

## Dimensions in Educational Game-Design

- perspectives on designing and implementing game-based learning processes in the educational setting.

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Abstract	Recent developments within learning games have shown that games hold a great potential for meeting current educational needs. These developments have also pointed out a number of challenges to address if games are to play a role in the educational setting. One key issue is the design of learning games, another is to implement them into the educational setting. Each of these issues provide a set of challenges, which is to be negotiated in order to create successful game-based learning. In order to meet these issues, eight key dimensions in educational game-design are presented, as well as a structure for implementing learning games into the educational setting in a beneficial manner.
Games and education – current practice	Games are often presented as easy means for creating learning processes (see e.g. Prensky (2001)), but in practice learning games are often difficult to design and to implement in educational settings. Furthermore, the edutainment genre, which tries to use games for combining entertainment and education (Konzack, 2003), has not been able to display convincing results (see Egenfeldt-Nielsen (2005) for a review). To use games in the educational setting, the learning game must be able to provide more educational value than merely being a provider of participational incentive. This could be achieved by starting to see the game as a content provider or a feedback mechanism. Such an approach, however, brings certain challenges, which are addressed through the dimensions presented below.
Rethinking games for the educational setting.	When looking at the current supply of educational games, most of these are based on an assumption that the mere exposure to educational material creates learning, framing the purpose of the game as keeping the participant occupied or entertained with the game. This approach might be fruitful when it comes to learning procedural knowledge, e.g. mathematical operations or how to ride a bicycle, but less fruitful when it comes to meeting more current learning objectives, such as reflection or change learning. Such learning objectives seem to call for a different game-design and for other means of participating in the learning game.
Great potential but little usage	Games seem to hold a great educational potential, especially for teaching procedural knowledge, and there are quite a lot of great learning games on the market already trying to meet this demand. Surprisingly enough they are usually used quite little, which seems to be due to poor implementation in the educational setting, making it hard for the facilitators or teachers to integrate the game into the rest of the educational setting. There are a lot of explanations for this, e.g. the lack of knowledge among practitioners on how to use the games, how to integrate them in the surrounding material, or simply due to a lack of information on the supply. Such factors should, along with the design considerations below, be considered when creating a game-based didactic design.

Bringing up eight dimensions

In order to break with the concept of learning games as a simple combination between a game and educational material, eight dimensions are proposed in designing learning games. The purpose of these distinctions is not to choose between them, but rather to consider them as distinctive elements to be considered in the design of the learning game, as well as in its implementation.

Games in learning settings, learning games or game-based learning processes?

It is relevant to consider the difference between games used for educational purposes, learning games and game-based learning processes. Whereas there have been some attempts to utilise a current game (e.g. Europa Universalis II) in an educational setting, this practice is not convincing (Egenfeldt-Nielsen, 2005). Learning games are games that are designed for an educational purpose, some with an emphasis on making education entertaining; some with a more extensive focus on the educational elements and learning objectives. The game-based learning processes are those processes that learning games use to create the learning process. Such processes are also recognisable in normal games, where they are used to learn game controls, content, strategies, etc. One distinct game-based learning process is the feedback mechanism, which provides the participant with an immediate, detailed evaluation of the actions and decisions conducted in the game.

Tools for designing learning games

Below, are considered eight dimensions of educational game-design that can provide the game-designer with tools for optimising the educational benefit of the product. Further below are considered considerations about the implementation.

## DESIGN DIMENSIONS

The following dimensions are distinctions in the learning game, which are relevant to consider when designing a game for educational purposes. The dimensions are

Content – Participation	Balancing the focus on content and participational incentives as well as optimising the relationship between the two.
Narratology – Ludology	Considering the approach to games, distinguishing between the story told and the rules manipulated.
Endogenous – Exogenous incentive	Considering the level of integration between participational incentives and content providing elements.
Construction based – railroading	Considering the degrees of freedom for the player, as well as the origin of legitimate knowledge in the learning game.
Analogue – Digital	Considering the media utilised for the game, as well as cross-media considerations.
In-game – Off-game learning	Considering the placement of the learning effort compared to the game element.
Simplicity – Complexity	Considering the balance between representational complexity and ease of use.
Reflection – Flow	Considering the desirable state of mind while playing the learning game.

Content vs. Participation

The discussion between content and participation is central to the design of learning games, and addresses the relationship between the educational elements of the game, weighted towards the elements used for facilitating participation in the game. The point is to determine where the emphasis is placed in the game and how the different elements are created in the game.

