Chapter 2
Related Work

As depicted before in Fig. 1.2 several research fields contribute to the results of this thesis. As such, one of the opportunities of this work is the interdisciplinary work and application of findings from pedagogy and sociology to the field of computer science. Thus, this chapter starts with the findings relevant for this thesis from the field of pedagogics intersecting with social media (Sect. 2.1) and afterwards with serious games (Sect. 2.2). The last section (Sect. 2.3) is most closely related to the thesis topic and states the findings on social network games in the intersection of serious games and social media (illustrated in Fig. 2.1). Each section will introduce the terms and models of pedagogy, serious games, and social media in the opening of each respective part.

Finally, the chapter concludes with the key aspects to be addressed in the following chapters.

2.1 Social Media and Learning

This section contains the pedagogical aspects of the work, focusing on different learning models and theories about learning. Based on this, group learning and its didactical implications are addressed. Beside pedagogy, social media is explained according to its difference from classical media and the characteristics for the use of social media in the learning context. Consequently, the intersection of both learning and social media is addressed and the different types of Personal Learning Environments (PLEs) are similarly attended to. The section concludes with an overview investigating the types of support for peer education concepts and social media functionality.

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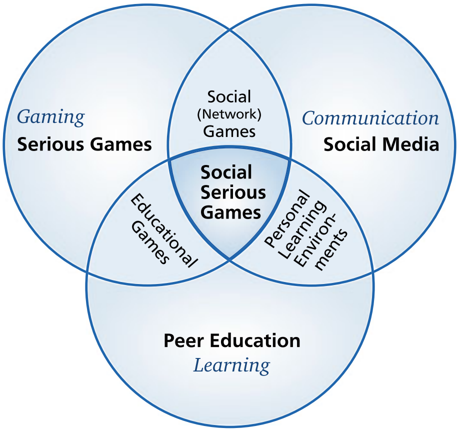

Fig. 2.1 Research fields and intersecting areas for the combination of serious games and social media using peer education concepts

2.1.1 Learning Theories and Models

The underlying theories about learning originate from the field of pedagogical psychology. The main researchers to name here are *Jean Piaget*, *Lew Vygotsky*, and *Albert Bandura*. Their models and empirical findings lead to recommendations, models, and guidelines in didactics, underlying learning with social media and serious games. While Piaget and Vygotsky belong to the school of constructivism, Bandura has his foundation in behaviorism. Still, it is argued that both schools of learning theories and all three researchers' models should not be considered isolated or as being disparate, as the didactic design of situations to support learning and the learning progress might profit from results of all of them.

2.1.1.1 Jean Piaget's Perspective of Socio-Constructivism

The three main aspects of Piaget's model of cognitive development are (1) maturation, and the strong influence of one's (2) physical and (3) social environment. By interaction with this environment the individual develops cognitive models of it. A basis for this cognitive development is the appearance of cognitive conflicts caused by interaction with the environment. These conflicts are eliminated by a mediating fourth factor, moderating all factors important for learning and development. By *assimilation* and *accommodation* an individual solves the conflicts and reaches a next step in development. Assimilation in this context means the integration of new aspects into the existing mental models. If such a synthesis is not possible or the model appears to be inadequate to suit the new aspects, accommodation processes re-structure the existing model accordingly [1, p. 56].

As Piaget explicitly names physical and social interaction as factors, he claims that physical and social activity of the learner are essential for development. As such, traditional forms of tuition, like teacher-centered teaching, are not suitable as learners remain passive and are constricted to consume the information *someone* (an instructor) presents. A key role for cognitive development is the interaction and exchange within a group, as it not only leads to activation of the individual, but also encourages the rise of conflicts and argumentation within the group as a positive mediator for cognitive development (cognitive conflicts) [2]. However, Piaget establishes that empirical foundations of the positive influence by group-learning are not easy to create [1, p. 196]. Still, from a Piagetian perspective Doise et al. [2, p. 377] could show that "social interaction leads to more complex structuring than does individual action."

2.1.1.2 Lew Vygotsky's Socio-Cultural Perspective

Vygotsky agrees with Piaget on the importance of interaction with the environment for cognitive development. For this interaction, individuals use culturally developed tools which are furthermore used collaboratively with others for interactions. His *activity theory* assumes that each self-development has a particular intentional activity as a basis. A learning activity, in specific, builds on existing learning prerequisites. These enabling prerequisites are created and enhanced by guidance and interaction with a more experienced individual (an instructor). This guidance broadens the possible mental development, that Vygotsky calls the *zone of proximal development* [3, p. 86ff].

Referencing Piaget's conclusions about the importance of social interaction for mental development, Vygotsky [4, p. 35] proposes that "the essential feature of learning is that it creates the zone of proximal development." He further points out the need for interaction of the learner with peers in the environment. In contrast to Piaget, Vygotsky sees interaction with others as an essential enabler for learning, whereas Piaget mentions it as one of the main factors, whose effect is mostly indirect, resulting in learning when resolved by the inner mediation process. In particular, the difference lies in the role of the interacting individual: while Vygotsky sees the interaction with a more advanced individual as even more effective than one with a peer on the same level for methodical skill training (externalization), Piaget sees the cognitive conflicts arising from peer interaction on the same level as the most beneficial (mental model and uncovering of misconstructions).

2.1.1.3 Albert Bandura's Social-Cognitive Perspective

With his background in behaviorism, Bandura sees an individual's development to be based on observations that result in more elaborated behavior. But these trained behaviors are not adapted unreflected. Rather the observer notices and reasons about the consequences an observed behavior has for the initial individual. After this mental re-considering the behavior is either adopted or refused. If adopted, it is then practiced and will be aligned to requirements and conditions resulting from the critical evaluation and reflection during practicing. Depending on these conditions, the practiced behavior may occur more or less often in future [5].

As such, learning is described by Bandura as a model-based approach. If the behavior (skill, knowledge) observed is considered to be worthy, it will be adopted. Here Bandura describes the necessary cognitive aspect of one's development. Reasoning and decisions are part of learning. They happen based on the existing trained models. Consequently, the individual depends in his development on the environment's stimulation to be able to observe behavior and build such models. Broadening the observation to symbols and more complex models, Bandura's perspective can also be applied to more abstract concepts that can be observed (e.g. by reading) and then be learned.

Model Summary

All three models emphasize that social factors are important (Piaget) or even necessary (Vygotsky, Bandura) for cognitive development. By observing, self-practicing, and interacting with the environment a learner mentally develops. The process continually contains critical review, reconstruction, and refinement of the mental models and related conditions when they may be applied. Possible development is promoted by observing (Bandura), mediating peers (Vygotsky) or interacting in a social group (Piaget).

In learning scenarios, several phenomena can arise that are not explainable by only one of these perspectives. When learners are confronted with new approaches to a stated problem, which stimulate reasoning and inner re-structuring, the model and principles behind can be made more clear by mutual discussion. This may lead to a collective ability to solve a tasks that was not solvable for each one alone before. In such a scenario learning can happen by adopting others approaches in specific situations. Based on the description, all models's aspects can be considered to be relevant for learning, cf. [6]. A comparison from multimedia learning perspective and the resulting implications for the design of learning systems is given in Steinmetz and Nahrstedt [7, p. 179ff].

We can conclude that individuals can either provide exemplary artifacts, act as tutoring peers, or be part of a collaborative group experience for learning. This very dense summary of all three theories required significant simplification. Nevertheless the simplification will serve the further sections of this thesis, providing a conceptual understanding of the aspects that can stimulate learning. Although, the three cited authors mainly focus on mental development in early childhood, they argue that all mental development and learning rests upon these concepts and are further diversified during maturation and remain valid at all ages. Thus, the application of these authors' findings to learning of more mature individuals, as focused in this thesis, remains valid.

2.1.2 Peer Education

The potential of peer learning concepts and the circumstances under which they lead to desired results are discussed by Damon [8]. He revises the peer learning aspects of Piaget and Vygotsky and concludes, consistent with the argumentation of this work, that education can benefit from both insights. Additionally, he adds aspect from the work of Harry Stack Sullivan, an American psychiatrist who developed his interpersonal theory of psychiatry [9]. As such, social relationships are a core aspect for the coconstruction of new insights. Damon consolidates the theories and describes that the three core concepts to be considered for peer learning are *peer tutoring*, *cooperative learning*, and *peer collaboration* [10]. The use of these concepts differ from intended learning effects and skills of the involved peers. Suitable dimensions to diversify the approaches are equality and mutuality.

Peer tutoring is characterized by low equality and low mutuality, where a more advanced tutor explains and guides a novice tutee and the flow of information is mainly unidirectional. But the advancement of the tutor can as well be marginal and only in one aspect of skills. It is desired that both switch the roles in the course of learning, in case the tutee can as well teach their tutor something. Peer tutoring is most suitable for skill training or drill and practice, but not expected to raise new complex insights for the tutee.

