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The Development of Guidelines to Design Collaborative Serious Games for a New Educational Game Platform.

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Abstract

Games can be played for fun, but there are also games that aim to teach players new skills or knowledge. These serious games can be used in education, but learning does not naturally occur form games. Research identified several factors that support learning in games, one of these factors is collaboration. A new educational gaming platform that uses collaboration as a key element, is Luqo. However, the company does not have sufficient knowledge about how to create a serious collaborative game. Besides, literature does not provide a clear overview of which elements should be incorporated in serious collaborative games. For this reason, a set of guidelines will be designed for Luqo, to guide the design of serious collaborative games.

The design process was guided by the generic design model from Mckenney and Reeves (2012). After analyzing the context, a theoretical framework was established to define relevant elements in the fields of serious games, learning support and collaboration. This has led to a first set of guidelines. After that, five evaluations were used to test and improve the guidelines. These evaluations consisted of assessing existing programming and collaborative games, discussions, interviews and a case study. After each evaluation, changes were made to the guidelines and a new version was established before starting the next evaluation.

The step-by-step process that was used to design and evaluate the guidelines provides a clear overview over the whole process. Each evaluation had some strong and weak points, but each helped to identify new points for improvement. However, the guidelines could still benefit from further research. For example, it was not tested if novice designers are able to design a game based on the guidelines. Also, it showed that the guidelines can elicit discussions about how certain elements can be applied. However, even though the guidelines seemed usable as a design tool, it was not tested if using the guidelines leads to games from which students effectively learn new skills or knowledge.

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1 Introduction

Many games are already available on the market for children. These are not only games that can be played just for fun, but also games from which children are supposed to learn new skills or knowledge. These so-called serious games can be used in education for a variety of subjects in different grades. It seems intuitive that children born in a digital world with a large role for computers, enjoy working with computers, are used to playing computer games, and are therefore receptive to learning with computer-based materials (Girard, Ecalle, & Magnan, 2013). This was supported by the finding that playing games is more motivating for students than traditional teaching methods (Papastergiou, 2009). However, existing research shows that students can learn from serious games, but learning does not occur naturally by playing a game (Wouters & van Oostendorp, 2013).

Several studies have researched relevant factors for learning in the context of serious games. According to Wouters, van Nimwegen, van Oostendorp and van der Spek (2013), games can affect learning by influencing motivation and by altering cognitive processes. Also, active cognitive processing of learning material is required for learning to be effective and maintained. It helps to construct or automate cognitive schemas (Wouters, Paas, & Van Merriënboer, 2008). This fits computer games, since activity is one of their key characteristics (Wouters et al., 2013). Besides that, if a game task overlaps with cognitive and psychomotor processes in real world situations, performance in the real world can increase as a result of playing the game (Tobias, Fletcher, Dai, & Wind, 2011).

Other factors that could improve learning from games were studied by of Wouters and van Oostendorp (2013). This study showed that learning from games can be improved when certain types of support are embedded. Ten types of support were identified, of which six positively affected learning, these are reflection, modeling, collaboration, modality, feedback and personalization (Wouters & van Oostendorp, 2013). One of these factors, namely collaboration, will highlighted because it has become one of the dominant instructional methods in schools and it can be used for different subjects and in different grades (Johnson & Johnson, 2009). Collaboration is sometimes also referred to as cooperation, both terms have a slightly different meaning based on the amount of task division in the group (Dillenbourg, 1999). However, since both terms are used interchangeably, it remains unclear when each term should be used and what is the exact distinction between them. In this study, the term collaboration will be used to refer to groups of students working together on a task, to avoid confusion between the two terms. Collaboration plays a key role in a new gaming platform called Luqo, which provides the context for this study. The Luqo company has

developed an interactive gaming platform on a new type of gaming device for which serious games can be designed.

Even though it seems to be an effective type of learning support that can be used in serious games, there is no clear overview of which factors should be present in a collaborative serious game. On the one hand, several game design frameworks are available that could be used to develop serious game, but collaboration is not part of these frameworks. (Annetta, 2010; Marsh, 2011; Mitgutsch & Alvarado, 2012). On the other hand, important factors to facilitate collaboration were identified by Johnson and Johnson (2009), but these were not directly linked to serious games. It is important to have such a framework for collaborative serious games, since collaboration requires more than just putting students together in a group to achieve effective learning (Johnson & Johnson, 2009). Consequently, there is a need to design a new framework that combines elements of collaboration and game design to develop collaborative serious games that can effectively support learning. A question that arises from this is: how do game developers think these guidelines can help the design process of collaborative serious games? Thus, the goal of this study is to establish a set of guidelines that will help to design collaborative serious games. This will be done in the context of the new gaming platform, Luqo.

2 Design process

The design process will be guided by a generic model for conducting design research in education. This model, presented in figure 1, was proposed by Mckenney and Reeves (2012) and consists of three topics. First, analysis and exploration, design and construction, and evaluation and reflection are the core phases that are applied in a flexible and iterative structure. The analysis and exploration phase consists of identifying the problem and a diagnosis within the relevant context, which in this case is Luqo. Theoretical inputs will help to fully understand the current situation. In the following design and construction phase, possible solutions are developed, based on theory and/or practice. After that, the evaluation and reflection phase results in ideas to refine the design. Second, there is a focus on both theory and practice in the model, which means that the result of the design process will contribute to both. The third topic, implementation and spread of the design, means that there is a constant interaction between practice and the design that grows in strength over time (Mckenney & Reeves, 2012).

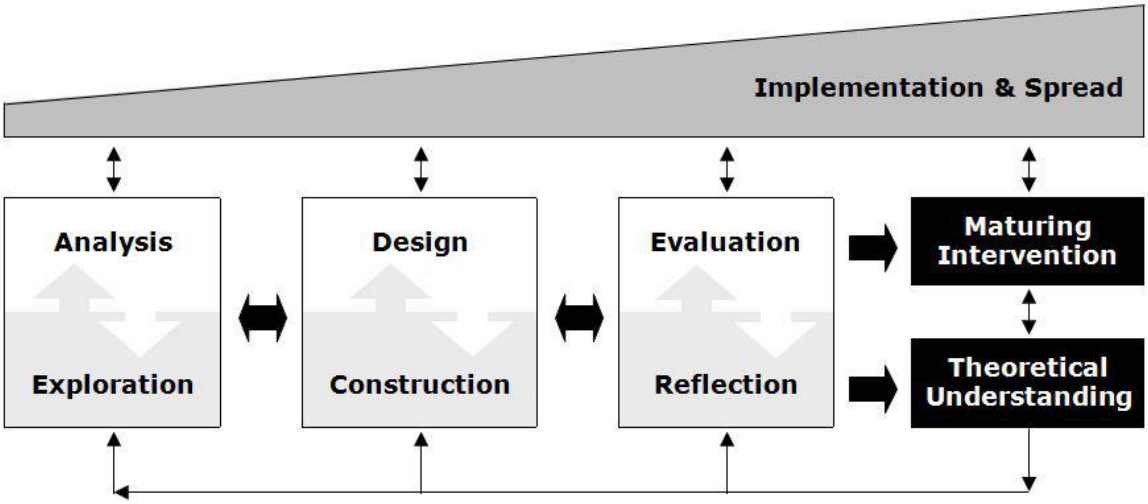

Figure 1 The generic design model (Mckenney & Reeves, 2012), which is used to structure the design process of the guidelines.

The design process will lead to a final version of the guidelines that is presented in Appendix A. All decisions that will be made in the design process will lead to that version. In order to get to this final version of the guidelines, several steps will be taken based on the design model. First, existing literature will be used to find out which elements are important for learning in games. Three topics are distinguished, namely game design, learning support, and collaborative learning. For every topic, some guidelines will be derived as a first design phase. This will contribute to the current theoretical understanding about serious collaborative games. A full overview of this first basis of the guidelines can be found in Appendix B. This basis has led to the first version of the guidelines, which can be found in Appendix C. Second, the guidelines will go through several rounds of evaluations to enhance their quality as much as possible. The biggest changes after each evaluation will be explained to show the development of the guidelines. The iterative structure of the model allows these iterations between different phases of the design process. This way, the guidelines can become more suitable to use in practice.

3 Analysis

The analysis will provide a description of Luqo and the current situation related to the design of Luqo games, in order to clarify the context of the study. After that, some findings from literature will be connected to the Luqo platform, from which the first guidelines will be derived. The numbers between brackets in section 3.1 correspond to the numbers in the lists of guidelines at the end of that section and Appendix B. Together with the guidelines from the theoretical framework in section 4, these guidelines form the basis for the first version of the guidelines.

3.1 Luqo

A new educational gaming platform, called Luqo, will serve as the context for the design of guidelines for collaborative serious games. Key elements of Luqo are, collaboration and playing independently, which means that students work together in the game instead of playing against each other as individuals. Besides that, games can be played without the presence of a teacher. This way, students can learn new skills, while the teacher can focus on teaching other subjects in classroom. In the future, the Luqo platform should be able to track and save the actions and performances of each student, so every student can receive learning challenges that are adapted to his own level. However, adaptivity is not yet incorporated in the Luqo platform and is therefore excluded from this study.

Luqo games are presented on a large digital game board that shows the same content to all students who stand around the board while playing the game, as can be seen in figure 2. This makes it easy for all students to refer to the same visual elements and to explain these to each other. Interaction between students can occur naturally, since everyone is directly facing each other, and players are not constrained by a screen standing between them. This way, players can simultaneously interact with each other and with the digital environment. Also, each student can physically manipulate game elements and be part of playing by using the personal button that they can use to execute actions in the game.

Figure 2 Students playing with Luqo

Currently, games are designed by the Luqo company in cooperation with schools and other third parties. However, in the future the company will not design the games, but the games will be developed by other parties from outside of the company, who may also not be familiar with designing games, educational material or both. These people should be able to design their own games for the Luqo platform, based on the needs of their target group. For example, teachers could design games that fit the needs of their students. An existing issue at the Luqo company is that there is insufficient didactical knowledge to design collaborative serious games with a strong theoretical basis. More specifically, knowledge is needed about

how to facilitate collaboration and learning in serious games. However, there is no tool yet that can be used during the design process that informs these new designers what elements should be part of a good educational collaborative game. For this reason, the Luqo company wants to have a set of guidelines that will provide designers of Luqo games with support that clearly shows which elements should be incorporated.

3.2 Guidelines based on requirements from the Luqo platform

Serious games can be presented on a computer screen, tablet, or a larger display. The Luqo platform uses a large screen that lies on a table, which makes it easy for students to stand around and to refer simultaneously to the same game elements, because of this all group members can easily contribute to the task (1) (Rogers & Lindley, 2004). A disadvantage of tablets and computer screens for playing games is that they may not be promotive for group interaction, especially if there is only one screen available for the whole group. These screens are relatively small, which makes it difficult for multiple students to sit properly in front of the screen and see it well at the same time (2). The chance that students will discuss the problem at hand decreases and opportunities for "thinking out loud" will become limited. This is unfavorable to create greater understanding, which is required for problem solving (Polya, as cited in Scarlatos, 2002). Also, it is difficult to work well with others, because only one person at a time can use the mouse or the touchscreen to have physical control over the game.

Using a large tabletop display is not a guarantee for successful learning on itself. It is also necessary for students to keep interested in working on the task, otherwise an opportunity to learn will be lost. Students will lose their interest, if they do not feel able to make progress and help is not directly available (Scarlatos, 2002). The game should be able to provide the support that students need, since Luqo games should not require presence of a teacher (3). This way, the game screen applies modeling as a type of learning support, by presenting hints or feedback on how to complete the task (Wouters & van Oostendorp, 2013). Other types of learning support, that can used as well in collaborative serious games will be discussed in section 4.2.

The absence of a teacher while playing Luqo games does not only have implications for the way support is provided to players, but also for monitoring performance. Players are supposed to learn something from the game, therefore it seems reasonable to check how much they have learned. Learning could be measured with a test, which is not part of the game, or it could be measured directly in the game. Linehan, Kirkman, Lawson and Chan (2011) argued that measuring if students have achieved the learning goals should not be done with a written

test separate from the game. Besides that, a separate test would not fit Luqo, because these games focus on learning by playing and do not aim to be a method for testing skills or knowledge.

Actions of students in the game should show whether learning goals are achieved. Thus, data can be used to analyze the gap between the current and desired performance of a student (4). Computer recordings can present data in a way that is easy to understand for teachers, for example in a line graph (5) (Linehan et al., 2011). This way, accuracy of the performance is measured, however this should not be the only source of information. Time related aspects should also be taken into account, since these indicate how fluent someone can work with the material (6) (Linehan et al., 2011). Besides that, data can be tracked over a longer period of time, which provides the opportunity to find a trend in a student's performance (Annetta, 2010).

The following guidelines were derived from the analysis and will be used as input for the first evaluation:

1. All students have the opportunity to manipulate game elements.
2. The display shows the same information to all students.
3. Help can be provided on-screen.
4. The game records data on players' actions.
5. Recorded data is available for teachers or students.
6. The game records how long players are working on a task.

4 Theoretical background

The analysis showed that Luqo needs a clear framework that can be used to design games for the platform. Next, an overview of the literature will be provided to identify the important elements that should be considered in collaborative serious games. This will be the design phase from the Mckenney and Reeves (2012) model, presented in figure 1. In this first design phase, a first draft for the guidelines will be made based on existing literature about games, learning support, and collaboration. Four frameworks related to game design will be used for this purpose. These are not specifically about serious games, but indicate what games in general should contain. The following frameworks are used: intrinsic motivation (Malone, 1981), applied behavior analysis, or in short ABA (Linehan et al., 2011), the six I' design framework (Annetta, 2010), and the assessment framework (Mitgutsch & Alvarado, 2012). A full description of each framework can be found in Appendix D. These frameworks share some characteristics and can be combined with relevant collaboration elements. This can be

useful in creating collaborative games for the Luqo platform, by directly connecting game design elements to collaboration and learning support. This will lead to an overview of the key characteristics that should be included in a collaborative serious game, according to existing literature and a basis for the first set of guidelines. The numbers between brackets in the text correspond to the numbers in the lists of guidelines at the end of sections 4.1, 4.2, 4.3, and Appendix B.

4.1 Game design

Before identifying relevant factors for learning and collaboration in serious games, it should be clear what serious games are and what makes them useful. A clear definition of serious games will provide a starting point from where important elements can be determined. Serious games are computer games that are used for the purpose of learning and instruction. This type of learning can also be referred to as game-based learning (Wouters et al., 2013). The following section will provide information about the most important characteristics of game design and how these can be related to serious games.

4.1.1 Game design guidelines

According to Prensky (2001) games in general contain six essential structural game elements, namely rules, goals or objectives, outcomes and feedback, competition or challenge, interaction, and representation or story. An overview of these elements can be found in figure 3. Guidelines were derived from all six elements. All elements can be applied to serious games with the addition of a purpose, which refers to what players are supposed to learn from the game (Marsh, 2011). This means that serious games are not meant to be played for fun only, but there has to be some other goal as well.

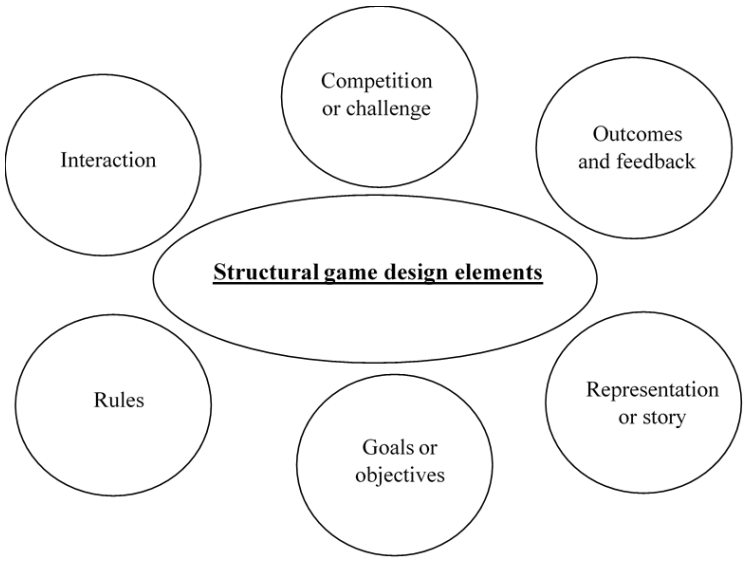

Figure 3 Six structural elements that should be included in game design according to Prensky (2001)

The first structural element that is described by Prensky (2001) is rules, which distinguishes games from free play by organizing it and determining the paths players can follow while playing (7). Rules determine what is fair in the game, impose limits, and force all players to take specific paths towards the goal. Usually, rules of non-digital games are written down, while computer game rules are built into the game. (Prensky, 2001). Another function of rules is that they enable increasing complexity within a level or between different levels. This helps to create an environment that matches the developing complexity level of players' knowledge and skills (8) (Annetta, 2010). As a result, curiosity, which is a crucial factor for eliciting intrinsic motivation, can be aroused (Malone, 1981).

Second, goals or objectives distinguish games from other sorts of play and non-goal-oriented games. These types of plays are referred to as toys. Achievement of goals is an important factor that motivates players, since people are naturally goal-oriented (9) (Prensky, 2001). It is important to note that players can only be oriented towards goals, if they are fully made aware of the goals (10). The implementation of goals is also incorporated in the assessment framework, which differentiates between in-game goals and learning goals. In other words, a difference can exist between what is to be accomplished in the game, and what the player is supposed to learn and remember from playing, (Mitgutsch & Alvarado, 2012). This distinction makes sense, since an important characteristic of serious games is that they are not just played for fun. Thus, the learning goal represents what the game aims to teach players (11).

Third, the outcomes and feedback component is about comparing a player's progress to the goals (12). Feedback can immediately inform players about the quality of their actions by making changes in the game. By directly responding to actions of players, the game becomes interactive. It helps players to learn how the game works and what leads to success or failure. This way, learning can take place from feedback (13) (Prensky, 2001). Besides just telling players whether an action was right or wrong, computer games can directly explain why an action is either correct or incorrect. These explanations enable players to improve themselves and lead to better performances than just informing players about the correctness of their actions (Moreno & Mayer, 2005). However, not giving enough feedback or giving too much feedback can easily frustrate players (Prensky, 2001).

Fourth, competition or challenge refers to the problems that need to be solved in the game. Problems or challenges can be presented that need to be solved against an opponent, or problems need to be solved to make personal progress in the game, without an opponent. In

most games, some kind of challenge is present which can be solved individually or collaboratively. This elicits excitement about playing and most people enjoy challenge, especially if the challenge is in balance with their ability (Prensky, 2001). A challenge can only be intrinsically motivating if players do not have the guarantee that they will either fail or succeed (14) (Malone, 1981). Annetta (2010) supported this idea by stating that students thrive when they are challenged to the range of their abilities. A challenge that is too difficult causes frustration, while on the other hand, boredom arises when the challenge is too easy. Thus, the right level of challenge can motivate players (15).

Fifth, interaction consists of two aspects. First of all, there is interaction between the player and the computer, which corresponds to the game providing feedback, as mentioned before in this section. Secondly, there is interaction between players (16). This social element of games makes that they are more fun to play than individual games (Prensky, 2001). Also, social interaction or communication is one of the requirements for effective collaboration, as will be discussed further in section 4.3.2 about collaboration (Johnson & Johnson, 2009).

Last, representation or story clarifies in an abstract or concrete way what the game is about, it includes the narrative and story elements in the game (17) (Prensky, 2001). It was also categorized by Wouters and van Oostendorp (2013) as a type of effective learning support. Fantasy is another way to create representation in a game-based learning environment, in which real-world elements can be included. Malone (1981) argued that fantasy refers to mental images of physical objects or social situations in the student's environment. Fantasy can help players to connect new knowledge to their prior knowledge, if skills and fantasy are integrated in the game. This means that the actions of the player can influence the represented fantasy in the game (18) (Malone, 1981). Another way to apply representation is to focus on providing a context for all the information that is embedded in the game. This serves as a context for actions that can be performed in the game, within the boundaries of the rules (Mitgutsch & Alvarado, 2012) (19). However, even though fantasy is included in different studies, research was not supportive of its learning value. This can be explained by the distraction hypothesis, which states that a strong narrative will have a negative effect on learning, since players need to direct too much of their cognitive capacity towards the story instead of the learning content (Adams, Mayer, Macnamara, Koenig, & Wainess, 2012). This implies that the context needs to be considered carefully to avoid asking too much cognitive capacity from players to process the story at the expense of capacity for learning.

The following guidelines were derived from game design theory:

7. The game has rules that places limits on the actions the player is allowed to execute.
8. The game becomes more complex while playing.
9. The game has one or more goals.
10. The player is made aware of the goals by the game.
11. The game serves to achieve a learning goal.
12. The game measures the progress towards the goal of the player.
13. Players receive immediate feedback on their actions.
14. It is not guaranteed beforehand that the goal will be accomplished.
15. The game presents challenges to the player that need to be solved.
16. The game promotes interaction between players.
17. The game contains story elements.
18. The actions of the player influence the game environment.
19. The game provides a context in which actions can be performed.

4.2 Learning support

Before designing the guidelines, it is important to know if and how serious games can lead to successful learning outcomes. However, not all studies are supportive of the effectiveness of serious games. In their meta-analysis Girard et al. (2013) found that only two out of six serious games in their review had a positive effect on learning when compared with different or no training. A review that was published some years earlier also found that games were not beneficial in comparison to traditional teaching methods, when learning was measured on an immediate posttest (Randel, Morris, Wetzel, & Whitehill, 1992). In other studies, positive effects were found on a delayed post-test for groups that played the games compared to the control group (Randel et al., 1992).

The fact that not all research results show beneficial learning results of serious games does not mean that they cannot be useful in education, since these games are more motivating for students than traditional teaching methods (Papastergiou, 2009). Besides that, according to Wouters and van Oostendorp (2013) learning from games can be supported by adding several types of support. In their meta-analysis, they aimed to investigate the role of learning support in game-based learning. Ten types of learning support were identified, of which six showed to improve learning. First, reflection encourages players to think about and explain their answers to themselves. Second, collaboration means that players are working in a group and engage in

discussions. Third, personalization presents ideas, characters and messages in a way that is interesting for players. Reflection, collaboration, and personalization can be combined with collaboration theories, guidelines will be derived from this in section 4.3.1. Since collaboration is a key element of Luqo games, and therefore a focus point of the guidelines, it is presented as a separate topic, even though it is also a type of learning support.

The fourth type of support is modeling, which indicates to players how a problem can be solved. This was already translated in the analysis to guideline 3; "help can be provided on-screen". Fifth, feedback refers to the information players receive about the quality of their answers or actions. The role of feedback in game design was already discussed in section 4.1. However, the role of feedback in relation to providing learning support has not yet become clear, this will be addressed in the next section. The sixth type of support, modality, will not be further discussed in this study. Modality means that textual explanations should preferably be presented in an auditory way (Wouters & van Oostendorp, 2013). However, games of the Luqo platform are fully visual and therefore modality is not applicable in this context.

4.2.1 Guidelines learning support

Feedback as a type of learning support was found to significantly enhance learning and can regularly be found in serious games. Research showed that support to select relevant information is more effective for learning than stimulating, modeling and integrating new information (Wouters & van Oostendorp, 2013). According to Malone (1981), feedback should address the gap between the current performance of players and the goal performance, to inform them whether they are achieving the goal. Also, students' curiosity can be supported by providing informative feedback that responds to performed actions and is given in a way that explains how they can make changes instead of just telling them their performance is inadequate (Malone, 1981). Prensky (2001) also mentioned it as a structural game element that informs players about the quality of their actions in the game (20). Feedback can be given to individual players or to the whole group. However, it does not seem intuitive to abandon group feedback in collaborative groups. Since students are working together to accomplish a shared goal, it makes sense to give feedback that informs them about how close they are to their goal (21).

The following guidelines were derived from learning support theory:

20. Students receive individual feedback.
21. Students receive feedback as a group.

4.3 Collaboration

Collaboration has become one of the dominant instructional methods in schools and can be used for different subject areas and in different grades (Johnson & Johnson, 2009). When it is compared with competition or individual work, collaboration results in greater long-term retention, higher intrinsic motivation, higher expectations for success, more creative thinking, greater transfer of learning, and more positive attitudes towards the task (Johnson & Johnson, 2009). Also, it is an effective types of learning support (Wouters & van Oostendorp, 2013).

In traditional classrooms, students mostly work on individual tasks and do not need their peers to complete their learning tasks. This way, every student is responsible for his own learning and there is room for competition between students, which does not necessarily enhance learning. Competition can be a poor motivator, especially for low-performing students (Slavin, 1995). Even if these students manage to improve themselves, they are still behind on their higher performing peers. This can be avoided by letting students work together effectively. If students want their team to be successful, they will help their team members in learning, encourage them, and boost their performance. This way, students can help each other to be successful (Slavin, 1995).

Another reason that supports collaboration is that communication with peers can help students to learn. If new information has to be stored in memory, it should be related to information that is already stored. This can be done by elaborating or structuring the material. Explaining things to others is one of the most effective ways to accomplish this (Slavin, 1995). Also, interaction on learning tasks between peers is effective in itself, because students can learn from cognitive conflicts that arise during discussions and expose their reasoning (Slavin, 1995). Despite the advantages of learning together, there are a few risks that should be considered. In some groups, a few students do all the work, while others profit from the work of their group members, this is called the free rider effect. Another problem that can arise is diffusion of responsibility, this means that not every group member feels equally responsible for the product the group has to deliver (Slavin, 1995).

4.3.1 Collaboration guidelines

A first guideline for collaboration was derived from the definition that was mentioned in the introduction. Collaboration refers to groups of students working together on a task to avoid confusion between the two terms (22). However, just putting students together in a group does not automatically foster effective learning. Johnson and Johnson (2009) mentioned five elements that are required for effective collaboration, namely positive interdependence,

individual accountability, promotive interaction, appropriate use of social skills, and group processing. Positive interdependence means that students need each other in order to successfully complete their task (23) (Sharan, 2015). Giving rewards or setting goals are ways to create interdependence (24) (Johnson & Johnson, 2009). More specifically, verbal rewards positively affect intrinsic motivation, while tangible rewards seem to have a negative effect on intrinsic motivation (25) (Deci, Koestner, & Ryan, 1999). Another possibility is to give individual instead of group feedback, this can increase achievement, positive relationships among members, self-esteem, and positive attitudes towards the subject (26) (Archer-Kath, Johnson, & Johnson, 1994). This element implies that communication is required if students need to work together and reach their goal, (27).

Second, when there is individual accountability, it shows how much every member contributes to the group. Every individual in the group is responsible and is assessed on his personal performance instead of only getting assessed by the performance of the whole group. (28, 29). In general, individual accountability is higher in smaller groups, where members believe their input is more necessary than in larger groups (Johnson & Johnson, 2009). Third, with promotive interaction, students encourage and facilitate each other's effort to reach their goal. Thus, interaction should be present in a way that students encourage and help each other to satisfy the promotive interaction element (30 and 31). Fourth, students must possess appropriate interpersonal and small-group skills if they want to work together effectively. Examples of these skills are being able to communicate accurately and unambiguously, and to resolve conflicts constructively. In order to achieve this, group members need to get familiar with each other and trust, support, and accept each other (32) (Johnson & Johnson, 2009).

Last of all, group processing means that individuals in the group reflect on the actions of group members and make decisions about which actions to take next. Reflection is also about stimulating learners to think about and explain their answers (33) (Wouters & van Oostendorp, 2013). Group processing can also be considered related to goals. If it is possible to accomplish a goal it in different ways, it will create the opportunity for group members to discuss past and future actions to find the best way to finish the task successfully. In case there is only one way to finish the task, there is only one path to follow and a discussion about what to do seems redundant (34).

Thus, positive interdependence, promotive interaction, appropriate use of social skills and group processing all require some form of communication. In a collaborative game, communication can exist between players, either face-to-face or via a computer-supported

chat. Players interact through a personal identity with the game and other players, experiencing this identity is also necessary to become fully immersed in the game. (35) (Annetta, 2010). Also, personalization is an effective type of learning support, it refers to adapting the context of the game and to presenting characters in an interesting way for players (Wouters & van Oostendorp, 2013). This means that the character through which players interact and receive messages from, should be meaningful for each player.