The dimension goes from Content-Heavy Environments to Pointless Entertainment:

Content heavy environments with bulks of knowledge, but without any incentive for the participant to engage in the material. Many libraries are suffering from being in this category. Pointless entertainment, to which eventual learned benefits have no or little value outside the game context.

Between the two extremes lies the successful learning environment that manages to provide content and to engage the participants. This balance is what the learning games attempt to achieve, using the participational incentives in the game to engage the participant. To engage the participant is seen as making the game fun, usually seeing fun as equivalent to entertainment.

Malone & Lepper (1987) have presented a list of elements for making games fun, or to create participational incentives:

Challenge	Challenge rating	Perceived self efficacy towards task Flow states
	Goals	Perceived self competence Explicit fixed goals Open ended (Emergent without fixed goals) Proximal goals (in opposition to distal or long-term goals) (as in "World of Warcraft")
	Uncertain outcome	Variable difficulty setting (determined by participant, automated response, determined by skill) Multiple levels of goals (similar or different kind) (eg. Majoong) Hidden information (or incomplete information) Optimised randomness
	Performance Feedback	Frequency Clear Constructive Encouraging
	Self-Esteem	Suggested that the performance goals should be personally meaningful to the participant, identifying three categories of relevance:  Instrumental relevance (towards e.g. the link between competencies and desires) Fantasy Relevance (emotionally appealing content) Social Relevance (cooperation, competition or recognition)
Curiosity	Sensory Curiosity Cognitive Curiosity	Used to attract attention to a specific object or phenomenon Used to sustain attention to a specific object or phenomenon
Control	Perceived control	The feeling of control is experienced as a major source of motivation in computer games, whereas DeCharms goes as far as seeing the desire for controlling one's environment as a basic human tendency.
	Mastery	Used to create a sensation of being in control.
	Contingency	Unpredictability, but only to a certain degree.
	Choice	Choice has a direct effect on motivation. Interaction is based upon the availability of choices and response to these actions/choices.
	Power	The effect of being able to display mastery in the game in concern to something attractive.
Fantasy		Fantasy referrers to the cognitive and emotional elements of being able to identify oneself with the game content, and thereby being able to create a personal fantasy that evolves beyond the game.

Interpersonal motives	Cooperation	Refers to the interpersonal co-creation of a fantasy, product or achievement used for creating motivation in the game. Refers to the interpersonal competition taking place between participants in order to achieve the best result.
	Competition	

Malone & Lepper's framework for implementing participational incentives into an educational game gives the game designer a more elaborate approach to make the game fun, and thereby engaging. Papert 1998 makes an interesting distinction between hard and soft fun; whereas soft fun resembles entertainment, which provides the participant with immediately pleasant experiences, the concept of hard fun means postponing the pleasurable reward until some (often frustrating) task is completed. Whereas classical edutainment often utilises the concept of soft fun, the use of hard fun is more often found among modern learning games. This distinction probably makes up a dimension in itself.

A key aspect to be considered is the fact that if one states the purpose of learning games to be entertaining, means and ends are confused, as the purpose of the game in the educational setting is always to educate. Entertainment is merely considered one possible mean to achieve this end. The implementation of content elements is addressed below.

#### Narratology vs. Ludology

The dimension between narratology and ludology is a distinction taken from the Danish game-scene, and is concerned with what is seen as the essence of the game; is it in the story told by the game, or in the rules governing the game?

The narratological approach is concerned with using the game for telling a story (see Crawford (2004)), using the story to immerse the participant into wanting more (Brooks, 1992), creating a narrative desire to maintain the participants interested in the game (Murray, 1997). This approach is similar to the engagement of watching a movie that makes one curious to see the rest of the movie and know how it ends.

The ludological approach, on the other hand, sees the rules as the essence of the game experience (see Juul, 2005), considering the mastery of rules desirable. The rules are explored in order to achieve greater mastery of the game as a whole, making the rules an element for creating engagement in the game. Such engagement is similar to that of sudoku, tetris or other games where the ability to master the game becomes the driving incentive.

The two different approaches contribute to the game-based learning process. Each can be used to provide the learning experience with participational incentive, but they also hold different potentials in providing content:

- the narratological approach can be used to provide facts, sequences, etc. as

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<sup>1</sup> Homicide is a science learning game, designed for the lower secondary school. The participants play forensic detectives, trying to solve one or more murder cases. The game utilises narrative desire in order to engage the participants in solving a number of science tasks within the areas of mathematics, biology, chemistry, physics, etc. The game has a penetration of 10% in Denmark, and is currently being converted to meet British requirements.

