Designing MOOCs for the Support of Multiple Learning Styles

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Abstract. "Internetworking with TCP/IP" is a Massive Open Online Course, held in German at openHPI end of 2012, that attracted a large audience that has not been in contact with higher education before. The course followed the xMOOC model based on a well-defined sequence of learning content, mainly video lectures and interactive self-tests, and with heavy reliance on social collaboration features. From 2726 active participants, 38% have participated in a survey at the end of the course. This paper presents an analysis of the survey responses with respect to the following questions: 1) How can a MOOC accommodate different learning styles and 2) What recommendations for the design and organization of a MOOC can be concluded from the responses? We finally give an outlook on challenges for the further development of openHPI. Those challenges are based on didactical and technical affordances for a better support of the different learning styles. We propose an evolution of the xMOOC, that bridges the gap to the cMOOC model by developing tools that allow users to create diverging paths through the learning material, involve the user personally in the problem domain with (group) hands-on exercises and reward user contributions by means of gamification.

Keywords: massive open online courses, learning styles, culture of participation, active learning, gamification.

1 Introduction

The concept and format of "Massive Open Online Courses" (MOOC) have been invested with hopes for radical changes in higher education, due to their potential to make high quality teaching accessible to everyone with broadband Internet access and motivated to invest their time into concentrated learning. While all MOOCs share the goal of bringing together thousands of learners into a common event, they largely differ with respect to the underlying concept of openness [11]. Minimally MOOCs are open because access is not restricted by cost, affiliation, or any other type of privilege. They differ with respect to the openness of the learning content and the learning process. Siemens [14] has suggested to distinguish between xMOOCs which rely on the traditional lecture format supplemented with interactive exercises and discussion boards, and cMOOCs that

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are based on a connectivist pedagogy [13] that invites learners to engage in a self-organized and social learning process. While xMOOCs tend to use learning materials with proprietary licenses and a relatively closed, predefined schedule, cMOOCs often make use of open educational resources, and allow learners to co-construct the learning process through their interactions. It has been argued (T. Bates cited by [11]) that the pedagogy of xMOOCs is better suited for learning domain knowledge that can be mastered through repetitive practice, but that only cMOOCs allow learners to acquire higher order creative skills.

The xMOOC format derives its name from the platform edX[1], founded by Harvard University and the Massachusetts Institute of Technology as joint venture for hosting online courses that extend the reach of the university's teaching to a massive audience. The first experiments with the xMOOC format though are ascribed to courses offered by professors in Stanford university[2] that have later inspired the two commercial projects, Udacity[3] and Coursera[4]. The cMOOC concept was derived from a course experiment led in 2008 by Canadian educational researchers, George Siemens and Stephen Downes, and the discussion it generated about the pedagogical theory of connectivism that conceives learning as the creative and social process of connecting nodes of knowledge [9].

In this paper, we report on our experiments in an xMOOC where we included practical exercises in order to go beyond the purely theoretical presentation of learning content and to invite learners to relate and to apply knowledge to their everyday environment. We believe that this strategy

- will allow mediation of the dichotomy of cMOOC and xMOOC,
- is attractive for different learning styles
- has the potential to nurture an active participatory culture.

openHPI [6] is a platform for xMOOCs, offered by the Hasso Plattner Institute (HPI) in Potsdam , Germany. In November/December 2012 it hosted the course "Internetworking with TCP/IP" (the first xMOOC in German language) that attracted a large audience that has partly not been in contact with higher education before.

The majority of our course participants belong to the 20-29 and 30-39 age groups (each approx. 30%). About 20% belong to the group from 40 to 49 and a remarkable high share of 16% comes from the "silver surfers" group above 50 years. The remaining 4% are pupils of 19 years and younger. The youngest participant stated his age with 12 years, the oldest with 91. About 24% of the participants said, that they never went to university, 21% chose a B.Sc. as their highest degree, 25% the M.Sc. or equivalent and 4% finished a PhD degree. The

[1] `https://www.edx.org`

[2] Artificial Intelligence by Sebastian Thrun and Peter Norvig (`https://www.ai-class.com/`, Machine Learning by Andrew Ng (`https://www.ml-class.org/`) and Introduction to Databases by Jennifer Widom (`https://www.db-class.org`)

[3] `https://udacity.org`

[4] `https://coursera.org`

remaining 26% answered with "other" when asked for their highest degree. Since openHPI focuses on ICT topics, we also ask for our users background in ICT on registration: approx. 6% stated to have no experience, 32% declared themselves as "beginners", 45% as "advanced" and 17% as "experts".

