideline and their opinions on applying it in their project.

The workshop's scope excludes the first phase of the Transforming Game Premise, which is to select reference games due to time limitations. However, the participants were introduced to selecting a reference game and were asked to give an opinion on the process at the end of the workshop.

6.2.2   *Participants*

Nine experts in game design and development in both academic (n=5) and game industry (n=4) were recruited to evaluate the Transforming Game Premise guideline. All participants have experiences in various roles in game development projects, such as game designers, game programmers, game artists, and project managers. Some of them are also researchers in games and SGs areas.

The backgrounds of participants are described in more detail. P1 is a 3D game artist and game design researcher working on game mechanics and aesthetic elements of serious games. P2 is a game developer and researcher working on the game pipeline and data analytics of massively multiplayer online role-playing games (MMORPG). P3 is an AI game researcher with a game developer background. He works on applying deep learning to create characters' behavior in games. P4 is a junior researcher in game design. She has experience in various game and SGs development projects as a game artist and game developer. P5 works as a game designer at a local game studio. He is involved in various game and serious game development projects and has experience working with the multidisciplinary team in SG development projects. P6 works as a game developer and game designer with a local game studio working on gameplay and the development of game mechanics. He has experience in applying a systematic approach to game development projects. P7 works as a game tester with a local game studio working on developing learning games. P8 is a junior researcher. He has experience in various games and SGs development projects as a coordinator and project manager. P9 is a freelance game developer working on gameplay and developing game mechanics of SGs. Participants are between 18 and 39 years of age, with eight males and one female. It is noted that there is only one female participant in this study. The number is statistically reasonable, confirmed by the statistics of game developers worldwide survey, which stated that 61 percent of responding game developers were men, while 30 percent were women. The demographics are summarized in Table 2.

Table 2.*Demographics of the participants.*

Group ID	Participant ID	Field of work	Exp. in SG projects	Gender
G1	P1	Game designer/2D-3D Artist	Yes	Male
	P2	Game programmer/ Game data analysis researcher	Yes	Male
G2	P3	Game programmer/ AI for a game researcher	Yes	Male
	P4	Game designer /2D-3D Artist	Yes	Female
G3	P5	Game designers from the industry	Yes	Male
	P6	Game programmers from the industry	Yes	Male
	P7	Game tester/ designer from the industry	Yes	Male
G4	P8	Game designer/ Project manager	Yes	Male
	P9	Game programmer (Freelancer)	Yes	Male

6.2.3   Interview

We were interested in evaluating the usefulness and usability of the Transforming Game Premise guideline for those transforming a game. We group interview questions into three parts.

The first set of questions is related to utilizing the approach to the existing game. Only the modification of the game premise is allowed. We asked the participants to give their opinions, concerns, and limitations to applying the approach in practice.

The second set of questions is related to the usability of the guideline procedures and their documents. The participants were asked to simplify the game using the guideline procedure and documents during the workshop session.

The last set of questions is related to their opinion on applying the guideline to their game studio or laboratory. The participants were asked to give an example of the existing projects that could use the guideline. Lastly, they were asked to discuss the possibility of applying the guideline to their projects. After that, the participants were asked to give feedback on the guideline.

6.2.4   Results

To analyze the interview results, we first collected the answers and classified them into three main categories mentioned in the previous section, i.e., utilization, usability, and application. Then, we summarized similar responses to reduce the number of statements. The selection criteria are set. Two authors repeatedly grouped the information to minimize bias.

We then scanned the answers for the emerging topics apart from the ones we defined for the interview. We identified the categories of i) General comments, ii) Usefulness and usability of the Transforming Game Premise guideline and iii) Limitations, and concerns of utilizing the Transforming Game Premise guideline. In the following, we present the results along with these categories as follows:

  i.   General comments

We asked participants to give their opinion on utilizing the Transforming Game Premise approach. Thus, we focused on the question of reusing the existing games, especially the game for entertainment purposes, to modify the premise to transform them into SGs. The answer includes (P1, P2, P5, P6, and P7) mentioned that the Transforming Game Premise is an interesting approach to minimizing the time and cost of developing SGs. The participants (P3, P9) said that the procedure similar to the practice generally utilized in the game industry is called "reskinning" games. However, it is interesting that the Transforming Game Premise guideline also includes the analysis process provided in Phase2: Develop a game blueprint guide developer to select specific game elements that need to be taken into account when reusing the existing games (P3). P5, P6, and P7 mentioned that keeping the core gameplay of the entertainment games that are already fun and balanced mechanics can reduce the development team's workload in implementing the whole new system. At the same time, it still ensures that players can enjoy the core mechanics that remain in the existing game.

  ii.   Usefulness and usability of the Transforming Game Premise guideline

Data regarding the usefulness and usability aspects have targeted the usability of procedures and documents for the Transforming Game Premise guideline. All participants were able to fill out the provided documents to follow the process of transforming the existing game's premise into the new learning content. (P1, P2, P5, P6) mentioned that the document supports the development team in cooperation. The game blueprint helps the team understand the requirements (P1, P9) and the game's structure that the team is implementing (P2). The blueprint also allows the team to improve game designers to structure game flow (P8). P5 mentioned that Phase3: Reframing game premise supports designers in modifying the game's learning content and helps designers and teams track back to the original design.

iii.   Limitations and concerns of utilizing the Transforming Game Premise guideline

P1, P2, and P5 mentioned that following the guideline's procedure is essential to effectively utilize the Transforming Game Premise guideline. To be more specific, the developers should analyze the existing games (Phase2: Develop a game blueprint) before reframing the premise. We asked for a particular reason regarding the suggestion. The participants also mentioned that it is essential to know the game structure before modifying its premise to ensure that the learning contents will be embedded in the game in a meaningful way.