<sup>1</sup> CHANGEMASTERS is a change management game, developed for training leaders and upper-level management in large European companies. The participants are to conduct change management on a smaller company recently acquired by a larger company, using a computer to evaluate their progress. The game is currently being converted to Swedish, Greek, Irish, Italian and Danish requirements.

- well as to provide a narrative frame for an exploration of rules;
- the ludological approach can be used to allow participants to experience and to explore social or technological processes.

A combination of the two approaches has proven fruitful in creating both content-rich and participant-engaging games; both the games Homicide<sup>1</sup> (Learning Lab Denmark) and CHANGEMASTERS<sup>2</sup> uses narrative desire to stage engagement, whereas the learning benefit is realised through ludologically-based feedback mechanisms.

Endogenous vs. Exogenous incentive

The integration of participational incentives and content elements is usually considered according to the endogenous vs. exogenous distinction. Whereas an endogenous approach utilises content elements to produce participational incentive, the exogenous approach utilises content-external elements to produce engagement.

The endogenous approach is often considered to be a better game-design, as it integrates the participational incentives and the content elements, thereby managing to frame the content as interesting in itself, a process that can be utilised after the game. The major drawbacks on this approach are the development cost, which is usually five times that of the exogenous-based game, and the fact that not all problems or fields of knowledge contain a struggle appropriate for creating the proper engagement.

The exogenous approach utilises a content-external element, often in the form of a separate game itself. The edutainment genre has numerous examples of learning games that consist of an educational element and a game element. Whereas the advantages of this approach are ease of design and the lower cost, the major drawbacks are the engagement contrast experienced by the participant when switching between the (exciting) game and the (boring) educational element, as well as the educational time wasted while playing game parts that are unrelated to the learning content.

Construction based learning vs. Railroad

There is an ongoing discussion between learning theorists about the normative element in educational theory. A key distinction in this discussion is whether students are to learn something in particular, the essentialist perspective, or if they are to find out themselves (the existentialist perspective).

When it comes to learning games, a very common setup is the railroad plot, setting up a start, an end and a long track of rails to ensure that the participants get a particular experience from the game.

The opposite approach is that of the construction based learning perspective, which consists of two approaches. The first, constructionism, allows the participants to co-create their challenges, tasks, problem understanding, means for solving (Papert, 1996), and sometimes even the rules as well. The second, constructivism, is concerned with how we personally construct an understanding of a problem in interaction with our personal knowledge, and how we choose to react from this (von Glasersfeld, 1995). Whereas the first is concerned with how we co-construct the game, the second is concerned with how we bring our personal knowledge into the game.

Whereas the first setup allows total control over the content communicated and the tools applied in the process, the second allows the participant to co-create problems and solutions, sometimes even the rules. The latter, construction-based, seems to have a higher learning value, but at the cost of control on what actually is being learned, both in terms of the actual benefit, as well as the process. The railroad seeks

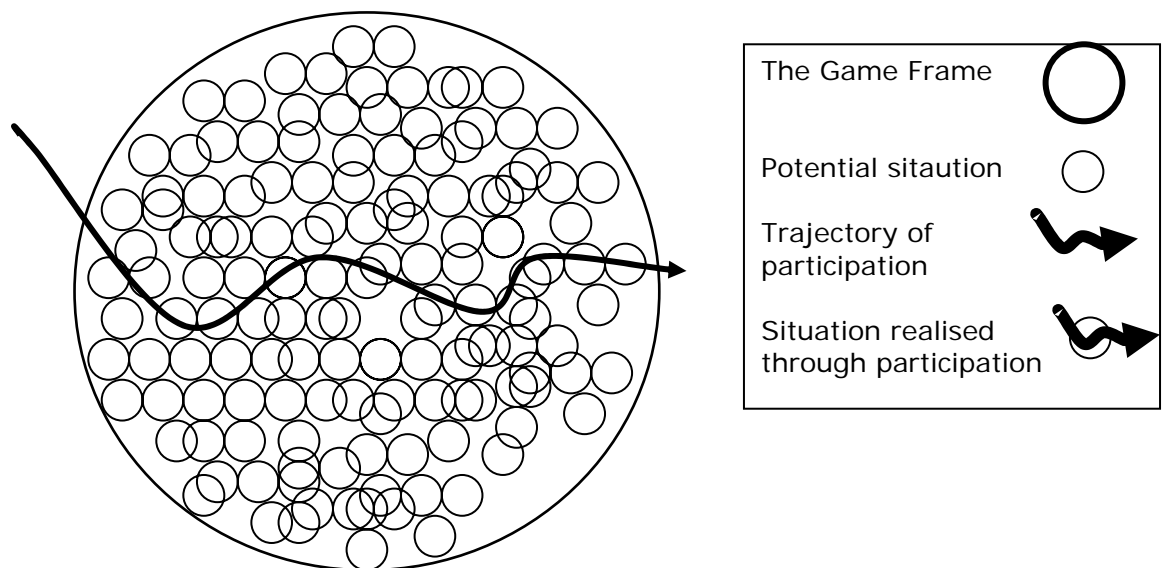
to provide the participant with a line of tasks to be solved in a specific manner, whereas the construction based approach invites the participant as a co-creator of problems and solutions. The first creates specific solutions to specific problems, the latter creative solutions to creative problems.