From a survey delivered to all of the approximately 10,000 registered participants (out of which 2,726 participated actively), we obtained more than 1,000 responses, that allow us to understand the motivations, conditions and expectations for taking part in the course, and to obtain a high number of valuable suggestions for improving the course content and format.

The structure of the paper is as follows: First, we explain the concepts of experiential learning and culture of participation. Next, we present the results of the survey and then our implications in form of design guide lines. We conclude with an outlook on further development of the platform.

2 Theory

Experiential learning describes a didactical model, where learning is not primarily based on abstract theorization, but on a holistic cycle that includes concrete experience, reflective observation, abstract conceptualization and active experimentation [8]. These phases are organized in two dimensions: perceiving (from abstract to concrete) and processing (from reflective to active). Learners prefer one of four combinations of these two dimensions:

- **Divergers** combine concrete experience with reflective observation. They learn from examples and can analyze these from different perspectives.
- **Assimilators** combine abstract conceptualization with reflective observation. They prefer learning from theoretical models.
- **Convergers** combine abstract conceptualization with active experimentation. They learn by processing ideas and concentrating on precise problems.
- **Accomodators** combine concrete experience with active experimentation. They learn from experiments and match models to their obtained insights.

xMOOCs predominantly cater to the assimilating learning style through the presentation of concepts and the video format that invites to reflective observation. In order to make the learning process more holistic, MOOCs need to integrate activities that allow active experimentation and that relate to concrete experience.

What is still missing in Kolb's theory is an explicit recognition of the social dimension of learning [17]. The social dimension of learning takes into account that learning occurs together with others in all kinds of social situations or contexts [1]. Wenger argues that a learner needs to participate in a community in order to understand and create meaning [16]. ICT in distance education has the role to to allow students to learn from and support each other despite the physical separation [10]. We believe that the problem ob the missing social dimension in Kolb's theory of learning can be alleviated through the inclusion of Fischer's concept *culture of participation*. This is the case, because Fischer's concept deals

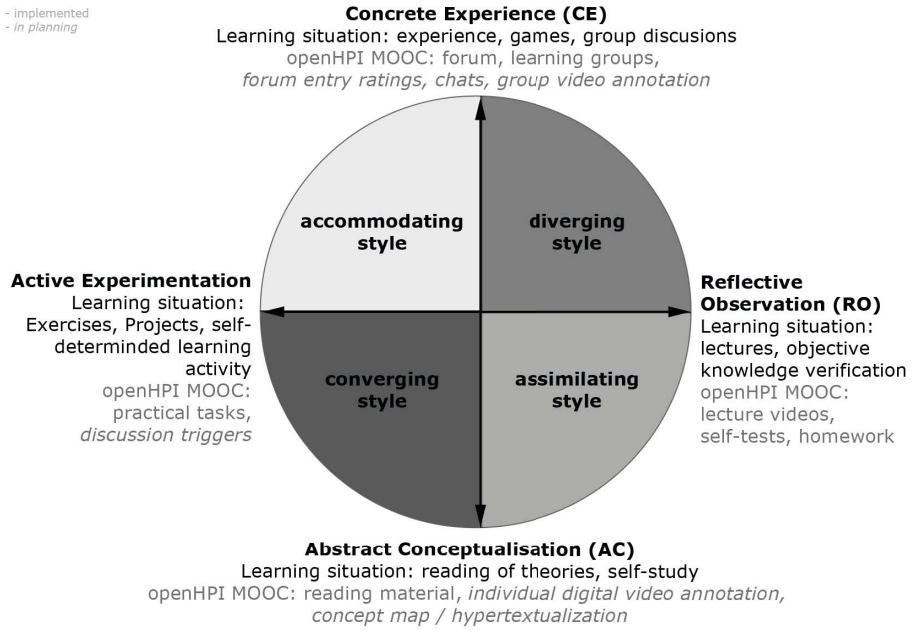

Fig. 1. Learning Styles by to Kolb (according to [8] and [15] pp. 67/70) and their specification in openHPI

with guidelines for socio-technical systems to be implemented in a participative manner so that individual are supported to engage in collaborative activities. And Wheeler explains, that the weekness of Kolb's theory is exactly that, not to consider the interactive digital media of today's world that is socially rich [17].