In contrast, peer collaboration is characterized by high equality and high mutuality and thus more suitable for approaching complex problems in a group using *discovery learning*. Peers exchange ideas and concepts, justify their point of view and consider the feedback of others seriously. This collaboration is "only possible in an atmosphere of mutual respect" [8, p. 334] where a close matching of peers in knowledge and ability is a prerequisite. Consequently, collaborative learning groups should be matched with a *symmetry of knowledge* [11, p. 7], complementing one another in partitions of the *knowledge space* (cf. [12]). A somewhat specialized form of collaborative learning is the group discussion and exchange to individually produced results to the same tasks. This can be applied when practicing problem-solving, e.g. with math problems [13]. The problems are approached individually, then the result and chosen approaches are discussed afterwards in groups (cf. [14, p. 45]). All such methods, peer tutoring, peer group collaboration, and problem-based learning are identified to have high positive impact[1] on learning progress of involved participants, as shown by John Hattie in a substantial meta analysis of 736 studies on learning effects [16].

Cooperative learning lies somewhat between peer tutoring and peer collaboration, with high equality and differing mutuality, depending on the setup [10, p. 15] as illustrated in Table 2.1. Still, mutuality will always be more restricted than in collaboration, as tasks are subdivided and learners are doing their work individually. This can lead to strong specialization as each learner adopts the role and takes the subtask they are most experienced with. In further cooperative work they may stick to these choices, preventing them from mastering other skills or aspects of the divided

[1] Cohen's d effect size greater than 0.5 [15, p. 20].

Table 2.1 Peer education concepts and their characteristics

Aspect	Peer tutoring	Cooperative learning	Peer collaboration
Equality	Low	High	High
Mutuality	Low	Varies	High
Skill development	High	Varies	Low
Problem-solving	Low	Varies	High

task. To prevent this, Cohen and Goodlad [17] propose the program of *complex instructions* where peers in the group alternate between roles in the group, so that everyone has the chance to participate on every component of the task. Still, following the argumentation of Damon, cooperative learning is considered the least suitable concept for the course of this thesis due to its unpredictable outcomes depending on the setup and difficulty in administration.

In conclusion, and based on the findings about the effectiveness of peer tutoring and peer collaboration [18], peer education can be considered as the use of peer tutoring for tutoring of methodical knowledge and skill practice on one side and peer collaboration for the collaborative problem solving on the other side. Based on this understanding, the author of this thesis defines peer education as follows:

Peer Education is the concept of using peer tutoring and peer collaboration for learning. The former for skill practicing when equality and mutuality of the peers are low, the later for problem solving with high equality and mutuality among the learners.

2.1.3 Group Formation Algorithms

When peer education is about to be applied to learning scenarios e.g. in school classes, social media applications, or serious games, algorithms can be used to assist the instructors and learners in finding appropriate members of their learning group.

Group Formation Problem As discussed in Sect. 2.1.1.3, matching peers for learning heterogeneously by various aspects, like learning style preferences, stimulates cognitive dissonances, supports interaction due to socio-cognitive conflicts and can enhance learning effects [19–21, p. 5]. Unfortunately students prefer to select primarily friends and others of the same status and level of proficiency as their group members [17, 22]. This leads to homogeneous group formation instead of the desired heterogeneity in the group. Above all, instructors do not have the capacities to establish an optimized grouping as matching criteria are manifold. Moreover, students

"…tend to be rebellious if they are forced to work in groups that are not of their own choosing" [22, p. 1].

The challenge to optimize learning group formation from a given set of peers to match, while respecting homogeneously to match criteria simultaneously with heterogeneously to match criteria and aiming for a balanced quality of the build groups, will be called the *Group Formation Problem* in the following work.

Relevant Matching Criteria Paredes et al. [23, p. 2883] state that homogeneous groups perform better for specific tasks, whereas heterogeneous groups are better on broader tasks (e.g. problem-solving). Likewise, as mentioned above, for peer education an atmosphere of mutual respect has to be established [8, p. 334], where a close matching of peers in symmetry of knowledge and ability is a prerequisite [11, p. 7]. Thus, level of knowledge can be considered as a homogeneous matching criteria, whereas the area of knowledge should be complementing each others previous knowledge (as a heterogeneous criterion). Generally, learners should have similar learning targets and the intensity of learning should be matched homogeneously to avoid fast separation in knowledge symmetry [24]. For the matching of learner's age Damon [8] recommends a homogeneous matching. Gender can be matched homogeneous or heterogeneous, but should equally distributed within the group [25].

Learning style preferences are expected to be most suitably matched heterogeneous to support cognitive dissonances, argumentation among the learners, and insight into each others' different approaches to problem solving [26, p. 6].

Concerning the personality traits, Barry and Stewart [27] argue that openness for new experience and conscientiousness should be matched homogeneous, while the level of extroversion should be heterogeneous. Consistently, group roles of leaders and followers should be matched heterogeneously within a group for better team performance [28].

In brief, no general advise can be given which criteria need to be matched homogeneous or heterogeneous for improvements in group learning performance. This depends not only on the type of tasks, but also on the learning environment and the participants themselves. Consequently, it remains most valuable to aim for a general algorithmic solution that allows the instructor to set the specific criteria and weightings for each scenario a group formation is conducted for.

Existing Approaches As outlined in Konert et al. [29], from an algorithmic point of view, two differing groups of approaches exist for group formation: *semantic matchmakers* and *analytic optimizers*.

The former use ontologies for calculating how well two (or more) learners suit each other for an effective learning process. The ontologies allow for the formulation of manifold boundary conditions, e.g. learning goals and skills, to be respected during group formation [30]. If a suitable ontology is missing, the use of such matchmakers becomes very costly. Furthermore, most of these matchers do not provide a calculated measure of the group formation quality and will not consider the aspect of creating equal distribution of group formation quality. One algorithm providing equal distribution is *Fits/CL* [30]. It uses an opportunistic group formation approach to find suitable peers for collaboration based on learning goal ontology and peers' roles in groups as tutor or tutee. In contrast, the *GroupMe* algorithm is able to calculate a group formation quality and supports weighting of the matching criteria [25]. To calculate possible valid solutions based on the semantic information in the underlying ontology the DLV logic solver is used [31].

In contrast to the semantic matchmakers described above, *analytic optimization* algorithms map the desired optimization criteria to a n-dimensional feature space of each learner. Comprehensive, group-specific criteria are respected as boundary conditions or they are integrated into calculation of the group formation quality (within their fitness function). Based on criteria to be matched homogeneously, similar learners can be grouped by cluster analysis using the feature space (e.g. Fuzzy-C-Means algorithm as used by Paredes et al. [23]). This approach appears to be limited if heterogeneous to match criteria exist in parallel to the homogeneous to match criteria. Then heuristics and iterative optimization procedures are used [24]. Such approaches use swapping of group members or calculation of groups in repeating cycles with varying starting conditions. This seems feasible for scenarios with a few hundred to thousand learners [24]. Seldomly existing approaches go beyond existing classical optimization procedures to address the issue of respecting heterogeneous and homogeneous to match criteria simultaneously.

The cited systems and their algorithms are compared according to the criteria of

- providing of a calculated measure for group formation quality,
- respecting the restriction to form groups with similar formation quality,
- allowing a theoretically endless number of criteria,
- providing the possibility to weight criteria's impact on group formation,
- allowing the use of several group formation algorithms depending on the desired group size and criteria characteristics,
- supporting the use heterogeneous criteria (clustering),
- supporting the use heterogeneous to match criteria (amendment), and
- supporting the use of both criteria types simultaneously.

As shown in Table 2.2 none of the researched approaches supports all of these eight criteria. Still, it might be suitable to consider further criteria, like interactive support and visualization for instructors, to manually influence the group formation as provided e.g. by *OmadoGenesis* in Gogoulou et al. [32]. Likewise valuable can be assessment of the capability to address the *orphan student problem* [25, p. 1] and handle missing data. As this thesis focuses on matching learners in the field of serious games and social media, a support for instructors is not the main focus. Nevertheless, it is expected that it could be possible to add support for instructors after the design of a pure automatic algorithmic solution. The problem of having unmatched participants will be partly addressed later by matching participants by group to prevent groups with only one member in the end. The aspect of missing data will not be addressed as participants′ profiles are expected to be complete as a basis for this thesis′ considerations. Investigating matching problems with missing data is an own research field that cannot be covered here in depth.