Balancing the game-design between railroading and the construction based approach is a matter of determining the degrees of freedom, which at the same time creates limits and opens limitations for the participant in the learning game.

The circle model below describes the problem of not railroading; if the game consists of a wide variety of potential situations (which is often the case with role-play), and only a number of them can be realised, then it becomes uncertain which ones are realised. When working with degrees of freedom, the certainty of the outcome is more undermined as the number rises. It is, in other words, easier to ensure the content with a low degree of freedom in the learning game. By allowing the participants to bring in knowledge from outside the game or to co-construct problems, challenges and solutions, the degrees of freedom rise.

The benefit from raising the degrees of freedom is mainly a higher degree of adaptation to participants' interests, as well as a higher engagement through the sensation of agency. These benefits should be viewed in the light of a higher production cost and the creation of a product more difficult to implement when compared to the railroad approach.

### The Circle Model



(Henriksen, 2004)

Analogue vs.  
Digital

This dimension is concerned with the media; whether the learning game should be digitally based, or if it should be kept analogue. Both media hold a great potential for providing good learning games as they each provide the seed for building very different approaches to designing learning environments.

Computers are good at crunching numbers, allowing extensive simulations to give participants feedback on their solutions, reruns on bad decisions, and evaluative feedback to whom it may concern.

Analogue games are, on the other hand, good for social learning, discussion and reflection. They also overcome a media problem; many schools lack the sufficient computer facilities to effectively use computer games, and within supplementary education, computer literacy cannot be expected among the participants.

A commonly applied solution is to combine the two, letting the game take place as a social, reflective process among the participants, creating a decision that the computer can generate feedback to. Such game-design is utilised by Homicide (Learning Lab Denmark) and CHANGEMASTERS (INSEAD), or even by games such as Medicon Game, Brainbuilders, Magasinspillet, etc.

Due to politics and technological advances, a breed of technology driven learning games have evolved. Designing such games clearly prioritises the use of some specific, often digital media for the game. In relation to such games, it is often fruitful to consider how they can be supplemented by other media, and how the implementation can be supported by other means.

In-game vs.  
Off-game  
learning

A very relevant question to ask any game-based environment is how it assumes that learning takes place at the learning game, and also how such knowledge is usable to problems outside the game context. Due to these questions, a distinction is often made on where to place the learning process compared to the game:

In-game learning refers to skills and perspectives acquired during the game-based activity. These skills and perspectives are usually visible through actions and decisions made in the game (e.g. solving game puzzles). Many edutainment games rely solely on this approach, as they require no outside facilitation, which makes them flexible in their usage.

Off-game learning refers to the activities surrounding the game in order to appoint key issues in the game, decontextualise issues by drawing lines to game-external issues, as well as reflection on the game experience. Such activities ensure the transferability of the skills and perspectives learned in the game, but require a game-external facilitation to conduct such facilitation. Such effort ensures a learned benefit, but it also makes the learning game inflexible, as it requires a game didactic competency with the facilitator using the game.

Finding a balance between the two approaches is a question of knowing what competencies are present among those that are supposed to be using the learning game, both on short and on long terms. It is furthermore a question of knowing what context the game is to be used in, both in terms of structural issues, as well as its educational purpose.

Simplicity vs.  
Complexity

An important dimension in game-design is the complexity representation in the learning game. Whereas a low complexity makes the game easier to use (either for the participants or for the facilitator) and grasp, a complex representation allows for a more elaborate feedback from the game, thus making it harder to play and use.

Several sliders can be used for achieving the proper balance between simplicity and complexity, e.g.

- through the narrative
- through rules
- through the combination of simple rules

Complexity is viewed as a tool for meeting desired educational objectives. Complexity seems relevant if it is to represent a complex reality, or if the participants are to induct from practice to theory. Simplicity, on the other hand makes the game easy to use, and thereby reduces the effort required to educate the participant in playing the game.