Gerhard Fischer [5] suggests design guidelines for socio-technical systems aiming at stimulating participation. Through certain key elements within the platform, social exchange and collaboration should be enabled and supported. The culture of participation consists of three parts:

- **meta-design**: where collaborative design is enabled by the infrastructure;
- **social creativity**: that shall support collaboration among learners;
- **different levels of participation** (see figure 2): those levels should allow different degrees of engagement with the system and its content. The different levels range from totally unaware consumers that have no knowledge about the possibilities they have to participate to the meta-designers who even go beyond the boundaries of the given environment and create new knowledge, tools and workflows.

Intrinsic motivation is basis on which the culture of participation is build upon. This motivation can be triggered by group support, the feeling of a common purpose and a collaborative creativity [5]. Fischer's design guidelines include the following outlines:

- Human-Problem Interaction as an advancement over human-computer-in"-ter"-ac"-tion shall be supported with the help of meta-design environments in order to make problem owners responsible and encourage social creativity.
- Underdesign to encourage lively and open information creation and encourage individual workflows instead of limitating the participants by fixed environments, contents and processes.
- Support diverse levels of engagement in order to respect and consider the different motivations, pre-requisites and needs of the participants and to smooth the path to more challenging roles.
- Awareness and rewards for contributions should be supported in order to strengthen the social incentives for participants. Those incentives include the possibility to build up a reputation within the community and receive feedback.
- Parallel development of the community and resources for system development shall be supported by encouraging cross-pollination between those two.

They are underlying some of our design guidelines for MOOCs that will be presented in the next but one section.

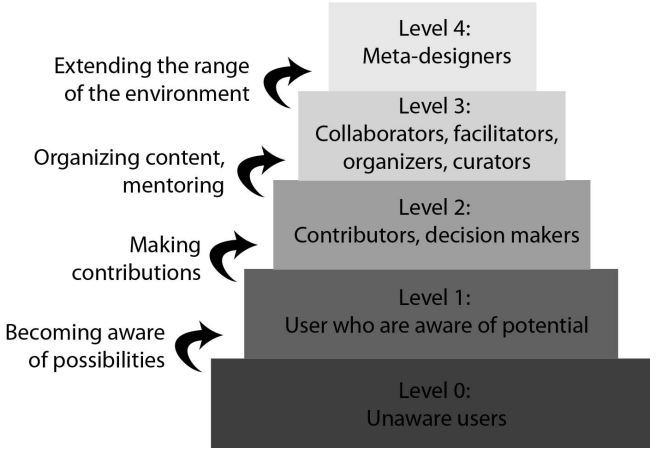

Fig. 2. Ecologies of Participation according to Gerhard Fischer [5]

Dick and Zietz [3] further analyzed different motivations within these cultures of participation. They identified social norm, social proof as well as peer pressure as the main motivational factors. The key enabler for this behavior to be triggered is the awareness of other group members' actions within the socio-technical-system. Dick and Zietz therefore concluded that instead of trying to make people more active, system designers need to focus more on the awareness of the users for the action they may take and the reward they may get from it.

The next section will deal with a mostly qualitative, but in key points also quantitative analysis of the participants of the "Internetworking" course. We aim at providing further information about which offerings were most accepted and useful as well as which further developments people wish for. We focus our analysis on elements identified within the learning styles and cultures of participation theories.

3 Survey Evaluation

At the beginning of 2013 we conducted a study among the students of the first German speaking MOOC at our institute, that is to our knowledge the German speaking MOOC with the largest number of participants so far. From the 2726 active participants of the course, 42,3% have taken part in the survey. The large number of questionnaires completed (n=1153) allows us to statistically evaluate the results. Nevertheless, there is the possibility of self-selection bias since we did not capture if only very successful participants or those who had a very positive experience completed the questionnaire.

