Design and Application of a Social Components Framework of Educational Games (SCFEG)

--Based on Popular Science Game “Huaxia Medicine Fairy”

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Abstract. Guiding by Activity Theory and previous studies, this study designed a Social Components Framework of Educational Game (SCFEG) as the theory-based mechanism or framework to guide the systematical design of social attributes for the Traditional Chinese Medicine (TCM) popular science game. By adopting SCFEG, this study depicts the initial design pictures of social structure of the first and second outposts of “Huaxia Medicine Fairy”. This study may bring some guidance and directions for the designers of popular science games, educational games or serious games.

Keywords. Activity theory, social components, popular science game, educational game, traditional Chinese medicine (TCM)

1. Introduction

With the development of science and technology, the global game market continues to develop and flourish. The educational nature of games attracts more and more attention. As Katharina Tillmanns, a researcher at the Cologne Game Lab, points out, "Games are not just developed for entertainment. It is also for sharing knowledge, experience or skills with others in an interactive entertainment way." [1]

As a branch of educational games, popular science games have been supported and developed because of their characteristics of both popularization and entertainment [2]. In the Science Popularization Development Plan of China Association for Science and Technology (2016-2020) issued by China Association for Science and Technology, promoting the development of science popularization games is included in the prosperity project of science popularization creation [3].

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Chinese herbal medicine is a precious treasure of China. Popular science education of Chinese herbal medicine knowledge is an important part of national health education. Chinese herbal medicine has played an important role in COVID-19 epidemic prevention and control. In April 2021, the Foreign Ministry and the State Administration of Traditional Chinese Medicine (TCM) held an international Cooperation Forum on TCM and the Fight against COVID-19 under the theme of "Deepening Exchanges and Cooperation in Traditional Chinese Medicine and Building a Community of Human Health".

In recent years, some scholars have used games as a carrier to spread TCM knowledge. For example, Hu, Xiao and Li (2021) demonstrated the educational value of medical science popularization games [4]. Wang et al. (2017) discussed the game learning activity design of "Herb Master" for the purpose of spreading TCM culture [5]. Yuen et al. (2021) discussed the application effect of medical game learning activity design [6]. However, as Zhu and Gu (2021) point out, the common problems of popular science games are lacking systematical social attributes design and related theory-based mechanism [7].

Based on the above statement, is there a theory-based mechanism or framework to guide the systematical social attributes design for the TCM popular science game? This is the main problem that this study aims to address. First paragraph.

2. Literature Review

Chinese doctors and scientists Luo, Duan and Chen (2018) used English term of "popular science games" in their Chinese paper, with taking the first health popular science game with the topic of Health China and Peking Union College Hospital's action as an example, they promoted "popular science games" as new mode of carrying out medical popular science in public [8].

The term of "popular science" is translated from Chinese term "Kepu". Some Chinese scholars defined Kepu games in Chinese. For example, according to Zhu et al. (2021), Kepu games are "electronic games that aim at popularizing science and from which participants can gain scientific knowledge, methods, ideas and spirit"[7].

In recent years, researches related to Kepu games in the field of Traditional Chinese Medicine (TCM) appear now and again. However, few of them are very famous studies, and hardly any game is well-known by publics. For instance, Wang et al. (2017) designed a Traditional Chinese Medicine (TCM) game named "Herb Master", players carry out an immersive game experience in the form of role-playing. The game is divided into four parts: Seeds Base, Herb Garden, Assistant and Guide, and Medical Museum. In different parts, they built different tasks for playing and learning. However, its research has not evaluated the effectiveness of TCM science popularization, the systematical design is rough and of poor quality, and lacks social attributes like team mechanism and related theoretical background [5]. Just as Zhu and Gu (2021) commented, one common problem of Kepu games is the lack of systemically effective design and social play mechanism [7].