Table 2.2 Group formation systems and algorithms

	Calculation of group formation quality	Uniform group formation quality	Infinite number of criteria	Criteria weighting	Several algorithms available	Homogeneous group formation	Heterogeneous group formation	Mixed group formation
System *Algorithm*	*Qualities*							
Fits/CL [30] *Opportunistic group formation (Learning ontology)*	-	+	-	-	-	+	+	+
GroupMe [25] *DLV solver*	+°	-	+	+	-	+	+	+
I-minds [33] *VALCAM/agent system*	-•	-	-	-	-	+	+	-•
GroupFormation [34] *Fuzzy C means/random tool*	-	-	-	-	-	+	+	-
Together [23] *Far-away-so-close*	+*	-	-	-	-	-	+	-
OmadoGenesis [32] *Homo-A/Hete-A/genetic algorithm*	+	-	+	-	+	+	+	+
TeamMaker [24] *Hill climbing*	+⋆	-	+	+	-	+	+	+

• VALCAM's agent system evaluates the suitability of candidates iteratively based on prior task solutions for a previously selected homogeneous or heterogeneous strategy, ° statement about restriction violations, * using a threshold, ⋆ using a heuristic

2.1.4 Knowledge Transfer

The aim of peer education is to support each individual's progress (learning). From a didactical point of view, situations facilitating peer education are desired to lead to knowledge transfer among peers. Knowledge is here defined and considered as the sum of all capabilities and skills an individual identifiably applies for problem solving [35, p. 1]. A prerequisite for knowledge is the availability of data and—by contextualizing this data—the resulting information. This underlines the difference of information to knowledge, as knowledge is always personal. On account of this, knowledge, per se, is tacit and its transfer is difficult as the objective aspects are not clear. Tacit knowledge can still be transferred among individuals by social and personal experience (e.g. dancing can only be learned by interaction as the attitude, mood and timings needed are hard to describe). Tacit knowledge needs to be transformed into a explicit instantiation to be rational [36]. Such *knowledge externalization* leads to the creation of *knowledge media* that can be transferred among individuals (or systems). This data is then again interpreted in a context to read the containing information and then transformed into the recipient's implicit knowledge in the case that the data contained any new information (for the recipient) [37, p. 164f].

2.1.5 Social Media

"Social media is a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content" [38, p. 61]. To make this more clear, *web 2.0* can be seen as the foundational technology and ideology for social media. The technological aspects are the upcoming solutions for dynamic website creation, like Asynchronous JavaScript and XML(AJAX)[2] and the wide use of Adobe Flash for video and rich interactive content, just to name a few. Ideologically, as websites turned into platforms providing services, the web began to be a continuously developing software system with beta-versions and strong end-user involvement in application and content development (also called the *participatory web* [39]). When users visit social media application websites they do not simply browse, but actively create assets and contribute to the further development of these assets. These contributions are called *user-generated content* when (a) it is published or accessible to a wide range of other users, (b) its creation required some depth of creativity, and (c) it evolved out of a non-professional practice [40, p. 18]. It is important for the course of this thesis to differentiate social media, that are applications, from user-generated content, that is the outcome of using such applications.

The spectrum of applications in the social media landscape is manifold. The Parisean Internet consultant Fred Cavazza publishes each year his (subjective) view

[2] Even though mostly the XML data is nowadays a different format, e.g. JavaScript Object Notation (JSON) for easier parsing by receiving Javascript objects.

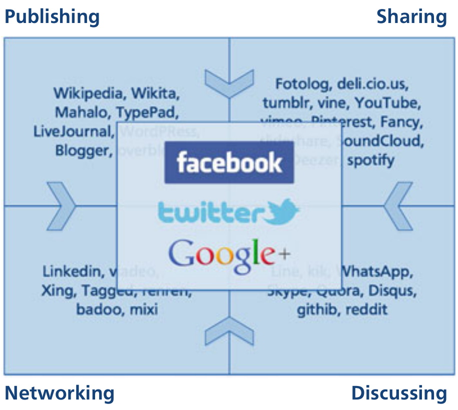

Fig. 2.2 Social media landscape 2013, based on circular illustration of Fred Cavazza (Fred Cavazza's Social Media Landscape 2013, source: http://www.fredcavazza.net/2013/04/17/social-media-landscape-2013/, last visited on August 13, 2013.). It shows the four main interaction patterns in social media and names exemplary applications with *Facebook*, *Twitter* and *Google Plus* in the center

of the development and trends in social media as a landscape that is illustrated in Fig. 2.2. Even though it is not academically founded, it is useful for a first insight, as academic resources on social media are very limited.

The major user needs addressed by these applications are publishing of individual content, sharing of own or found content, discussing opinions or content, and networking with other users.

Currently three applications are dominating the market: Facebook,[3] Twitter,[4] and Google+,[5] as these serve all the mentioned needs and provide an API for third party developers to integrate content into the application or read profile information and data. In 2012, Facebook reached about 700 million active users, Twitter about 280 million and Google+ 340 million as illustrated in [41]. All three emerged from the core service of social networking and function now as a hub for publishing, sharing, discussing and networking.

Julien [42] provides a list of 12 social interaction patterns that strongly relate to the four core interactions from Fred Cavazza mentioned above: Publishing is subdivided to posting and commenting. Sharing includes updating (of shared posts). Discussing contains voting and tagging. Networking groups the interaction patterns of chatting, inviting (to join), and joining (as response to invites). Additionally, Julien names the interaction patterns of buying and playing as his research is focused on users of online social networks applications. It can be argued that these two are quite special activities occurring in social network applications and even violate the conditions of interactivity that needs at least two individuals (sender, receiver). As such, buying

[3] http://www.facebook.com/, last visited on August 13, 2013.

[4] http://www.twitter.com/, last visited on August 13, 2013.

[5] http://plus.google.com/, last visited on August 13, 2013.

and playing are not considered as pure social interaction patterns in the further course of this thesis. All of the mentioned patterns can as well be found in the list of more than 100 social patterns described by Crumlish and Malone [43] for the design of social interfaces.

2.1.6 Social Media for Learning: Personal Learning Environments

Even before the rise of social media, web-platforms were created to support knowledge acquisition using the Internet as the fastest and most convenient transport channel for E-Learning content. As part of E-Learning, Web-Based Trainings (WBTs) became a popular way for institutions and companies to deliver their learning content to recipients in distance learning or blended learning scenarios. In WBTs the content is organized in a traditional way: learning units are arranged in chapters, pages and testing questions in the end of each unit. Therefore web-based trainings can be considered as unidirectional E-Learning (from institution to learner) without the ideological and technical aspects of social media.

A term of wider coverage in this context is Virtual Learning Environment (VLE), which is also called Learning Management System from an institutional perspective. A VLE allows for content management and alignment with a learner's curriculum and covers administration aspects. Modern virtual learning environments allow collaboration of learners in online learning communities within the environment [44]. A learner-centered perspective is provided by Personal Learning Environments (PLEs) (or Adaptive Personal Learning Environments). They evolved from VLEs and provide the learner with abilities to chose their favorite learning tools that interact with the learning environment, load the learning content and provides social media functionality for sharing, discussing, and networking [45, 46]. The idea of PLEs is to connect users with each other and with the learning content, but also allow the use of individual tools to grasp, manipulate, and create content. Here users can arrange their learning content in their own competency portfolios and review the topics continuously [47, p.101ff]. Exemplary in the use of high-quality PLEs are the learning-platforms offered by renowned universities, which provide free video-based lecture material in courses with schedules, assignments, and basic networking capabilities. Prominent examples are on *edx*[6] with lectures from the Massachusetts Institute of Technology (MIT), Harvard University, Berkley University of California and many more. Likewise, MIT Open Courseware,[7] Open Yale courses,[8] and Coursera[9] offer high-quality university course content. Commercial operators like

[6] https://www.edx.org/, last visited on August 14, 2013.

[7] http://ocw.mit.edu/, last visited on August 14, 2013.

[8] http://oyc.yale.edu/, last visited on August 14, 2013.

[9] Offered by University of California, Irvine at http://oyc.yale.edu/, last visited on August 14, 2013.

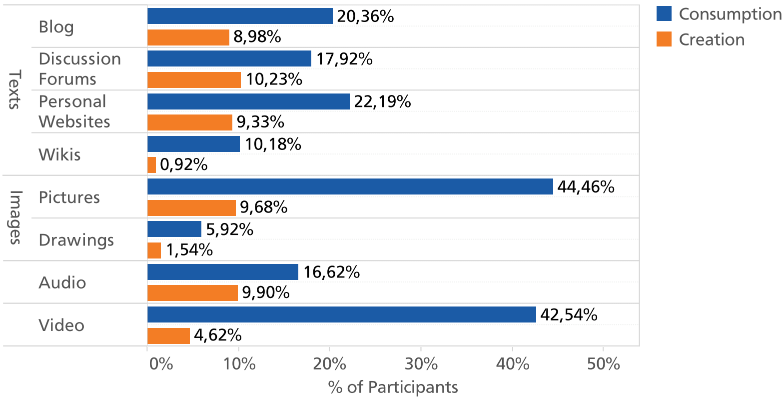

Fig. 2.3 Types of user-generated content with distribution of consumption and creation [51, 52]

Udacity[10] try to keep up by offering courses also for free, but charge for examinations that are approved for college credits or official degrees.