The survey allowed us to confirm a high degree of satisfaction amidst the participants with the course content and structure: High satisfaction with the expertise of the learning material was expressed by 92.1% (70.7% very satisfied, 21.4% rather satisfied) for the lecture videos, 88,8% (63.7% very and 25.1 rather satisfied) for the tutorial videos, 89.8% (58.3% very and 31.5% rather satisfied) for the slides, 70.8% (44.8% very and 26.0 rather satisfied) for the reading material, 87.7% (56.6% very and 31.1% rather satisfied) for the quizzes. At the same time, the usefulness of the different types of learning materials was also confirmed to a large extent, as can be seen in figure 3. Interestingly the social features of the platform (forums, learning groups) were not seen as having a positive impact on the learning success. We also asked users to express their self-assessment of their expertise in five different topic domains before the start and after the end of the course, on a scale with the following values: 0 (no knowledge), 1 little knowledge, 2 substantial knowledge, 3 expert knowledge. The average delta for the cumulative knowledge across the five domains was 4.86 points, i.e. the average user was able to advance approximately one level in each of the five domains. 8.6% of the users even expressed an advancement of 10 points and more. We cannot eliminate the optimism bias, though, since the knowledge delta was calculated based on a self-evaluation of the participants.

The survey also gave us access to qualitative feedback and recommendations for improvements to the platform and to the course content, from which we will deduce guidelines in the following section. In the following, we summarize some salient topics:

– **Consistency** Learners expressed very thoughtfully their dissatisfaction with several occurrences of inconsistencies in the content. For example when quizzes made references to concepts that had not been covered in the preceding video lecture, when definitions were contradictory or not sufficiently precise.

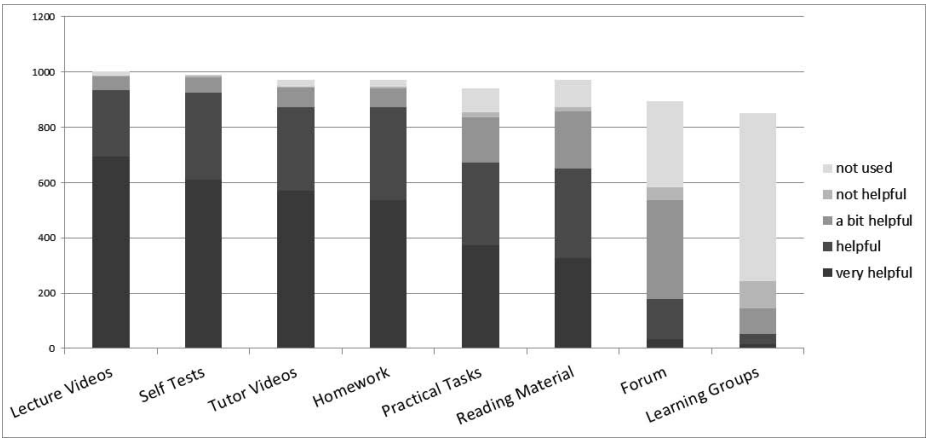

Fig. 3. Reception of the learning materials by the participants of openHPI

- **Multimedia** Participants suggested to move beyond the traditional lecture format and make more intensive use of visualizations, animations and simulations, which helps grasp complex concept relationships.
- **Hypertext** Numerous respondents requested more extensive collections of links that allow them to discover valuable resources on the Internet.
- **Synchronous communication** Several participants expressed the wish for more immediate communication, which can be supported through the establishment of private and group chat functions.
- **Practical relevance** Most important, survey respondents asked for still more practical examples and exercises, for example by using virtual laboratories, or by presenting challenges that would require investigating the learner's own network environment.

4 Design Guidelines for MOOCs to Support Experiential Learning

MOOCs have the potential to deliver high quality learning experiences to an unprecedented high number of learners. Our survey confirmed on the one hand that learners acknowledge the quality of video lectures and textual learning resources, and we conclude that these effectively support the assimilating learning style and that they explain the high level of self-estimated positive learning results. On the other hand, learners ask for more intense support of active experimentation and are interested in relating the concepts to their own experience. MOOCs can go beyond the concentration on the assimilating style through the adoption of the following guidelines, that are based on the integration of a social dimension into Kolb's concept of experiential learning. First we describe how learning tools can target the four learning styles separately, then we show how they can be integrated into a holistic process through the integration of a culture of participation.