Few foreign scholars used the term of "popular science games", and international researches in the field of popular science games are also limited. A large number of researches all over the world are related to educational games or serious games. Laine and Lindberg (2020) conducted a systematic literature review in the field of educational games and proposed 56 game motivators in 14 classes and 54 DPs(Design Principles) in

13 classes. The 14 classes of game motivators include: Challenge, Competence, Competition, Control, Curiosity, Emotions, Fantasy, Feedback, Immersion, Novelty, Rules and Goals, Real World Relation, Social interaction, and Usefulness. The 13 classes of DPs are listed as: Challenge, Learning, Control, Profile and ownership, Relevance and relatedness, Creativity, Resources and economy, Exploration, Fairness, Social play, feedback, Goals, Storytelling and fantasy. However, they did not explain the relationship and operating mechanism among the game motivators in details either in text or in DPs. For instance, they listed 6 principles in the category of Social play, however, none of the principles explained the structure of social interaction [9]. Martin, Ruiz-Rube, López-Martín, Calvo, and Lopez (2020) designed a collaborative educational game named BECO Games platform for an Economics subject. They tested the effectiveness by comparing the performance of Bachelor students in the control group and the experimental group. They described the functional features of the platform and the computed formula for individual performance with considering of the contribution of each group member. However, the computed formula is only adaptable in certain Economics subject, furthermore, they did not describe the game element in the social collaborative play which make the activity not clearly presented, and not real-world relation, and also lack a theoretical framework either for designing or evaluating or describing the social structure [10].

“Serious games are generally defined as digital software the primary purpose of which is learning rather than entertainment.”[11][9] “serious games are games that incorporate concept of notation and that give the user skills, knowledge or attitudes that can be applied in the real world”. [12][13] Derksen, Van, Kunst, Daams, Jaspers and Fransen (2020) systematically reviewed 15 studies on serious games aimed at changing smoking behavior, and extracted game elements from the game descriptions of those studies. In their study, social features (eg, social aspects of game playing) mainly emphasized social support networks which offer platforms for increasing motivation in quitting smoking [14].

Aubeux D et al. (2020) included 18 dental students into 4 groups as research objects to analyze the impact of teamwork activity design on the completion of practical tasks in the medical game called "escape game". The medical game adopts the mechanism of puzzle driven, intra group collaboration and expert support. The results show that most students believe that “escape game” is helpful for them to recall/apply knowledge whilst promoting teamwork. However, they lack a theoretical framework either for designing or evaluating or describing the social structure [12].

Law and Xu (2012) borrowed Engeström’s (1987) extended framework of Activity Theory (AT) as the theoretical framework for evaluating the interactions between the game players, especially for understanding the contradictions and breakdowns in group User Experiences (UX). Although AT which is rooted in cognitive psychology does not explicitly address affective constructs, they see it as a chance rather than a hindrance, and extend it to cover the experiential aspect of human-technology interaction. They put forward a four-dimensional evaluation framework (table 1). However, their framework has limitations, as they claimed, the social dimension is implicit rather than explicit in the framework (table 1), and the game they tested was originally designed for individual players. The attributes of each dimension deviated much from the original AT, causing incoherence and confusion (Law & Xu, 2012) [15].

Carvalho, Bellotti, Berta, Gloria, Sedano, Hauge, Hu and Rauterberg (2015) presented a model named Activity Theory-based Model of Serious Games (ATMSG), which depicts three main activities – gaming activity, learning activity and instructional

activity. Each activity is formed by a sequence of actions, which mirror the triangle of activity. Each activity also mediated by tools, with specific goals. However, as Carvalho et al. (2015) indicated, “While considering a variety of gaming and learning factors, the ATMSG model does not contemplate the underlying social structures that mediate the relationship of the subject and the object with the community. This limitation reflects the features offered by the great majority of serious games, but should be addressed in the near future. In particular, the model should incorporate the analysis of collaboration and cooperation aspects in a serious game” (p.180) [16].

Based on the above literatures, it can be seen that most former studies lack an explanation of systematical design of the social structure, and lacking related theory-based mechanisms underlying the aspect of social play. As activity theory is demonstrated to be a reasonable theoretical framework for evaluating the interactions between the game players (Law and Xu, 2012; Carvalho et al., 2015), this study aims to design a Social Components Framework of Educational Game (SCFEG) based on activity theory, and adopt it to design pictures of the first and second outposts of a new popular science game named “Huaxia Medicine Fairy”.