As social media changes the usage of the Internet, online learning environments change accordingly. In the sense of web 2.0, learners become consumers and creators of learning content simultaneously. Online applications supporting peer-learning and sharing of user-generated learning content emerge [48–50].

Most content created and shared online consists of text, images, audio or video [40, p. 34f]. On a daily basis, 87 % of web-users consume such content and 22 % of these create such content themselves [51, 52, p. 9ff]. In more detail, users prefer to consume primarily images (44 %) and videos (43 %), followed by text (up to 22 %). Users create primarily text-based formats as discussion forum comments (10 %), personal websites (9 %) and blogs (9 %), followed by pictures (10 %). An overview is given in Fig. 2.3 based on [51, 52]. In summary, text and images are the formats widely consumed and created, followed by video.

Platforms focusing on articles and learning videos[11] offer limited networking functionality as their focus is on content creation, sharing, and discussion. Other solutions focus primarily on creating a community environment for learners. With *PeerSpace*, Li et al. [49] have shown the positive influence on peer community building and provision of mutual feedback when social media applications are used alongside learning content provision. In *PeerWise* [53] students create questions to lecture topics, provide peer assessment on the quality of the questions, answer explanations, and give peer feedback for improvements. Unfortunately the authors neglected to measure the learning impact or effects the system usage had on student engagement and final marks. Nevertheless, the frequent usage of the system for exam preparation supports the findings on the positive aspects of social environments,

[10] https://www.udacity.com, last visited on August 14, 2013.

[11] Eg. http://www.ehow.com/, http://www.lynda.com/, http://www.ted.com, and http://www.youtube.com/education; all last accessed on August 14, 2013.

peer tutoring, and feedback for learning. Stepanyan et al. [54] have used a VLE to voluntarily allow students to access each others' work and provide peer assessment. In the specific setup of this study the provision of content to be assessed was low, but interest in accessing other peers' work was high. The authors point out the impact of anonymity and the provision of marks on the willingness to contribute. This indicates a sensitivity of content creators for privacy issues and an awareness of rewards.

More recently, the term Massive Open Online Course (MOOC) emerged for the new generation of learning resources available online. The term is not yet well defined and "since MOOCs are a relatively new kind of online learning, there are relatively few studies written about them" [55, p. 2396]. Still, as one key success factor for MOOCs Russell et al. [55, p. 2396] identified their "…engaged and socially active communities of students that pose problems, resolve questions, add additional material to the class, and support other students' learning"—key aspects supporting learning (cf. conclusion on learning perspectives in Sect. 2.1.1.3).

Currently, operating MOOC providers—offering PLEs with the social media functionality described above—are The Open University[12] with their SocialLearn platform, probably the oldest provider (since 1971), or KHAN Academy.[13] If the term MOOC is seen in a more strict definition, sticking to openness and considering less the social media publishing aspect, then the PLE examples of edx, MIT Courseware, and Open Yale courses mentioned above can be considered to be best-practice MOOC provider examples, too. The other (commercial) PLE providers do not offer their courses for free. Consequently openness is not fulfilled as needed for MOOCs.

The considerations of this work on the different types of learning environments and their support for peer education aspects and social media needs are summarized in Table 2.3. In conclusion, among the considered E-Learning platform variants, MOOCs appear to be the most close to the aspect of bringing social media and learning together. They are a good base for the intersection of educational games and social media.

Table 2.3 Examples of learning environment types and their support for peer education and social media

	WBT	VLE	PLE	MOOC
Peer tutoring	No	No	No	Yes
Peer collaboration	No	Basic	Basic	Yes
Publishing	No	No	No	Yes
Sharing	No	Basic	Yes	Yes
Discussing	No	Yes	Yes	Yes
Networking	No	Yes	Yes	Yes

[12] http://sociallearn.open.ac.uk/, last visited on August 14, 2013.

[13] https://www.khanacademy.org, last visited on August 14, 2013 providing all content for free in a social media application environment.

2.1.7 Section Summary

In this section (Sect. 2.1) the theories of learning have been compared and lead to the conclusion that all three theories can be used in conjunction to support learning scenarios. As described, social interaction for learning by *peer education* can greatly support knowledge transfer among peers. In the context of social media, the user-generated content can be used as the media for knowledge externalization and transfer among users of social media applications. Most promising types of applications—supporting the intersection of learning (by peer education) with social media—are Massive Open Online Courses as they allow all the social media interactions of publishing, sharing, discussing and networking as well as peer tutoring and peer collaboration.

2.2 Serious Games and Learning

> Tell me and I will forget,
> Show me and I will remember,
> Involve me and I will understand.
>
> (Confucius, 450 B.C. [56, p. 179])

By the time individuals in the United States have officially become an adult (achieving the age of 21) they have spent around 10.000 hours playing with computer and video games [57, 58, p. 266], all to become good in one set of skills: "cooperating, coordinating, and creating something new together" [57, p. 348]. Game researcher McGonigal summarizes this as one of 14 core aspects[14] that make games[15] more than fun and rather how they make individuals better.[16]

The term *serious games* evolved from the entertainment field of computer games (pure entertainment games). They build on the entertainment value of such games and add an extra value with an educational purpose [59, 60]. As such, they have a serious purpose which leads to the easily misunderstood term *serious games*. In the course of this thesis the term serious games is understood as digital games which are developed for another purpose beside pure entertainment (in relation to the discussion in [61, p. 6]).

Terms used instead of serious games and meaning something similar, but not an identical group of applications, are *edutainment* games as the broad intersection field of education and entertainment [62]; *games with a purpose* [63]; *game-based learning* [64]; and *applied games* [65]. The term *applied games* nicely points out the interdisciplinary aspect of serious games, which are used in application fields like knowledge gain, (social) skill development, health and medical treatment, fitness,

[14] McGonigal calls them *fixes* in her book.

[15] When referring to games in the course of this thesis it covers primarily electronic games in forms of video games, computer games, browser games, and mobile games, if not otherwise stated.

[16] With *better* McGonigal refers to improvement in the skills trained by the games.

collaboration, recruitment, or persuasion and attitude change [66, p. 119]. Most of the games have primarily academic educational content (63 %), followed by games related to social change (14 %), occupation (9 %) and health (8 %) [67, p. 14]. Serious games referring to the academic field—addressing knowledge gain and skill development—are called *educational games*. Before focusing on educational games in the further course of this thesis (Sect. 2.2.2), an overview over the research field serious games is given as it is understood and approached at Technische Universität Darmstadt.

2.2.1 Serious Games at Technische Universität Darmstadt

> All serious games are games; i.e. analogue to any other (pure entertainment) games serious games contain game play, goals and rules and use game technology. These elements are combined with further domain-relevant methods, concepts and technologies, e.g. pedagogic and didactic concepts for educational games or sensor technology for exergames and are applied within a broad range of serious game application fields.
>
> (Göbel and Gutjahr [59, p. 1])

The serious games group at the Multimedia Communications Lab (KOM) defines the understanding and approach to serious games as the use of game technologies as a basis, supplemented and enriched by the knowledge and models from related interdisciplinary fields around, to be applied in manifold application areas.

Reference examples for serious games cover a broad range of application domains including educational settings (from kindergarten to collaborative workplace training), sports and health applications (prevention and rehabilitation) or other societal relevant topics.

In particular, serious games technologies are used as 3D training and simulation environments for pilots, firefighters, medical staff, police women, bus drivers, train guards and service staff, as visualization and construction tools for architecture and urban planning, or as research tools for human perception and action. Serious games concepts are used to support learners and teachers in educational settings at school or university, to motivate humans for a healthy, active life, to encourage (especially young) people to explore their cultural heritage, to increase public awareness of societal issues (religion, politics, security, energy, climate, etc.), or to assess human behavior and experience in complex and dynamically changing environments.

Challenges and Research Areas

Serious games are a highly complex scientific area considering the multifaceted characteristics of pure digital games plus the dimension of the serious part: The key challenge of serious games is to reconcile and balance true gaming experience on the one hand and the fulfillment of the additional purpose beyond pure entertainment, on the other. Thus, research in serious games is necessarily multi-disciplinary, and most of the currently available systems are specifically designed for a particular target application area. Such solutions for specific application areas have to be subjected to formative and summative evaluations considering the complex interplay of numerous factors.