- The accommodating learning style should be supported through practical exercises that call upon learners' existing experience. In the "Internetworking" course we included tasks like using Wireshark[5] to find out about certain details of the protocol usage within one's own computer. The hands-on tasks were introduced by a tutor video (or screencast) and heavily questioned and discussed in the forums. Inquiry-based learning is a long-standing paradigm in the educational sciences, but scaling these approaches to the context of a MOOC is still an open challenge.
- The diverging learning style is inspired by the inclusion of many perspectives, and the high number of participants in a MOOC can be leveraged to create these perspectives. In order to nurture a vibrant discussion culture, we introduced discussion triggers, discussion threads where the community should discuss issues strongly related to the course content, but not directly covered. This can even result in learners contributing these triggers, as we could observe with a posting containing an assignment question concerning the behavior of nodes on a network route. Salmon [12] has developed an extensive framework on best practices for stimulating discussions in on-line learning.
- The importance of consistent and well presented learning materials has been mentioned in the preceding chapter, and this is particularly true for learners that prefer an assimilating learning style. Beyond the necessary quality assurance, we also suggest to provide glossaries for quick reference and concept maps that facilitate the cognitive orientation in the knowledge domain. More generally speaking, learning materials in MOOCs should not fall back behind the advancements made in educational hypertexts during the last decades: Hypertextual links should allow learners to understand relations between concepts, and also to navigate beyond the boundaries of the course.
- Converging learners are best inspired by visualizations, simulations and experiments that involve problem solving and decision making. MOOC platforms like Udacity and edX provide virtual environments that allow learners to directly interact with simulations for electronic circuitry or a programming environment. At openHPI, we are actively investigating how virtual IT environments can be made scalable for massive participation. Fischer et al. [4] have shown that presenting learners with content-specific visualization tools can foster the collaborative construction of knowledge.

The massive nature of participation in a MOOC creates new opportunities for strengthening the social dimension of learning. As we have described, a learning community with an active culture of participation can constitute an environment where the four phases of experiential learning are more dynamically intertwined. In the following paragraphs we present in more detail how active participation in a community allows learners to enrich abstract concepts through group annotations, to engage more actively in experiments that allow for creative interpreta-

[5] Wireshark is a well-known tool for the inspection of network traffic – a so-called network sniffer – that is used for network administration and diagnosis as well as for eavesdropping, see `http://www.wireshark.org/` .

tion of concepts, to develop new perspectives on concrete experience from group discussions and to reflect one's learning process more thoroughly by linking it to how one's peers learn.

Different Participation Levels. In order to support social interaction, different levels of engagement should be open for the participants, dependent on their interest in social interaction. The levels can be seen adjacent to the levels proposed by Fischer in his design guidelines for the culture of participation [5].

- Level 0 in the hierarchy of participation levels in MOOCs is describing the passive consumer, who watches videos, consumes the reading material, does his exercises for himself.
- Level 1 is the aware consumer, who is reading the forum, but not actively participating in other activity.
- Level 2 is the active participant who writes forum posts himself and participates in learning groups.
- Level 3 is the enabling participant who starts own forum threads, user groups and chats and triggers discussions and other group learning activities, like manuscript writing in groups.
- Level 4 describes meta-designing participants who move beyond the given learning platform and implement their own games, tools, tutorials, blogs and other material that fellow learners may use.

Awareness, Judgment and Reward for Contributions. As awareness is the key to active participation and social judgment and reward a major motivational factor [7], these should be supported intensively. Rating of forum entries, a public board for the most active users, and promotions to forum moderators are possibilities for the implementation of this design guideline.