3. Theoretical Background

Engeström (1987) views all human activities as contextualized within an interdependent activity system, and depicts a triangular structure of an activity system with seven components which are described as Subject, Object, Tools, Community, Division of Labor, and Rules (Figure 1). Each of these seven components serve a distinct function and work together to set up an activity.

- A. Subject: an individual engaging in an activity;
- B. Object: an objective or motive held by the subject for performing an activity;
- C. Tool: material or mental agency mediating the subject – object interaction;
- D. Rule: regulations of actions and interactions in an activity;
- E. Community: one or more people sharing the objective with the subject;
- F. Division of labor: how tasks, power and status are divided among cooperating members of the community;
- G. Outcome: an idea, a situational status, or a specific positive/negative emotional response.

Figure 1. Activity triangle model (Engeström, 1987, p. 78)

According to Engeström (1987), Activity Theory is a psychological and multidisciplinary framework for studying human practice by interlinking the individual and social levels (Heo & Lee, 2013). Activity Theory explains the learning processes

that result from particular actions of learners in a particular context, actions that eventually benefit the learners through expanded knowledge, skills, and attitudes as the final result (Heo & Lee, 2013).

4. Social Components Framework of Educational Games

Leading by Activity Theory (AT), based on former studies, especially based on Carvalho et al.'s (2015) ATMSG model, this study put forward a Social Components Framework of Educational Game (SCFEG),

Table 1 depicts two main social activities and seven elements, and the relationships between activities and elements in this system. The two main social activities are Community Game Activity, Community Learning Activity. The seven elements are Actions, Subjects, Goals or Objectives, Tools, Rules, Labor Divisions, and Community. Among them, only “action” is an element beyond the six components of the Activity triangle model (Figure 1). Based on the activity theory, the activity is realized by a sequence of actions, each of which may be directly related to the motives or the goals/objectives (Devane & Squire, 2012, chap.10; Carvalho et al., 2015).

It is possible to see that the community gaming and the community learning activities share the same subject (the player/learner), but they have different driving motives or objectives, thus they also have different rules, tools and labor divisions at most conditions (Table 1) .

Table 1. Social Components Framework of Educational Games

	Community Game Activity	Community Learning Activity
Actions	How does the game unfold? What story? How many/what game levels?	What tasks does the subject do in the game for learning?
Subjects	Who is the player?	Who is the learner?
Goals/ Objectives	What does the subject have to achieve in the game at this game level or point?	Which knowledge or skills the learner is expected to acquire at this learning activity/moment?
Tools	Which instrument are involved/used at this game level of point?	Which instrument the learner is expected to acquire at this learning moment?
Rules	What rules are involved/used at this community game level of point?	What rules are involved/used at this community learning activity/moment?
Labor Divisions	What is each player's labor in the community game activity?	What is each learner's labor in the community learning activity?
Community	Who are the game community member?	Who are the learning community member?

5. Application of SCFEG in “Huaxia Medicine Fairy”

5.1. Story of Huaxia Medicine Fairy

The story takes place in the future world. There is an island deep in the Pacific Ocean. It is said that there are immortals living on the island. The immortals know magic and

take charge of all kinds of Chinese herbal medicine. Because the medicine fairy comes from ancient China, the medicine fairy is called "Huaxia Medicine Fairy".

People from all over the world came to the island one after another, some because of curiosity, some want to become a magic doctor. Those who came to the island trying to become a magic doctor met a series of magical things...

Players will be asked to form a team, because it is difficult for a person to break through a series of outposts. A group of 2-4 people is required, so that it is easier to successfully see the medicine fairy, and learn knowledge. The whole game is initially designed into five outposts: 1. Team Slogan; 2. Knowledge Palace; 3. Apprentice Hall; 4. Team Practice; 5. Huaxia Pharmacist.