Another element that is important regarding communication, is the way group members communicate with each other, since this influences how much they will learn. Mercer, Wegerif and Dawes (1999) compared the communication and performance of groups who received instruction about ground rules for exploratory talk to a group of students who did not receive this instruction. Exploratory talk can be defined as communication in which all members of the group are critical and work constructively with ideas of others. Knowledge is explicitly shared among group members, statements are challenged and reasoning has an essential role (Mercer et al., 1999). The study showed that students who had received the instruction, worked more effectively together on problem-solving tasks, used more exploratory talk, and showed larger individual gains on a problem-solving posttest compared to the pre-test than students who did not receive the instruction. A later study also showed that games can support students to engage in exploratory talk and communication is not automatically effective (36) (Rojas-Drummond & Mercer, 2003).

Communication is needed, but also takes up a certain amount of time (37, 38). If there is no time limit to complete a task, players have the full opportunity to do this. However, Karau and Kelly (1992) found that groups that have an abundance of time to solve a task are less focused and engaged in less task activity than groups who received the optimal amount of time. In contrast, limited time can lead to a higher performance rate, but with a decrease in quality (Karau & Kelly, 1992). If time is scarce, students' attention is more focused on the most important task characteristics. This means that time scarcity can decrease performance, because students are not able to attend to all relevant information in the available time. Therefore, a balance should be found between the available and needed time for a task.

The following guidelines were based on literature about collaboration:

22. At least two students can work simultaneously on the task.
23. At least two students are required to solve the task.
24. The game provides clear goals to the player.
25. groups receive rewards based on their performance.

26. Players need to communicate with each other to reach the goal.
27. Players receive individual feedback based on their actions in the game.
28. Students receive a group score.
29. Students receive an individual score.
30. Interaction between students is needed to solve the task.
31. Input from every student is required to solve the task.
32. At the beginning the game provides an opportunity for players to get to know each other.
33. Students receive prompts to reflect on their actions.
34. There is more than one way to accomplish the goal.
35. Each player has his or her own character in the game.
36. The game supports players to communicate on a high level.
37. Time is available in the game to discuss next steps.
38. Time is available in the game to reflect on past steps.

5 Guidelines

Literature research identified many elements were found that should be part of a serious collaborative game. 38 guidelines were found to be related to learning support, collaboration and game design theory. Since literature from different research areas was used, it was possible that some overlap would occur. Guidelines that overlapped were deleted or combined, after which 31 guidelines remained that formed the first complete set of guidelines. An overview of which guidelines were combined, the result of those combinations can be seen in Appendix B. Also, six categories based on the literature were added to make the list of guidelines more structured and give the user a better overview of its components. These categories are feedback, multiplayer, goals, data, screen, and other.

The first complete set of guidelines can be found in Appendix C, these will be used for the first evaluation. An example that shows the structure of the first version of the guidelines is shown in figure 4. Most guidelines will be usable for games in multiple topics, but there are also a few guidelines that apply specifically to a new Luqo game. This game will serve as a case study in a later stage of the design process. The rationale behind these guidelines will be discussed later in section 7, because these are not generally applicable for all games. However, since they will go through the same evaluations as the other guidelines, they are already presented with the other guidelines of the first version.

Theory	Category	Guideline	Present	Clarification
Collaborative learning	Feedback	Players receive individual feedback based on their actions in the game		

Figure 4 Example of the first version of the guidelines

6 Evaluations

The set of guidelines in Appendix C was a first version, but it was unsure whether they were useful and complete. Practical experience with the guidelines was necessary to establish this, and to determine possible changes or additions to improve the quality of the design. For this purpose, there will be five rounds of evaluations and improvements of the guidelines. The methods and results of each evaluation will be described, including the most important changes that were made as a consequence of each evaluation. Figure 5 presents an overview of where descriptions of each evaluation can be found, and which version of the guidelines was used for each evaluation.

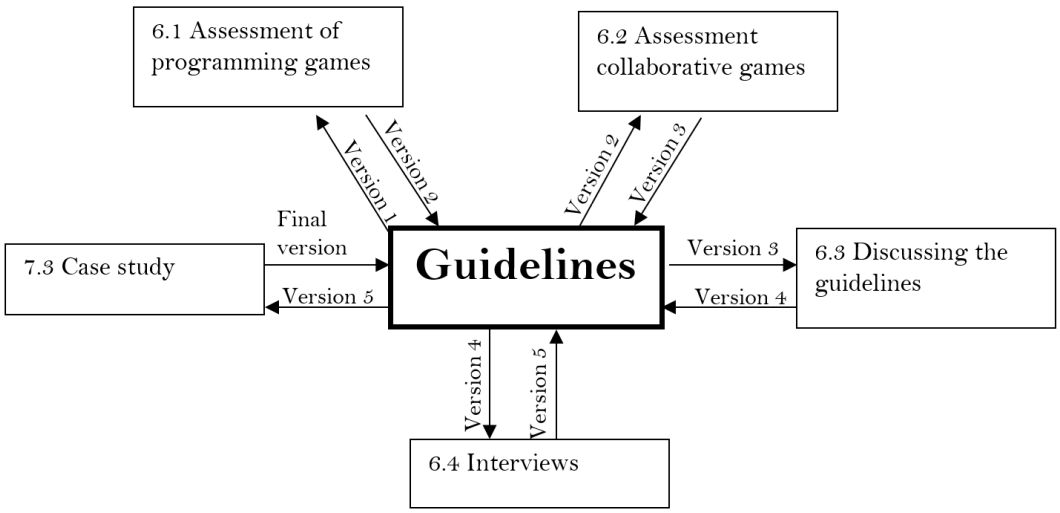

Figure 5 Overview of which evaluation can be found in which section of the reports and which versions of the guidelines were used for each evaluation.

In the first evaluation, the guidelines will be used to assess existing programming games. This will show how clear and complete the guidelines are and it will identify where changes need to be made. The second evaluation will be similar to the first round, since it is also an assessment of existing games. However, in this case the focus will be on collaborative games to see how key elements of collaboration are applied. The goal of these two

evaluations is not only find flaws in the guidelines, but also to see if and how they are already applied in existing games. Both evaluations will be executed by the designer of the guidelines.

The third and fourth evaluation are more focused on how the guidelines are interpreted by other people than the designer, to gain new perspectives. Also, the guidelines will now be treated as a design tool, which is their main function, instead of using it as an assessment tool. During the third evaluation, the guidelines will be the subject of a discussion at Luqo. The goal is to analyze the formulation of every guideline and to check interpretation and applicability in a design process. The fourth evaluation will consist of two parts to see if people who are unfamiliar with designing educational games and the Luqo platform can understand the guidelines. This is important, because the guidelines can only be used properly if people understand their meaning and perceive them as sufficiently clear to design a game. First, people will be asked to assess the guidelines on paper. Then, based on these assessments, personal interviews will be conducted by the designer. For the last evaluation, a concept version of a new game, specifically a programming game, will be used as a case study to find out if and how the guidelines for collaborative serious games can be applied in a real design process at Luqo.

6.1 First evaluation

The first evaluation was aimed at finding out whether the guidelines were usable for assessment of existing serious games. In order to do this, nine programming games were selected by the designer to test the guidelines, this way flaws could be determined and adapted. Descriptions of all the games can be found in Appendix E. A ‘yes’ or ‘no’ was noted by the designer for each guideline to indicate if it was present in a game or not. This provided two sources of information. First, it became clear which guidelines are currently applied and missing in existing games. This served to establish differences between and similarities of the games. Second, by using programming games for this evaluation, the characteristics of existing programming games became clear. This way, it can be avoided that the new programming game, that is currently being developed at Luqo, becomes a copy of an existing game. The new game will be discussed later in section 5 about the case study.

The analysis showed that many elements from theory are not always applied in practice. Only seven of the guidelines seem to be naturally incorporated in programming games, since these were present in all games. This contrasts to six other characteristics that were missing in all games. However, it must be noted that the missing guidelines were mostly about collaboration, while most games in this analysis were individual games. This shows that

a game is not automatically suitable for collaboration, but attention is needed to include these characteristics. Special attention is also needed for the 18 guidelines that were only applied in some of the games. This finding indicates that a large group of the guidelines is not automatically applied, therefore attention to these guidelines is desired in a design process.

The first use of the guidelines showed that not all formulations were clear or complete. Consequently, changes had to be made to the content of the guidelines. Also, the table structure of presenting guidelines was adapted. A short explanation of the most important changes in the guidelines will be provided next two sections.

6.1.1 Changes in the content

Some of the guidelines were revised because of the way they were formulated. The original guidelines were in some cases vaguely formulated, therefore it was ambiguous what was meant exactly. For example, the guidelines about feedback were quite general, and it was not specified when feedback was given. In a game with a level structure, it is possible that feedback is given after finishing a level, during a level or both, but this was not specified in the guidelines. A distinction in the feedback guidelines was made about the moment the feedback is given. This way, the guideline became more specific. Guidelines can be used better when they are more specific, because then there is little space for different interpretations and confusion. It is important that the guidelines are clear and specific, because unexperienced designers of serious games should be able to work with them.

The evaluation did not only show overlap or vague formulations of the guidelines, but it also indicated that some theoretical aspects did not work out in a practical use. For example, one of the guidelines stated that the game should support students to find the most efficient solution. During the assessment of the programming games, it showed that most games contain the opportunity to repeat a level, but there is no explicit encouragement. Therefore, a distinction had to be made between providing the opportunity to find the most efficient solution and encouraging players to do this. Another guideline was also changed because of practical issues, it stated that every action of a player should be recorded and saved. This was too strict, since most games do save some data but not everything, which would cause a negative assessment of the guideline. This way, it does not become clear what type of information the game does save. Also, the question is which information is necessary to get an overview of how students are performing and if some information may be redundant. This guideline is improved by making a distinction between different types of information that can

be recorded. Finally, one guideline was added from a practical point of view. Students should be able to play Luqo games outside of the classroom without needing their teacher. Thus, it would not make sense if a teacher was needed to set up the game. This means that it should be easy for players to start the game.

6.1.2 Changes of the Structure

The original format was changed after the first evaluation, in the first version of the guidelines there were no different levels. During the assessment of the guidelines it showed that some guidelines are part of a broader guideline or can only be present if another guideline is present as well. For example, a game can only present goals to players if there are goals in the first place. For this reason, the guidelines were divided in main guidelines and sub-guidelines after the first evaluation. If a main guideline is not present in a game, the sub-guidelines that belong to it, are automatically absent as well. Thus, sub-guidelines only need to be checked if their main guideline is present. Adding these levels makes it more efficient to fill in the guidelines. A consequence is that one main category can contain guidelines that originate from different theories. In order to avoid confusion, the theories column was deleted from the guidelines. An example of the new format is presented in figure 6.

It is still possible to give an explanation about why a guideline was scored with yes or no, however in some cases a few additional questions were added that need to be answered in case the guideline is present. Answering these questions results in a more detailed analysis that provides information about characteristics of a game, so changes can me made accordingly. The questions were not included in the guidelines themselves, but in a separate column, since giving an answer requires an explanation. The answers to the additional questions and optional explanations can be put in the box for explanations that was already present in the first version of the guidelines.

Category	Guidelines, second version	Present Yes/No	Additional questions (only applicable if the guideline is present) and explanations
Feedback	Players receive individual feedback based on their actions in the game • Individuals receive rewards based on their performance		

Figure 6 Example of the second version of the guidelines with a main guideline and sub-guideline

6.2 Second evaluation

6.2.1 Analysis of collaborative games

The analysis of programming games showed which elements from the guidelines were missing in existing games. However, these games were mostly aimed at individuals playing a game and were not specifically designed for collaboration. Therefore, the guidelines about collaboration could not be tested properly. Since collaboration is a key aspect for Luqo games, more information was needed to find out how the guidelines regarding this topic are currently applied in collaborative games. In order to do this, one computer game and four non-computer games were assessed by the designer, based on the second version of the guidelines. Again, the presence of each guideline was assessed for all games. Some of the guidelines were not assessed, because they were not applicable to non-computer games, these were for example about the screen that is used in digital games. Besides that, the second evaluation helped to identify some more flaws in the guidelines that were missed during the first evaluation. The most important changes based on this evaluation will be explained in the next section.

Analysis of the guidelines about collaboration showed positive results, a full overview of the games can be found in Appendix F. The analysis showed that even though some guidelines about collaboration are generally applied, other important aspects are not always present in collaborative games. This indicates that designers need to be informed and reminded of important elements regarding collaboration. In all games, at least two players could work on the task at the same time, could manipulate game elements, and players had to communicate to solve the task. Even though all games required communication, only one game supported communication on a high level. Besides that, only one game supported players to get to know each other before playing.

6.2.2 Changes of the second evaluation

Based on the evaluation of collaborative games, some changes were made to the content of the guidelines, the structure remained the same. Two guidelines were changed because they automatically assumed the presence of certain elements in games. For example, the guideline ‘scores are based on actions from individuals and from the group’ assumed that scores are always given. It does not provide the option to say that scores are not given in the game. Therefore, this guideline was changed to ‘scores are given in the game’. The other guideline that was changed for the same reason, ‘the game provides the opportunity to repeat a level’, assumed that each game consists of levels, and that these levels are the only units in a game

that can be repeated. These things need to be adapted, since the assessed programming and collaborative games have shown that not all guidelines are always present in games. It is important that missing elements can be easily reported, so designers can clearly see what is missing to improve their games.

A new guideline was added to the feedback category in addition the guideline ‘help can be provided to students if they keep making mistakes’. This guideline aims at help or feedback provided by the game. However, the collaborative games showed that help can also be provided by group members, but this was not yet included in the guidelines. Next to adding a new guideline, the formulation of the original guideline was changed as well, so there is a clear distinction between feedback from the game and feedback from peers. This makes the guideline more complete and it shows the different options of how a guideline can be used. Users can consider these options and make a well-informed decision about which one to use.

A remarkable change was the removal of a guideline that caused confusion during the evaluation. The terms goals and challenges are two different words that refer to the same concept in the guidelines. Both indicate what players need to accomplish. Therefore, two guidelines are basically the same. The guideline ’the game presents challenges to the player that need to be solved’ is kept. This one is more clear and specific than ‘the game makes players aware of the goals’, which is now deleted from the guidelines. Confusion about the meaning of terms should be avoided, since wrong assessments can be made if terms are not understood properly. This is important, because adequate assessments are required to properly improve a game.

6.3 Third evaluation

The first two evaluations confirmed that the guidelines are usable for the assessment of games, but nothing could be said yet about their usability as a design tool. The third evaluation consists of two separate discussions at the Luqo company. The first one is focused on the general structure of the guidelines, while the second discussion is about the specific formulation of each guideline. After the first discussion, initial changes will be made to avoid double work in the second discussion. The goal of these discussions is to find out if changes need to be made, so it is clear how each guideline should be used.

Before, the guidelines were formulated in a way that made them usable for assessment purposes. However, since the guidelines should mainly have a design function, they should have a different formulation. Also, the guidelines were developed and evaluated by the same

person. Therefore, it was unknown how they would be interpreted by other people. Interpretation of the guidelines and the guidelines as a design tool will be the focus points of this evaluation. The designer and founder of Luqo took part in both discussions, two other people working at Luqo only participated in the first discussion. The designer mostly had an observatory role during this discussion to allow the other participants to freely discuss their interpretation, but they could ask questions to the designer. In the second discussion, the designer did actively participate.

6.3.1 Changes after the third evaluation

During the first discussion, not all guidelines were discussed in detail. After looking at several guidelines, some general points for improvement were clearly identified already. The most important finding was that the guidelines needed some clarifications. First, it became apparent that some of the terms lacked clarity. These terms stem from educational research and the people participating in the discussion, besides the designer, were no experts in this field. Therefore, it is not surprising that some terms required an extra explanation. For this reason, a list of definitions was added for all the terms that could be unclear or interpreted in different ways. This is important, since the guidelines are designed for people who may not be familiar with these terms and educational research. Second, most guidelines now have a context description that is based on literature to provide them with a strong theoretical basis and to explain their importance. Third, some examples are now provided for each guideline to show users some possibilities of how guidelines could be applied.

Another point that came up during the discussion was when, and on what level each guideline could be applied. This led to the insight that a single guideline can often be used at different moments in the game, and can be applied on the individual or the group level. It would make the guidelines too complicated to add these moments and levels to each separate guideline. Therefore, a scheme is added that represents the different levels and moments in which the guidelines can be applied, these levels are called dimensions. This means, a guideline can be applied to a group or an individual, as is indicated by the dotted line in figure 7. Furthermore, the figure shows that a game can consist of multiple levels, guidelines can be applied to the separate levels or to the game as a whole.

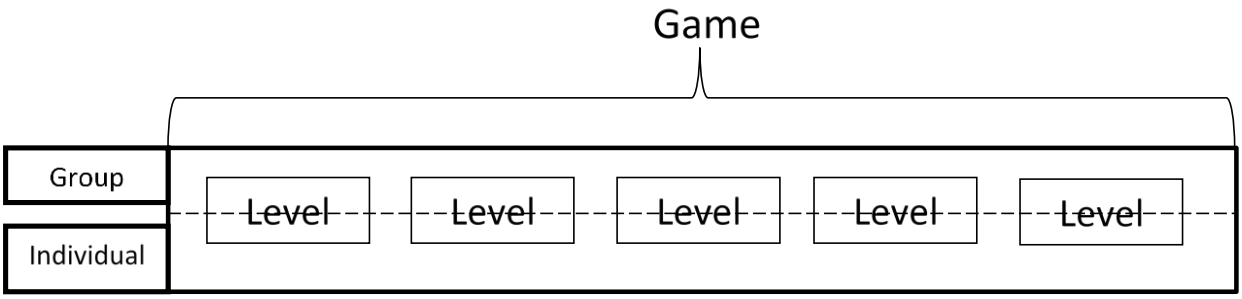

Figure 7 Guideline dimensions as presented in version 4 of the guidelines

Before starting the second discussion, some steps were taken to make the guidelines suitable for a design process. Originally, the guidelines were presented as statements that could be either present or absent, which made them usable as an assessment tool. The guidelines were changed into a more active mode by starting each sentence with a verb, which indicates that something still needs to be done, opposed to something that should already be there. This fits the main purpose of the guidelines as a design tool.

The guidelines that Nielsen (1995) used for his ten usability heuristics for interface design, served as a template for the new formulation of the guidelines. This means that first a situation is mentioned in which the guideline can be relevant, then the guideline tells users what to do, and finally an example clarifies how the guideline can be applied. This new formulation of the guidelines was subject of the second discussion at Luqo. The goal was to determine if the text conveyed the intended content. As a result, some changes were made again. This did not have a large impact on the content, but it was mainly a clarification of what was already present in the previous version by using a different way of formulating. When discussing the new formulation, it also became clear that some of the guidelines were put in a category where they did not belong, these were moved to another category in which they fit better. Most of these guidelines were first placed in the "other" category, because initially they did not seem to fit well within one of the regular categories. However, during the discussion it became clear that they matched with categories like 'multiplayer' or 'goals'.

Two changes were made regarding the structure of the guidelines to make them more attractive for users. First, the situation, guideline and example were separated instead of presented as one piece of text to give users a better oversight over the three different parts and to create a clear distinction between the three elements. Second, the guidelines were made more attractive by presenting them in a visual format. On top of the page, the full guideline, including situation and example, is stated. This is followed by a picture that to visualize and clarify the guideline. On each page, a context and relevant definitions were added for each guideline. This way, users can go through the guidelines without having to look back for

background information or definitions, an example of the new format is present in figure 8. A last thing that was added, is a short introduction and instruction to the guidelines. This will inform users about what the guidelines are, and how they should be used. The new guidelines in the visual format, including the instruction can be found in Appendix G.

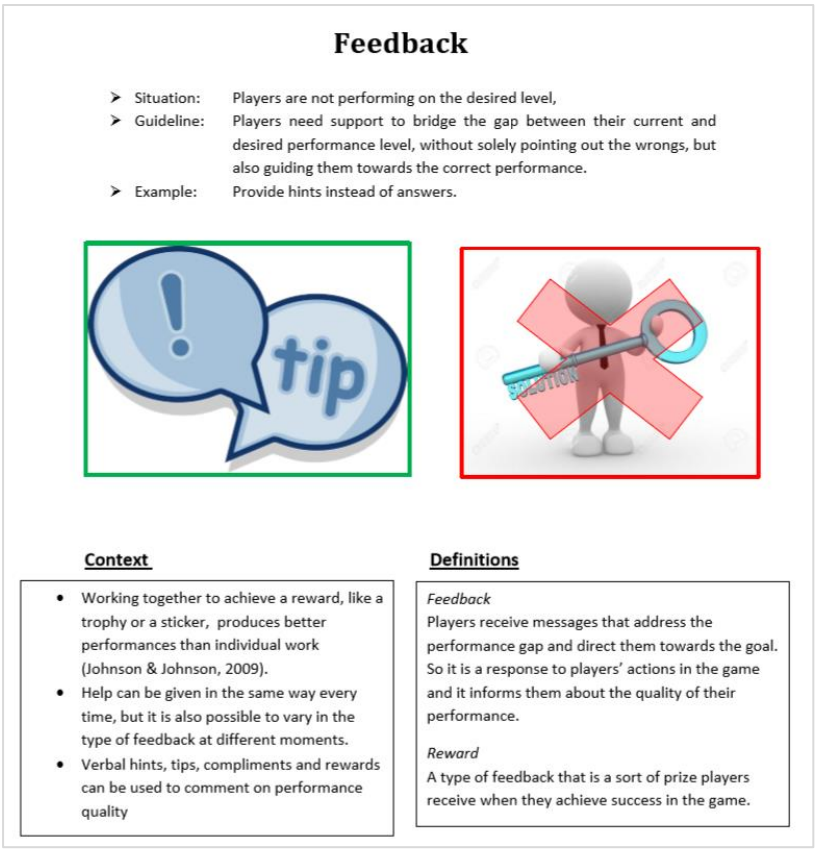

Figure 8 Example of the fourth version of the guidelines

6.4 Fourth evaluation

So far, the evaluations have shown that the guidelines can be used to assess games, but changes in the formulations were needed to make them suitable as a design tool. However, it was not tested yet if the new formulations would be helpful in a design process. The guidelines should be able to help novice designers of collaborative serious games, for this reason it is important that everyone can interpret and understand them. Therefore, some people who were not familiar with the guidelines or serious game design were asked to assess the guidelines in the fourth evaluation. This was done with the plus-minus methods, followed by an interview. This method is a simple way to find problems in a text and it offers concrete indications for improvements (Vroom, 1994). In total, eight persons with different backgrounds participated. All participants were students or were recently graduated. Two of them attended higher vocational education, the other six were university students. Three of the

participants were psychology students, but only one of them was specialized in learning. None of the participants was an expert in game design.

First, participants received the visual format of the guidelines via e-mail and they were asked by the designer to add a plus-sign for each positive or clear element and to put a minus-sign for everything they disliked or did not understand. Plusses and minuses could be added to small or large pieces of text and to the pictures. Participants were free to decide the size of elements to comment on. After this, a one-on-one interview was held by the designer with each participant to find out the reasons behind the comments. These steps are in accordance with the plus-minus method from Vroom (1994). Besides discussing their comments, participants were asked about their general impression of the guidelines, their impression of the structure of document, and if they thought they would be able to design a game themselves with the guidelines.

6.4.1 Changes after the fourth evaluation

The interviews made it clear some changes were necessary. These were related to formulation and content related issues, but the overall structure seemed to be clear and did not have to be changed. Even though all participants mentioned different points, some guidelines received similar comments from several participants. The most important changes will be described in this section.

The biggest overall change refers to the pictures. In the fourth version, the pictures did not support the text by representing their meaning. For this reason, all pictures were changed, even though some elements could be used to create a better picture. In the new version of the guidelines, every picture consists of two parts. One part represents the guidelines, by showing what should be applied in the game, while the other part emphasizes what should be avoided. This way, the picture tells a story of how to interpret each guideline.

During the interviews, it became apparent that a few things were not easy to understand. First, it was not clear what of positive interdependence and cognitive conflict meant, therefore they were added to the list of definitions. These terms may be clear for people with knowledge of psychology or collaboration, but it showed that the terms can be unfamiliar to others. Another element that was unclear, was the dimensions picture, as presented figure 7. Participants did not know how to interpret this picture, but when it was explained to them with an example, they were able to understand it. For this reason, an example of how to use the dimensions was added to the guideline manual.

Besides adding elements, some parts were moved to another place or removed. For example, some participants found the repetition of the guidelines and definitions annoying and unnecessary. For this reason, the guidelines on each category overview page were removed. An overview of the guidelines per category is already presented in the manual, therefore a second overview was redundant. Also, the full list of definitions is now placed after the guidelines. Since the important terms are presented each time they are used in a guideline, it is not necessary to read all definitions beforehand, especially since some users may already be familiar with the terms. By moving the definitions there is still a full overview available, so users can easily look up terms if they wish or ignore it.

It became clear that some guidelines were generally found very clear, while others were less clear and needed alterations. Most changes were made because some guidelines were not specific enough or information was missing. This could mean that participants did not understand what was meant or they interpreted the guideline in a different way than it was meant. For example, participants thought ‘align the game theme with the learning goals. Integrate actions, game goals, and learning content’ meant that games should contain a story. It was not clear that the guideline means that the tasks in the games should match the context in which they are performed. By adding more focus to the guideline, it should become clearer what is meant. Another reason for changing formulations was that some guidelines seemed to oppose each other, which caused confusion. One guideline explains for example that feedback should do more than just telling that an answer is wrong, but should guide players towards the desired performance. The example clarifies that feedback should not provide the answer, but the next guideline arguments to give players the key so they can keep playing. An addition was made to this guideline to state explicitly that the full answer should not be given, but only the key to the next step Even though, it was also mentioned that the full answer should not be given, it seemed to oppose the previous guideline that does not want to give players the answer.

7 Case study

The previous evaluations showed that the guidelines can be used to assess existing games and that they are understandable for people who are not familiar with the design of serious games. However, this did not show if the guidelines can actually help to design a new game. During the development of the guidelines, a new game to learn programming skills was being designed for the Luqo platform. A game concept was already available that could be used for a case study. First, some literature research was done to establish the need for learning programming skills. This led to a few specific guidelines for this topic, that are presented in Appendix B. After that, the game concept will be compared to the guidelines.

7.1 21st century skills

Society is nowadays strongly affected by technological developments. This can be seen by the massive use of different media, like television, social media or other uses of the internet. These developments also have an influence on the labor market, where there is a growing demand for employees with flexibility and problem solving skills, instead of people who can merely execute routines (Thijs, Fisser, & Van der Hoeven, 2014). Two of the skills that children now have to learn are computational thinking and collaboration, which are both part of the so-called 21st century skills. These can be defined as generic skills which are linked to knowledge, insight, and attitudes that are necessary to function in and contribute to a knowledge-based society (Thijs et al., 2014).

One of the targets from the Netherlands institute for curriculum development (SLO) that fits the 21st century skills is that children in primary education learn how to design, execute and evaluate solutions for technical problems (SLO, n.d.). This connects to the computational thinking skills that children need to develop and means being able to interpret processes as a way to structurally edit information. Besides that, computational thinking is a prerequisite to understand and control the opportunities and risks of digitalizing information and communication (KNAW, 2012). These skills are applicable to programming skills and could be used in everyday life as well. The application of the computational thinking skills can take place in different situations and for different reasons (Brennan & Resnick, 2012).

Due to the increasing demand for sufficient 21st century skills, it is desirable that every child starts to develop these skills at a young age, however not all skills are properly addressed yet in primary education. This becomes particularly clear when looking at programming skills. Even though it seems important to learn this, only 30% of Dutch primary schools worked on programming in 2015 (Kennisnet, 2015). Most of the schools that do teach

programming skills, only spend one hour or less on it per week (Kennisnet, 2016). Schools should spend more time on programming skills, to prepare children to what is required of them in the future. Approximately half of the schools report they need better devices in order to start teaching programming at their school (Kennisnet, 2015). This implicates that new devices are required that can be easily implemented in the classroom without asking too much effort from teachers or taking up too much time in the classroom. Schools can possibly be encouraged to work on programming by providing them with a qualitatively good and easy to use tool. What makes the Luqo platform attractive in this situation, is the strong emphasis it places on games that students can play on their own without needing the presence of a teacher. This way 21st century skills, like programming, can be practiced without asking a lot of time and effort from the teacher.