Additionally, all participants mentioned that Phase2: Develop a game blueprint support analysis of games. However, the game blueprint could not show the interaction of the multiplayer. For, Phase3: Reframing game premise, it is vital to consider adding core mechanics for flexibility in embedded learning contents to the games (P4, P5, P7, P9). P1 noted that the Transforming Game Premise guideline might suit small studios rather than medium and big ones.

6.3   Discussion

In the following subsections, we discuss the interview data related to RQ2 and RQ3 of this article. For RQ2, we would like to know how the Transforming Game Premise guideline (procedure and documents) helps support developers in systematically converting cooperative entertainment games to SGs. For RQ3, we would like to know the considerations developers need to consider for applying the Transform Premise guideline or approach in their studios or labs are?

6.3.1   Transforming Game Premise approach as an option for developing cooperative SGs

Our participants positively support that the approach is practical to transform the premise of the existing cooperative entertainment games or SGs for developing cooperative SGs. Especially the approach of using entertainment game elements to engage players in non-entertainment games. The mentioned interview results are in line with the research from Deterding [22], which stated that the usage of entertainment game elements in gamification could maintain players' engagement while keeping the game's educational value. Additionally, the participants emphasized that the guideline could help developers maximize the existing game elements, saving overall development time. This beneficial guideline helps developers reuse facilities of the previous project. The results of our study support the reusing approach stated in Carvalho's research [1]. Moreover, the participants emphasized that the analysis of the existing game using ATMSG [1] can support developers in selecting suitable existing games.

Based on this finding, we are confident that the proposed Transforming Game Premise guideline is a beneficial approach that can be an option for developing SGs.

6.3.2   Using the Transforming Game Premise guideline (procedure and documents for supporting developers in systematically converting cooperative entertainment games to SGs

We collect positive feedback from participants during the procedure and documents. The participants point out that the analysis tools such as the flow chart and Activity Theory-based taxonomy support them in team communication. The illustration of the diagram from ATMSG gives extra explorations to the game in many different aspects depending on the participant's role in the development team. However, this work focuses on supporting the development of cooperative SGs. Thus, it is essential to analyze the relation between game elements and players' interaction/cooperation [33]. From this point, the participants comment that identifying player interaction in the game still needs more clarity. The participant's comment on social interaction and the multiplayer game is also discussed as a research gap in Carvalho's works [1].

Further, it is found that the arrangement of the guideline should be modified according to the participants' feedback. The documents produced from the game premise conversion procedure are followed initially by the reframing premise documents. However, it is suggested by the participants that this sequence should be inserted with the game analysis process, i.e., before the reframing process. By doing this, the team can have the same gameplay overview to phasing the premise and modifying the learning contents.

6.3.3 Considerations for applying the Transform Premise guideline or approach in game studios or game research labs

We noted feedback on the consideration and limitations of applying Transforming Game Premise and listed them as follows.

- Copyright of the selecting games: even the "reskinning game" is a similar approach in the game industry. However, it is a sensitive issue for creative works. Therefore, the participants suggest selecting the in-house game to implement this approach to avoid unexpected problems. Note that for this article, the Pandemic game is used for experimental purposes only.
- Project stage: the guideline suggested to apply in the pre-production of a game development project to gather requirements and illustrate the game flow in the project's initial phase.
- Adding game elements: In some cases, the game elements may need to be added to link the elements with learning content. The analysis tools provided in Phase 2 can support the process of adding the game elements. The devices can help developers ensure that the added elements link with the learning element of the game.
- Size of the development team: participants suggested that the Transforming Game Premise guideline is suitable for application in small and medium-sized studios/labs (5-10 persons) to decrease complexity in communication.

7   Conclusion and future work

We proposed the guideline to transform cooperative entertainment games into cooperative SGs. Our method includes a set of guidelines that helps the SGs development team to select the existing cooperative entertainment games. The procedure is to develop an initial design, game blueprint, that shows the relation of the learning and the game elements, then transfer the entertainment premise to the serious game premise while keeping track of the modified version.

The main contribution of this paper is to provide the guideline for converting the full-fledged game, then changing the game's premise instead of reusing elements/parts of the games, which is the regular practice for developing SGs.

Based on the two us er studies, we could verify the guideline's usefulness and usability from two perspectives, i.e., the content user (player) and the developer user.

The first study was a preliminary study to verify the game developed following our guidelines by measuring the learning improvement of the players. The learning improvement can be considered the guideline's effectiveness indicator because it is the outcome of the serious game value. Therefore, this statement supports RQ1, RQ2, and RQ3, which are mainly focused on developers' points of view. The semi-structured interview results of the first study led to further investigation in the second study.

In the second study, we validate the usability and usefulness of the Transforming Game Premise guideline with game and SG developers. The first study results confirm that the game developed using our guideline support players in achieving learning outcomes. In the second study, game developers approved that the guidelines were helpful in the game development process. According to the evaluation results of the second study, we conclude that the transforming game premise guideline is beneficial in supporting a developer team

in systematically developing cooperative SGs. The guideline can help identify requirements and build game blueprints in the initial stage of game development projects.

Additionally, the guideline provides the documents to keep track of the original design to the modified version. The documents can support developer teams in rephasing premises with different learning contents in future projects. The qualitative results of the second study respond to research questions (RQ1, RQ2, and RQ3) directly.

In the future, we will iteratively improve our guidelines based on the feedback collected from game and SGs developers. In the refinement stage of our guideline, we will compare our guideline with other approaches to verify the usefulness and usability of the final version of our guideline.

Disclaimer Statements

In this article, the Pandemic game is used for educational purposes only and will not be used in commercials. Additionally, the testing was conducted in an academic environment only. We suggest developers who would like to apply our guidelines to their projects first consider the in-house games to avoid copyright issues.

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