These aspects are approached by enhancing the openHPI platform software with a comprehensive set of gamification features. Gamification is defined as "the use of game elements and game design techniques in a non-games context" [2], where the game elements toolbox contains concepts like points and scores, levels, badges, progress bars, leader boards, challenges (or quests), etc. Some common functionality of e-learning platforms fit into a gamification system, in precise all kinds of quizzes (which gain points) or the reception of learning material (which can show up in an overall progress display). For other functionality specific to MOOC platforms – in particular discussion boards – there are sophisticated best practice examples, such as *Stack Overflow* (see `http://stackoverflow.com/`) that show, how gamification can result in an enhanced contribution feedback experience. The *Stack Overflow* discussion boards for example allow voting on everything, i.e. questions, answers or even comments to answers. Users gain points and badges based not only on the number of contributions, but also on the quality of their contributions as experienced by the community. This concept can be mapped directly on most user generated content in the context of a learning platform and will be part of the openHPI gamification feature set.

Stimulate Contributions. In order to evolve from a closed and pre-defined learning setting to an open learning culture, participants should be stimulated to provide own content and enhancements to existing content. openHPI participants for example generated their own audio podcasts to our video lectures and their own exercises – even though the current state of the platform does not provide any facilities for users to integrate these contributions. The participants actually used the course forum to make their contributions available to the learning community [6]. Participants' video tutorials and other enhancements mentioned in participation level 4 already are further contributions that can be thought of. The task of the platform provider is to offer a space where those contributions can be made accessible to fellow learners. Current plans for a platform extension cover, among other things, tools for:

- community-driven subtitles and translations for the lecture videos;
- uploading participants' media files (podcasts, tutorial videos, mind maps, etc.);
- a *battle ground* for user generated quizzes and challenges.

Supplying rating capabilities for all of those items is a suitable way of quality assurance and integrates seamlessly with the above-mentioned gamification concept. Besides this, many participants positively replied to the question about the usefulness of group annotation features for videos. Considering the only moderate acceptance of general learning groups, this new group annotation feature should be closely linked to the lecture video and should again incorporate awareness and reward mechanisms.

Human-Problem Interaction. An approach for leveraging human-problem interaction is the provision of hands-on exercises. There are numerous solutions for courses and online laboratories in the domain of programming (e.g. *Codeacademy* or *CodingBat*[6]), and databases (e.g. Standfords online course *Introduction to Databases*, mentioned before as *DB-Class*). More general approaches for such laboratory environments from the past years usually build on virtualized computer labs that provide remote access to virtual machines running on a central server (respectively the cloud) or are distributed on removable media (rather unsuitable for MOOCs). The problem with these virtual laboratories in the context of a social learning experience is that the assignment tasks usually are static or must be personalized manually, which doesn't scale for a massive amount of users. Thus, these hands-on assignments would not be cheating proof, since learners just could share the results of a practical task allowing other users to omit the task but still being able to solve the assignment. The authors of [18] propose a more generic approach for the automatic assessment of hands-on exercise assignments: the lab management system asserts a student- and task-specific pre-condition that is configured inside a training machine before the student can get access. During the exercise, the student can reveal a "secret" that is affected by the pre-condition and thus prove the successful completion of

[6] see `http://www.codeacademy.com` and `http://codingbat.com`

the practical task by submitting the unique secret value to a quiz environment. Future openHPI courses will integrate a virtual lab automatic online assessment.

5 Conclusion and Future Work

Pedagocical models and technical frameworks for MOOCs are in the focus of scholarly debate and media attention. Based on the experience of openHPI's "Internetworking" course and on an evaluative survey, we have presented arguments for a future development of the xMOOC model that bridges the gap towards the cMOOC model: 1) Learning materials could be enriched through concept maps and hypertextual links that allow diverging, learner-defined paths; 2) Hands-on exercises allow learners to feel personally involved in the problem domain through their active experimentation and to grasp the complex relations to their own concrete experience; 3) Group discussions that support awareness, and reward contributions, allow learners to feel responsible and to collaboratively strengthen the learning process and to provide richer perspectives for reflective observation. This development heavily depends on the emergence of a culture of participation, where learners are motivated to contribute to a network of resources. We have outlined some guidelines for supporting this culture, that we are adopting and improving in our current research and development activities: human-problem interaction in scalable virtual laboratories, and learning services and practical tasks that connect with learners' living environment; gamification features that increase the learning motivation and create responsibility and engagement; social communication tools that allow users to evolve from lower to higher degrees of participation.

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