7.2 21st century skills guidelines

As mentioned before, there are some guidelines specifically related to 21st skills that would be explained separately from the general guidelines. This section addresses these guidelines, which are focused on computational thinking. The guidelines are represented in the text by the numbers between brackets. Computational thinking is a fundamental skill, it refers to formulating challenges, logically structuring, analyzing, abstracting and presenting information to find solutions, finding the most efficient steps to get an answer, and generalizing the process to other applications (39). This leads to development of skills like spatial aptitude and problem solving skills (Kennisnet, 2016). An exemplary curriculum plan for computational thinking in Dutch education involves skills like collecting and analyzing data, decomposing problems, abstracting, and automating. Besides that, students need to be able to deal with complexity and ambiguity, show persistence when dealing with complex problems, and they need to work together and communicate (40) (SLO, 2015).

A way to learn computational thinking skills is programming (Brennan & Resnick, 2012). Serious games can be used to learn programming skills, several games already exist for this purpose. Some examples that were analyzed in the first evaluation are described in Appendix E If students can play these games together, an opportunity arises to develop appropriate collaboration skill, while playing a programming game. These programming games can use more traditional programming language, which is usually rather specific for a domain. Another possibility is to use visual programming, which entails graphical representations instead of language symbols. Visual representations make it easier for novice

programmers to use the interface and to practice, because objects can be physically manipulated (41). By showing users this concrete representation of programming, their computational thinking skills are supported (Turchi & Malizia, 2016).

39. Students are supported to find the most efficient solution to a task.
40. Solving problems is required to reach a goal.
41. The game uses a programming language that is understandable for the player.

7.3 Fifth Evaluation

7.3.1 Game concept

Currently, a new game to teach children programming skills is being developed for the Luqo platform. As mentioned before, an important reason for schools not to teach programming is a lack of tools that can be easily implemented in the classroom, without asking too much effort from teachers (Kennisnet, 2015). This problem would be avoided with the new Luqo game, since all games of the platform can be played without presence of a teacher. A market analysis of existing programming games was already performed in the first evaluation, so it is already clear what programs and methods already exist and what their qualities are. This will help to avoid making a copy of an existing game. Students from fourth to sixth grade can learn basic programming skills. Since the game is designed for the Luqo platform, it will be a collaborative game. This way, students can develop programming and collaboration skills at the same time. However, the goal of the programming game is broader than just learning programming skills. The game is situated in the context of a farm. Thus, besides learning programming skills, acquiring knowledge about what happens on a farm is an important learning goal as well. This way, players do not just learn the trick of how to program, but they learn to use programming as a tool, that can later be applied in other situations.

At the beginning of the game every player needs to log in with their personal pawn, so the game knows who is playing. Next to that, every player receives one of the four colored buttons that are used to perform actions in the game. This way, every player can actively participate in the game. While playing the game, players are presented with small units of information and several mini-games, that are not all about programming. In the mini-games, players are asked to answer a question, match words to pictures or to program an external robot. The information texts in the game need to be read aloud by one player. The game gives turns, so every player gets a turn to read and everyone stays involved in the game.

In the mini-game in figure 8, players are asked to estimate how many eggs a chicken lays per week. The bar fills with a yellow color, which indicates the amount of eggs. Players need to push their button when they think the yellow bar shows the amount of eggs a chicken lays per week. An example of a programming mini-game is that players are asked to program a route for a robot to pick up eggs. The robot is not integrated in the game, so before players can start to program, they need to set up an external board to place the robot on. Some other examples of the game can be found in Appendix H.

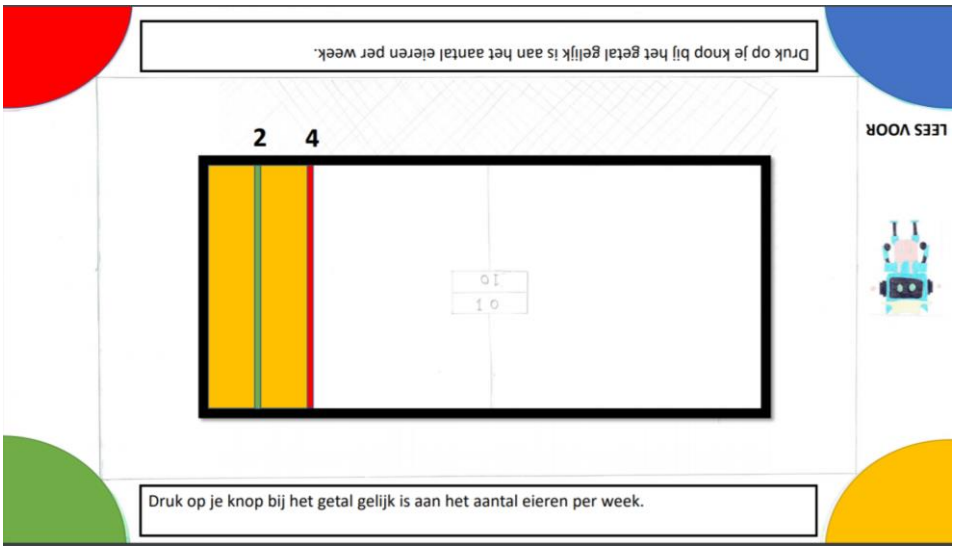

Figure 9 Example of an information text in the game concepts

7.3.2 Practical application of the guidelines

An existing concept of the new programming game, that was described in the previous section, was used to test if the guidelines could be applied in the design phase of an actual game. One level of the game was used for this purpose. Each guideline was tested by starting from an assessment point of view, and then moving on to the design function. In other words, first it was checked whether a guideline was already applied in the concept. After that, it was discussed how each missing guideline could be applied. For a guideline that was already applied, it was discussed how improvements could be made. This process was used for all guidelines by the people from Luqo. The designer was present to observe how the guidelines were used and to answer possible questions, but did not actively participate in the discussion. The concept for this game was very useful to test the functionality of the guidelines, since a theme and game flow with mini-games were already developed. The goal of this test was to find out what would happen in the design process when using the guidelines.

The evaluation showed that most of the guidelines led to a discussion about the possibilities of how to use a guideline. Besides that, only a few of the guidelines were already used in the game concept, for example “graphic elements and general game information are

shown to all players to give all players the same points of reference as a basis" was already present. Other guidelines, like "every individual needs to give input in order for the group to solve the task" were partially used. In one of the mini-games, players are asked to match a picture to a word, which are both marked with the colors that correspond to the four pushing buttons of the players. To solve the task, every player needs to push his own button at least once to complete the game. Other mini-games did not have this feature yet.

For most of the guidelines that were missing, a discussion arose about how they could be implemented. However, for some guidelines the question was asked if it was desirable to apply them in this game. For example, "show the composition of the score and the range of possible scores at different moments in the game" did not seem fully applicable. The focus of the game is not on testing but on learning. By giving scores, players are assessment on their performance, which is similar to a test setting. However, after the programming game, players are informed about the time they spent, how many action they used and if this was the minimal amount of necessary actions. Since no number is tied to this, it is more a performance summary than a score or assessment. The same principle goes for having multiple goals in a game that can be failed or succeeded, because if learning is the main focus it should not be about failure or success, but the playing itself is more important. These two examples show that even when the goal of a guideline is clear, it can occur that it does not fit within the context of a game. However, the guidelines are still helpful in these cases, because they prompt game designers to think about these concepts and to make a well-informed decision.

7.3.3 Changes of the fifth evaluation

After using the guidelines, it became clear that most guidelines are usable to brainstorm about how elements of educational support, collaboration and serious games can be applied in a game. A few changes were made to clarify some guidelines, because some questions came up during the evaluation. These changes have resulted in the final version of the guidelines, which can be found in Appendix A. For instance, the example of the guideline 'urge players to participate in full conversations that stimulate discussions that can elicit cognitive conflict and build shared understanding' was replaced. The new example 'ask players to explain their answers and to respond to the explanations of their group members' is more specific and therefore a better representation of the guideline than the old example 'design tasks that cannot be solved without communication'. Besides this, some information was added to a few context boxes to provide a stronger rationale for some guidelines.

Also, while using the guidelines, the same process was used to apply each guideline to the game, which helped to structure the process. The scheme in figure 10 was created for designer, so they can easily follow these steps when working with the guidelines. This will help users to go through the design process in a structured way and to think about different options of how to use each guideline. The scheme will be printed on a separate page, as a bookmarker, so users can always refer to it without having to search for it in the guideline booklet.

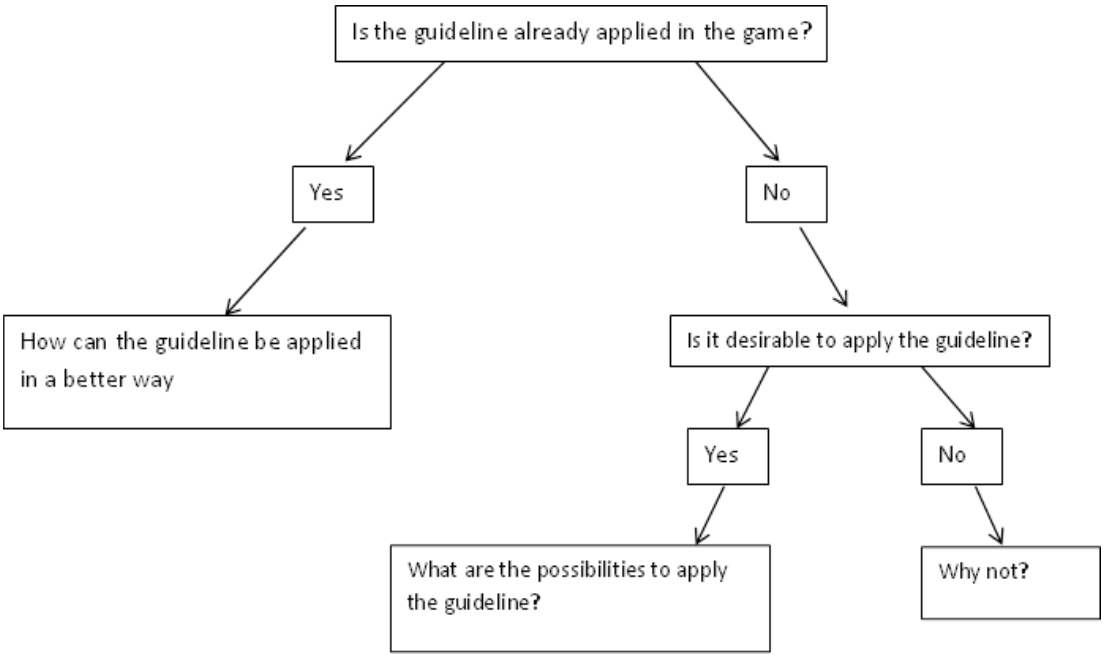

Figure 10 Flowchart of steps to follow for each guideline in the design process

8 Discussion

The aim of this study was to develop a set of guidelines to design serious collaborative games for the Luqo platform. After an analysis of the existing literature, a first version was created, but it was not sure if and how these new guidelines could help to design a new game. Four rounds of evaluation and alterations led to a set of guidelines that was very different from the first version. Initially, the guidelines were not yet supported by pictures, context information, definitions, a situation description, an example, and a manual. These changes resulted in a version that seemed usable in a real design process. To test this, a fifth evaluation was needed to determine whether the guidelines were applicable in practice. The evaluations helped to identify elements that needed alterations to enhance the quality of the guidelines. This can be placed in the maturation the phase of the generic design model of Mckenney and Reeves (2012), which means that after each evaluation the guidelines became more suitable for

application in practice. All evaluations were focused on practical application of the guidelines. This fits the implementation and spread component of the model, since it contributed to a continuous interaction between the guidelines and practice. By separating the different evaluations and alternations, the design process became more orderly than it would have been with one large evaluation. The strengths and weaknesses of each evaluation will be discussed shortly.

The first and second evaluation used the same method to assess presence of the guidelines in existing games. Since the information that was used to assess games is publicly accessible, anyone could check the assessments that were made. Also, using the guidelines clearly showed when an element was not clear and needed a change. However, this method of assessment also had some weak points. Since every guideline was only coded with a 'yes' or 'no', there was no information about how a guideline was applied or why it received a certain assessment. It must be noted though that it was possible to add an explanation for each guideline and some remarks were made. However, most of these explanations were quite short, which would make it difficult to improve a game accordingly, since details were missing in the assessment. The lack of information in the explanations could be related to the fact that there was no instruction about how to assess the guidelines and what kind of explanation should be given. Also, the focus of this assessment was on the presence of the guidelines in the games and there was no specific attention for providing additional information. The goal was to find out what was already present in games to demonstrate the need for designing serious collaborative games based on guidelines, and not to improve existing games. It became clear that many elements that are included in the guidelines, are absent in many serious and collaborative games. This may indicate that these elements are not automatically incorporated in games. Thus, game designers need to be reminded about important elements for serious collaborative games

The third evaluation is more difficult to check and repeat than the first two evaluations, since a discussion was used to evaluate the guidelines. However, the fourth version of the guidelines that resulted from this, can be compared to the guidelines from Nielsen (1995). The format he used, served as a template for the new formulation of the guidelines. Even though, this did not have large consequences for the content of the guidelines, it was an important part of the process. By looking at the guidelines from a design view, they became better suitable to fulfill their main function of being a design tool.

An important goal of this study was to create a set of guidelines that can be used by everyone, even without experience in education or game design, to design serious collaborative games. However, possible users of the guidelines had not worked with the guidelines until the fourth evaluation. By asking people from different backgrounds to assess the guidelines, it became clear that elaborate experience with education or game design was not necessary to understand the guidelines. However, it was not actually tested if these people would be able to design a game with support of the guidelines. For future research, it would be interesting to let people come up with concrete ideas about how to apply a guideline in a game concept. This way, it could be studied if the guidelines provide sufficient support for unexperienced designers. Finally, the fifth evaluation was very useful to determine the usability of the guidelines in practice. It showed that the guidelines led to discussions about why and how to implement different elements. However, it would be interesting to see how the guidelines could be used from the beginning of a design process. This was not the case in this evaluation, since an existing concept game was used.

The overall process was guided by a step-by-step method. It would be advisable to follow a similar method in other design processes, since it helped to keep an overview over all changes that were made in the guidelines. If larger steps would have been taken before establishing a new version of the guidelines, it would be more difficult to identify the rationale for changes, especially for people who were not involved in the process. Another strong element of the process was the use of different types of evaluations, this provided a lot of insights from different perspectives. As a designer, it may be difficult to keep a fresh eye and every new type of evaluation helped to see the guidelines from another perspective. Therefore, it was possible to keep making improvement to the guidelines.

Even though all guidelines were derived from theory, there is no evidence that games designed according to the guidelines lead to positive learning results. Research with a pre-posttest design could be used to find out if students learn something from playing a game designed with the guidelines. This way, it is not only a practical tool for unexperienced designers, but it could also have a strong educational value if it helps to design games that lead to positive learning results.

A recommendation for a future design process is to have a clear goal for the design from the start of the process and to regularly check if the design is growing towards that goal. In the beginning of this process, the guidelines were focused on assessment. Even though the guidelines can be used for assessment, it is not their main function. This led to some

confusion and extra work later in the process when the guidelines had to be made more suitable for their design function. Having a clear goal can also help to determine the end of the design process. Usually, it is difficult to determine the final version of a design, since every evaluation brings up new points that could be adapted. When there is a clear goal, the current and goal state of the design can be compared to each other. This assessment could then help to determine if more steps for improvement should be taken. In this case, the goal was to create a set of guidelines to design serious collaborative games. The last evaluation showed that the guidelines were clear enough to be applied on a game concept. As a result of using the guidelines, discussions arose of how each guideline could be used in the game. If the guidelines had not been ready for use, this would probably not have happened and there would have been a lot of questions about how to interpret the guidelines. A final version was established, but this does not mean that there can be no more changes in the future. If the guidelines are used several times in a design process, flaws may become apparent and changes will need to be made.

The guidelines were developed for Luqo games, but they could probably be used for other types of games as well. The first two evaluations already showed, that most guidelines were applicable to games not designed for the Luqo platform. It should be noted though, that this was in an early stage of the guidelines and the main focus was not yet on designing but on assessment. However, the content of the final guidelines is based on the same theoretical framework as the earlier versions. Thus, it is expected that the guidelines are usable in other contexts as well.

In conclusion, the question posed at the beginning of this study asked how the guidelines could help the design process of games according to developers. This question was mainly answered in the fifth evaluation, when the guidelines elicited several discussions about how a guideline could be translated to a concrete game element. It is not prescribed how each guideline should be used in practice precisely, so users have sufficient space to be creative and come up with their own ideas to translate the guidelines to a game. Thus, the guidelines help developers to consider different options, to find the best way to use a guideline in a game. Besides that, using the guidelines for design purposes, the first two evaluations have shown that they can also be used to assess existing games. This way, game elements can be identified that need improvement. This shows the double function of the guidelines, which makes them more attractive for practice, since users only need one tool for the design and evaluation of their games.

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Appendices

Appendix A: Final version of the guidelines

Guideline manual

Composition of the guidelines

There are a lot of elements that need to be considered when designing a serious collaborative game. The guidelines that will be presented, aim to guide this process by stating which elements should be present in this type of game. The guidelines are placed in six different categories and can be used to justify choices during the design process.

All guidelines are presented in a visual format. The formulation of the guidelines is based on the structure used by Nielsen (1995) in his ten usability heuristics for user interface design. This means, every guideline is placed in a situation where it can be applied, and an example shows how the guideline can be used in practice. Some extra information about each guideline is presented in a context description, which is mostly based on literature to provide the guidelines with a strong theoretical basis. For a quick overview of all the guidelines, a list with only the guidelines is provided in the next section. The set of guidelines is accompanied by a set of definitions. For each guideline the relevant definitions are provided that clarify some terms that may be unclear. The full list of definitions can be found in Appendix 1.

Categories

The guidelines are divided in six categories, these are feedback, multiplayer, goals, game content, game controls, and data. These categories structure the design process by informing designers about which guidelines belong together and what part of the game they are focusing on. It also enables them to specifically attend to a certain category whenever that is needed during the development of a game. First, the feedback guidelines are aimed at the messages that players can receive based on their performance. On one hand they serve to inform players about their performance and development. On the other hand, it should also guide players towards the desired performance, if their level is not sufficient. Second, multiplayer focuses on multiple persons playing a game together through collaboration. Important elements are communication, positive interdependence, individual accountability, and time. Third, in the category goals, guidance is provided about what players should be able to do while or after playing the game, and how this can be accomplished. Fourth, the guidelines about game content describe the importance of having a context in which the playing takes place. Fifth, game controls, is about what needs to be done by players to start playing and to perform an action. The sixth and last category is data, it contains only one guideline. It describes that everything players do is recorded and saved by the game. This can be presented to players and teachers, to monitor progress.

Using the guidelines

The guidelines are helpful to design a serious collaborative game. It is recommended to include as many of the guidelines as possible, since they were derived from a literature study, as can also be seen in the context boxes. Therefore, the guidelines can be seen as relevant to design a good collaborative educational or serious game. It is not required to strictly follow the order in which the guidelines are presented, but it is recommended to work through the guidelines of one category before continuing to the next category to keep an overview. The bookmarker in Appendix 2 guides the process of how to use each guideline. After creating a first version of a new game, the guidelines can also be used to check if and how the different elements from the guidelines were applied as intended and to create a second version of the game.

There are multiple possibilities to include a guideline in the game, these are presented in figure 1 below. In this figure, two dimensions are distinguished, these are the group/individual dimension and the level/game dimension. This means that for every guideline the designer should decide whether to focus on the individual player, the whole group, or both. Also, the designer needs to decide whether to use a guideline before, during, after the game or a level, or to use it at multiple moments. However, not every guideline is equally suitable to apply in every situation.

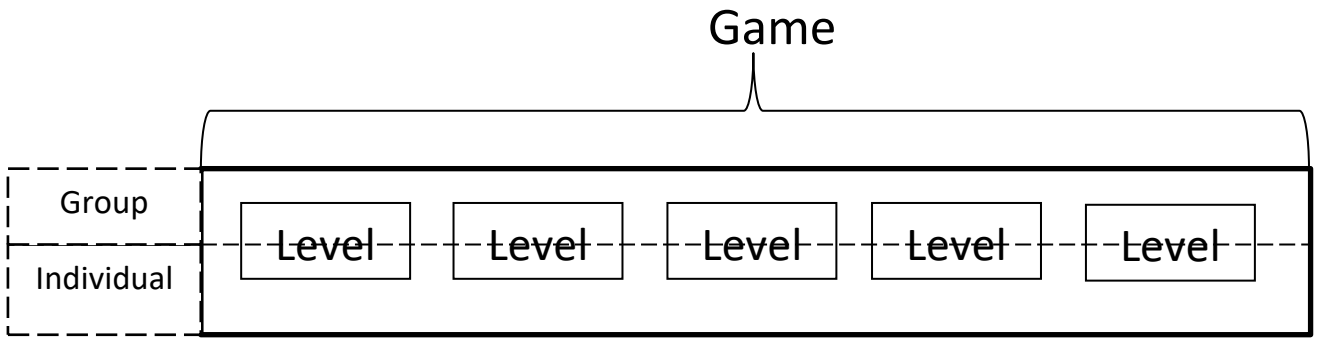


Figure 1. Dimensions in which the guidelines can be placed

An example of how to use these dimensions is presented in figure 2. It clarifies that feedback can be given to an individual player, the group, or both. Also, feedback can be given at several moments. It does not seem to make sense to give feedback before the game, because there is no data to base the feedback on. However, during and after a level or the entire game, feedback can be used to inform players about their performance.

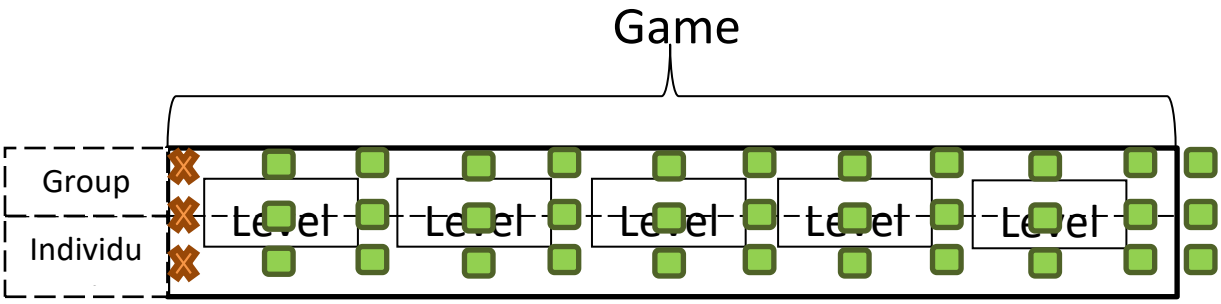


Figure 211. Example of how the dimensions can be used with the guidelines to determine when and to who feedback can be given.

Overview guidelines

1. Feedback

1.1 Players need support to bridge the gap between their current and desired performance level, without solely pointing out the wrongs, but also guiding them towards the correct performance.

1.2 Provide help that provides the key to let players continue, without directly giving the full answer.

1.3 Show the composition of the score and the range of possible scores at defined moments in the game.

2. Multiplayer

2.1 The game needs to stimulate these interactions, without filling in the content of these conversations for the players.

2.2 Support full conversations that build shared understanding and stimulate discussions that can elicit cognitive conflict.

2.3 Players need to be made aware of how they can communicate effectively in a simple way, so it won't interfere with playing the game.

2.4 A sense of community needs to be built to make them not feel on their own.

2.5 Tasks and execution of these tasks must be divided over multiple players.

2.6 The game supports this focus by providing a balance between available time and complexity of the task in a way that matches players' experience of that time.

2.7 Graphic elements and general information are shown to all players.

2.8 Support dependence by not making certain information available to all players, so tasks can only be solved if everyone contributes.

2.9 Make every player individually responsible for the end result.

3. Goals

3.1 Players solve multiple challenges in the game, however it is not guaranteed that players will complete each challenge successfully.

3.2 Inform players and teachers about what they can expect from the game, the steps towards this learning goal can be clarified by adding subgoals.

3.3 Define game rules that clearly guide players through the game to let players focus on the playing and not on discussing the rules.

3.4 Players should be encouraged to repeat that task to find the best solution that leads to attainment of the goal.

3.5 The game should respond to this by adapting the complexity of the tasks to maintain players' curiosity.

4. Game content

4.1 Align the game theme with the learning goals. Integrate actions, game goals, and, learning content.

4.2 The game should contain elements that clearly represent each player's presence, through which they can interact.

5. Game controls

5.1 Setting up the game is sufficiently easy, and the rules and tasks should be clear, without taking a lot of time.

5.2 The commands need to be made clear for players, so they can focus on the challenges from the game, if a command differs from the usual commands used in games, clarify this to the player.

6. Data

6.1 Use data as input to give feedback, and to let teachers and players monitor progress.

6.2 Only data that is relevant for the goals in that game has to be recorded.

Feedback is aimed at the messages that players can receive based on their performance. On one hand, they serve to inform players about their performance and development. On the other hand, it should also guide players towards the desired performance, if their level is not sufficient. yet.

Relevant terms

- **Feedback**

A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.

- **Help**

A way to assist players if they are not able to come up with a solution by themselves.

  - *From the game*

    A hint given by the game when players are not able to complete a certain part of the game. Hints can differ from being rather vague to explicitly telling players what to do.

  - *From other players*

    Advice or information given by other players that helps to solve the task

- **Key**

A part of the task's solution that allows players to step over a blockade, so they can continue playing and solve the rest of the task.

- **Reward**

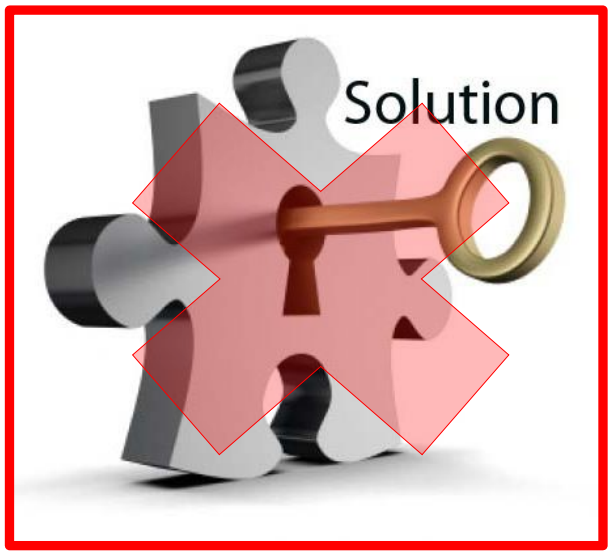
A prize players can receive if they successfully solve (part of) a task, it is a type of feedback.

- **Score**

Provides an Indication of how well a player has performed, so it represents the level of a player.

1.1 Feedback

- Situation: Players are not performing on the desired level,
- **Guideline:** **The game needs to support players to bridge the gap between their current and desired performance level, without solely pointing out the wrongs, but also guiding them towards the correct performance.**
- Example: Provide hints instead of answers.



Context

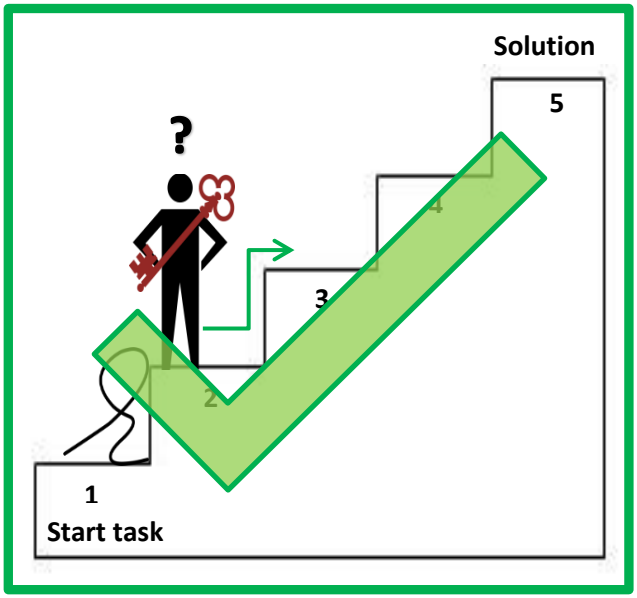
- Help can be given in the same way every time, but it is also possible to vary in the type of feedback at different moments.
- Verbal hints, tips, compliments and rewards can be used to comment on performance quality
- No explicit parts of the answer are given yet.
- If a player is still unable to make progress after receiving several hints, consider applying guideline 1.2.