Research objectives include an in-depth analysis of serious games, and the elaboration of new methodologies for (1) efficient, single-user or collaborative authoring of serious games, (2) personalized, adaptive, and context-sensitive control, and (3) empirical versus objective, technology-enhanced evaluation of serious games. Figure 2.4 shows the overall structure of research on serious games.

The serious games group at Technische Universität Darmstadt aspires to synthesize these objectives in a reference model for the description and evaluation of serious games, with the option to serve as a quality label in the long-term perspective [59, 68–70].

2.2.2 Educational Games

Educational games evolved by continuously adapting the evolved principles of various learning theories for serious games. First generations were limited to drill and practice tasks, respecting behaviourism-based theories. They had limited value for sophisticated knowledge acquisition or change of attitudes towards learning content, because the first generation of these applications did not support the adaption to the progression of learners. The second generation moved to constructivism-based theories focusing on the learners—not their behavior—and respecting their learner- and player-profile. Finally, the evolved third generation integrated a socio-cultural perspective to constructivism adding situations and settings to the games [71, p. 25].

Still, these types of games, supporting cognitive problem solving beyond knowledge gain through exploration, are only about 24 % of the available serious games.

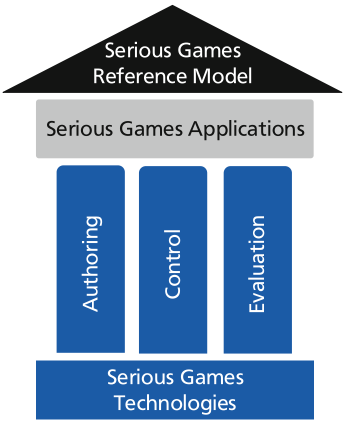

Fig. 2.4 Serious games research areas

Second generation games (exploration) are 21 % and first generation are still the biggest share of 48 %. The remaining 7 % are attributed to games beyond third generation, including social interaction for problem solving like collaboration [67, p. 17].

Gros [71, p. 26] names seven genres of educational games. Among them, adventure games seem most appropriate for peer education, as these games are characterized by tests the player has to solve to progress in the game. Educational adventure games therefore appear to be less action-laden or time-restricted than other genres. In the course of this thesis the focus is on such educational adventure games of third generation and beyond as they allow the social interaction, explorative learning, content exchange for *deep learning* [72, p. 89], and peer education concepts identified as most important in the preceding section of this chapter. Deep learning refers to the software- and game-based support of learners to develop skills "that prepare all learners to be life-long creative, connected, and collaborative problem solvers" [73, p. 6].

2.2.3 Player Modeling and Learner Modeling

For all aspects of serious games creation, support for suitable representations of players′ state are beneficial. The better the underlying models, the more accurate the game can control the players′ level of engagement and thus, the learning progress.

To provide a player with the best gameplay experience the game has to adapt to a player's mental state (needs) and cognitive development (abilities). The psychological theory of *flow* describes a channel of optimal experience where someone is engaged and immersed in an activity, if the current goal and presented challenges fit with their abilities [74]. For games where players develop their skills over time, this means that the game has to measure and detect such changes and adapt the difficulty and task characteristics accordingly.

As the theory originally has not been designed with games as its focus, Sweetser and Wyeth [75] propose and evaluate the *game flow* model. It builds on the flow theory and has eight elements, with seven of these linked to flow criteria to achieve the enjoyment of games. The eighth "(…) element of player enjoyment, social interaction, does not map[17] to the elements of flow, but is highly featured in the literature on user-experience in games. People play games to interact with other people, regardless of the task, and will even play games they do not like or even when they don't like games at all" [75, p. 4]. To achieve game flow, developers must adapt to the different personal flow zones users have—depending on preferences and skills [76]. When adapting to player preferences, adapting to different player types (player models) is meant. Adaptation to skills refers to different levels of ability and learning preferences (learner model).

For differentiating player types, two approaches can be identified. The first is a psychologically driven approach using established models on personality traits

[17] i.e. link (author's remark).

and personality types from psychological research. The second approach focuses on player preferences and their expected game experience.

2.2.3.1 Personality Models: Traits or Types

To differentiate the personality of individuals in general two widely used approaches have emerged.

On one side, the psycholexical perspective of [77] combined with the differential-clinical perspective of [78] has emerged and been further developed over the last decades [79]. Starting with the two personality traits of extraversion and neuroticism, it has been extended by Costa and MacCrae [80] with the concept of openness, and resulted in the 5 factor Neuroticism Extraversion Openess (NEO)-Personality Inventory Revised (NEO-PI-R) model, adding the dimensions conscientiousness and agreeableness. Its validity has been widely shown and is accepted worldwide as a stable method to describe human personality and is therefore also called the Big5 model.[18] A reliable 21-item short questionnaire to measure the dimensions is available from [82].

On the other side, the Myers-Briggs Type Indicator (MBTI) based on Jungs' types of personality measures individual's preferences with 93 items on four dimensions, resulting in 16 possible psychological types [83]. That said, the main difference lies in the measurements and scales. While with NEO-PI-R, personality traits themselves are measured on five independent scales, MBTI assesses personality types and then classifies a person into the most suiting category accordingly. As the categories can be used as stereotypes, the MBTI seems to be more accepted in the business field for classifying human resources and for career planing.

In summary, NEO-PI-R is a absolute measurement of personality itself (traits) with continuous results while MBTI is comparative and has discrete (preference) results as exhibited in Table 2.4.

Corroborated by manifold studies, these models can claim to be valid independent of application context, cultural aspect, or target groups. However, their direct application to games has to be investigated as it remains unclear what adaptation consequences a specific personality profile of such models has for the gameplay experience as the mapping to the game elements is missing.

Table 2.4 Examples of personality models (NEO-PI-R, MBTI)

Model	Dimensions	Measure	Items[a]	Result
NEO-PI-R [82]	5	Absolute	21	Continuous
MBTI [83]	4	Comparative	93	Discrete

[a]For MBTI listed in Myers-Briggs Type Indicator Explanation (Development Edge), available at http://www.dec.co.th/mbti_explanation.htm/, last visited on August 17, 2013

[18] And different from the Five-Factor Model (FFM) that appears to be less robust to cultural differences (cf. [81]).

2.2.3.2 Player Models: Preferences

Describing player interests, a widely known and frequently implemented model of player types, has been proposed by Bartle [84] based on his analysis of user-behavior and preferences in Multi User Dungeon (MUD) games. He classifies player interests onto the axes of acting versus interacting and player versus world, resulting in four[19] player types: achievers, explorers, socialisers, and killers. Players afford more or less peculiarities in each (ranging from 0 to 100%).

Achievers are acting in the world, focusing on completing game tasks. Explorers are interacting with the world, knowing secret features and gaining expertise in knowing what is possible where (and how). Socialisers are interacting with other players, using the game environment as the foundation for communication. Finally, killers are acting on other players aiming to be superior and applying game expertise to differentiate from other players. As Bartle [84] aims to argue how these types influence each other and can be balanced in MUDs, he points out the disharmony of killers with achievers and socialisers (and even among killers themselves). Therefore the only way to reduce the presence of killers is to strongly increase the number of explorers. For the course of this thesis, interest is given less to the balancing of such player types in multi-player games, but more so to modeling and tracking players' needs in order to serve the appropriate game content (or peer player). Surprisingly, no sophisticated direct method for measuring these player types could be found during the research underlying this thesis. Bartle [85, p. 145] himself mentions a set of test questions not yet academically published, but available as a web application [86]. For usage concerning this research, the authors of this test were contacted and asked for the questionnaire items and permission to use.

From traditional pen and paper role-playing games, similar models exist. Laws [87] (as cited in [88]) defines six player types of power gamer, butt-kicker, specialist, method actor, storyteller, and tactician. Unfortunately, a measure and underlying questionnaire items were not stated in the literature. From computer science theory, Charles et al. [89] propose a more dynamic model using pre-defined criteria and continuously adapting the model in a game control loop to match players to (pre)-defined clusters depending on in-game behavior. Consequently no questionnaire measuring the model criteria exists as it is calculated from in-game behavior directly.

The three models are listed in Table 2.5 for comparison. As apparent, the dimensions depend on the developer-defined amount of clusters. As this research did not reveal a questionnaire for the types of Laws and due to the fact that Charles et al. leaves open the definition of meaningful criteria and cluster-mappings to the developer, the model from Bartle seems appropriate to be used as a starting point to identify player type preferences of individuals.