This study takes the first and second game outposts of Huaxia Medicine Fairy as examples to explain the application of Social Components Framework of Educational Game (SCFEG).

5.2. Description of Team Slogan

Team Slogan is the first outpost, in this part, the activity mainly belongs to Community Game Activity. The seven components are described in the following subsections.

5.2.1. Actions

The system of “Huaxia Medicine Fairy” requires players to find partners and form team, all team members need finish several actions, which are listed in table 2.

Table 2. Actions of 1st Outpost Pass

Actions				Description
Sincerity Test				Some questions to test Sincerity and be given score
Form Team				Find and invite others to form team
Set Team Roles				Discuss and set team roles, system will set some roles for them to choose
Set	Group	Name	and	Name group and set a Slogan
Slogan				

5.2.2. Subjects

In terms of each team, the subjects are team players or members. They have several attitudes, for instance, Decorations (tops, pants, boots, armor, skirts, hats, bracelets, earrings, rings, watches, etc.), which can be updated to be different levels. Beauty service, which can be updated to different grades: ordinary, bright, beautiful and stunning)

Decorations and beauty services can be obtained through gold coins. These are consumables and will cost gold coins, but it is conducive for players to find better partners.

5.2.3. Objectives/Goal

The core objective is 1st Outpost Pass, or pass the 1st Outpost. In order to success, each team member need fulfill the following sub-objectives showing in Figure 2. The sub-objectives are:

- A. Experience coins: players will get a certain number of experiences coins every time when they complete a task or action.

- B. Teamwork Jewels: it refers to teamwork ability in the process of finishing all the actions.
- C. Time: It refers to the time consumed in each outpost. In different outpost, the system has a deadline or time limit, that is, the limit value, which means players need finish all the actions within a certain time, or they will lose and start again.
- D. Title or reputation: it refers to the final action, when the completed the final task or action, they can be upgraded and have a title. This game has 11 titles in total.

Figure 2. Objectives of 1st Outpost Pass

5.2.4. Tools

First of all, players will have an additional "Backpack System". In the backpack system, there are their action lists. Hence, in the first outpost, tools mainly include Backpack System; Action Lists; Clothes related to Roles and so on.

5.2.5. Rules

Rules in the 1st Outpost Pass can be summarized in table 3.

Table 3. Rules in the 1st Outpost Pass

Rules	A. Peers should unify goals, establish trust mechanisms, and help each other B. For each additional member, all players will add a Teamwork Jewel C. Each player must choose a role according to the situation and get the consent of the team members D. Collaborative partners are satisfied with each other's roles and feel fair E. Once a partner is selected and leaves the team halfway, his/her Teamwork Jewel will be cleared
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5.2.6. Division of Labors

In the first outpost, the division of labors is mainly embodied in the Roles that they choose, the roles are designed as Leader, Trouble Shooter, Coordinator, General Member...

5.2.7. Community

In the first outpost, the community members mainly include the group members of each team from the narrow sense. While in a broad sense, the community members mainly include all the players or all the groups in the game.

5.3. Description of Second Outpost- Knowledge Palace

Knowledge Palace is the second outpost, in this part, the activity can be divided into Community Game Activity and Community Learning Activity. However, most actions mainly belong to Community Learning Activity. The seven components of Community Learning Activity are described in the following subsections.

5.3.1. Actions

In this part, the system requires learners to learn knowledge, they meet different Herb Goblins or elves. These elves came from the cultivation of Chinese herbal medicine. They turned into human shapes and were imprisoned on the island by drug immortals to help apprentices cultivate. All team members need finish several actions, which are listed in table 4.

Table 4. Actions of 2st Outpost Pass

Actions	Description
Lesson1 by Herb Goblins	Learners learn some stories about Chinese herbal medicines by Herb Goblins
Knowledge Test1	Learners do the knowledge test1
Lesson2 by Herb Goblins	Learners learn some new stories about Chinese herbal medicines by Herb Goblins
Knowledge Test2	Learners do the knowledge test2
Lesson3 by Herb Goblins	Learners learn new stories about Chinese herbal medicines by Herb Goblins
Knowledge Test3	Learners do the knowledge test3

Every time one passes the test, his/her title will be promoted one level. As there are three tests, their title/reputation can upgrade three levels when they successfully pass the 2nd outpost.