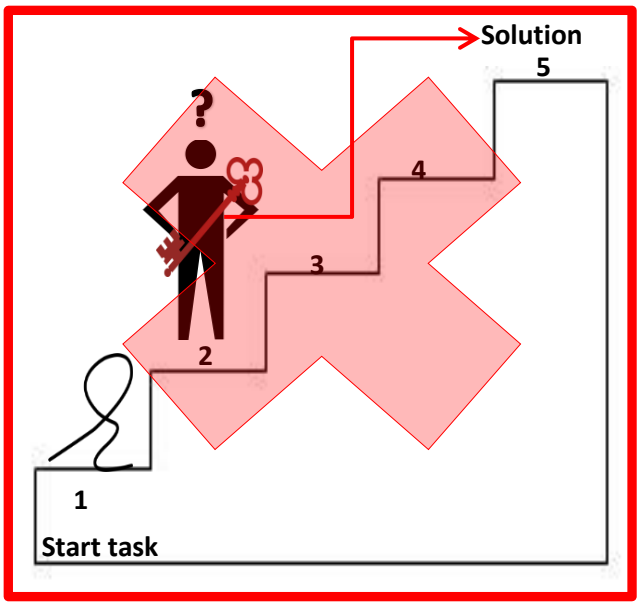
Definitions

Feedback
A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.
Reward
A prize players can receive if they successfully solve (part of) a task, it is a type of feedback.

1.2 Feedback

- Situation: Regardless of adequate feedback and hints, players can keep making mistakes, which block their game progress.
- **Guideline: Provide the first step that is the key to let players continue, without giving the full answer.**
- Example: Give the first step towards the solution that enables progression.





Context

- If the hints from guideline 1.1 are not sufficient and players are still stuck in the game, the first part of the answer can be given. This way, players can continue to solve the rest of the task themselves.
- To correct mistakes, it is required to define what counts as a mistake and after how many mistakes support is given or when players can ask for help.
- Players quickly lose interest if they are unable to complete a task and there is no help available. Consequently, they miss a learning opportunity (Scarlatos, 2002).
- This guideline is best applicable for more elaborate tasks that require multiple steps or actions from players

Definitions

Feedback
A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.

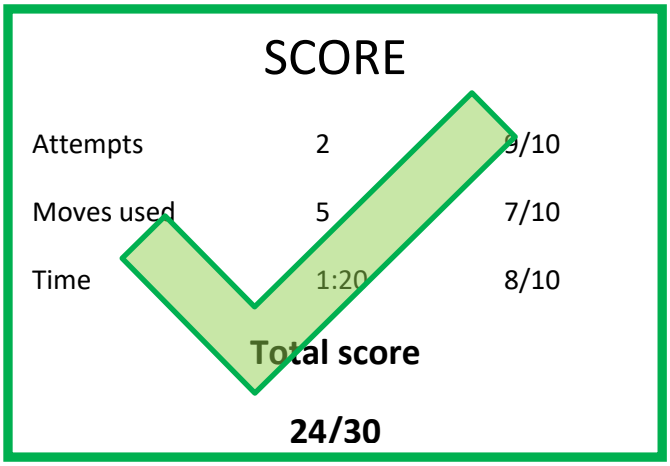
Help
A way to assist players if they are not able to come up with a solution by themselves.

- *From the game*
  A hint given by the game when players are notable to complete a certain part of the game. Hints can differ from being rather vague to explicitly telling players what to do.

Key
A part of the task's solution that allows players to step over a blockade, so they can continue playing and solve the rest of the task.

1.3 Feedback

- Situation: Scores inform players about their performances by providing information about their learning development and game performance.
- **Guideline: show the composition of the score and the range of possible scores at different moments in the game.**
- Example: Use previous level scores to determine a final score.



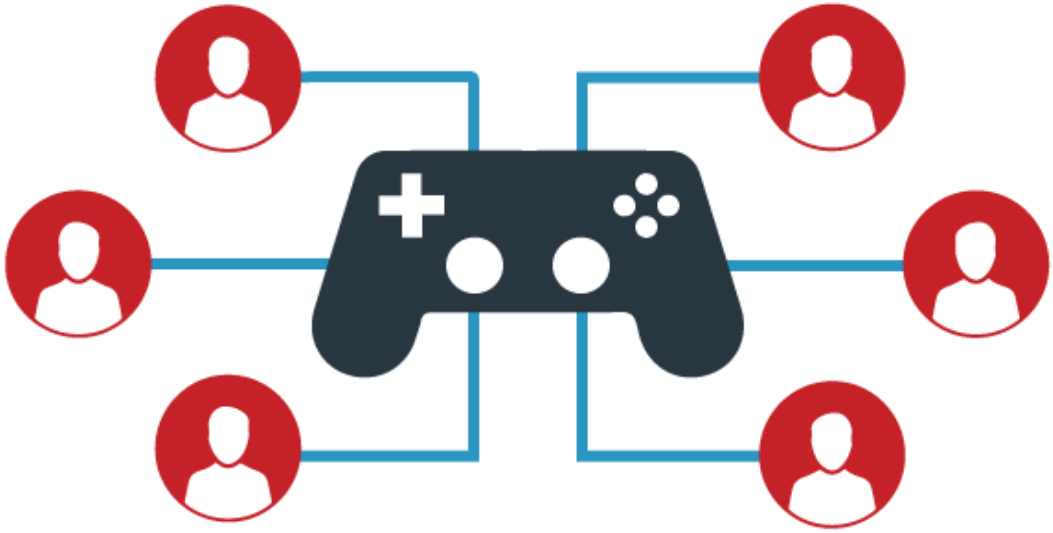
Context

- Scores can indicate development in the game in two ways. First, during a level or game the score can be constantly updated and at the end of the level or game a final score can be given. Second, before the game or level an old score could be given, that is compared to the new score.
- By letting individual scores influence group scores individual accountability is applied (Lanzilotti et al., 2015).

Definitions

Score
A numerical indication of how well a player has performed, so it represents the level of a player.

2 Multiplayer



Multiplayer focuses on multiple persons playing a game together through collaboration. Important elements are communication, positive interdependence, individual accountability,

Relevant terms

- **Cognitive conflict**

The realization that new information is not in accordance with their existing knowledge

- **Communication**

A conversation that players need to have with each other while playing. Players share information, discuss next and previous actions, and give each other feedback.

- **Exploratory talk**

All group members take part in a critical way, knowledge is explicitly shared amongst group members, statements are challenged, and reasoning has an essential role

- **Free-rider effect**

An effect that occurs in groups where a few students do all the work, and others only profit from that work without contributing themselves.

- **Input**

A contribution from a player to the game by performing an action, giving information, hints, or an opinion with the intention to solve a task.

- **Task**

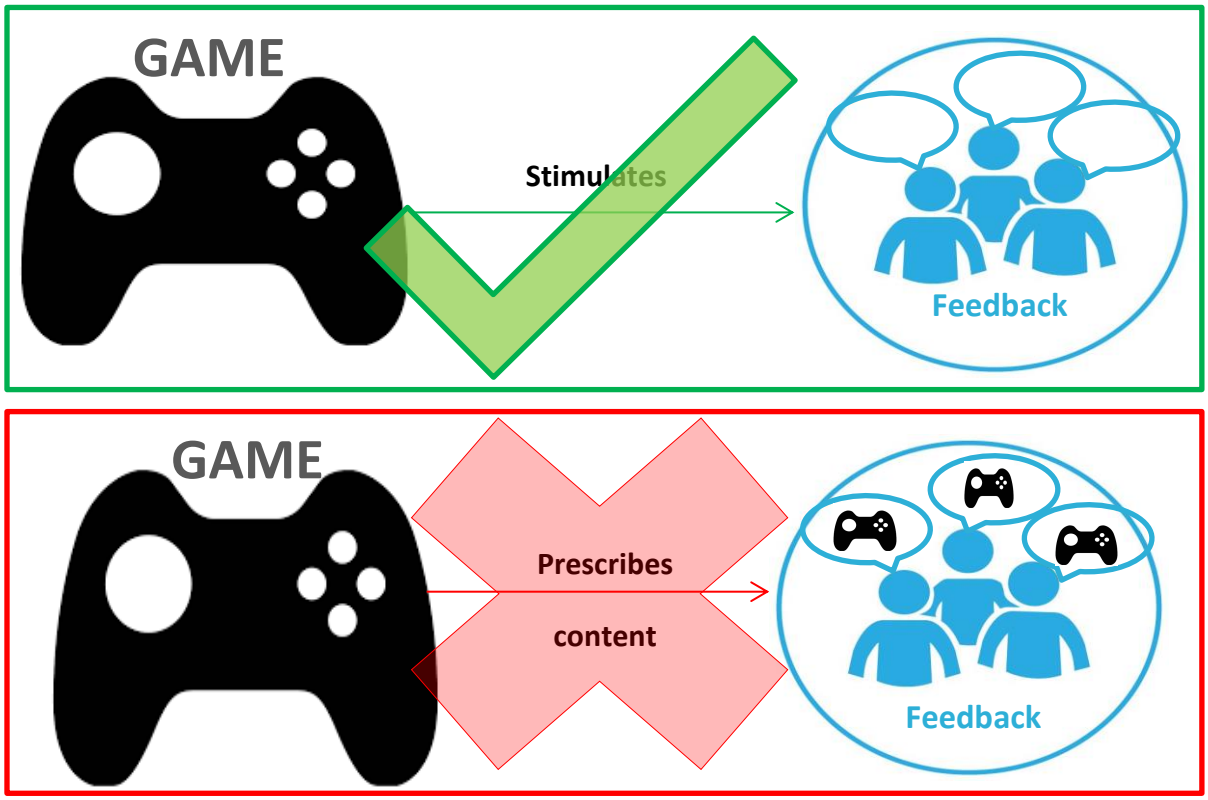
A defined part of the game that players need to complete in order to reach their goal.

- **Positive interdependence**

Individual players believe they can only reach their goals, if their group members reach their goals as well.

2.1 Multiplayer

- Situation: Collaborative learning is a social process that requires players to give each other feedback on their ideas during discussions.
- **Guideline: Stimulate feedback interactions between players, without filling in the content of these conversations.**
- Example: Ask a player to comment on the ideas of another group member.



Context

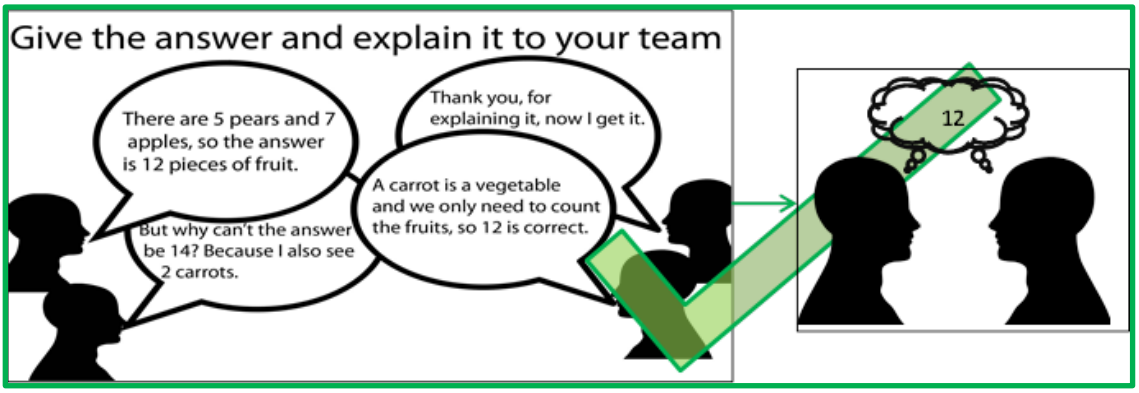
- Since players are working on a collaborative game, the whole group has an interest in individual actions, so players are willing to give feedback (Slavin, 1995).
- Players need to pay attention to each other, so they know what's going on in case someone needs help or if they are asked to give feedback.
- Players need to think themselves and help each other instead of that the game tells players exactly what to do.

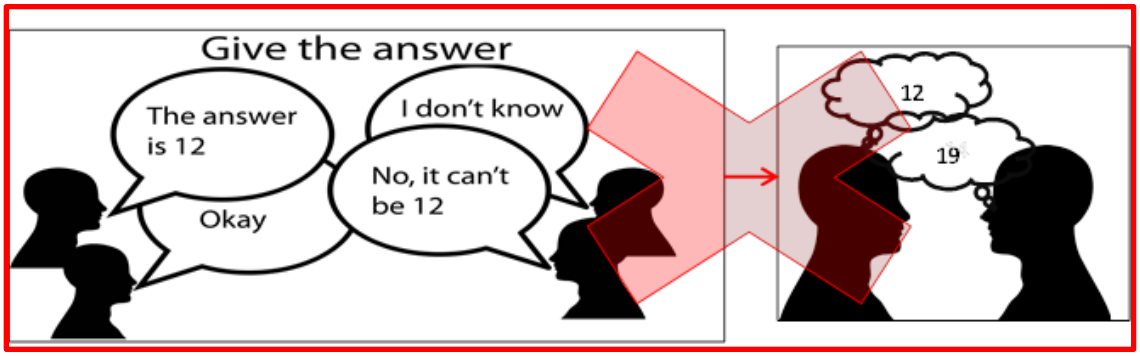
Definitions

Not applicable

2.2 Multiplayer

- Situation: When players need to work together on a task, communication is a key element, but this needs to be more than just asking and answering questions.
- **Guideline: Urge players to participate in full conversations that stimulate discussions that can elicit cognitive conflict and build shared understanding.**
- Example: Ask players to explain their answers and to respond to the explanations of their group members.





Context

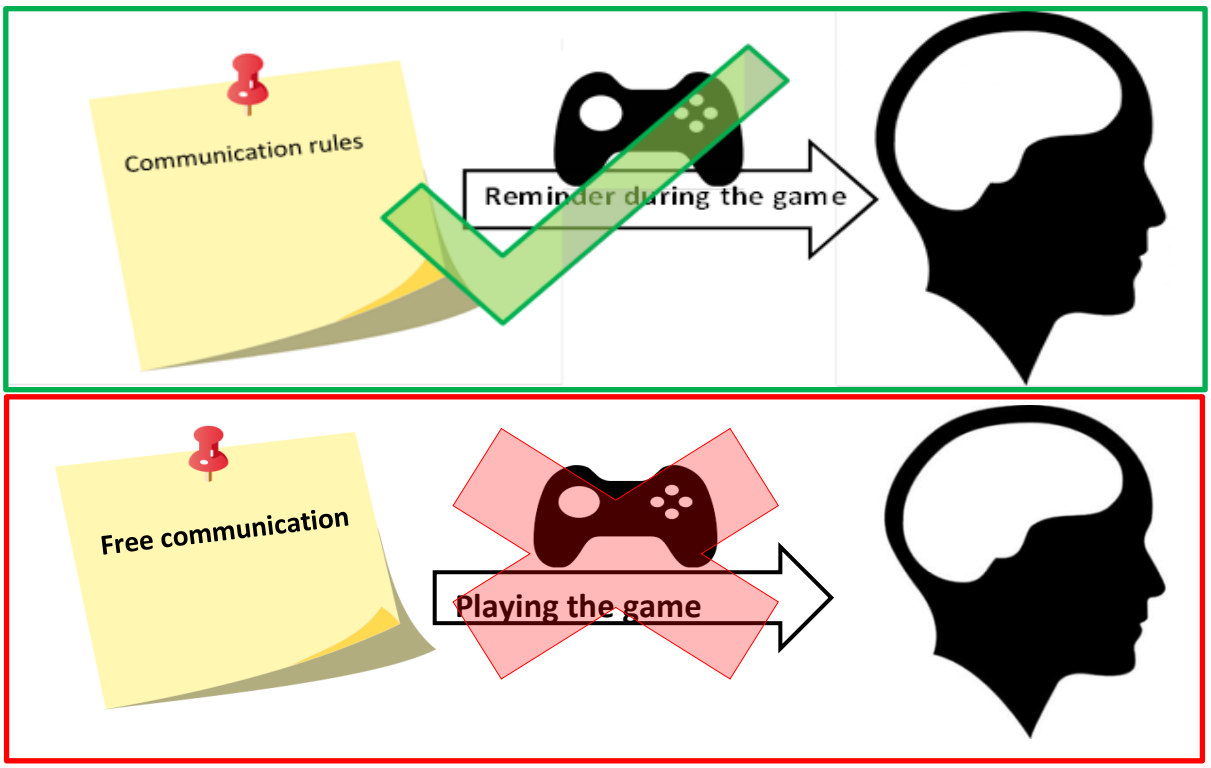
- During discussions cognitive conflict can arise and the reasoning of each player is exposed, which is effective for learning (Slavin, 1995).
- Interpersonal and small-group skills are required for effective collaboration, an example of these skills is being able to communicate unambiguously (Johnson & Johnson, 2009).
- Players share information, give feedback, discuss solutions, take decisions, and solve possible conflicts.

Definitions

Communication
A conversation that players need to have with each other while playing. Players share information, discuss next and previous actions, and give each other feedback.
Cognitive conflict
The realization that new information is not in accordance with existing knowledge.

2.3 Multiplayer

- Situation: Even though communication is required when working in a group, not all communication is equally effective for learning, so players need to agree on how they will talk to each other.
- **Guideline:** **Players need to be made aware of how they can communicate effectively in exploratory talk, so it won't interfere with playing the game.**
- Example: Ask players questions that force them to explain their actions with arguments to remind them of how they should communicate.



Context

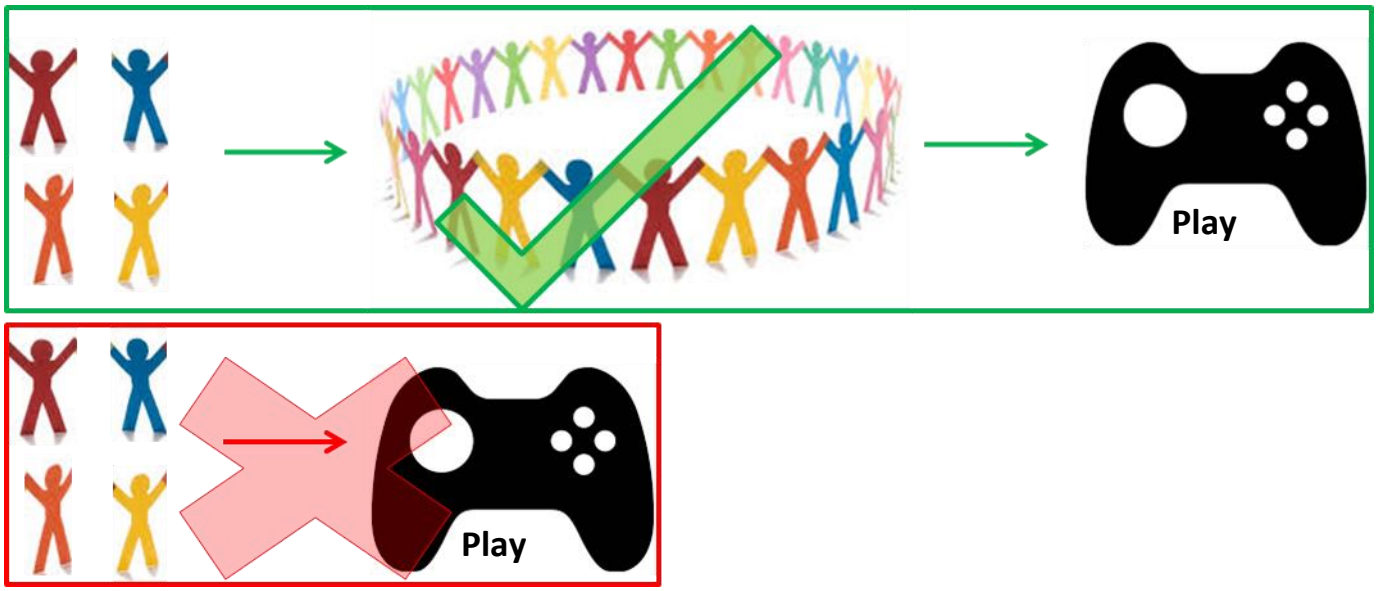
- Players should engage in exploratory talk, which means that relevant information is shared, group members are critical, challenge each other's ideas in a constructive way, and reasons are given (Rojas-Drummond & Mercer, 2003).
- Players who are instructed how to communicate, work more effectively on solving problems (Rojas-Drummond & Mercer, 2003).
- In their interaction players need to encourage each other and provide help to ensure promotive interaction (Johnson & Johnson, 2009).

Definitions

Communication
A conversation that players need to have with each other while playing. Players share information, discuss next and previous actions, and give each other feedback.
Exploratory talk
All group members take part in a critical way, knowledge is explicitly shared amongst group members, statements are challenged, and reasoning has an essential role.

2.4 Multiplayer

- Situation: Players need to trust each other, feel comfortable and experience a sense of belonging, before they are willing to engage in collaboration and express appropriate social skills.
- **Guideline: A sense of community needs to be built to make players feel part of the group.**
- Example: Support players to get to know each other before they actually start playing by providing an ice breaker.



Context

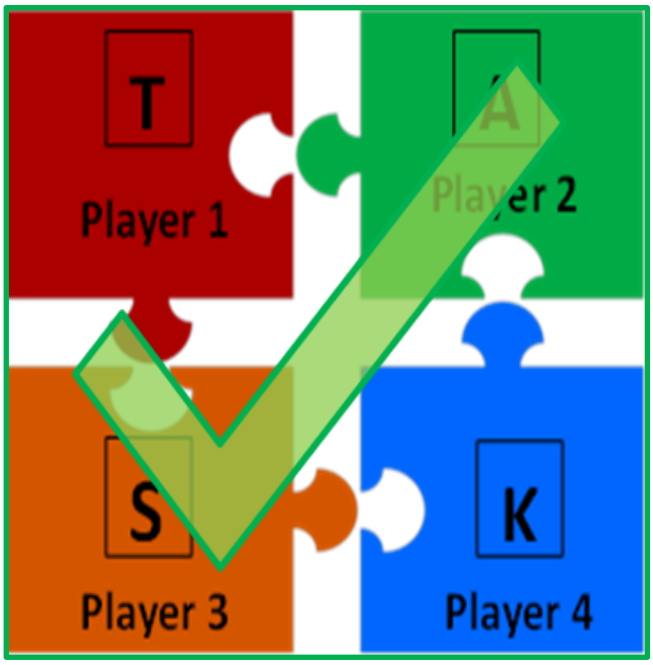
- Group cohesion is built from social relations, equal understanding, intension for collaboration, and the wish to stay part of the group (Kreijns, Kirschner & Jochems, 2003).
- Based on impressions group members have of each other a social working relationship can be developed (Kreijns, Kirschner & Jochems, 2003).
- Building a sense of community can take less time and effort if players are already familiar with each other.

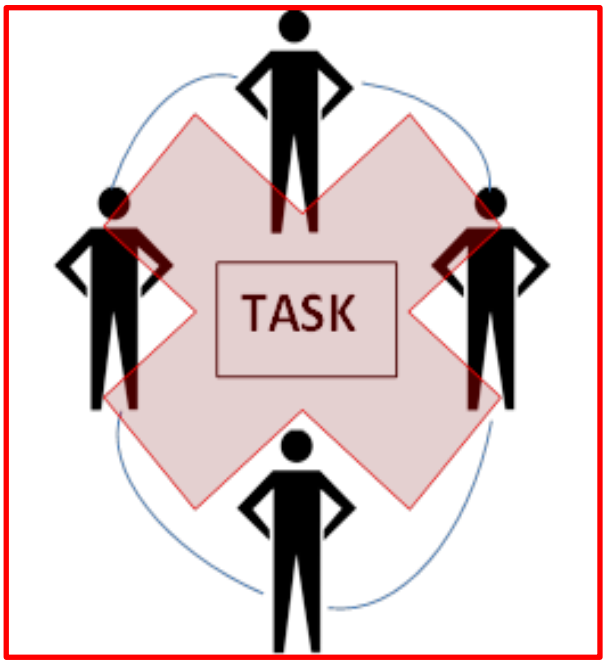
Definitions

Not applicable

2.5 Multiplayer

- Situation: For collaboration it is necessary that players are dependent on each other, every player should contribute equally.
- **Guideline: Tasks and execution of these tasks must be divided over multiple players.**
- Example: Create small subtasks that need to be combined to fulfill the group task.





Context

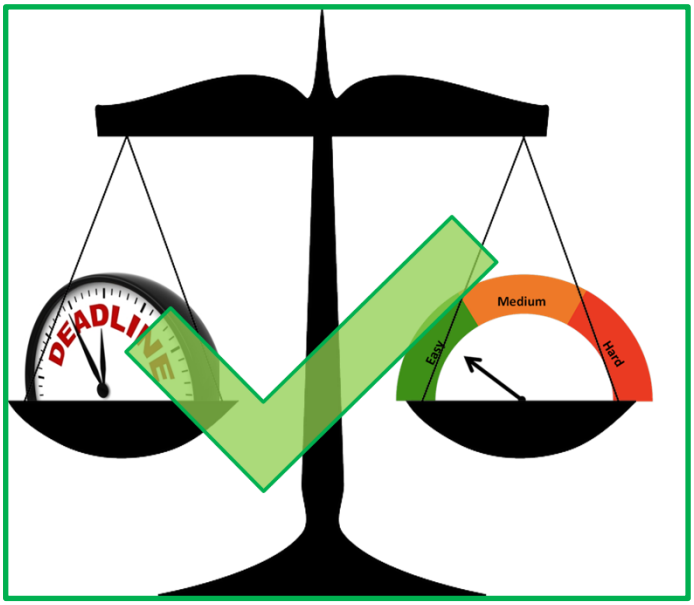
- If group members think they are dependent on each other, they will be more likely to get into contact with others (Kreijns, Kirschner & Jochems, 2003).
- If only one player can constantly manipulate game elements it decreases discussion in the group (Scarlatos, 2002).
- Players can work separately on subtasks, but are working on the group task at the same time.

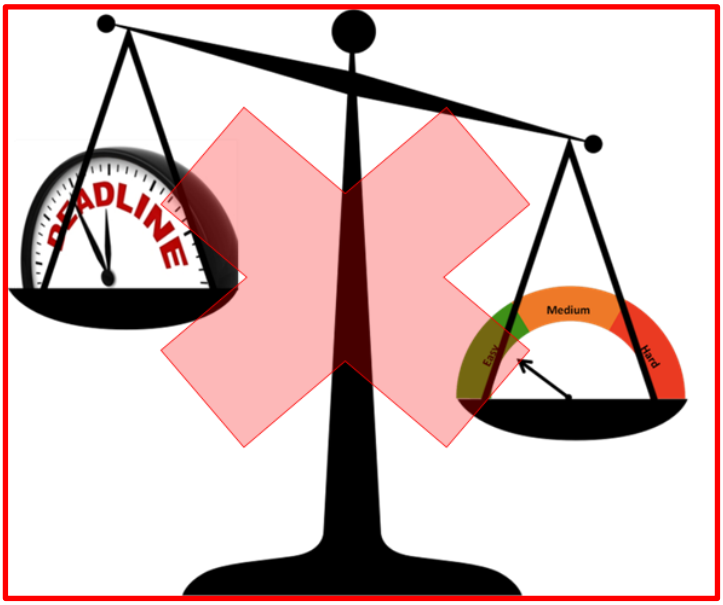
Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

2.6 Multiplayer

- Situation: Players need to maintain focus on task related activities and be able to engage in interactions, to deliver optimal quality and quantity.
- **Guideline: Provide a balance between available time and task complexity to help players focus on task related activities.**
- Example: Inform players about the available time.