[19] According to Bartle's blog there exists also a version with 8 players types that could not be found in academically publications unfortunately (cf. http://www.youhaventlived.com/qblog/2008/QBlog251108B.html, last visited on August 16, 2013.).

Table 2.5 Examples of player models [84, 87, 89]

Model	Dimensions	Measure	Items	Result
Bartle [84]	4	Comparative	39	Continuous
Laws [87]	6	N.S.	N.S.	Discrete
Charles et al. [89]	Variable	N.A.	N.A.	Continuous

N.S. for *not stated* in literature, N.A. for *not applicable*

2.2.3.3 Learner Models: Types or Preferences

Modeling learner types and learning style preferences is somewhat orthogonal to player types and preferences. It is specifically challenging for educational games to additionally include learner types and learning style preferences, compared to classical entertainment games. In theory, the models of player and learner are independent.[20] Hence all combinations need to be considered in a game while adapting the game flow.

As no single universally accepted method exists, several models and approaches have been developed. Still there is criticism that some of the existing models' dimensions or categories of learning types and preferences measure personality traits more than learning aspects. A concise overview considering the results, benefits, drawbacks, and limitations of four major models is given in [90]. Study results investigating which of the models appears to be better under certain conditions imply that the choice for once specific model does not matter much as long as the implications from each models' types are very similar from a didactic point of view [91]. Two of the most widely used models are briefly described below. Felder and Silverman [92] developed a model to classify their engineering students based on the approach to interpret learning as a two-step process in both perception and processing. At present, this model consists of the following four dimensions: (1) active versus reflective, (2) sensory versus intuitive, (3) visual versus verbal, and (4) sequential versus global. They abandoned the formerly existing fifth dimension (inductive versus deductive), concluding that in a sense of problem-based learning and discovery, learning inductively is always to be the favorite method for teaching college students. According to these dimensions, they created a self-scoring instrument, called the Index of Learning Survey (ILS), which, in the current version, has 44 items and has already been used multiple times even though it has not yet been validated [90]. It can be concluded that one reason for the model's popularity appears to be the provided direct mapping of preferred styles (diagnose result) to corresponding recommended teaching styles. That said, the index is a practical tool for adapting learning content delivery depending on a learners style. Additionally, a compact, adaptive questionnaire version exists from [93].

The second model described here was proposed by Kolb [94] and is named the *Learning Style Inventory (LSI)*. This model is not classifying, but identifying the learning style preferences on two axes: collection of experience as abstract

[20] For evaluation results see Sect. 7.1.6.

Table 2.6 Examples of Learner Models (ILS two times, LSI)

Model	Dimensions	Measure	Items	Result
ILS [92]	4	Comparative	44	Discrete
ILS [93]	4	Absolute	4–5	Discrete
LSI [94]	2	Absolute	12	Discrete

conceptualization (AC) versus concrete experience (CE) and processing of experience as active experimentation (AE) versus reflexive observation (RO). The LSI model results in the style preferences of accommodating (CE/AE), converging (AC/AE), assimilating (AC/RO), and diverging (CE/RO). The validity proven questionnaire for the Kolb Learning Style Inventory is not published and can be retrieved upon request from HayGroup.[21]

Both learner models are compared in Table 2.6 and are equally suitable. As [92] lack a validated questionnaire currently, the model of [94] is preferred, even though their questionnaire items are only available upon request.

2.2.3.4 Learner Assessment Models: Knowledge-Based or Evidence-Driven

Modeling of learners' progress to select the next most appropriate task is a separate aspect for maintaining flow experience with educational games. The behavioristic knowledge space theory has been complemented with constructivistic elements resulting in the Competency-Based Knowledge Space Theory (CBKST) [12]. The model contains the knowledge structure and the knowledge space. The structure consist of the set of problems $Q = \{q_1, q_2, \ldots, q_n\}$ and the binary transitive relation ρ defined as $\forall q_i, q_j, q_k \in Q : (q_i \leq q_j \wedge q_j \leq q_k) \Rightarrow q_i \leq q_k$. It can be interpreted that if a learner has shown the competence to solve the problem q_k, the deduction is reasonable that he also can solve problem q_i (and q_j) as it is a smaller problem and the required skill-set (knowledge) exists if a related (greater) task has been solved. The set of problems Q and the set of all instances of the defined relation $R = \{\rho_1, \rho_2, \ldots, \rho_m\}$ span the directed graph of prerequisites (e.g. q_i before q_j) and paths through the knowledge structure. This graph is called the knowledge space as it spans all possible trajectories to explore the structure as shown in Fig. 2.5. The model's simplicity and applicability has lead to its use in educational games and studies, as well as in the authoring tool StoryTec for single-player educational games [95–97].

As several researchers stated the importance of problem solving, interaction, and self-directed approaches towards problems,[22] it seems necessary to broaden the abilities of the underlying model to dynamically identify evidence for task solutions that are related to problems. As such the tasks do not need to be mapped directly to the

[21] http://www.haygroup.com/leadershipandtalentondemand/contact/, last visited on August 15, 2013.

[22] As learning tasks with several possible solution approaches.

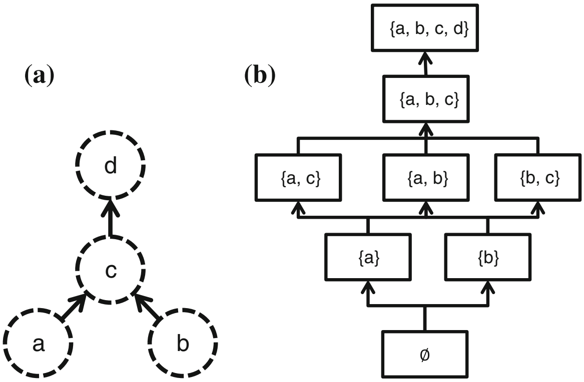

Fig. 2.5 Scheme of a simplified **a** knowledge structure and **b** resulting knowledge space from competency-based knowledge space theory [12]; *source* [97, p. 71]

knowledge in the knowledge structure, but activities (as evidence) moderate between game tasks and the competency model. Such a model of Evidence-Centered Design (ECD), to support creative problem solving assessment of learners' progress, has been developed and proposed by Shute et al. [98, p. 295ff]. Similar to the knowledge structure of Albert and Lukas [12] a competency model is created containing more specific constructs on a lower level, which are connected to more generalized constructs on higher levels (e.g. the concept of novelty informs creativity). Additional to this fully-connected, directed graph (a tree), the model consist of an evidence model and action model. The interdependence of these three components is illustrated in Fig. 2.6.

Actions are activities of a player, measurable in real-time, within the game environment. The actions are weighted by experts, machine learning, or continuous player adaption for all basic items in the competency model. A high value basically means a high relation to an aspect. The heart of the system is the evidence model in which one or more evidence indicators are defined as distribution tables collecting information on several actions and one of the action's aspects. The tables have programming code scripts attached, defining the scoring and accumulation rules for scores. This

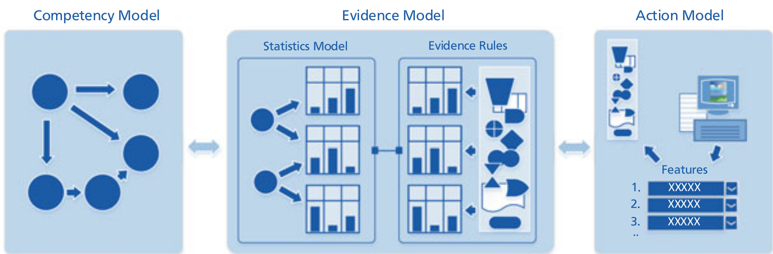

Fig. 2.6 Symbolic scheme of structures from Evidence-Centered Design assignment assignment, based on Shute et al. [98, p. 302]

evidence indicators are connected to one or more items in the competency model to update them when the observed distribution changes (e.g. a highly unexpected action for a specific problem may be encoded as an evidence table observing these actions and informing the competency of novelty if it occurs while working on this problem). Shute and Ventura [99] call the pervasive evidence based measurement of learner's progress *stealth assessment*.

2.2.4 Section Summary

Educational games have great potential to deliver what conventional teaching alone cannot: continuous, individual leaner support by providing the most suitable tasks. Essential are models that connect game activities to intended learning targets (skills) and the provision of tasks for creative problem solving. As games mean entertainment, fun is essential. Most important for this thesis is the finding that many researchers from game based learning research have stated the importance of peer education, creative solutions, and sociability as essential for effective deep learning and fun (flow) together.