5.3.2. Subjects

In this part, learners are the players who pass the 1st Outpost, and at the same time, they still stayed in their team.

5.3.3. Objectives – 2nd Outpost Pass

The core objective is 2nd Outpost Pass, or pass the 2nd Outpost. In order to success, each team member need fulfill the following sub-objectives showing in Figure 3. Compared with the 1st Outpost Pass, in this part, learners need fulfill two more sub-objectives, which are Herbal Knowledge and Gold Coins.

- A. Chinese herbal medicine knowledge: learners will get certain Chinese herbal medicine knowledge points every time they do a right question. One can pass the exam only after having a certain number of points.
- B. Gold coin, refers to money: players will get a certain number of gold coins every time they do a right question. Gold coins are synchronized with Chinese herbal medicine knowledge points.

Figure 3. Objectives of 2nd Outpost Pass

5.3.4. Tools

They mainly refer to the typical learning environment of each learning activity link, herbs planted in the virtual herb garden, Chinese herbal medicines in the backpack system, Chinese herbal medicine books, Chinese herbal medicine pharmacies, herbal medicine cutting tools such as sickle, traditional Chinese medicine processing tools such as medicine cutting knife, etc.

It is worthy to mention the Gold Coins they earned by learning knowledge are their new tools to beg help from their peers. Besides, fairness cards and unfairness cards are used for collaboration, a team member can ask their peers for teamwork jewel when they find more Herb goblins, if their peers reject their member, their member can post them unfairness card.

5.3.5. Rules

Rules in the 1st Outpost Pass can be summarized in table 5.

Table 5. Rules in the 1st Outpost Pass

Rules	<p>A. Each test must be completed within the specified time</p> <p>B. Divide labors to find Herb goblins, and feel fair for everyone.</p> <p>C. When completing the task, you can ask your partner for help. You will gain 1 teamwork jewel, a certain amount of experience coins (3) and lose a certain amount of gold coins (5)</p> <p>D. Companions who provide help will obtain 1 teamwork jewel, and get the same number of (5) gold coins and a certain number of (3) experience coins</p> <p>E. If you still can't answer the question with the help of your partner, both your partner and yourself will lose a certain amount of (3) gold coins</p>
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5.3.6. Division of Labors

In this part, team member will have the same number of opportunities to meet Herb goblins, they need find the Herb goblins together following the clues in the game. For instance, in the knowledge hall, there are 60 Herb goblins, within the certain time, one group find 10 different goblins, they can have one test. Members need divide labors, for instance, each member of a group with 4 members at least find 3 Herb goblins, listen to their lesson and story. After that, they will have test1 with the help of each other.

In the process of collaboration, attention to the belief of fairness and justice, and cooperative attitude are very important.

5.3.7. Community

In the second outpost, the community members mainly include the group members of each team and the Herb goblins they met from the narrow sense. While in a broad sense, the community members mainly include all the learners of all the groups and all the Herb goblins inside the knowledge palace.

6. Discussion and Conclusion

Based on Activity theory, this study put forward a Social Components Framework of Educational Game (SCFEG), which are supposed to be helpful for the design and evaluation of the social attributes of educational games, popular science games or serious games.

This study takes the first and second game outposts of Huaxia Medicine Fairy as examples to explain the application of Social Components Framework of Educational Game (SCFEG). The Community Game Activity and Community Learning Activity with the seven components are well designed respectively by using SCFEG. It can be seen that the SCFEG is an adaptive and meaningful theory-based framework.

This study is limited. "Huaxia Medicine Fairy" is a new and undeveloped game with a preliminary design. The effects of "Huaxia Medicine Fairy" on students' learning result and attitudes have not been tested. The research group of this study will further investigate the design and effects of "Huaxia Medicine Fairy" on students' learning in the future, as well as further improve the content of SCFEG.

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