Context

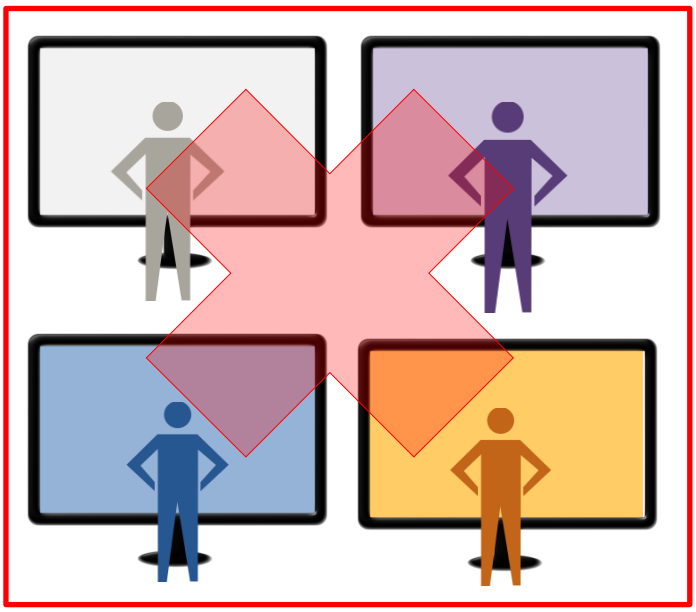
- If players experience scarcity of time, they are more focused on the elements that are most useful for solving the task, other elements are missed, which decreases performance. Also, there is less time for discussion (Karau & Kelly, 1991).
- Groups that have more time, spend more time on non-task related activities than groups that have less time (Karau & Kelly, 1991).
- If players can keep working on a task as long as they want, but their score decreases as they work longer on it.

Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

2.7 Multiplayer

- Situation: If everyone can refer to the same elements that are relevant for the whole group, they are easily accessible, and it becomes easier to collaborate and to contribute to discussions and completing the task.
- **Guideline: Graphic elements and general game information are shown to all players to give all players the same points of reference as a basis.**
- Example: The game shows the rules of the game to all players.



Context

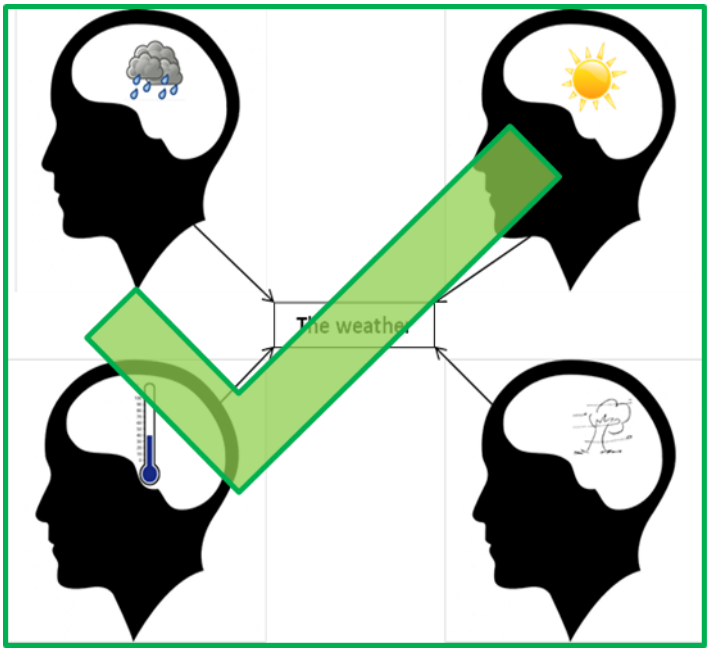
- If players stand around the game, they all have access to the same information, which can be used for discussions (Rogers &Lindley, 2004).

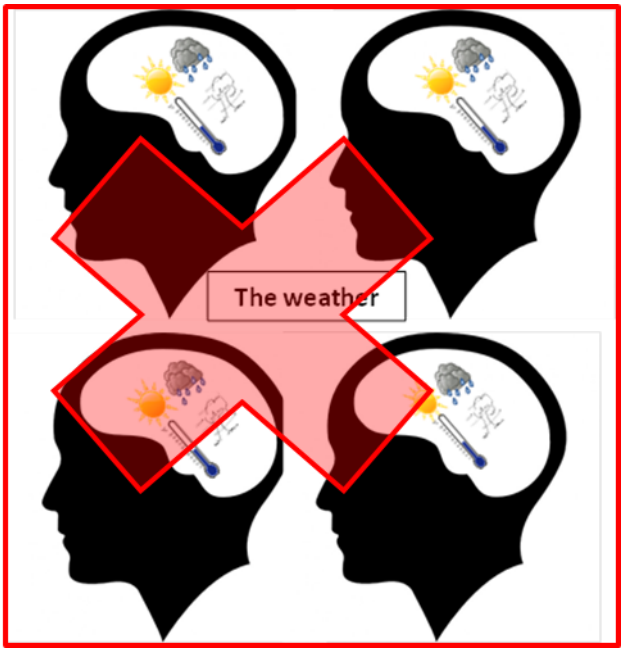
Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

2.8 Multiplayer

- Situation: If not everyone has the same tools and resources that are necessary to solve tasks, everyone in the group is needed to solve it and members are dependent on each other, which is positive for collaboration.
- **Guideline:** **Support dependence by not making all task-related information available to all players, so tasks can only be solved if everyone shares their part of information.**
- Example: Every player receives a bit of information when the groups start working on a task.





Context

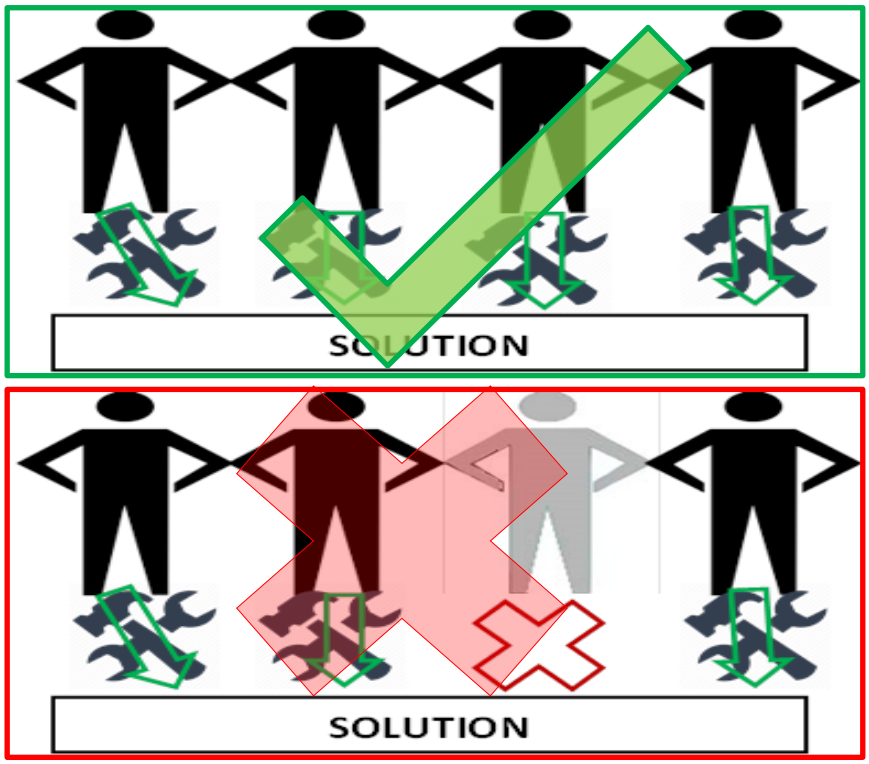
- Positive interdependence as mentioned by Johnson and Johnson (2009) is created, since players need each other's information to complete the task.

Definitions

Positive interdependence
Individual players believe they can only reach their goals, if their group members reach their goals as well.
Task
A defined part of the game that players need to complete in order to reach their goal.

2.9 Multiplayer

- Situation: During collaboration the free-rider effect can arise when there is only a single group task that does not hold individuals responsible for their actions and the end result.
- **Guideline: Every individual needs to give input in order for the group to solve the task.**
- Example: Make every player responsible for part of the group product.



Context

- It is not required that all players deliver input at every moment, it is also possible that each player is responsible at another moment in the game. Thus, there can be a distinction between group tasks and individual tasks in the game.
- Individual accountability (Johnson & Johnson, 2009) is applicable, every player is responsible for part of the task and is assessed on that part, so they can't just profit from others.

Definitions

Free-rider effect
An effect that occurs in groups where a few students do all the work, and others only profit from that work without contributing themselves.
Input
A contribution from a player to the game by performing an action, giving information, hints, or an opinion with the intention to solve a task.
Task
A defined part of the game that players need to complete in order to reach their goal.

The category goals guidance is about what players should be able to do while or after playing the game, and how this can be accomplished.

Relevant terms

- **Challenge**

A difficult task with no straightforward solution, for which players need to find a solution.

- **Complexity**

A state that arises in players when there is an optimal level of complexity of information.

- **Feedback**

A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.

- **Goals**

A thing that should be accomplished by playing the game.

  - *Game goal*

    A thing that has to be accomplished by completing the levels.
  - *Learning goal*

    A skill or knowledge that players will learn by playing the game.

- **Task**

A defined part of the game that players need to complete in order to reach their goal.

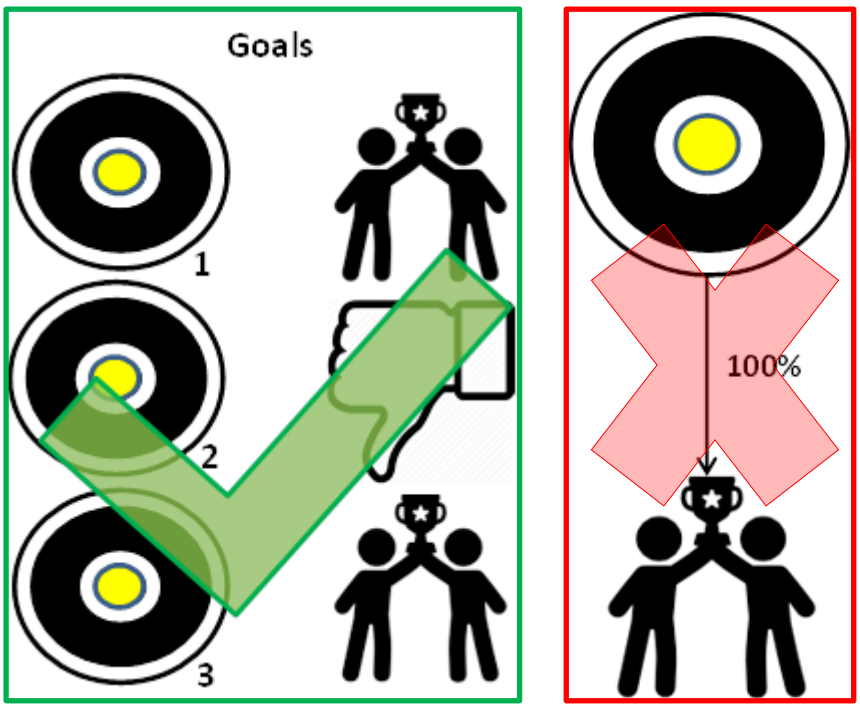
  - *Individual task*

    A task that can and should be completed by one person.
  - *Group task*

    A skill or knowledge that players will learn by playing the game.

3.1 Goals

- Situation: In a game, players are working to reach goals, these can only be challenging if achievement of the goals is uncertain before playing.
- **Guideline: Provide players with multiple game goals that can be either failed of succeeded by executing certain actions.**
- Example: When the solution of a task is the most efficient one, the task is completed successfully and a goal is reached.



Context

- A game goal is a goal within the game, and is different than the learning goal.
- Challenges should be at a level that matches the players' ability (Malone, 1981).
- A game can contain multiple challenges that are presented at different moments.
- If there is more than one way to accomplish the goal, group processing can take place. This means that players reflect on previous action and which actions should be changed for the next time (Johnson & Johnson, 2009).

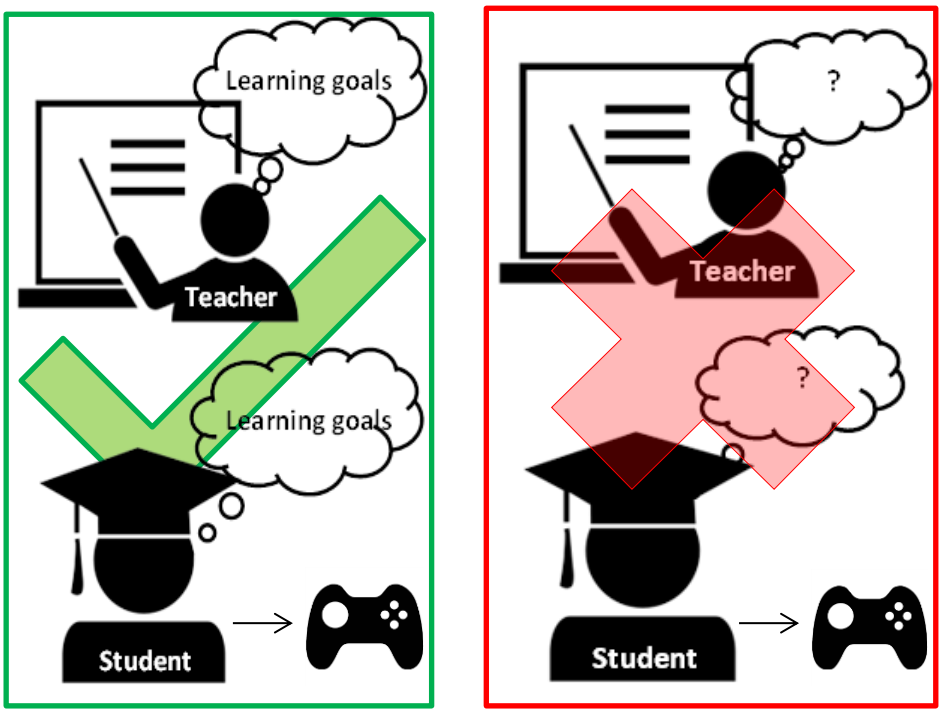
Definitions

Challenge
A difficult task with no straightforward solution, for which players need to find a solution.
Goals
A thing that should be accomplished by playing the game.

- *Game goal*
  A thing that has to be accomplished by completing the levels.

3.2 Goals

- Situation: Games in education are not just played for fun, but players need to transfer something from it to real life, this is stated in the learning goal.
- **Guideline:** **Inform players and teachers about what they can expect from the game, the steps towards this learning goal can be clarified by adding subgoals.**
- Example: Define the learning goal and communicate it to users before playing the game.



Context

- A learning goal is what players are supposed to learn, and is not the same as a game goal.
- Feedback can be used to effectively guide players towards the learning goal (Linehan et al, 2011).
- The learning goals can be communicated to players in another way than they are communicated to teachers.

Definitions

Feedback
A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.
Goals
A thing that should be accomplished by playing the game.

- *Learning goal*
  A skill or knowledge that players will learn by playing the game.

3.3 Goals

- Situation: The game is structured by rules that define the limits of what players are allowed to do and create fairness in the game.
- **Guideline: Define game rules that clearly guide players through the game to let them focus on the playing game and without needing to discuss the rules is not necessary.**
- Example: Clearly communicate rules to players.

Context

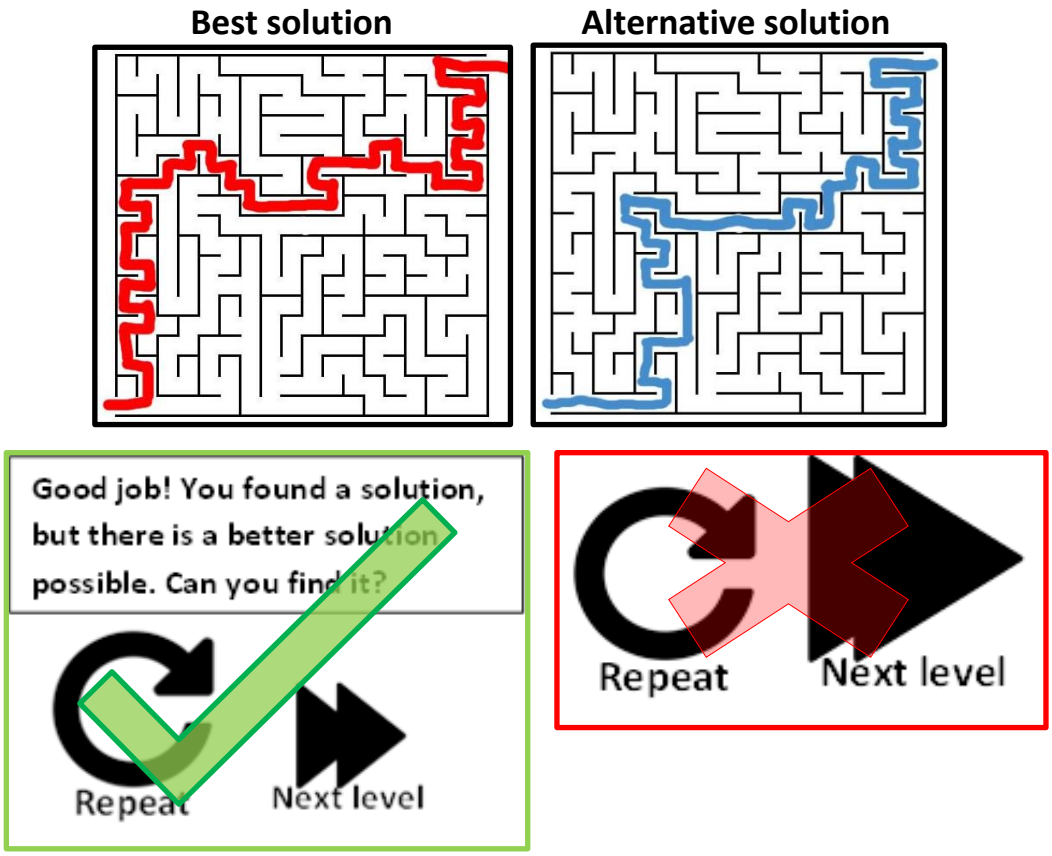
- Rules are required to increase complexity of learning (Annetta, 2010).
- Rules may become more elaborate as the game progresses, to slowly build up the complexity of the game.
- A game manual can be used to present the rules

Definitions

Not applicable

3.4 Goals

- Situation: If a task can be solved in different ways, there can be one way that fits the goal of the task best. It can happen that players find another solution and therefore don't fully reach the goal.
- **Guideline: Players should be encouraged to repeat the task to find the best solution that leads to attainment of the goal.**
- Example: Only providing the opportunity to repeat a task is insufficient, trigger players to try again.



Context

- Only presenting a repeat button does not encourage players to find the best solution, it only provides the opportunity to find another solution.

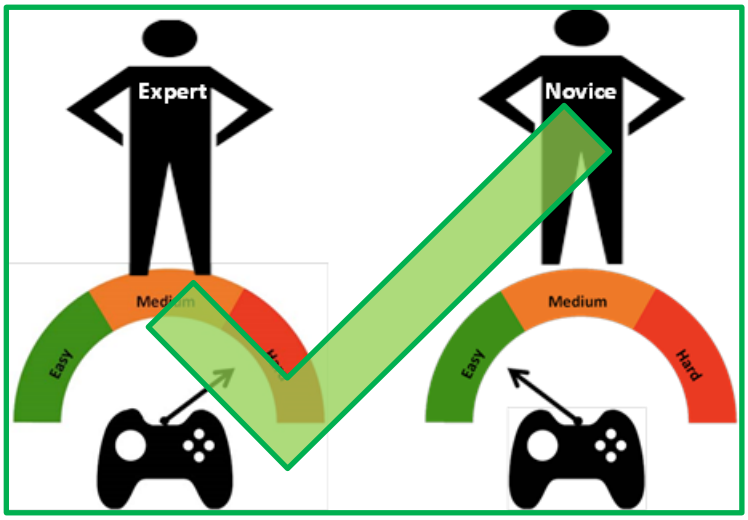
Definitions

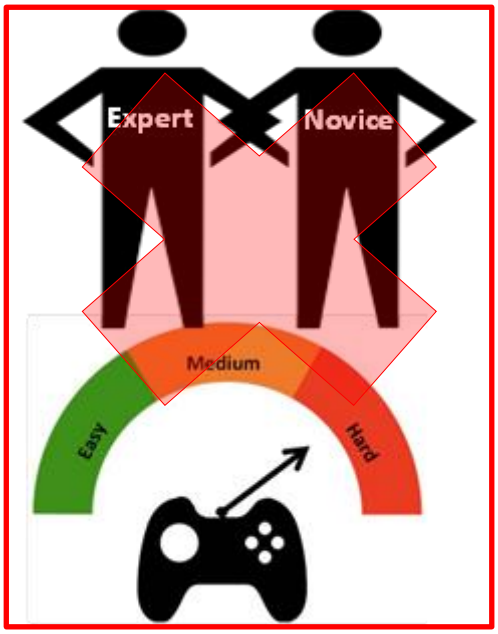
Task
A defined part of the game that players need to complete in order to reach their goal.
Goals
A thing that should be accomplished by playing the game.

- *Game goal*
  A thing that has to be accomplished by completing the levels.

3.5 Goals

- Situation: While playing the game, players acquire or improve skills.
- **Guideline:** **The game should respond to this by adapting the complexity of the tasks to maintain players' curiosity.**
- Example: Match tasks to the ability level of the players.





Context

- Complexity at a level that matches the player supports curiosity, which is positive for intrinsic motivation (Malone, 1981).
- Players can first get familiar with how the game works
- Players can first practice the basic skills, which they will need to combine in the more complex part of the game.
- The game can keep players in a state of flow if it adapts to player's actions, in this case players are highly concentrated and enjoy what they are doing (Prensky, 2001).
- Adaptivity can take place at an individual or at group level.

Definitions

Curiosity
A state that arises in players when there is an optimal level of complexity of information.
Task
A defined part of the game that players need to complete in order to reach their goal.

4

Game content

The game content guidelines describe the importance of having a context in which the playing takes place.

Relevant terms

- **Goals**

A thing that should be accomplished by playing the game.

- *Game goal*

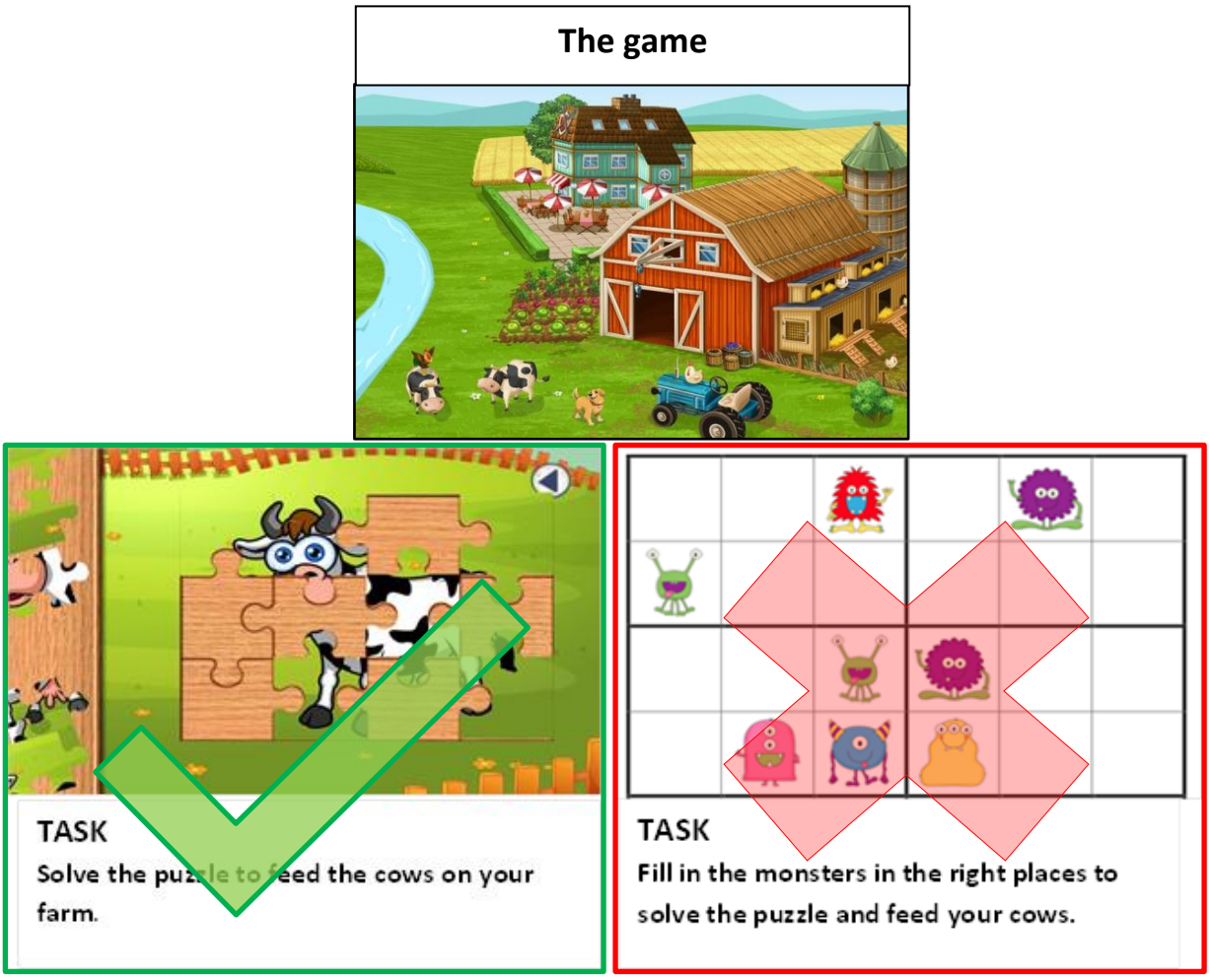
  A thing that has to be accomplished by completing the levels.

- *Learning goal*

  A skill or knowledge that players will learn by playing the game.

4.1 Game content

- Situation: Narratives make a task more meaningful, but can distract players from learning if it is not directly related to learning content
- **Guideline:** **Match the game theme and the actions that can be performed in the game environment to the learning goals.**
- Example: Create a game environment that stays largely the same over the course of the game.



Context

- Tasks and actions are placed within a fictional context or game world (Mitgutsch & Alvarado, 2012).
- If too much cognitive capacity is required to process the narrative, little space remains to process and acquire the learning content (Adams, Mayer, Macnamara, Koenig & Waines, 2011).

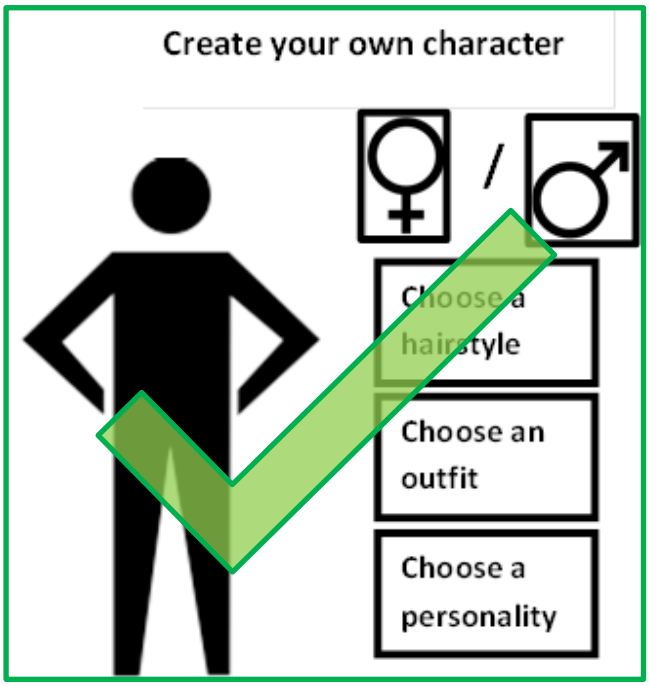
Definitions

Goals

- *Game goal*
  A thing that has to be accomplished by completing the levels.
- *Learning goal*
  A skill or knowledge that players will learn by playing the game.

4.2 Game content

- Situation: Players who experience a unique identity in the game, will become more engaged in the game which intrinsically motivates them to work through presented obstacles.
- **Guideline:** **The game should contain personal elements that clearly represent each player's presence, through which they can interact with the game.**
- Example: Players can pick a character and adapt it to their own preference.



Context

- Being an individual is an idea intrinsic to human nature, it is about the need to feel unique (Annetta, 2010).
- Players become motivated if they experience a personal identity, this can be accomplished by letting players. emphasize with or become a character (Annetta, 2010).