#### Reflection vs. Flow

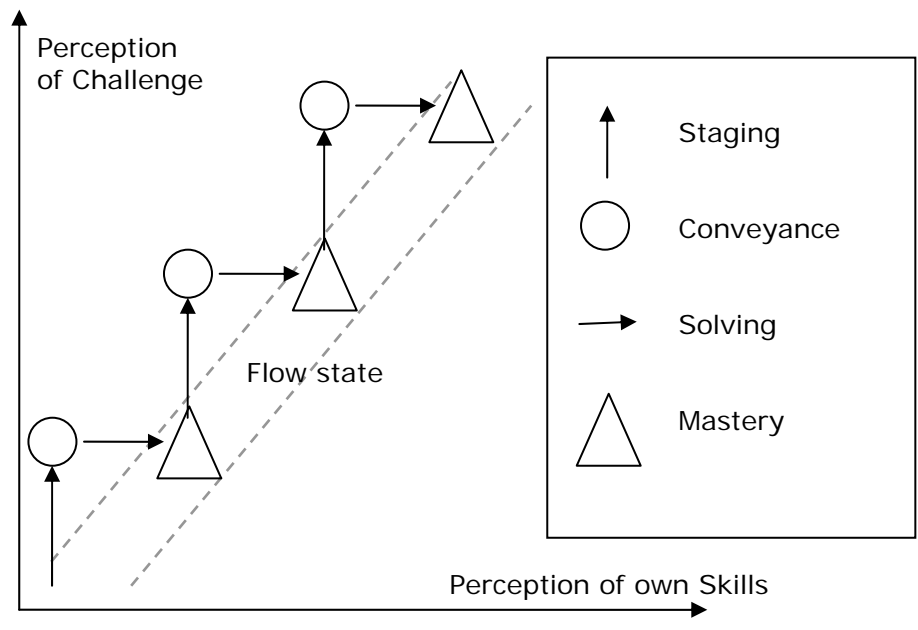
The discussion on what state of experience the participant should be in during the learning game is a rather new one, and it breaks away from the mainstream conception of learning game design. The main issue is whether the design of learning games should produce and maintain a play-like, illusory state created through Huizinga's magical circle (1938), or if it should seek to utilise selected parts of the game-based experience to make an educational environment.

A common conception within game-design is to aim to produce a flow-like experience, where the player completely immerses into the game, losing the sensation of time and self (Csikszentmihalyi, 1975). The primary factor in producing such an experience is the optimisation of the participant's experience through the relationship between current task challenge and own skills. Such experience has tremendous effect on participant experience, and creates a lot of engagement, and seems beneficial in building learning environments for procedural knowledge, and attempts to base the whole learning environment on games.

The alternative approach seeks to produce a state of reflection over the game-based experience, encouraging the participants to stop-and-think about their actions and decisions in the game. This violates the immersive experience of the suspension of disbelief, which is required to maintain Huizinga's magical circle. Although harmful to the classical game-experience, such approach seems relevant in producing learning processes based on reflection or change learning. The major difference compared to the previous approach is that instead of making a complete learning game, a learning environment is created, which utilises game-based learning processes.

Rather than choosing between the two approaches, the game-design should be able to switch between them, thereby utilising immersion and reflection in a fruitful combination. Game immersion should be used for staging a problem relevant to the participants, after which the problems are conveyed to the participants, who will then solve the problem. A model for designing such process is illustrated below in the Stairway model:

## The Stairway Model



(Henriksen, 2006)

The distinction between the two approaches also addresses the competencies applied to the game-design. Whereas the flow-based approach is based on the game-designer's ability to create engaging and immersing experiences as the primary element, the reflection-based approach uses different competencies in producing the game-based learning experience; the game-designer is used for staging a problem relevant to the participant, a content expert is used for providing the proper content, the didactic designer (or teacher) is used for converting this into tasks, and the game-mechanic is used for integrating the designed tasks into evaluating feedback mechanisms.

### Conclusive remarks

This short paper presents eight dimensions relevant for designing educational games. The main purpose of these dimensions is to provide game designers with a tool for focussing the educational game-design, as well as giving others a tool for understanding and evaluating the efficiency of game-based learning environments.

As both sides of each dimension contain pros and cons, no final directions for how learning games should be turn out is given. The dimensions are rather usable as perspectives for adapting the educational game to the educational challenge at hand.

A major point is that when games are used in the educational setting, it might be relevant to reconsider the existing understanding of games, and rather than building a full game-based learning environment, it can be beneficial to combine non-game activities with game-based learning processes.

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