Finally, game aspects that have a positive impact on players' motivated deep learning with educational games, considering specifically the aspects related to *peer education*, are identified as:

1. **Social Interaction** creating, sharing, discussing, networking of game content and game experiences.
   [100, p. 39] [101, p. 60]
2. **Peer Tutoring** explaining, documenting, and helping other players.
   [102, p. 71]
3. **Peer Collaboration** collaboration and cooperation on game problems.
   [103, p. 273] [104, 327]
4. **Suitable Tasks** creative problem solving assessment, open format tasks, and self-created tasks. This includes accurate modeling and tracking of players progress by stealth assessment.
   [98, p. 307].

2.3 Serious Games and Social Media

> Compared with games, reality is disconnected. Games build stronger social bonds and lead to more active social networks.
>
> Jane McGonigal, 2011 [58, p. 82]

As outlined in Sects. 2.1 and 2.2 serious games and social media have key benefits for learning. Now both fields are brought together in order to identify the potential of this connection. As the research on the intersection of serious games and social media is quite young, this section will predominantly rely on best practice examples.

In addition, concise definitions are currently missing. Thus, first the view is broadened on the intersection of entertainment games with social media to identify the characteristics of social games and existing technical solutions to use social media in games. Afterwards the view is narrowed to serious social games. Based on these findings, an individually-developed clarification of the term social (network) game as a base for later focused social serious games (in Chap. 3) is realized.

2.3.1 Social Games

The first steps towards the interconnection of entertainment games and social media were the manifold social casual games available free to play online. These were games that were casually played with easy to use interfaces, which were connected to online social networks [105]. Loreto and Gouaïch [105] identify *asynchronous play* as one important characteristic of such games. Players interact by e.g. exchanging items or favors, but do not have to be online or in the game at the same time.

As O'Neill [106] states in his criteria list about social games, these games were (1) mostly turn-based, (2) connected to online social networks, and (3) multiplayer, in a sense that there was (4) an awareness of others' actions in games. His four criteria can be summarized as *casual multiplayer*, which means a single-player game play, but multiplayer atmosphere due to asynchronous play and awareness—and thus interplay—of the activities of others. Such awareness of the activities of others fits with the theory that online social networks are virtual third places providing playful experiences [107]. O'Neill [106] even names as a fifth criterion that these games need to be based on social (media) platforms for player identity and basic communication. It is agreed that such a connection is necessary for a social game, but for other reasons.

Such reasons are explained by Järvinen [108] in the design framework for social network games. He describes, how the structure of an online social network can be integrated into gameplay and how a beneficial interdependency with (and impact) the online social network can be achieved (what he describes as four interacting parts). His criteria are summarized as *beneficial social media interaction*.

The computer game magazine PlayGen published an article in 2010 discussing and defining the core aspects of interaction that make a social game. Two of the four mentioned aspects are competition and collaboration [109]. Competition is described as achieving goals and measurements of performance in a relative way. Collaboration is described as sharing resources, coordinating activities or simply dividing tasks (cooperation). Competition is meant indirectly here as no direct drawbacks (like loss of resources or end of game) for each player should appear. It is a comparative competition. The social games allow players to keep their achieved status and activities of others do not directly cause disadvantages for one's own game play. This concept is called *coopetition* in business studies [110]. It is a key difference in the comparison of social games to traditional multiplayer games.

By these criteria, the term social game[23] is defined by the author of this thesis as follows (based on Konert et al. [111]):

A social game is a video game satisfying the criteria of *asynchronous play*, *casual multiplayer*, *coopetition*, and *beneficial social media interaction*.

2.3.2 Serious Social Games

Using serious topics as game content and designing a game with the intention that players remember key facts and insights related to the topics, are design aspects to make a social game a serious social game, because these aspects add an additional purpose beside pure entertainment. Indeed, Spiegal and Hoinkes [112, p. 469ff] argue this to be one part. In their deep learning model for the creation of serious social games two conditions of the participants need to be ensured: personal relevance to the topic and stickiness.

Stickiness means continuous engagement with the game. This is quite closely related to the continuous state of game flow [75].

Personal involvement can be supported by (1) non-linear narration, (2) adding game elements for physical interaction with the game environment, and (3) supporting interaction among players. Physical is meant as well as immersion into a virtual world. The deep learning model stresses the non-linearity and interaction aspect, due to the fact that the model evolved from the research on immersive cinema concepts and its use in public places like museums. For games, the interaction is obviously an inherent aspect of the games themselves. The second condition of stickiness is (1) the formation of social networks around topic and participants, (2) the persistence of the user-created creative content, and the support of (3) co-creation.

Inter-dependencies of the factors can be identified, e.g. interaction among players relates to co-creation and formation of social networks. Finally, the model emphasizes the aspects of dialogue among players and co-creation for deep learning.

Among existing social games, some can be considered to be serious social games as they allow dialogue, co-creation, and have a serious topic. Exemplary some examples are described here for a better impression on these games' characteristics.

poweRBrands (category: occupation[24]) It challenges the player, who is a marketing and sales employee, to decide on budgets, make allies with other players for campaigns, and ascent to become the company's boss.[25]

[23] In a broader—and historical—view a social game is in principle every game with a group of participants interacting (like e.g. the olympic games or chess).

[24] Referring to the serious game categories, listed in Sect. 2.2 [67, p. 14].

[25] http://www.rb.com/powerbrands/, last visited on August 17, 2013.

GreenSightCity (category: social change) In the simulation of building up a sustainable city, the player can improve the eco-value of buildings, usage of e-bike stations in the city and modern public transport in order to create a green city that attracts more visitors and thus brings more income. Cooperation is possible for building construction with city neighbors.[26]

Many casual (not necessarily social) games exists that are of game category social change, aiming to rise a player's awareness about a serious topic. Even though these games do not fulfill the criteria mentioned above (e.g. co-creation or beneficial social media interaction) a brief list is given here to underline the difference from the serious social games.

EnerCities (category: social change) The scenario of a world without oil is about to come up for the player, who has to manage a prospering city in this simulation. The main task is to switch to renewable energy resources before the limited amount of available oil is empty. The game is well-balanced, but has no content sharing functionality and is purely single-player[27] [113].

Flutter (category: social change) An adventure game, where the player explores the rainforest and has to care about the collected butterflies. Beside the fact that the logo of the World Wildlife Foundation (WWF) appears in the game, it seeks to sensitize to the beauty and clear that social games addprotection of the rainforest eco-system.[28]

DataDealer (category: social change) Recent scandals concerning the collection, selling, and (ab)use of personal information left and shared by individuals online and while using digital information technology, are the core aspects of the game. The player collects data, "hacks" databases, and sells information to build up his data empire.[29]

FoodForce (category: social change) The farming of crops, preparing humanity help packages and sending food to crisis areas in the world, are some of the tasks a player has to manage when playing this game that tells how the United Nations World Food Programme (WFP) works. Indirectly, each purchase of goods in the game has an impact on real world help visualized by the in-game real-world impact tracker.[30]

WeTopia (category: social change) Like other social games, WeTopia is a city simulation that challenges the player to build up a prospering city, build allies with friends and collect a special currency called Joy. The unique key concept is to spent Joy for real-world non-profit charity projects. The advertisement income

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[26] https://www.greensightcity.de/, last visited on August 17, 2013.

[27] http://www.enercities.eu/, last visited on August 17, 2013.

[28] The game was available at https://www.facebook.com/fluttergame/ (discontinued). A new tablet-based version is available, see https://www.facebook.com/flutterbutterflysanctuary/, last visited on August 17, 2013.

[29] http://datadealer.com, last visited on August 17, 2013 (a multiplayer version is in preparation).

[30] http://apps.facebook.com/foodforce/, last visited on August 17, 2013.

of WeTopia is shared with these nonprofit projects and organizations according to the spending of players' Joy in game.[31]

The examples have been chosen thoroughly as representatives of available games, even though it seems impossible to give a broad overview in a few lines. A very well maintained database of games for social change is available online (using peer review for game recommendations).[32]

In conclusion, these examples make clear that social games add the following benefits to gaming and fulfill two of the demanded aspects for deep learning with serious games (as listed in Sect. 2.2.4):

Peer Collaboration by coopetition to accomplish tasks together that are too big for one player alone, and

Social Interaction by beneficial social media interaction enabling sharing and discussing of gameplay experiences.

The currently available social games and models are missing to fulfill the aspects of *peer tutoring* and from a content-perspective as well the provision of *suitable (user-generated) tasks*. The mentioned criteria for social games can be used as mediators for a mapping of social media interactions to the demanded aspects for deep learning in educational games, as proposed later in Chap. 3.

2.3.3 Architectures for Social Media Interaction

While researching existing solutions for interconnection of (serious) games with social media applications, only few scientifically founded architectures could be found. Therefore, best-practice examples from game industry are discussed first, followed by academical solutions.