Definitions

Not applicable

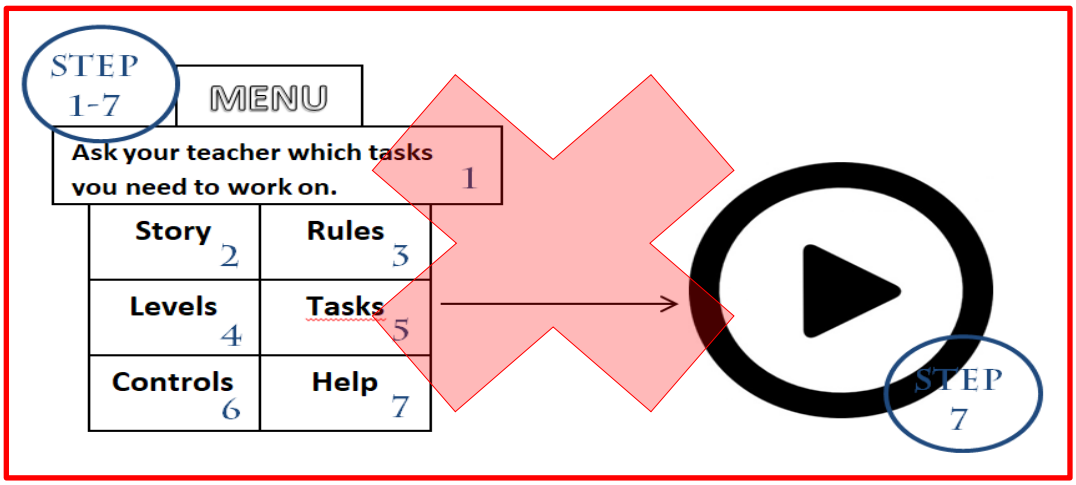
the game controls guidelines are about what needs to be done by players to start playing and to perform an action.

Relevant terms

Not applicable

5.1 Game Controls

- Situation: Groups can start playing the game independently without a teacher
- **Guideline:** **Setting up the game is sufficiently easy and the rules and tasks should be clear, without taking a lot of time.**
- Example: Players can start playing without help from a teacher.



Context

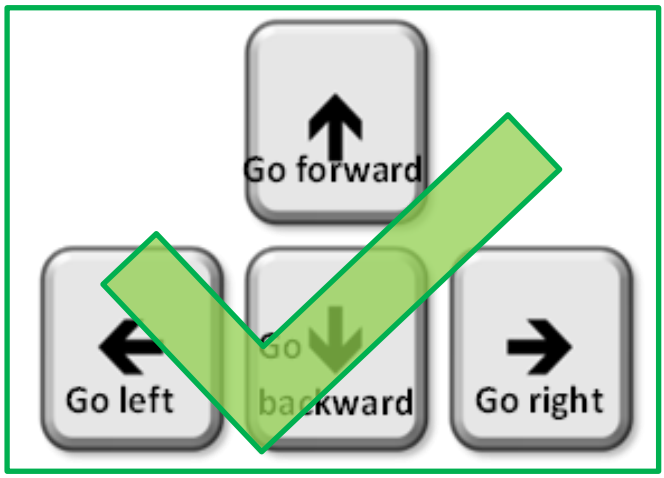
- It saves time and effort for the teacher if he does not need to help with setting up the game.
- The game should present itself in a way that makes it clear where to begin.

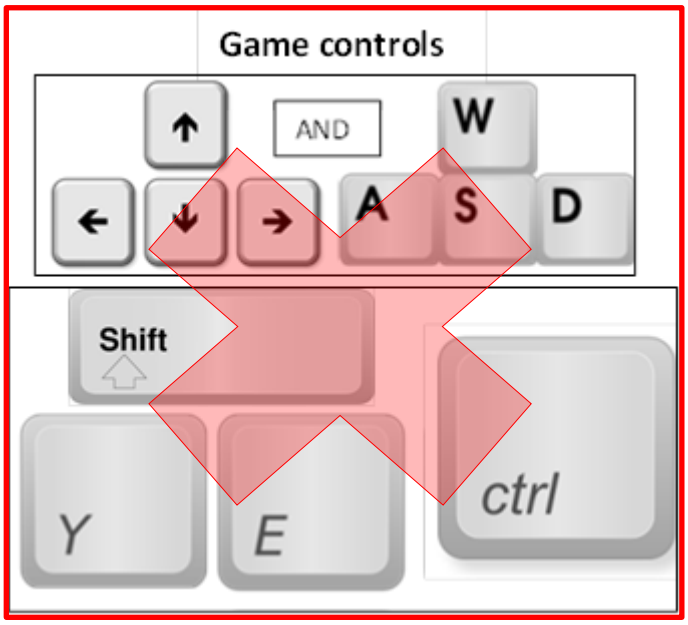
Definitions

Not applicable

5.2 Game Controls

- Situation: Commands through which the game can be controlled can have several meanings or can be unclear because the context in which they are used.
- **Guideline:** **The commands need to be made clear for players, so they can focus on the challenges from the game, if a command differs from the usual commands used in games, clarify this to the player.**
- Example: Use an existing language that is common in similar.





Context

Not applicable

Definitions

Not applicable

Everything players do is recorded and saved by the game.

Relevant terms

- **Data**

A recording of everything players do in the game, this provides information about players' performances.

- **Feedback**

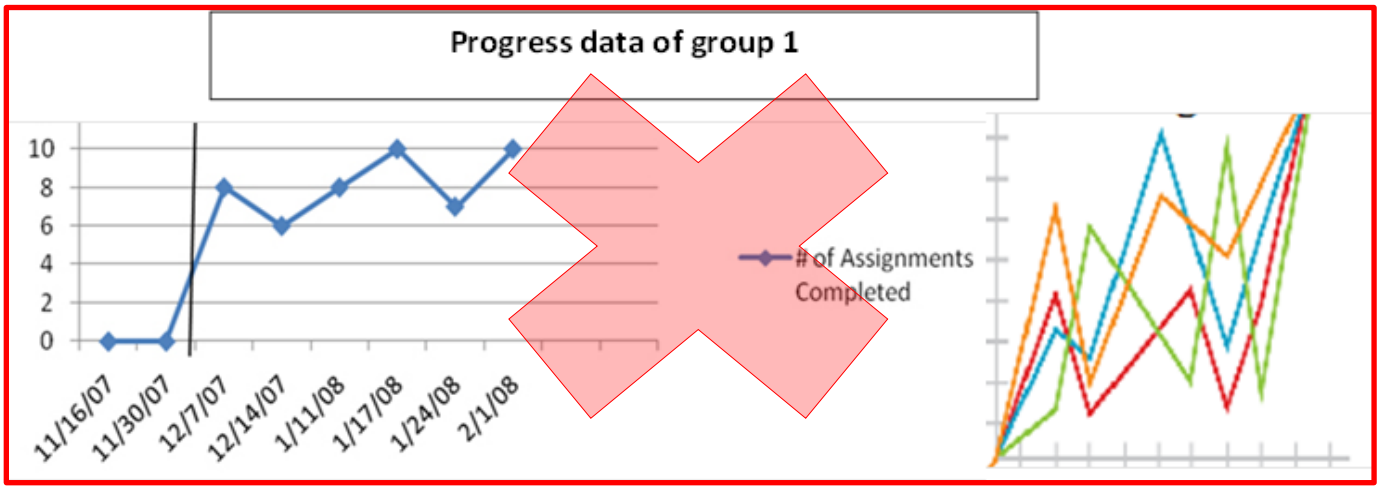
A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.

- **Performance gap**

A difference exists between an actual performance and the desired performance of a player.

6.1 Data

- Situation: Games can collect data about players' actions, information that comes from this data can be used to determine a performance gap.
- **Guideline:** **Use data as input to give feedback, and to let teachers and players monitor progress. Only data that is relevant for the goals in that game has to be recorded.**
- Example: Present the data in a way that is easy to interpret for the user.



Context

- Data can be used by players and teachers to monitor the player's progress towards a desired performance (Linehan, Kirman, Lawson & Chan, 2011).
- The data that needs to be recorded depends on the reason for collecting data.

Definitions

Data

- A recording of everything players do in the game, this provides information about players' performances.

Feedback

- A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.

Appendix 1 Definitions

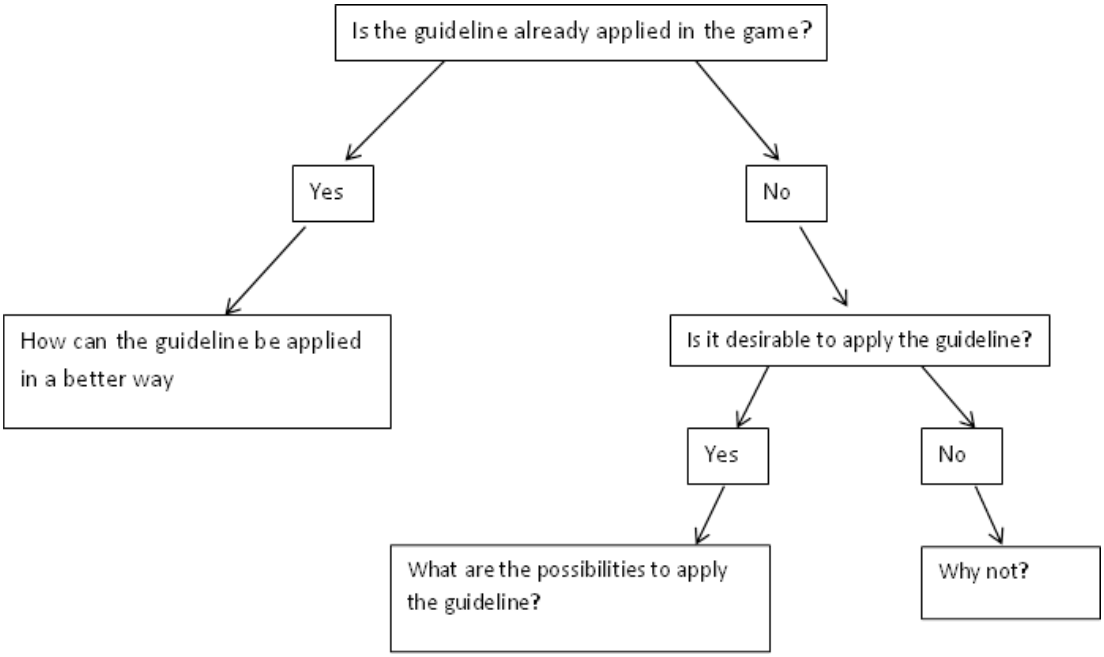
Table 1

Definitions of relevant terms

concept	Definition
Challenge	A difficult task with no straightforward solution, for which players need to find a solution.
Cognitive conflict	The realization that new information is not in accordance with existing knowledge.
Communication	A conversation that players need to have with each other while playing. Players share information, discuss next and previous actions, and give each other feedback.
Data	A recording of everything players do in the game, this provides information about players' performances.
Exploratory talk	All group members take part in a critical way, knowledge is explicitly shared amongst group members, statements are challenged, and reasoning has an essential role.
Feedback	A response to players' actions in the game, it informs them about the quality of their performance and guides them towards the desired level if necessary.
Free-rider effect	An effect that occurs in groups where a few students do all the work, and others only profit from that work without contributing themselves.
Goals	A thing that should be accomplished by playing the game. There are two types of goals:
o Game goal	A thing that has to be accomplished by completing the levels.
o Learning goal	A skill or knowledge that players will learn by playing the game.
Help	A way to assist players if they are not able to come up with a solution by themselves.
o From the game	A hint given by the game when players are not able to complete a certain part of the game. Hints can differ from being rather vague to explicitly telling players what to do.
o From other players	Advice or information given by other players that helps to solve the task.

Input	A contribution from a player to the game by performing an action, giving information, hints, or an opinion with the intention to solve a task.
Reward	A prize players can receive if they successfully solve (part of) a task, it is a type of feedback.
Score	A numerical indication of how well a player has performed, so it represents the level of a player.
Support	An encouragement from the game to let players perform an action, instead of only providing an opportunity.
Performance gap	A difference exists between an actual performance and the desired performance from a player.
Positive interdependence	Individual players believe they can only reach their goals, if their group members reach their goals as well.
Task	A defined part of the game that players need to complete in order to reach their goal.
o Individual task	A task that can and should be completed by one person.
o Group task	A task that requires more than one person to solve it.

Appendix 2 Bookmarker



Appendix B: Basis for the guidelines from the theoretical framework.

The following list formed the basis for the first version of the guidelines. The headings show from which part of the theoretical framework they were derived. Some guidelines form different parts of the theory turned out to have the same meaning, these were combined as can be seen in table 1.

Analysis

1. All students have the opportunity to manipulate game elements.
2. The display shows the same information to all students.
3. Help can be provided on-screen.
4. The game records data on players' actions
5. Recorded data is available for teachers or students.
6. The game records how long players are working on a task

Games

7. The game has rules that places limits on the actions the player is allowed to execute.
8. The game becomes more complex while playing.
9. The game has one or more goals.
10. The player is made aware of the goals by the game.
11. The game serves to achieve a learning goal.
12. The game measures the progress towards the goal of the player.
13. Players receive immediate feedback on their actions.
14. It is not guaranteed beforehand that the goal will be accomplished.
15. The game presents challenges to the player that need to be solved.
16. The game promotes interaction between players.
17. The game contains story elements.
18. The actions of the player influence the game environment.
19. The game provides a context in which actions can be performed

Feedback

20. Players receive individual feedback based on their actions in the game.
21. Students receive feedback as a group.
22. Students receive individual feedback.

Collaboration

23. At least two students can work simultaneously on the task.
24. At least two students are required to solve the task.
25. The game provides clear goals to the player.
26. groups receive rewards based on their performance.
27. Players need to communicate with each other to reach the goal.
28. Students receive a group score.
29. Students receive an individual score
30. Interaction between students is needed to solve the task.
31. Input from every student is required to solve the task.
32. At the beginning the game provides an opportunity for players to get to know each other.

33. Students receive prompts to reflect on their actions.
34. There is more than one way to accomplish the goal.
35. Each player has his or her own character in the game.
36. The game supports players to communicate on a high level.
37. Time is available in the game to discuss next steps.
38. Time is available in the game to reflect on past steps.

21st century skills

39. Students are supported to find the most efficient solution to a task
40. Solving problems is required to reach a goal
41. The game uses a programming language that is understandable for the player

Table 1

Combined guidelines

Original guidelines	New guidelines
20. Players receive individual feedback based on their actions in the game. 22. Students receive individual feedback. 13. Players receive immediate feedback on their actions.	1. Players receive individual feedback based on their actions in the game.
21. Students receive feedback as a group.	2. students receive feedback on their group performance.
28. Students receive a group score. 29. Students receive an individual score.	7. The end assessment is based on the actions of each student and the group product.
17. The game contains story elements. 18. The actions of the player influence the game environment.	21. The game contains story elements that provide a context in which actions can be performed.
30. Interaction between students is needed to solve the task. 38. Time is available in the game to reflect on past steps. 33. Students receive prompts to reflect on their actions. 27. Players need to communicate with each other to reach the goal. 16. The game promotes interaction between players.	23. Communication between students is obliged to solve the task.
10. The player is made aware of the goals by the game. 19. The game provides clear goals to the player	24. The game makes players aware of the goals.

Appendix C: First version of the guidelines

Theory	Category	Guideline	Present	Clarification
Collaborative learning	Feedback	1. Players receive individual feedback based on their actions in the game		
Collaborative learning	Feedback	2. Students receive feedback on their group performance		
Collaborative learning	Feedback	3. Groups receive rewards based on their performance		
Collaborative learning	Feedback	4. The end assessment is based on the actions of each student and the group product		
Collaborative learning	Multiplayer	5. At least two students are required to solve the task		
Collaborative learning	Multiplayer	6. Input from every student is required to solve the task		
Design framework	Multiplayer	7. Communication between students is obliged to solve the task		
Design framework	Multiplayer	8. At least two students can work simultaneously on the task		
Design framework	Multiplayer	9. All students have the opportunity to manipulate game elements		
Collaborative learning	Multiplayer	10. At the beginning the game provides an opportunity for players to get to know each other		
Collaborative learning	Multiplayer	11. Time is available in the game to discuss next steps		
Serious games	Goals	12. The game serves to achieve a learning goal		
Serious games	Goals	13. The game presents challenges to the player that need to be solved		
Serious games	Goals	14. The game has rules that		

		places limits on the actions the player is allowed to execute		
Design framework	Goals	15. It is not guaranteed beforehand that the goal will be accomplished		
Design framework	Goals	16. The game has one or more goals		
Design framework	Goals	17. The game makes players aware of the goals		
Computational thinking	Goals	18. Solving problems is required to reach a goal		
Design framework	Goals	19. There is more than one way to accomplish the goal		
Computational thinking	Goals	20. Students are supported to find the most efficient solution to a task		
Design framework	Data	21. The game records and saves every action from each player		
Design framework	Data	22. The game records how long players are working on a task		
Design framework	Data	23. Recorded data is available for teachers or students		
Serious games	Data	24. The game measures the progress towards the goal of the player		
Display	Screen	25. Help can be provided on-screen		
Display	Screen	26. The display shows the same information to all students		
Design framework	Other	27. The game contains story elements that provide a context in which actions can be performed		
Programming game	Other	28. The game uses a programming language that is understandable for the player		
Design framework	Other	29. The game becomes more complex while playing		
Design	Other	30. The game supports		

framework		players to communicate on a high level		
Design framework	Other	31. Each player had his or her own character in the game		

Appendix D: game design frameworks

Intrinsic motivation

Motivation seems to be a relevant factor for educational games. As is argued by Malone (1981), students who are intrinsically motivated to learn, might be more willing spend more time and effort on learning and feel better about it. This type of motivation should be more effective, than motivation aroused by external rewards. The framework of Malone (1981) mainly focuses on factors for intrinsic motivation in games. In his paper three main categories are defined, namely challenge, fantasy, and curiosity. Challenge means that a game should contain goals, without the guarantee of successful completion. However, not all goals are automatically good, they should be meaningful to the learner, be clear or easily generated, and provide feedback about how the learner is doing in attaining the goals should be provided (Malone, 1981). Whether a student can reach a challenging goal influences his self-esteem. This means that the level of the tasks that students are working on should match their ability level and feedback should be provided in a way that prevents damaging students' self-esteem. A balance needs to be found between enhancing challenge and reducing self-esteem, so the challenge won't become discouraging.

The second category, fantasy, refers to mental images of physical objects or social situations that are likely to be present in de student's environment. A distinction can be made between extrinsic and intrinsic fantasies. The first means that the fantasy is affected by the skill, but not the other way around. In intrinsic fantasies, skill and fantasy depend on each other. This type of fantasy is preferred by Malone (1981), since cognitive advantages of fantasy, like being able to connect previous knowledge to new information in order to understand it, are only applicable to intrinsic fantasies. Besides, cognitive effects, emotional aspects apply to these fantasies as well in a way that a fantasy can be more or less appealing to different persons.

Curiosity, the third category, can arouse motivation in a student by making use of an environment that is not too simple or too complicated for the student's current ability level. In other words, the environment should be understandable, but also surprising and new. Attention can be attracted by sensory stimuli or it can address changing higher level cognitive structures, by for example providing an incomplete solution or paradox. An environment can be made more complex by making it responsive to a student's actions by giving informative feedback in a surprising and constructive manner. Thus, feedback can be given at random moments and supports learners to see how to change their knowledge.

Applied behavior analysis

Applied behavior analysis (ABA) is a method that provides a basis for designing educational games, while including elements that are essential for motivation in normal games with an entertainment purpose (Linehan, Kirman, Lawson & Chain, 2011). Teachers already exhibit some behavior that fit ABA, but they may not be fully aware of it. They often give rewards or punishment to students based on previous behavior. ABA demonstrates this has been effective in increasing students' academic and social performance. This method has some resemblances with games, for example both teachers and games can make an assessment about the difference between the current level of a student and the goal level. Also, highly engaging games usually contain clear and measurable goals, repetition of skills is needed to complete those goals, and feedback is constantly provided. Increasing the complexity of the game over the course of the game is highly valued in successful games as well (Linehan et al., 2011).

In order to design educational programs or games, a few steps should be considered to increase the chance that the game will support students to reach the goal. The first step is defining and measuring behavior, it is important that the game objectives are defined in a clear way that can objectively be observed and are specific enough to define when a student has reached the goal (Linehan et al., 2011). This accounts for both the main goal and subgoals. Once a subgoal has been completed the student can continue to a bigger challenge. In measuring performance, ABA does not only rely on good or bad performance, but time related aspects are also included. This indicates how comfortable someone is with the material. The second step is recording and analyzing behavioral change, to record every occurrence of the target behaviors. This data should easily be read and analyzed by the system and can be presented to students and teachers (Linehan et al., 2011). The data can be used to analyze change in students' game behavior, by comparing current performance with the learning goal to see if the gap between these two is decreasing as a result of learning (Linehan et al., 2011).

Presenting corrective feedback is mentioned as the third step by Linehan et al. (2011) and has the intention to support students in reaching optimal performance. Feedback can influence behavioral change by operant conditioning. This can be executed by positive reinforcement, negative reinforcement, positive punishment, or negative punishment. The first two aim to let certain behavior reoccur, while the latter two aim to avoid certain behavior. Positive in this context means that a stimulus is given to the student, while negative refers to taking something away. These different ways of providing feedback can be provided to

effectively guide students towards the learning goal. Timing of giving feedback is another important aspect, since offering a reward after every single action is not sufficient to maintain behavior. In order to achieve this maintenance of behavior, the amount of actions or time to provide feedback on should be adapted. The fourth step is focused on adapting the game to performances in a dynamic way, in other words the challenge should match the level of the student who is playing the game. The adaptations cover clear goals or target behavior and a schedule for providing rewards.

The six I's design framework

Serious games provide an opportunity for teachers and students to make a connection between school curriculum and real-world scenarios (Annetta, 2010). Annetta (2010) proposes a hierarchal and nested model consisting of six elements to develop and test serious games, see figure 1. The elements are ordered to their degree of importance, namely identity, immersion, interactivity, increasing complexity, informed teaching, and instructional.

Identity refers to the ability of games to make players believe they are unique individuals within the game. Giving players this sense of individuality matches the human need to belong and the need to feel unique. A game can accomplish this by letting players create their own personal avatar to play with. By means of this experience of identity in the game students have a higher sense of presence and they are more intrinsically motivated to successfully complete the game objectives. If this is accomplished in a game, players are immersed in the game and can reach a state of flow, in which the players experience high energy, concentration and focus. If there is more interaction between player and computer, the chance for high engagement and flow increases (Annetta, 2010).

Games not only allow interaction between player and computers, but also between players in a multiplayer game. Immediacy is an important element for interaction to include in the design. This term refers to verbal or nonverbal behaviors that support physical or psychological closeness in communication between persons. Interactivity becomes more important as games become more complex. Game complexity can be increased by using multiple levels or by making the task more difficult. A game can only become more complex if the rules are explicitly stated. While increasing the complexity and difficulty of the game, the skills of the players should also enhance to keep them in a state of flow (Annetta, 2010).

When using games for education, it becomes much harder to observe students than in a classroom setting. These real-life observations can be replaced by virtual observations,

which consist of data recorded by the system, like user ID or chat logs. The advantage is that information about all students is available and performances can be tracked over a period of time. The data provides information to teachers and can be used to assess students (Annetta, 2010).

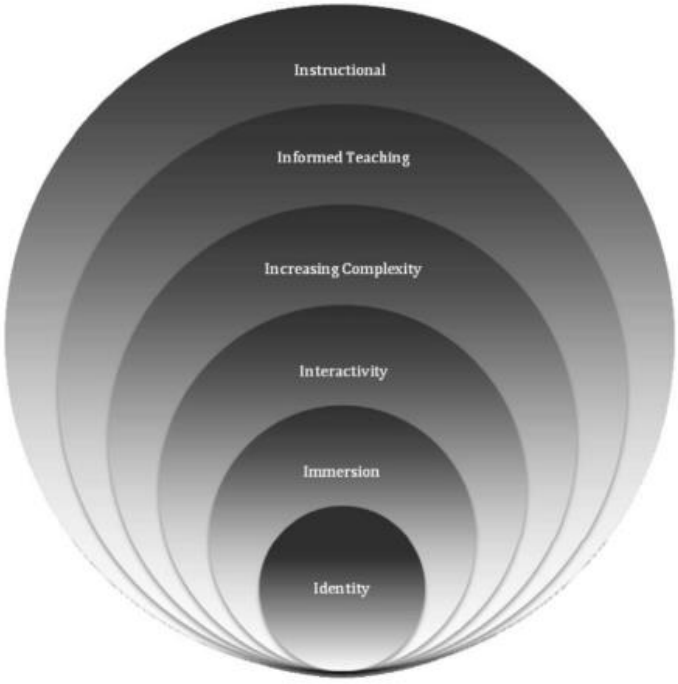


Figure 12 Six I's design framework

Assessment framework

An analytical framework to analyze serious games is presented by Mitgutsch and Alvarado (2012) to compensate for a shortage of assessment tools for these games. Six components were identified for this serious game design assessment framework that underlie a serious game, namely purpose, content, fiction and narrative, mechanics, aesthetics and graphics, and framing. Besides that, there is a focus on the relation of the elements to the goal of the game. The framework, as presented in figure 2, does not prescribe a fixed order to assess these elements (Mitgutsch & Alvarado, 2012).

First, an essential goal of serious games is to have an impact on the player beyond the game itself, in other words the game should have an influence on the actual life of the player. Second, content and information, facts and data that are shown in the game and can be accessed by players. The third element, game mechanics is about establishing rules that determine all possible actions in the game. These mechanics can be framed in verbs, so it is about actions that can be executed within the boundaries set by the game rules. Besides that,

the goal of the game, the reward system, obstacles and challenges, difficulty balancing, and win situation are part of the game mechanics. Fourth, fiction and narratives provide a fictional context for the information provided by the content element and a context in which the game mechanics can be executed. Fifth, the way the game looks is determined by the aesthetics and graphics element that is about audiovisual language to display game elements. This defines the aspects that frame the content, the game world and characters, the target group, setting, and game mechanics. These first five design element all have to be framed in terms of target group, the play literacy of that target group, and the broader game topic.

Figure 2 Assessment framework

Appendix E: Programming games

Lego Mindstorms: Fix the factory

An application of Lego Mindstorms is the game fix the factory, an app for a tablet or telephone. In this game the player is challenged to solve puzzles by giving a set of commands to the robot. First, the commands need to be put in place, after which the play button should be used to let the robot execute the given commands. The goal is to let the robot put the batteries back to where they belong. Along the way, some obstacles can be placed which need to be moved by the player before the level can be completed. Four stars can be earned for each level, the number of stars is based on the performance in four categories. These categories are attempts, error runs, moves used, and time. For each category one star can be earned. Figure 1 shows what the game looks like.

Figure 1 Lego Mindstorms

Bomberbot

Bomberbot is a way to learn students how to program in the classroom and is shown in figure 2. It combines classroom lessons provided by the teachers with a game on a tablet. In the latter, students are asked to solve different types of programming assignments spread over several missions or levels. For example, students can be asked to collect all stars in as few steps as possible. It also possible for students and teachers to create their own levels. Bomberbot provides fully developed lesson materials and PowerPoint presentations for teachers to give programming lessons. These lessons address different concepts that are relevant for programming. When children are practicing with the game, the teacher can follow their progress through a teacher dashboard.

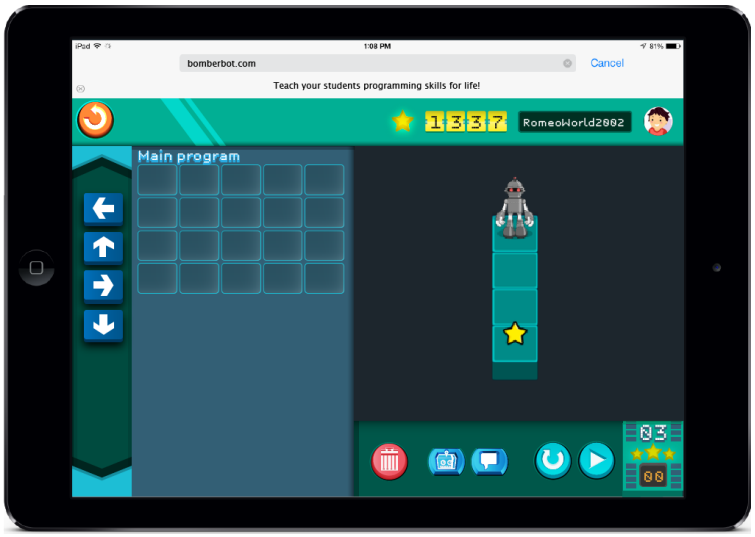


Figure 2 A level in the Bomberbot game

CodeWise

CodeWise is a combination of a computer tool and a card game, which can be used together or independently of each other. The card game contains three card types that represent different challenges. In the CodeWise programming tool, as presented in figure 3, students can pick their own background and character to program a route. Students can decide themselves what the character needs to accomplish and have to write a program according to this. Commands can be selected by clicking them or by using a drag-and-drop principle. By running the program, students see if the character is doing what they intended. The computer tool and the card game can be combined by taking a code that was created in the tool and to recreate with the cards. Students can check if their actions match the actions of the character in the tool to see if their program is right.

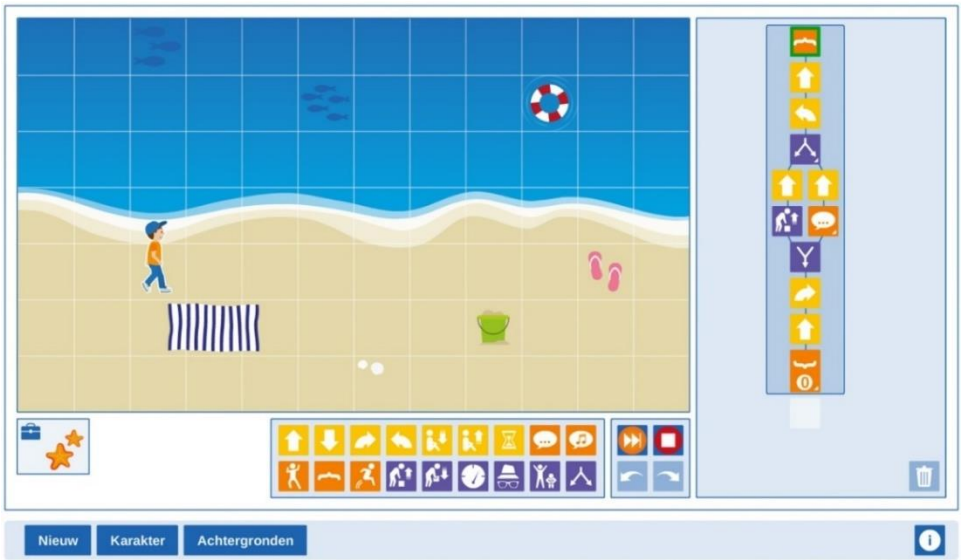


Figure 3 CodeWise programming

Kodable

Kodable is a programming game that can be used in education from kindergarten to fifth grade. This game can be embedded in a classroom practice where there is some direct instruction given by the teacher about programming. It is up to the teacher to decide which levels students have to play. The game system tracks how many stars a student has earned for each level, how many attempts were done, and how many times the level was completed. The maximum score for a level is three stars. This information is not available for students, but only for the teacher who can also see an overview of how many levels have been completed.

In the easiest levels, students only have commands to program direction. If a command for a direction is used, the character will keep moving until it is stopped by the walls of the grid. When the student progresses through the game, other types of commands are added, which makes the game more complex. Figure 4 shows what the game looks like.

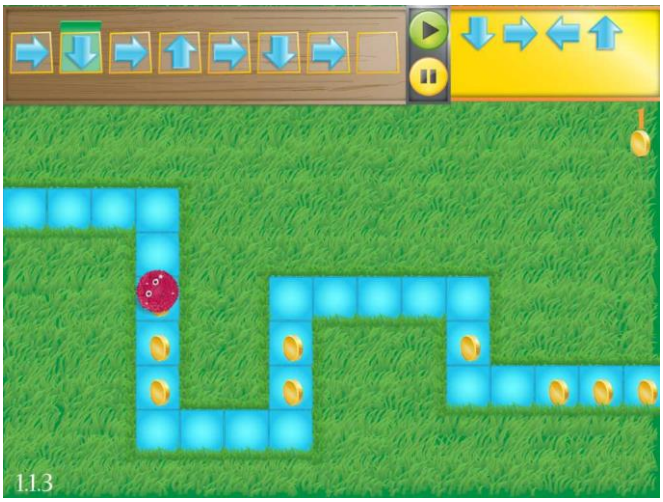


Figure 4 Kodable game

Ko de Kraker

The game Ko de Kraker is about a bird called Ko who likes to crack nuts, the game is shown in figure 5. It is an individual game and the task of the player is to overcome obstacles to make Ko get to his nut by programming him in the most efficient way. The goal is to complete all 50 levels. The height of the end score is dependent on the number of steps used by the player in each level to reach the goal. At the end of the game the player earns a bronze, silver or gold nut depending on the total score. More points can be earned if the programming for that level is done more efficiently. It is not possible to save game progress to continue playing at a later time. This also means that it is not possible to record and save players' actions to monitor their performance.

Figure 5 Ko de kraker game

Lightbot

Lightbot is a game with a grid structure, figure 6 shows one of the levels. An app is available for tablets and for the computer there is a demo version. Players need to light up the blue square on the field by directing a robot from its starting point to that square. This has to be done by placing commands in the right order and executing them by selecting the play icon. There are three categories with multiple levels that teach different programming skills, these are basics, procedures, and loops. At the beginning of each category, an explanation of new commands is given through a few pop-up windows. This information can be shown again by clicking the question mark icon. A player can only continue to the next level if the previous level has been completed. Each level can be repeated, but it is not possible to enhance the score, since no scores are given in this game. The game does save the number of commandos used to complete a level and players can see how they solved the levels. However, there is no feedback about how close the player came to the most efficient solution. If the commands do not lead to success, the robot stops moving at the place where it can no longer continue moving. Players can choose if they want to play with a blue or pink robot.

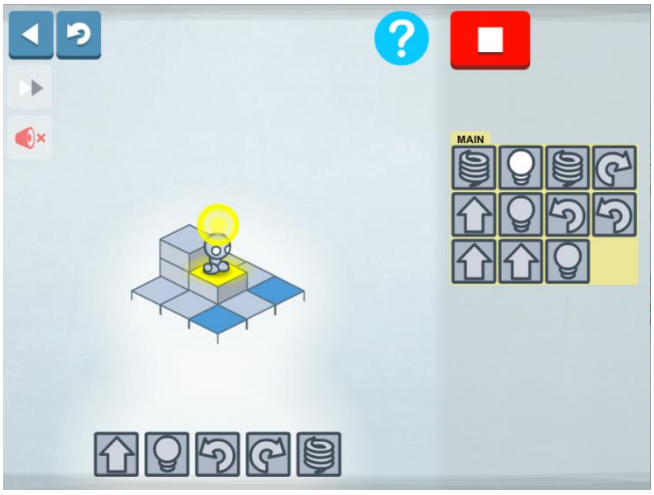


Figure 6 Ligthbot game

Osmo

Osmo is a gaming accessory that can be used in combination with an iPad that includes multiple games. The apps are designed for children from age five to twelve. Osmo consists of a stand in which an iPad is placed and a reflector for the iPad camera. Some apps can be played by just downloading them from the Osmo website, but this is not possible for games that need external materials. Since the Osmo apps use external material as well, they seem more appropriate for collaboration than traditional tablet games. Multiple students can manipulate the materials at the same, something that was not possible in other tablet or computer games. As a teacher it's possible to create an account for each student, which provides the opportunity to track every student's progress.

In the coding game children play with a character named Awbie who really likes strawberries. The game is structured in levels through which players can make progress in the game and learn computational thinking and logical reasoning skills. By using the right commands, Awbie can collect strawberries and animals that are placed in the game field. By collecting strawberries, players can earn seeds for rainbow strawberries that can be planted in the garden. With these special strawberries, upgrades can be bought. The commands are placed with physical blocks in front of the iPad, as shown in figure 7. This makes the game suitable for working together on one iPad.

Figure 7 Osmo coding game

CodeMonster

CodeMonster is a website that aims to teach children the basics of programming and stimulate logical thinking. There are 59 levels in which children have to solve different tasks by making codes in JavaScript programming language, an example is given in figure 8. These tasks become more complex as progress is made. Instructions about the tasks are given by a monster on screen. Students can progress through the levels in their own pace and can decide for themselves when they are ready to continue, since a new instruction is given when the student clicks the green instruction box. After reading the instruction, students can execute the task, but no explicit hints and feedback are given. Students are supposed to work through the levels in the given order, but it is possible to skip levels or go back. A list of levels is available, but there is no overview of which levels have been completed. On the bottom of the screen a bar shows how far a student has progressed through the game. This progress only gets saved for one student on the same browser and cannot create a personal account.

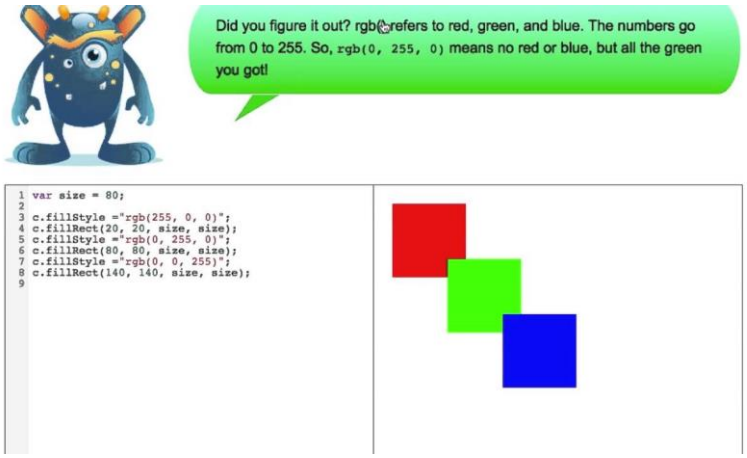


Figure 8 Codemonster

Cato's hike

Cato's hike can be played on an iPad or iPhone to teach programming skills to primary school students. It is about a boy named Cato, who likes to play outside, but the boy stepped through a portal and discovered a new world that followed different rules than his own world. These rules refer to programming which enable him to overcome obstacles. Children who play this game have the role of Cato. Small pop-ups at the beginning of a level give information about the challenges and story of the game.

The game consists of 12 tutorials and 60 levels, but children can also create their own levels in the map editor. One level is presented in figure 9. In each level the goal is to reach the star by overcoming the obstacles in Cato's way. This can be done by first writing a

programming and then executing it. The game counts how many steps someone takes to reach the star. A pop-up screen confirms that someone has completed the level successfully. The game contains an opportunity for social interaction between players with the option to e-mail their codes to their friends, this way students can help each other to solve levels and give each other feedback.

Figure 913 Cato's hike

Appendix F: Collaborative games

Escape the room – Mystery at the Stargazer's manor

In Mystery at the stargazer's manor, players have to look for clues and objects to solve puzzles and eventually escape the room. This game can be played with three to eight players, one of these players is the host who introduces the other players to the game story. The game is situated in 1869 where the former caretaker of Stargazer's Manor invites his friend to secretly investigate the behavior of the astronomer who lives there. This man disappeared into his estate after his wife's death. Now, it looks like strange things are going on outside of the house. The players should find out what is happening within a fixed amount of time. This can be accomplished by finding the clues and solutions for puzzles. Everything players need, is placed in envelopes that can only be opened after finding the right solutions. The content of these envelopes provides hints to solve other puzzles If players are stuck in the game they can consult hints that can be found online. The game material can be seen in figure 1 below.

Figure 1 Stargazer's manor game materials

The forbidden desert

The game the forbidden desert is a cooperative board game for 2-5 players about a group of adventurers that is on a mission to dig up an old city from the desert to find a legendary flying machine. Unfortunately, the adventurers get stranded, so they need to find the parts to fix the flying machine to get home. Players must work together, because the whole team loses if one player dies or if the storm in the desert becomes too powerful. The game is won if all parts of the machine are collected and put together. Players can decide at which difficulty level they want to play by determining the strength of the sandstorm. Before the game starts, every

player randomly gets one of the six adventure cards. Each card represents a different role and a special characteristic for that role. Players should think about how they can use each other's characteristics to win the game. This game is played in turns, each turn a player can execute a maximum of four actions. Other players are allowed to advise on which actions to take. An impression of the game can be found in figure 2 below.

Figure 2 The forbidden desert

Samen praten

"Samen praten", translated as "talking together" is a game that can be played by two children. Figure 3 shows what the game looks like. The goal is to understand each other by engaging in good communication. First, a story card is placed in a standard and one of the players picks an assignment card. Both children take a magnet with the same color. The first player has to explain to the other one where the magnet should be placed on the story card. Both children place their magnets at the same time, if the magnets stick together, they did it well. There are assignment cards with different difficulty levels and children can also give each other assignments without using the cards.

Figure 3 Samen praten

Cijfertoren

Tower of numbers, or Cijfertoren in Dutch, is a collaborative game for 4 to 12 children from 4 years old, that aims at mathematical skills. Players stand in a circle and every player holds a rope. Each rope is connected to the same board that needs to be used to pick up wooden blocks with numbers, colors and dots on the different sides of each block. By tightening the ropes, the board can be used to move the wooden blocks. Players need to communicate, because they stand in a circle around the block and they all see another side of the blocks, therefore everyone has different information. Several games can be played, examples are make a number tower from low to high or the other way around. Figure 4 shows how the game is played.

Portal 2

Portal 2 is a puzzle game that is played on the computer and contains a single-player version and a collaborative version for two players. Figure 5 shows one of the levels. The game characters are two robots, Atlas and P-Body, each player gets the role of one of these two robots. Players need to help each other to solve the puzzles presented in each level. Both players have a portal gun with which they can both shoot linked holes to move objects or themselves through walls. Meanwhile, they have to avoid lasers and water, which can hurt them. If one of the players dies in a level, he directly reoccurs at the start of the level. This does not have consequences for the other player or for the actions that were already performed in that level. The game has five so-called test chambers that consist of multiple levels that increase in difficulty. After completing a test chamber, the robots are reassembled in the next test chamber. Players are dependent on each other to complete the levels, so they need to communicate. This can be done verbally outside of the game or by signaling where to look or where to shoot a portal in the game.

Figure 4 Cijfertoren

Figure 5 Portal 2

Appendix G: Fourth version of the guideline

Guideline manual

Composition of the guidelines

The guidelines consist of six different categories to design a collaborative educational game, these are feedback, goals, multiplayer, data, screen, and other. Each category consists of separate guidelines and a clarification on how it can be used. The set is accompanied by a list of definitions in table 1 that clarifies some terms that may be unclear. All guidelines are presented in a visual format that can be used to justify choices during the design process. The formulation of the guidelines is based on the structure used by Nielsen (1995) in his ten usability heuristics for user interface design. So, every guideline is placed in a situation where it can be applied and an example that shows how the guideline can be used in practice. Some extra information about each guideline is present in a context description, which is mostly based on literature to provide the guidelines with a strong theoretical basis. For a quick overview over all guidelines, a list with only the guidelines is provided.

The guidelines are divided in six categories, these are feedback, multiplayer, goals, game content, game controls, and data. These categories structure the process by informing designers about which guidelines belong together and what part of the game they are focusing on. It also enables them to specifically attend to a certain category whenever that is needed during the development of the game. First, the feedback guidelines are aimed at the messages that players can receive based on their performance. On one hand, they serve to inform players about their performance and development. On the other hand, it should also guide players towards the desired performance, if their level is not sufficient yet. Second, multiplayer focuses on multiple persons playing a game together through collaboration. Important elements are communication, positive interdependence, individual accountability, and time. Third, in the category goals guidance is provided about what players should be able to do while or after playing the game, and how this can be accomplished. Fourth, the game content guidelines describe the importance of having a context in which the playing takes place. Fifth, the game controls guidelines are about what needs to be done by players to start playing and to perform an action. The sixth and last category is data, this is only one guideline. It describes that everything players do is recorded and saved by the game. This can be presented to players and teachers, so progress can be monitored.

Using the guidelines

The guidelines are helpful to design an effective serious game. It is recommended to include as many of the guidelines as possible, since research has shown that these were relevant to design a good collaborative educational game. There are multiple possibilities to include a guideline in the game, these are presented in figure 1. Depending on the game, a guideline can be applied in one or more places of this figure. Besides that, not every guideline is equally suitable to apply at every moment in the game. However, depending on the game concept it can be possible that a less usual dimension is used after all. After creating a first version of a new game, the guidelines can also be used to check if all elements were applied as intended and to create a second version of the game. It is not required to strictly follow the order in which the guidelines are presented, but it is recommended to work through the guidelines of one category before continuing to the next category to keep an overview.

Table 1
Definitions

concept	Definition
Challenge	A difficult task with no straightforward solution, for which players need to find a solution.
Communication	A conversation that players need to have with each other while playing. Players share information, discuss next and previous actions, and give each other feedback.
Data	A recording of everything players do in the game, this provides information about players' performances.
Feedback	A message players receive that is a response to players' actions in the game and it informs them about the quality of their performance and guides them towards the desired level if necessary.
Free-rider effect	An effect that occurs in groups were a few students do all the work, and others only profit from that work without contributing themselves.
Goals	A thing that should be accomplished by playing the game. There are two types of goals:
○ Game goal	A thing that has to be accomplished by completing the levels.
○ Learning goal	A skill or knowledge that players will learn by playing the game.
Help	A way to support players if they are not able to come up with a solution by themselves.
○ From the game	A hint given by the game when players are not able to complete a certain part of the game. Hints can differ from being rather vague to explicitly telling players what to do.
○ From other players	Advise or information given by other players that helps to solve the task.
Input	A contribution from a player to the game by performing an action, giving information, hints, or an opinion with the intention to solve a task.
Reward	A type of feedback that is a sort of prize players receive when they achieve success in the game.
Score	A numerical indication of how well a player has performed, so it represents the level of a player.
Support	An opportunity is already present, but the game also guides players to perform the action.
Performance gap	A difference exists between an actual performance and the desired performance from a player.
Task	A defined part of the game that players need to complete in order to reach their goal.
○ Individual task	A task that can and should be completed by one person.
○ Group task	A task that requires more than one person to solve it.

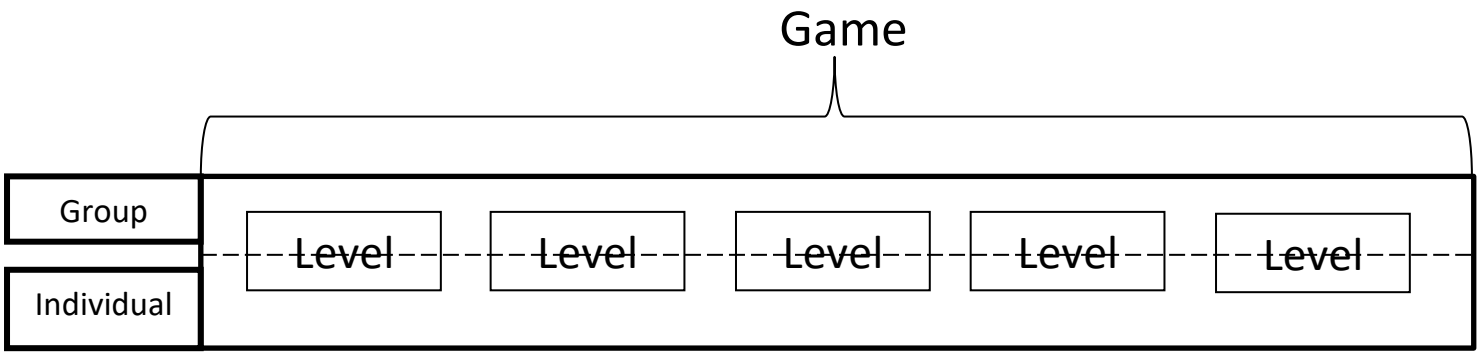


Figure 1 Dimensions

Overview guidelines

Feedback

1. Players need support to bridge the gap between their current and desired performance level, without solely pointing out the wrongs, but also guiding them towards the correct performance.
2. Provide help that provides the key to let players continue, without directly giving the full answer.
3. Show the composition of the score and the range of possible scores at defined moments in the game.

Multiplayer

4. The game needs to stimulate these interactions, without filling in the content of these conversations for the players.
5. Support full conversations that build shared understanding and stimulate discussions that can elicit cognitive conflict.
6. Players need to be made aware of how they can communicate effectively in a simple way, so it won't interfere with playing the game.
7. A sense of community needs to be built to make them not feel on their own.
8. Tasks and execution of these tasks must be divided over multiple players.
9. The game supports this focus by providing a balance between available time and complexity of the task in a way that matches players' experience of that time.
10. Graphic elements and general information are shown to all players.
11. Support dependence by not making certain information available to all players, so tasks can only be solved if everyone contributes.
12. Make every player individually responsible for the end result.

Goals

13. Players solve multiple challenges in the game, however it is not guaranteed that players will complete each challenge successfully.
14. Inform players and teachers about what they can expect from the game, the steps towards this learning goal can be clarified by adding subgoals.
15. Define game rules that clearly guide players through the game to let players focus on the playing and not on discussing the rules.
16. players should be encouraged to repeat that task to find the best solution that leads to attainment of the goal.
17. The game should respond to this by adapting the complexity of the tasks to maintain players' curiosity.

Game content

18. Align the game theme with the learning goals. Integrate actions, game goals, and, learning content.
19. The game should contain elements that clearly represent each player's presence, through which they can interact.

Game controls

20. Setting up the game is sufficiently easy, and the rules and tasks should be clear, without taking a lot of time.
21. The commands need to be made clear for players, so they can focus on the challenges from the game, if a command differs from the usual commands used in games, clarify this to the player.

Data

22. Use data as input to give feedback, and to let teachers and players monitor progress. Only data that is relevant for the goals in that game has to be recorded.

Feedback is aimed at the messages that players can receive based on their performance. On one hand they serve to inform players about their performance and development. On the other hand, it should also guide players towards the desired performance, if their level is not sufficient yet.

Guidelines

1. Players need support to bridge the gap between their current and desired performance level, without solely pointing out the wrongs, but also guiding them towards the correct performance.
2. Provide help that provides the key to let players continue, without directly giving the full answer.
3. Show the composition of the score and the range of possible scores at defined moments in the game.

Relevant terms

Feedback: Players receive messages that address the performance gap and direct them towards the goal. So, it is a response to players' actions in the game and it informs them about the quality of their performance.

Help: A way to support players if they are not able to come up with a solution by themselves.

- From the game — A hint given by the game when players are not able to complete a certain part of the game. Hints can differ from being rather vague to explicitly telling players what to do.
- From other players — Advise or information given by other players that helps to solve the task

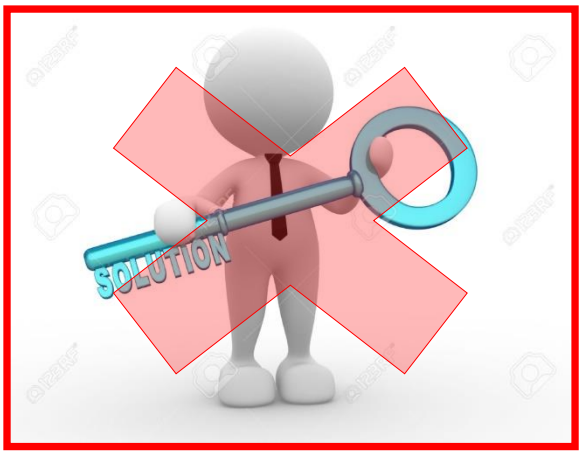
Reward: A sort of prize players receive when they achieve success in the game, for example players can receive a trophy after completing a level. A reward is a type of feedback.

Score: Provides an Indication of how well a player has performed, so it represents the level of a player.

Support: When the opportunity is present, but there the game also hints to perform the action, by for example highlighting something or a remark.

Feedback

- Situation: Players are not performing on the desired level,
- Guideline: Players need support to bridge the gap between their current and desired performance level, without solely pointing out the wrongs, but also guiding them towards the correct performance.
- Example: Provide hints instead of answers.



Context

- Working together to achieve a reward, like a trophy or a sticker, produces better performances than individual work (Johnson & Johnson, 2009).
- Help can be given in the same way every time, but it is also possible to vary in the type of feedback at different moments.
- Verbal hints, tips, compliments and rewards can be used to comment on performance quality

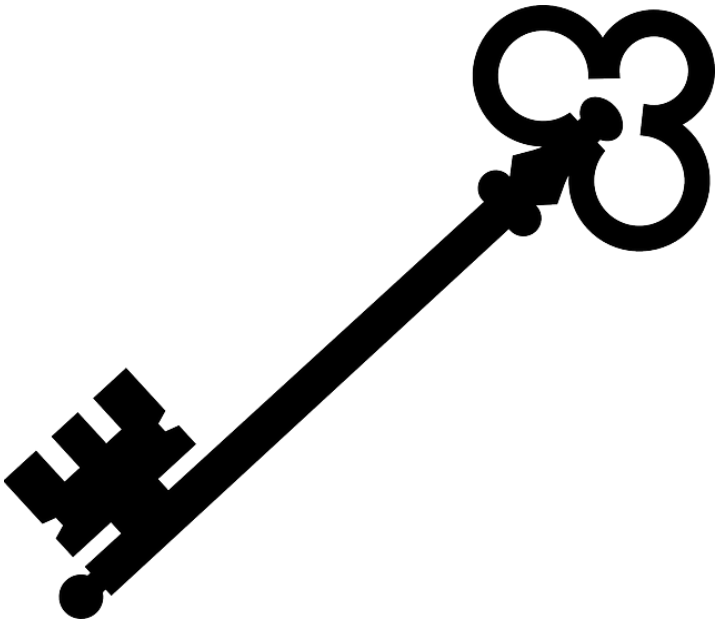
Definitions

Feedback
Players receive messages that address the performance gap and direct them towards the goal. So, it is a response to players' actions in the game and it informs them about the quality of their performance.

Reward
A type of feedback that is a sort of prize players receive when they achieve success in the game.

Feedback

- Situation: Regardless of adequate feedback, players can keep making mistakes, which block their game progress.
- Guideline: Provide help that provides the key to let players continue, without directly giving the full answer.
- Example: Give the first step towards the solution.



Context

- In order to correct mistakes, it is required to define what counts as a mistake and after how many mistakes support is given or when players can ask for help.
- Players quickly lose interest if they are unable to complete a task and there is no help available. Consequently, they miss a learning opportunity (Scarlatos, 2002).

Definitions

Feedback
Players receive messages that address the performance gap and direct them towards the goal. So, it is a response to players' actions in the game and it informs them about the quality of their performance.

Help
A way to support players if they are not able to come up with a solution by themselves.

- *From the game*
  A hint given by the game when players are notable to complete a certain part of the game. Hints can differ from being rather vague to explicitly telling players what to do.

Support
An opportunity is already present, but the game also guides players to perform the action.

Feedback

- Situation: Scores should inform players about their performances by providing information about their learning development and performance through
- Guideline: showing the composition of the score and the range of possible scores at defined moments in the game.
- Example: Use previous scores to determine a new score.

Context

- During a level or game, the score can be constantly updated, at the end of the level or game a final score can be given. Before the game or level an old score could be given.
- Individual scores can influence group scores.

Definitions

Score
An opportunity is already present, but the game also guides players to perform the action.