Game Industry Solutions

Steam Overlay. The online game distribution platform Steam[33] includes the Steam Overlay into games distributed and managed via Steam. Technically the overlay is part of the steam client that runs on the players' machines and contains the games. It offers screenshot functionality (including sharing with Steams own community website[34] or popular social media applications), gifting virtual items, and inviting befriended players for multiplayer games. The overlay provides quick browser and community profile access [52, p. 20].

Steam Workshop. Game developers can create their own modifications or assets for games supporting the content loading via Steam Workshop[35] platform. There

[31] https://apps.facebook.com/wetopia/, last visited on August 17, 2013.

[32] http://www.gamesforchange.org/play/, last visited on August 17, 2013.

[33] http://www.steampowered.com/, last visited on August 17, 2013.

[34] http://www.steamcommunity.com/, last visited on August 17, 2013.

[35] http://steamcommunity.com/workshop/, last visited on August 17, 2013.

is no uniform Application Programming Interface (API) defined, but each game has its own rules and conditions (and possibilities what can and) how to develop content. As operator Valve offers a share of the generated revenue with user-generated content to the contributors, the system contains manifold high-quality extensions. The content needs operator-based approval before being visible for other players. Technically the Steam Workshop works as a central asset repository, accessed by games to load content the player subscribed to. Content creators upload assets to the workshop manually or use their third party editors [52, p. 21].

XFire. Traditionally the XFire client[36] is a versatile messaging client, specialized to the needs of multiplayer gamers communicating within their teams. Additionally, it offers functions to record screenshots and screencast that can be shared on the XFire community site. Social interaction features are also provided for sharing and networking. XFire offers direct in-game browsing, chatting, and game purchasing (like Steam) [52, p. 21].

Still, as it developed recording and sharing functionality independently from the games and decoupled from the own community platform, it appears to be more open to integration and interconnection with third-party social media applications.

Academic Solutions

Community Network Game. The project aims to insert graphical interface elements (overlays) and replace textures in games without necessity of game client code changes. Additionally, it is game independent and uses peer to peer technology to allow overlay-applications to interconnect players independent of the currently played game. Envisioned core functionality consist of live streaming of gameplay video and integration of collaboration tools. The authors speak as well of integration and exchange of user-generated content, but mean exchange of files, votes, chat messages, and screenshots or video [114]. As defined in Sect. 2.1 this does not fulfill the criteria for user-generated content used in this thesis.

Technically the solution consist of an incubating client that starts an embedded game. This client intervenes with the input-output system of the hosting operation system to manipulate graphical elements of the current game and processes inputs meant for currently displayed overlays. All overlays will be realized by browser-technology, rendering HTML-based windows with Adobe Flash and/or JavaScript technology [115].

Virtual Context Based Services. Like the Community Network Game, the *Virtual Context Based Services* framework, proposed by Bergsträßer et al. [116] and Hildebrandt et al. [117] in their coordinated research, offer an infrastructure independent from a specific game and running as an stand-alone client on the player's system. The main focus lies in defining service connectors and virtual contexts that cause a service to be invoked, if specific conditions are met. The service connectors detect running game instances on the client machine and connect to

[36] http://www.xfire.com/, last visited on August 17, 2013.

Table 2.7 Comparison of existing architectures supporting educational game criteria (5–8) and social media interaction functionalities (9–12)

	SteamO	SteamW	Xfire	CNG	VCBS
Design approach	Incubator	Middleware	Incubator	Incubator	Client & Services
Game adaptation needed	Yes	Yes	N.A.	No	No
Reading game data	Yes	No	Yes	Yes	Yes
Writing game data	(Yes)	Yes[a]	No	Yes[b]	Yes
Social community	Yes	Yes	Yes	No	(Yes)
Social interaction	Yes	(Yes)	Yes	Yes	Yes
Peer tutoring	Yes	No	Yes	Yes	Yes
Peer collaboration	No	No	No	No	No
Suitable tasks	No	No	No	No	Yes
Publishing	Yes	Yes	Yes	Yes	Yes
Sharing	Yes	No	Yes	Yes	Yes
Discussing	Yes	Yes	Yes	Yes	Yes
Networking	Yes	Yes	Yes	No	Yes

(SteamO) Stream Overlay, (SteamW) Steam Workshop, (CNG) Community Network Game, and (VCBS) Virtual Context Based Services. [a] pull by game only, [b] visual elements only

the processes by using the game API to read status parameters and manipulate game elements. The services can offer interface elements to the player, allowing the implementation of any service possible (as long as suitable methods can be found in the game internal API). As such, the concept differs significantly from the Community Network Game as the Virtual Context Based Services focus on context detection and need game specific service connectors to work. Contrariwise, this game-specific implementation allows more game element manipulation than pure graphical elements, like game status and object attribute manipulation. In conjunction with Hildebrandt et al. [117] the work allows the extraction of reliable game player profile information, aggregation, and publication on social media platforms maintaining game players' profile information (e.g. hours of gameplay or level of expertise in game) [116, 118].

The proposed solutions differ in focus, scope of supported games, and underlying technology. Therefore a condensed comparison is provided in Table 2.7, focusing on two sets of requirements: First, the criteria derived from the analysis of demands from researchers for deep learning in educational games (based on the core aspects for learning from pedagogy) as described in Sect. 2.2.4 and second, the support for the core concepts of social media applications as they are necessary functionalities to integrate social game functionality into serious games as discussed above (at the beginning of Sect. 2.3.

A detailed description about the assessment of the individual criteria in Table 2.7 is listed in Sect. A.2.1.

2.3.4 Section Summary

The preceding section has outlined, how the key strength of social media (support for creation and content publication, sharing, discussing, and peer networking) can be used to support the desired aspects demanded for educational games to evolve learning with games to deep learning:

- *Social media* can support knowledge transfer and suitable tasks in games with it's created and shared content as learning resources,
- *Peer collaboration and tutoring* in games can be enhanced by adding loose coupling and networking, content discussions and sharing.
- Finally, *social interaction*, as a core functionality of social media (by networking), can be strongly enhanced by creation of learning communities and learning group formation.

2.4 Chapter Summary and Focus of this Work

In Sect. 2.1 this chapter on related work first outlined the fundamentals of learning theory and the importance of observation possibilities, self-practice, and interaction for learning with a focus on peer education, consisting of peer tutoring (low equality, low mutuality) and peer collaboration (high equality, high mutuality).

Social media applications offer possibilities for observation, self-practice, and interaction based on user-generated content that is published, shared, and discussed by individuals on a non-professional basis. It is the inherent ideological foundation behind the usage of social media applications to support active participation in the creation of content by each individual. Interaction is supported by social media applications' social networking support.

In the intersection of both, learning and social media, Massive Open Online Courses (MOOCs) evolved as the Personal Learning Environment (PLE) concept supporting peer education and all social media interaction patterns.

In Sect. 2.2 the concept of game flow explained the necessity to adapt the difficulty of challenges to players' abilities in entertainment games. As not all players are equal, modeling of players' preferences is necessary to adapt difficulty and task type individually. From the intersection with learning, the field of education games evolved, adding the challenge to connect game flow with learn flow. Accordingly, models of learning style preferences are needed as not all learners are equal. It is still a high claim to support deep learning with educational games. Stealth assessment as continuous monitoring of evidence for learning progress and especially the support for problem-based learning have been claimed as requirements.

It is concluded that the discussed research approaches and current status of educational games would especially benefit from support for (a) *social interaction* to allow deep learning and reflection of game experiences, (b) *peer tutoring* to add learning by teaching to games, (c) *peer collaboration* to support creative problem-based learning, and (d) *suitable tasks* based on player modeling, learner modeling, and continuous stealth assessment.

Finally, in Sect. 2.3, the intersection of serious games and social media has been identified as a research field with limited research results and models available due to the novelty of the field. Based on publications of several game developers and researchers from the field of social and casual games, four core concepts that a social game needs to support were identified: (a) *asynchronous play*, (b) *casual multiplayer*, (c) *coopetition*, and (d) *beneficial social media interaction*. These concepts support the four demanded aspects to be added to educational games.

Game examples were briefly described supporting social interaction and peer collaboration. Further research is required to determine how peer tutoring and suitable task provision can be likewise added to educational games. How the overall depth of the learning experience can be enhanced, similarly necessitates greater study. From a technical point of view, first architectural concepts exist that can add some of these functionalities to existing games.

In conclusion, the intersection of the three research fields (serious games, social media, and peer education) provides the potential to enhance educational games further by combination with social media applications and user-generated content as knowledge media. A content-centered support for peer education concepts is expected to enhance deep learning in educational games and fulfill the requested improvements of open task provision, social interaction, peer tutoring, and peer collaboration in such games.

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