Multiplayer focuses on multiple persons playing a game together through collaboration. Important elements are communication, positive interdependence, individual

Guidelines

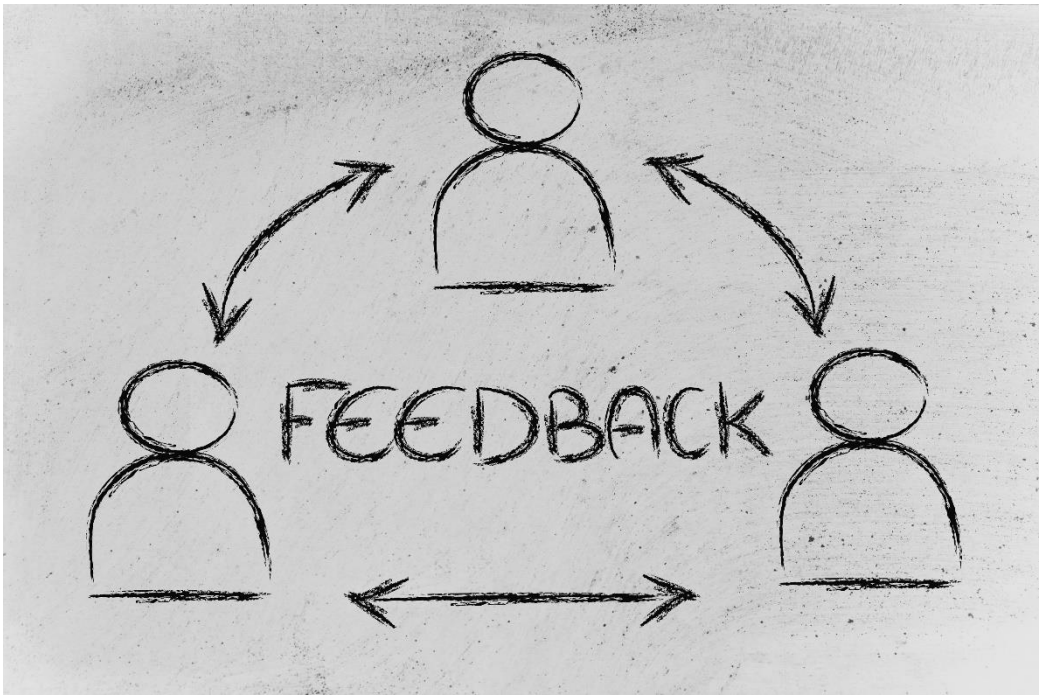
23. The game needs to stimulate these interactions, without filling in the content of these conversations for the players.
24. Support full conversations that build shared understanding and stimulate discussions that can elicit cognitive conflict.
25. Players need to be made aware of how they can communicate effectively in a simple way, so it won't interfere with playing the game.
26. A sense of community needs to be built to make them not feel on their own.
27. Tasks and execution of these tasks must be divided over multiple players.
28. The game supports this focus by providing a balance between available time and complexity of the task in a way that matches players' experience of that time.
29. Graphic elements and general information are shown to all players.
30. Support dependence by not making certain information available to all players, so tasks can only be solved if everyone contributes.
31. Make every player individually responsible for the end result.

Relevant terms

Communication:	A conversation that players need to have with each other while playing. Players share information, discuss next and previous actions, and give each other feedback.
Free-rider effect:	An effect that occurs in groups where a few students do all the work, and others only profit from that work without contributing themselves.
Input:	A contribution from a player to the game by performing an action, giving information, hints, or an opinion with the intention to solve a task.
Task:	A defined part of the game that players need to complete in order to reach their goal.

Multiplayer

- Situation: Collaborative learning is a social process that requires players to give each other feedback on their ideas during discussions.
- Guideline: The game needs to stimulate these interactions, without filling in the content of these conversations for the players
- Example: Ask a player to comment on the ideas of another group member.



Context

- Since players are working on a collaborative game, the whole group has an interest in individual actions, so players are willing to give feedback (Slavin, 1995)
- Players need to pay attention to each other, so they know what's going on in case someone needs help or if they are asked to give feedback.

Definitions

Multiplayer

- Situation: When players need to work together on a task, communication is a key element, but this needs to be more than just asking and answering questions.
- Guideline: Support full conversations that build shared understanding and stimulate discussions that can elicit cognitive conflict.
- Example: Design tasks that cannot be solved without communication.

Context

- During discussions cognitive conflict can arise and the reasoning of each player is exposed, which is effective for learning (Slavin, 1995).
- Interpersonal and small-group skills are required for effective collaboration, an example of these skills is being able to communicate precisely and unambiguously (Johnson & Johnson, 2009).
- Players share information, give feedback, discuss solutions, take decisions, and solve possible conflicts.

Definitions

Communication
A conversation that players need to have with each other while playing. Players share information.

Multiplayer

- Situation: Even though communication is required when working in a group, not all communication is equally effective for learning.
- Guideline: Players need to be made aware of how they can communicate effectively in a simple way so it won't interfere with playing the game.
- Example: Remind players about communication rules before they begin to play.

Context

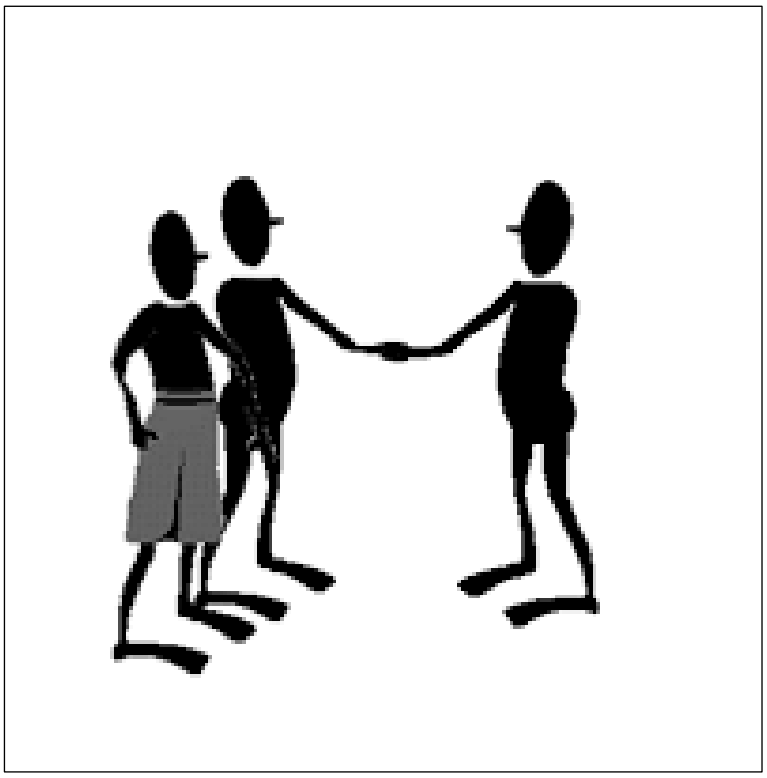
- Players should engage in exploratory talk, which means that relevant information is shared, group members are critical, challenge each other's ideas in a constructive way, and reasons are given (Rojas-Drummond & Mercer, 2003).
- In their interaction players need to encourage each other and provide help to ensure promotive interaction (Johnson & Johnson, 2009).

Definitions

Communication
A conversation that players need to have with each other while playing. Players share information, discuss next and previous actions, and give each other feedback.

Multiplayer

- Situation: Players need to trust each other and experience warmth and a sense of belonging, before they are willing to engage in collaboration and express appropriate social skills.
- Guideline: A sense of community needs to be built to make them not feel on their own.
- Example: Support players to get to know each other before they actually start playing.



Context

- If group members think they are dependent on each other, they will be more likely to get into contact with others (Kreijns, Kirschner & Jochems, 2003).
- Based on impressions group members have of each other a social working relationship can be developed (Kreijns, Kirschner & Jochems, 2003).
- Players discuss what they can expect from each other, by sharing prior knowledge and experience.

Definitions

Not applicable

Multiplayer

- Situation: For collaboration it is necessary that players are dependent on each other, every player should contribute equally.
- Guideline: Tasks and execution of these tasks must be divided over multiple players.
- Example: Create small subtasks that need to be combined to fulfill the group task.

Context

- If only one player can constantly manipulate game elements it decreases discussion in the group (Scarlatos, 2002).
- A group task can be divided in multiple smaller tasks. So, players can work separately on subtasks, but are working simultaneously on the group task.
- Positive interdependence (Johnson & Johnson, 2009).

Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

Multiplayer

- Situation: Players need to maintain focus on task related activities and be able to engage in interactions, to deliver optimal quality and quantity.
- Guideline: The game supports this focus by providing a balance between available time and complexity of the task in a way that matches players' experience of that time.
- Example: Inform players about the available time.

Context

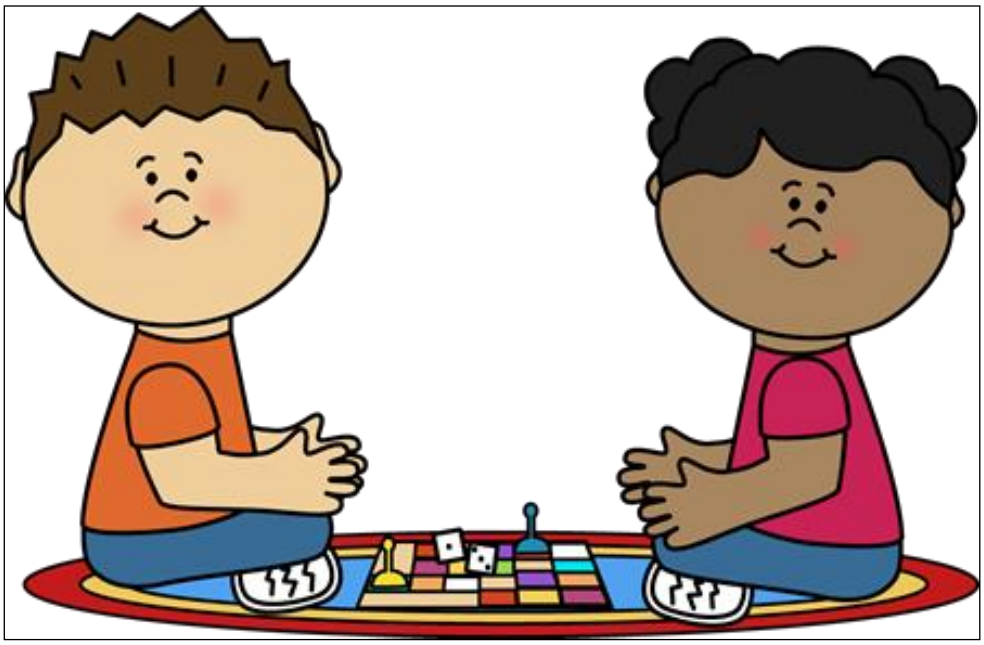
- If players experience scarcity of time, they are more focused on the elements that are most useful for solving the task, other elements are missed, which decreases performance. Also, there is less time for discussion (Karau & Kelly, 1991).
- Groups that have more time, spend more time on non-task related activities than groups that have less time (Karau & Kelly, 1991).
- Players can keep working on a task as long as they want, but their score decreases as they work longer on it.

Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

Multiplayer

- Situation: If everyone can refer to the same elements that are relevant for the whole group, they are easily accessible, and it becomes easier to collaborate and to contribute to discussions and completing the task.
- Guideline: Graphic elements and general information are shown to all players.
- Example: The game shows the same graphic elements, assignments and general information to all players.



Context

- If players stand around the game, they all have access to the same information, which can be used for discussions (Rogers &Lindley, 2004).

Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

Multiplayer

- Situation: If everyone has the same tools and resources, not everyone in the group is needed to solve the task and members are not dependent on each other, which is negative for collaboration.
- Guideline: Support dependence by not making certain information available to all players, so tasks can only be solved if everyone contributes.
- Example: Every player receives a bit of information when the groups start working on a task.

Context

- Positive interdependence is created this

Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

Multiplayer

- Situation: During collaboration the free-rider effect can arise when there is only a single group task that does not assess separate individuals.
- Guideline: Make every player individually responsible for the end result.
- Example: Every individual needs to give input in order for the group to solve the task.

Context

- It is not required that all players deliver input at every moment, it is also possible that every player is responsible for a different part. So, there can be a distinction between group tasks and individual tasks in the game.
- Individual accountability is applicable, every player is responsible for part of the task, they can't just profit from others.

Definitions

Free-rider effect
An effect that occurs in groups were a few students do all the work, and others only profit from that work without contributing themselves.
Input
A contribution from a player to the game by performing an action, giving information, hints, or an opinion with the intention to solve a task.
Task
A defined part of the game that players need to complete in order to reach their goal.

The category goals guidance is about what players should be able to do while or after playing the game, and how this can be accomplished.

Guidelines

1. Players solve multiple challenges in the game, however it is not guaranteed that players will complete each challenge successfully.
2. Inform players and teachers about what they can expect from the game, the steps towards this learning goal can be clarified by adding subgoals.
3. Define game rules that clearly guide players through the game to let players focus on the playing and not on discussing the rules.
4. players should be encouraged to repeat that task to find the best solution that leads to attainment of the goal
5. The game should respond to this by adapting the complexity of the tasks to maintain

Relevant terms

Challenge: A difficult task with no straightforward solution, for which players need to find a solution.

Feedback: A message players receive that is a response to players' actions in the game and it informs them about the quality of their performance and guides them towards the desired level if necessary.

Goals: A thing that should be accomplished by playing the game.

- Game goal: A thing that has to be accomplished by completing the levels.
- Learning goal: A skill or knowledge that players will learn by playing the game.

Task: A defined part of the game that players need to complete in order to reach their goal.

- Individual task A task that can and should be completed by one person.
- Group task A skill or knowledge that players will learn by playing the game.

Goals

- Situation: In a game players are working to reach the end goal, achieving goals is a motivating factor for players and a basis to assess skills.
- Guideline: Players solve multiple challenges in the game, however it is not guaranteed that players will complete each challenge successfully.
- Example: Completion of a challenge means reaching a goal.

Context

- Challenges should be at a level that matches the players' ability (Malone, 1981).
- A game can contain multiple challenges that are presented at different moments.
- If there is more than one way to accomplish the goal, groups can discuss previous actions which steps should be taken to decide what is the best action.
- A learning goal is what players are supposed to learn, and is not the same as a game goal.
- Completing a level can be seen as a subgoal.

Definitions

Challenge
A difficult task with no straightforward solution, for which players need to find a solution.
Goals
A thing that should be accomplished by playing the game.

- *Game goal*
  A thing that has to be accomplished by completing the levels.

Goals

- Situation: Games in education are not just played for fun, but players need to transfer something from it to real life, this is stated in the learning goal.
- Guideline: Inform players and teachers about what they can expect from the game, the steps towards this learning goal can be clarified by adding subgoals.
- Example: Define the learning goal and communicate it to users.

Context

- Feedback can be used to effectively guide players towards the learning goal (Linehan et al, 2011).
- A game goal is a goal within the game, and is not the same as a learning goal.

Definitions

Feedback
A message players receive that is a response to players' actions in the game and it informs them about the quality of their performance and guides them towards the desired level if necessary.

Goals
A thing that should be accomplished by playing the game.

- *Learning goal*
  A skill or knowledge that players will learn by playing the game.

Goals

- Situation: The game is structured by rules that define the limits of what players are allowed to do and create fairness in the game.
- Guideline: Define game rules that clearly guide players through the game to let players focus on the playing and not on discussing the rules.
- Example: Clearly communicate rules to players.

Context

- Rules are required to increase complexity of learning (Annetta, 2010).
- Rules may change as the game progresses.
- A game manual can be used to present the rules

Definitions

-

Goals

- Situation: If a task can be solved in different ways, there can be one way that fits the goal of the task best. It can happen that players find another solution and therefore don't fully reach the goal.
- Guideline: Players should be encouraged to repeat that task to find the best solution that leads to attainment of the goal
- Example: Only providing the opportunity to repeat a task is insufficient, trigger players to try again.

Context

- Only presenting a repeat button does not encourage players to find the best solution, it only provides the opportunity.

Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.
Goals
A thing that should be accomplished by playing the game.

- *Game goal*
  A thing that has to be accomplished by completing the levels.

Goals

- Situation: While playing the game, players acquire or improve skills.
- Guideline: The game should respond to this by adapting the complexity of the tasks to maintain players' curiosity.
- Example: Match tasks to the ability level of the players.

Context

- Complexity at a level that matches the player supports curiosity, which is positive for intrinsic motivation (Malone, 1981).
- Players can first get familiar with how the game works
- Players can first practice the basic skills, which they will need in the more complex part of the game.
- The game can start with practicing separate basic skills, which are combined at later stage.

Definitions

Task
A defined part of the game that players need to complete in order to reach their goal.

The game content guidelines describe the importance of having a context in which the playing takes place.

Guidelines

1. Align the game theme with the learning goals. Integrate actions, game goals, and, learning content.
2. The game should contain elements that clearly represent each player's presence, through which they can interact.

Relevant terms

Goals: A thing that should be accomplished by playing the game.

- Game goal A thing that has to be accomplished by completing the levels.
- Learning goal A skill or knowledge that players will learn by playing the game.

Game content

- Situation: Narratives make a task more meaningful, this allows players to state ideas, interpret events and guide actions, but can distract from acquiring the learning content.
- Guideline: Align the game theme with the learning goals. Integrate actions, game goals, and, learning content.
- Example: Actions that can be performed match the game environment in which they take place.

Context

- Players become motivated if they experience a personal identity, this can be accomplished by letting players. emphasize with or become a character (Annetta, 2010).
- Tasks and actions are placed within a fictional context or game world (Mitgutsch & Alvarado, 2012).
- If too much cognitive capacity is required to process the narrative, which leaves little space to process and acquire the learning content (Adams, Mayer, Macnamara, Koenig & Waines, 2011).

Definitions

Goals

- *Game goal*
  A thing that has to be accomplished by completing the levels.
- *Learning goal*
  A skill or knowledge that players will learn by playing the game.

Game content

- Situation: Players who experience a unique identity in the game, will become more engaged in the game which intrinsically motivates them to work through presented obstacles.
- Guideline: The game should contain elements that clearly represent each player's presence, through which they can interact.
- Example: Create a personal element for each player.

Context

- Being an individual is an idea intrinsic to human nature, it is about the need to feel unique (Annetta, 2010).

Definitions

-

the game control done by players to start playing and to pe

Guidelines

1. Setting up the game is sufficiently easy, and the rules and tasks should be clear, without taking a lot of time
2. The commands need to be made clear for players, so they can focus on the challenges from the game, if a command differs from the usual commands used in games, clarify this to the player.

Relevant terms

-

Game Controls

- Situation: Groups can start playing the game independently without a teacher
- Guideline: Setting up the game is sufficiently easy and the rules and tasks should be clear, without taking a lot of time.
- Example: Players can start playing without help from a teacher.

Context

- It saves time and effort for the teacher if he does not need to help with setting up the game.
- The game should present itself in a way that makes it clear where to begin.

Definitions

-

Game Controls

- Situation: Commands through which the game can be controlled can have several meanings or can be unclear because the context in which they are used.
- Guideline: The commands need to be made clear for players, so they can focus on the challenges from the game, if a command differs from the usual commands used in games, clarify this to the player.
- Example: Use an existing language that is common in similar games or create a new language.

Context	**Definitions**
-	-

Everything players do is recorded and saved by the game.

Guidelines

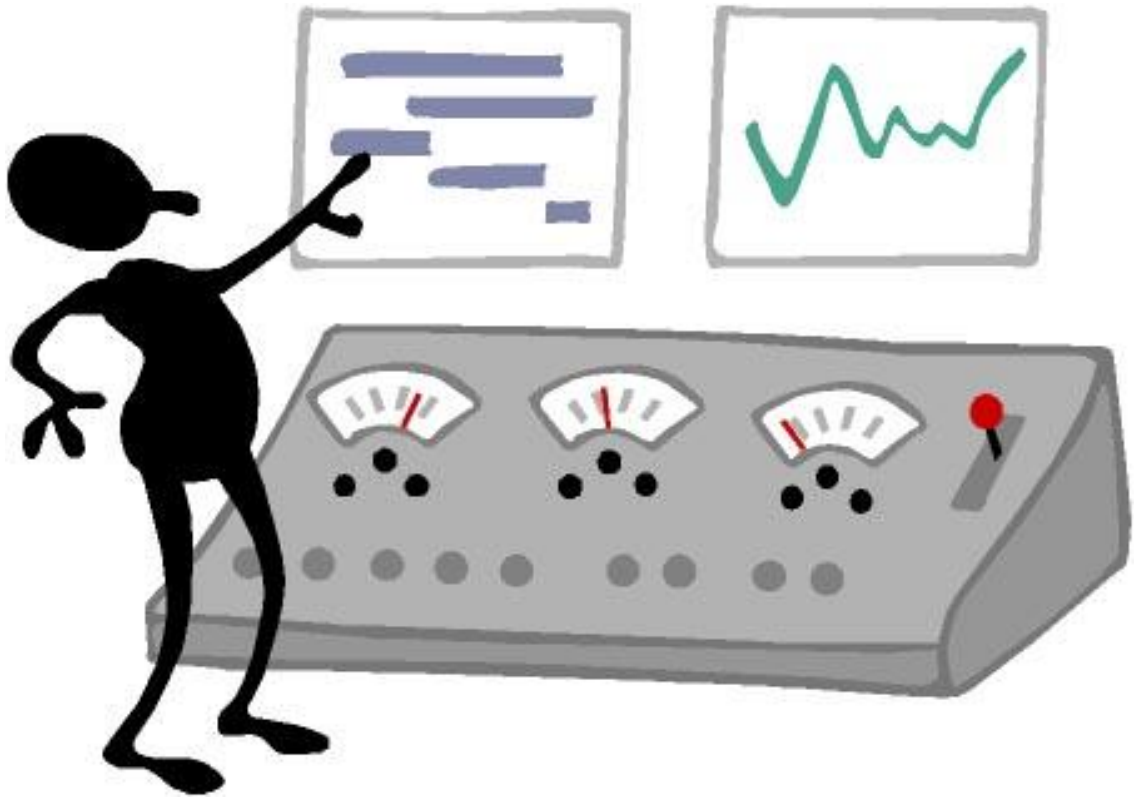
1. Use data as input to give feedback, and to let teachers and players monitor progress. Only data that is relevant for the goals in that game has to be recorded.

Relevant terms

Data:	A recording of everything players do in the game, this provides information about players' performances.
Feedback:	Players receive messages that address the performance gap and direct them towards the goal. So, it is a response to players' actions in the game and it informs them about the quality of their performance.
Performance gap:	A difference exists between an actual performance and the desired performance from a player.

Data

- Situation: Games can collect data about players' actions, information that comes from this data can be used to determine a performance gap
- Guideline: Use data as input to give feedback, and to let teachers and players monitor progress. Only data that is relevant for the goals in that game has to be recorded.
- Example: Present the data in a way that is easy to interpret for the user.



Context

- Data can be used by players and teachers to monitor the player's progress towards a desired performance (Linehan, Kirman, Lawson & Chan, 2011).
- The data that needs to be recorded depends on the reason for collecting data.

Definitions

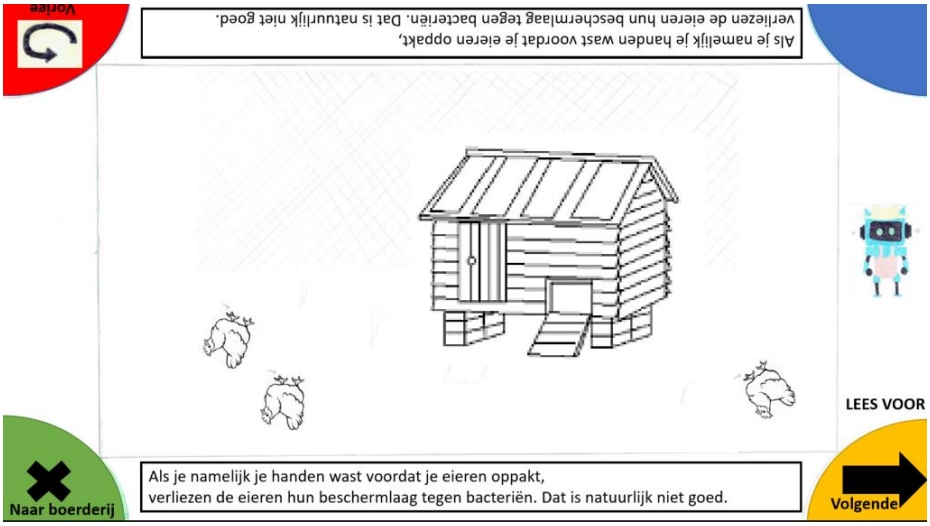
Data

- A recording of everything players do in the game, this provides information about players' performances.

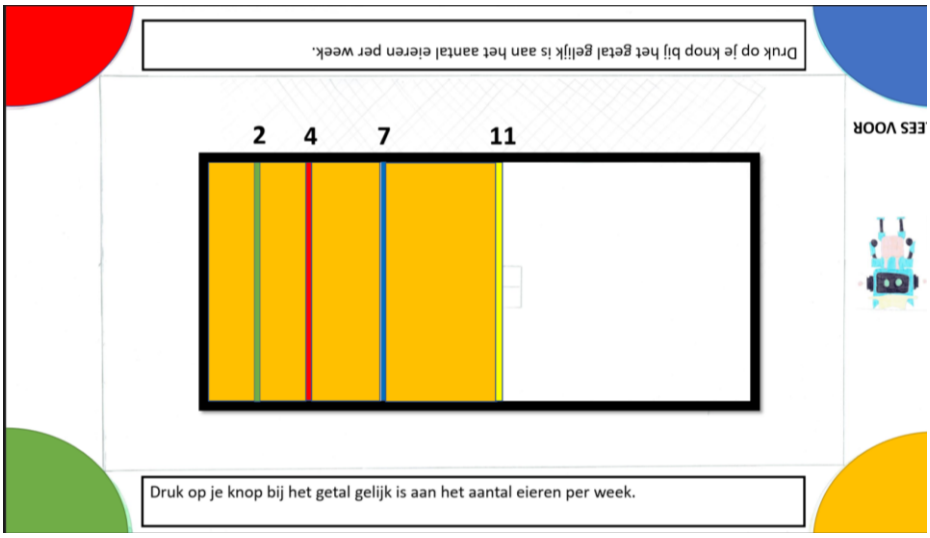
Feedback

- Players receive messages that address the performance gap and direct them towards the goal. So, it is a response to players' actions in the game and it informs them about the quality of their performance.

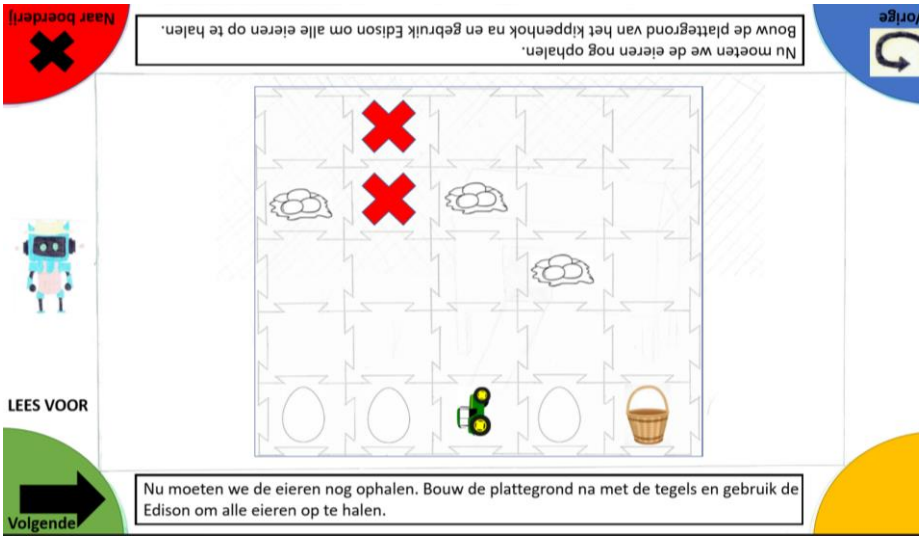
Appendix H: Example of the game concept



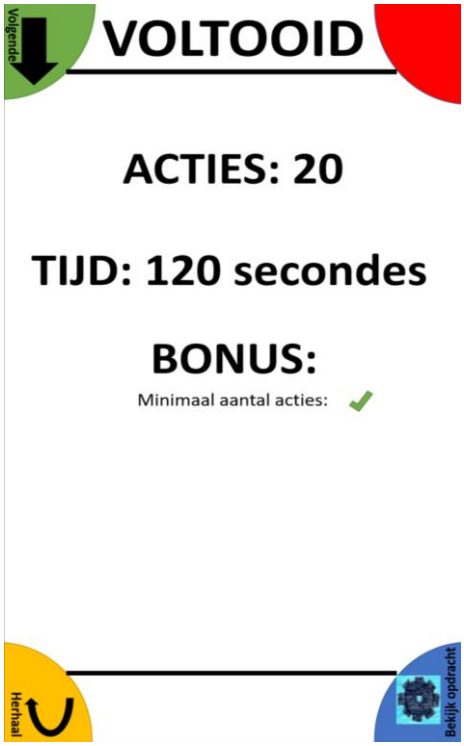
1. One of the players reads the information aloud to the other players.



2. Players are asked to indicate how many eggs they think a chicken lays per week.



3. Players to build a board, externally from the Luqo device, to do a programming task.



4. Players receive a summary of their performance, after finishing the programming game.